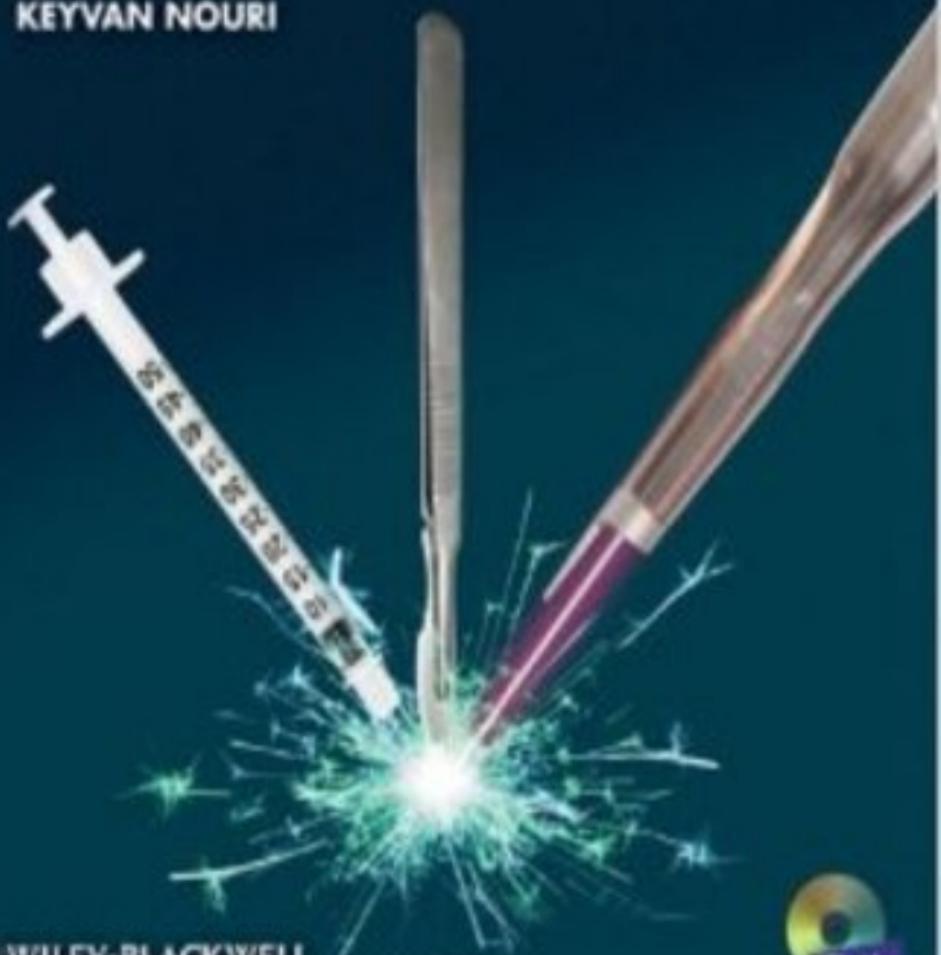


Dermatologic Surgery

Step by Step

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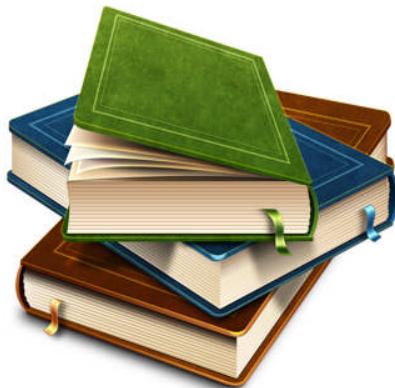
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Dermatologic Surgery

I dedicate this book to my dear family and friends who have been there for me throughout my life.

I love you all.

Keyvan Nouri, MD

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A John Wiley & Sons, Ltd., Publication

This edition first published 2013, © 2013 by Blackwell Publishing Ltd.

Blackwell Publishing was acquired by John Wiley & Sons in February 2007. Blackwell's publishing program has been merged with Wiley's global Scientific, Technical and Medical business to form Wiley-Blackwell.

Registered office: John Wiley & Sons, Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial offices: 9600 Garsington Road, Oxford, OX4 2DQ, UK
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Library of Congress Cataloging-in-Publication Data

Dermatologic surgery : step by step / edited by Keyvan Nouri.

p. ; cm.

Includes bibliographical references and index.

ISBN 978-1-4443-3067-0 (hardback : alk. paper)

I. Nouri, Keyvan.

[DNLM: 1. Skin—surgery. 2. Skin Diseases—surgery. 3. Laser Therapy—methods. 4. Reconstructive Surgical Procedures—methods. WR 650]

617.4'77—dc23

2012017387

A catalogue record for this book is available from the British Library.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books.

Set in 9/12pt Minion by Toppan Best-set Premedia Limited, Hong Kong

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Foreword

Dermatologic surgery is evolving quickly. The popularity of dermatologic surgery and procedures are rapidly growing to the extent that they are now becoming one of the main cornerstones of any dermatology practice.

The incidence of skin cancers is rising annually. Non-melanoma skin cancers constitute the majority of all skin cancers. In general, more than half of all the cancers are skin cancers. More than 3.5 million new cases per year are reported in the United States, and there is a noticeable rise in these among those patients who are immunosuppressed, such as those who have received organ transplants or have acquired immunodeficiency syndrome.

Dermatologic surgery is expanding significantly. Not only are new techniques for removal of skin cancer and defect repair arising, but many cosmetic procedures are much more popular. They are becoming incorporated into the daily practice of many physicians, including dermatologists. Owing to patient demand and innovative technology, procedures commonly performed by dermatologists consist of Mohs micrographic surgery/skin cancer excision, reconstructive surgery involving flaps and grafts, injecting fillers and neurotoxins, lasers, chemical peels, and sclerotherapy, among others.

Dermatologic Surgery: Step by Step edited by Dr. Keyvan Nouri illustrates the techniques mentioned above, along with many more, in great detail. They are taught in a stepwise fashion, and most have accompanying video demonstrations. The book is divided into three main

conceptual sections: general dermatologic surgery, cosmetic surgery, and lasers and miscellaneous topics. Each chapter is written in a concise format and features preoperative care, step-by-step surgical technique, postoperative care and follow-up, complications, and prevention and management of complications. The chapter includes clear descriptions and illustrations. The superb format provides physicians with easy-to-read information for quick review and reference. The DVD secures teaching with visual demonstration.

To sum up, I strongly recommend the textbook *Dermatologic Surgery: Step by Step* by Dr. Keyvan Nouri and published by Wiley-Blackwell as one of the best textbooks in this area. This is an excellent review and study book to learn oncological and cosmetic dermatologic surgery procedures from A to Z. It can be a cornerstone for dermatologists, plastic and oculoplastic surgeons, family medicine physicians, otolaryngologists, and other physicians of specialties that are performing these procedures. I congratulate Dr. Nouri and all the authors and publisher for putting together such a thorough, detailed and illustrious textbook.

Perry Robins, MD
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Preface

The field of dermatology, including dermatologic surgery, is quickly evolving. Newer lasers along with new indications of these lasers and various cosmetic procedures, such as fillers and neurotoxins, are constantly being introduced. Research on dermatologic techniques is rapidly expanding and can be overwhelming. This book offers a detailed outline of many dermatologic procedures, namely Mohs surgery/skin cancer excision and reconstructive surgery, among others.

Dermatology is a procedure-based practice that requires the understanding of techniques in dermatologic surgery and standard of care. This book has been written with the authors' and editor's sincere hope that it will serve as a cornerstone for learning how to perform these procedures.

Each topic is presented in a comprehensive yet readable and understandable format. The chapters consist of an introduction and a step-by-step explanation and video demonstration of each procedure or technique. The book begins with an understanding of the basic, daily procedures such as anesthesia infiltration, suture techniques, biopsy techniques, and wound healing. Surgeries that involve reconstruction, flaps, grafts, facelift, and hair transplant are outlined as well.

Other cosmetic procedures are described, such as sclerotherapy, laser treatment, botox, and fillers. Acne is one of the most common complaints encountered in this field, and procedures to treat acne and acne scars are addressed in two separate chapters. The psychological, medicolegal, and ethical components of dermatologic surgery are discussed, too. Rather than a review of literature focusing on procedures, this book is designed as a stepwise approach to learning procedures. When the conceptual background of a procedure is present, the most clinically pertinent points are highlighted.

We are extremely grateful to our excellent contributing authors, who anticipate that this book will be of interest to all the physicians who encounter dermatologic procedures frequently in their practice, as well as for dermatologic surgeons. This book will serve as a potential study source for dermatologists, plastic and oculoplastic surgeons, family medicine physicians, otolaryngologists, and laser specialists in different specialties of medicine and surgery.

Keyvan Nouri, MD

Acknowledgements

I sincerely thank all the authors of this textbook. Without their time and energy, writing this book would have not been possible. These individuals have made this a comprehensive, up-to-date, and reliable source on dermatologic surgery. I truly appreciate their hard work and thank them for their contributions.

Throughout my career, my family has always supported my many endeavors. I cannot thank them enough for their kind encouragement and love.

I would like to give a special thanks to Dr. Lawrence A. Schachner, Chairman of the Department of Dermatology and Cutaneous Surgery at the University of Miami Miller School of Medicine. He has been my mentor throughout my professional career. His guidance and role as an advisor over the years have influenced my efforts.

I am grateful to Dr. William H. Eaglstein, former Chairman of Dermatology at the University of Miami Miller School of Medicine for helping and guiding me since my start in dermatology. I appreciate all of his guidance and support.

Thank you to Dr. Perry Robins, Dr. Robin Ashinoff, Dr. Vicki Levine, Dr. Seth Orlow, the late Dr. Irvin Freedberg, Dr. Hideko Kamino, and the entire faculty and staff at New York University School of Medicine Department of Dermatology. You have all created a wonderful learning and friendship experience during my surgery fellowship.

I would like to thank the faculty, dermatology residents, and staff of the Department of Dermatology and Cutaneous Surgery at the University of Miami Miller school of Medicine for their teaching, expertise, and friendship. I give special acknowledgements to the Mohs and Laser Center staff at the Sylvester Cancer Center for their hard work and support on a daily basis. I would also like to thank the Mohs staff: Maria D. Garcia, my administrative assistant, Cathy Mamas, Juana Alonso, Tania Garcia, Liseth Velasquez, and Destini Miller for their diligence and hard work. Thank you for making my job a pleasure.

Thank you to my research fellows, Dr. Mohamed L. Elsaie, Dr. Sonal Choudhary, Michael McLeod, Kate Ferris, Dr. Anna Chacon, and Jennifer Ledon for their hard work and dedication to composing the book. Thank you to Dr. Yasser Al-Qubaisy, Marilyn Zabielski, and Dr. Katlein Franca for their contributions.

I would also like to acknowledge the publishing staff Dr. Martin Sugden, Ms. Jennifer Seward, and the entire Wiley-Blackwell Publishing team for having done a superb job with the publication. It has been a pleasure working with them on this excellent project.

Keyvan Nouri, MD

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PART 1

Dermatologic Surgery

Cutaneous anatomy in dermatologic surgery

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Introduction

Knowledge of anatomy is essential to every surgeon. The subtleties of surface anatomy require a special, fine-tuned understanding and are meaningful for a successful dermatologic procedure in both cutaneous oncology and cosmetic surgery. Understanding the cutaneous anatomy of the head and neck is essential in directing appropriate anesthesia, reducing postoperative complications, and providing for an acceptable cosmetic outcome. The anatomy of the face is often regarded in terms of cosmetic subunits and will be discussed as such in this chapter.

Scalp and forehead

The frontal hairline separates the forehead from the scalp superiorly and laterally, and the temporal region is separated from the scalp by the temporal hairline.¹ The forehead ends at the zygomatic arch inferiorly, while the inferior scalp is separated from the neck by the nuchal line inferiorly. The anatomy of the layers of the scalp can be recalled by the mnemonic S-C-A-L-P, which refers to the skin, connective tissue, aponeurotic galeal layer, loose connective tissue, and periosteum. In its most anterior segment, the skin of the scalp measures about 3–4 mm in thickness and reaches up to 8 mm in the more posterior segments. Blood vessels, lymphatics, and cutaneous adnexa reside within the connective tissue layers, while

the underlying musculature connects to the galea aponeurotica. Muscles of the forehead and scalp include frontalis, temporalis, procerus, corrugator supercilii, and superior fibers of the orbicularis oculi (Figure 1.1a). Deep to the aponeurotic layer is the loose connective tissue that is largely avascular but does contain perforating emissary veins. Lastly, the periosteum envelops the bony skull and contains another layer of vasculature.

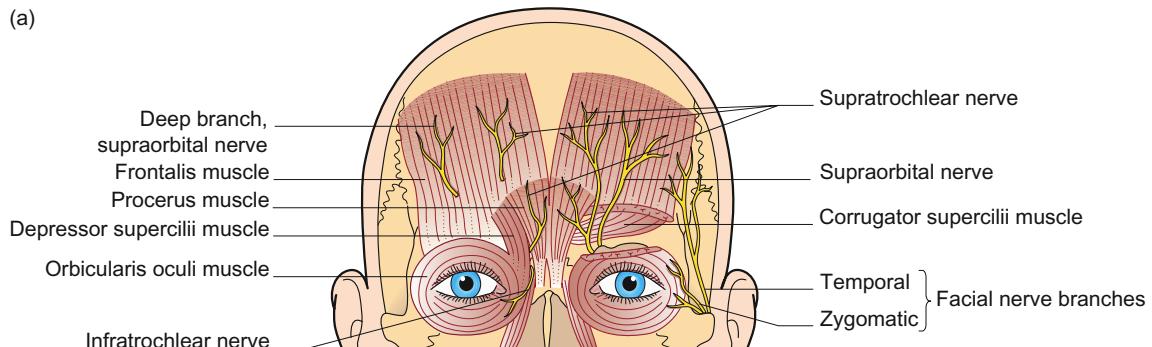
Vasculation

The blood supply to the forehead and scalp subunits is provided by branches of both the internal and the external carotid arteries. The supratrochlear and supraorbital arteries supply the central forehead and anterior scalp and originate from the ophthalmic artery branch of the internal carotid (Figure 1.1b). The lateral forehead and scalp are supplied by the superficial temporal and posterior auricular branches of the external carotid artery (Figure 1.1c). The posterior scalp is supplied by the occipital artery, another branch of the external carotid (Figure 1.1c).

Nerves

The motor and sensory anatomy of the forehead and scalp are a crucial part of surgery on these subunits. Motor innervation of the forehead is provided by the temporal branch of the facial nerve (CN VII). This branch runs along the temple and the zygomatic arch but courses more superficially superiorly to innervate the

(a)



(b)

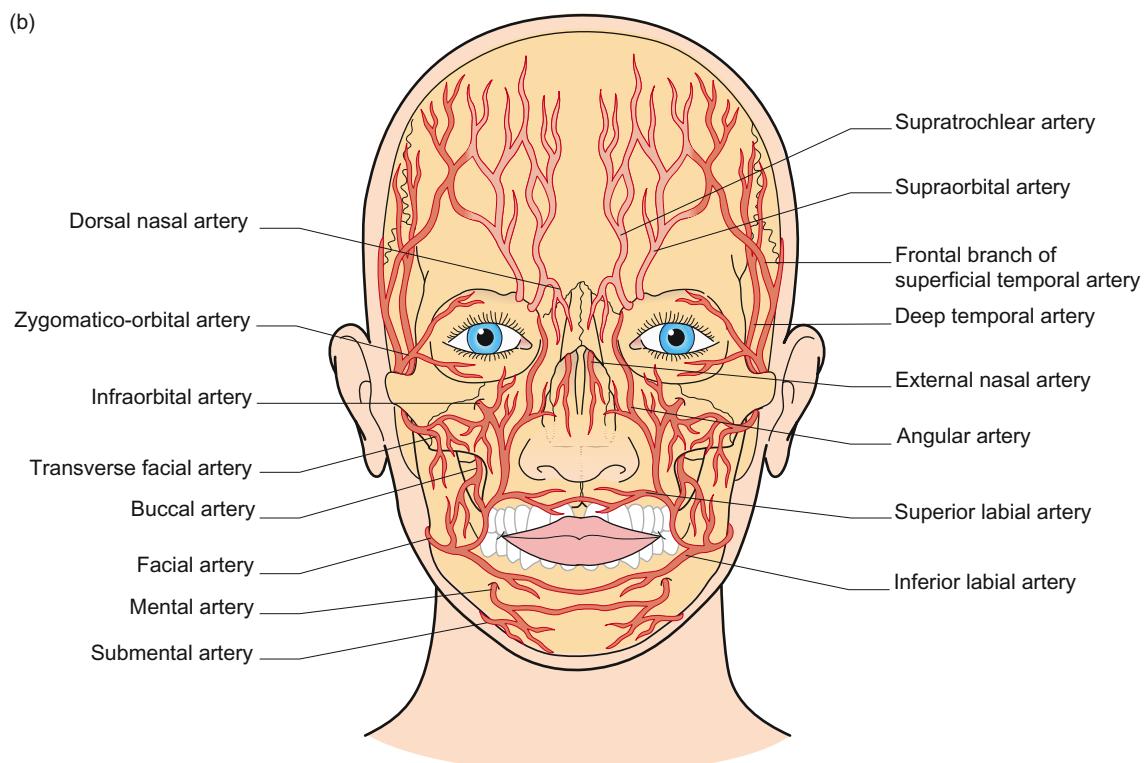


Figure 1.1 (a) Periorbital and forehead musculature and nerves; (b) facial vasculature; (c) scalp vasculature.

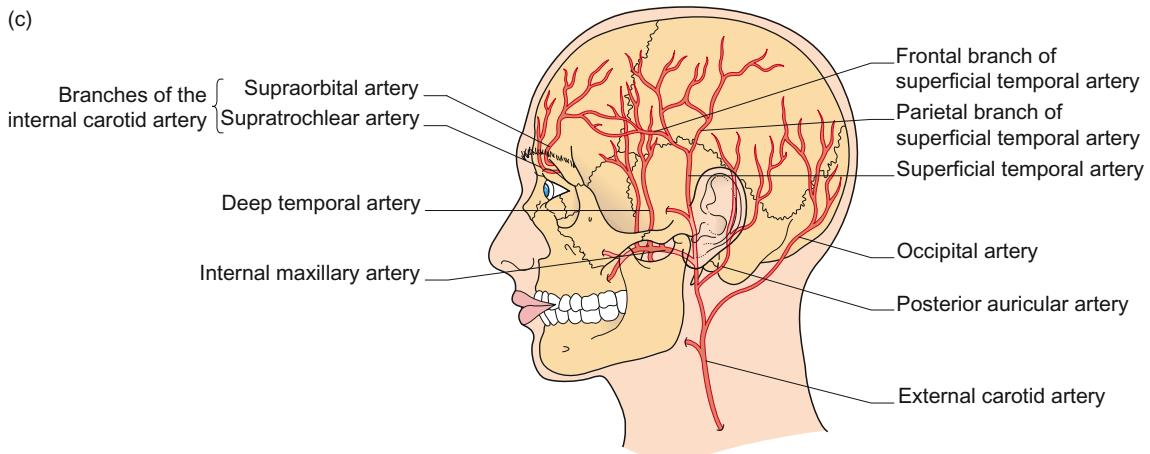


Figure 1.1 (Continued)

frontalis muscle at its deep surface. It is therefore most susceptible to injury at its superficial course, which may result in ipsilateral brow ptosis and pronounced asymmetry of the face (Figure 1.1a).

The sensory innervation of the forehead and scalp is provided by branches of all three divisions of the trigeminal nerve (CN V). The supraorbital and supratrochlear nerves branch off from the ophthalmic nerve (CNV1) to supply the scalp up to the vertex (Figure 1.1a). The zygomaticotemporal nerve, arising from the maxillary division of the trigeminal nerve (CN V2), supplies sensory innervations to the anterior temple. The auriculotemporal nerve, a branch of the mandibular division (CN V3), supplies the rest of the temporal area. Branches of the cervical spinal nerves (C2, C3) innervate the posterior scalp.

Lymphatic drainage

The lymphatic drainage of the scalp is collected by the occipital and posterior auricular lymph nodes (Figure 1.2). The basin responsible for lymph drainage of the forehead subunit is located within the parotid glands bilaterally.

Mid-face

Nasal subunit

The nasal subunit is generally further subdivided into a number of cosmetic subunits.² These consist of the nasal

sidewall, nasal dorsum, tip, alae, soft triangles, and the columella (Figure 1.3a). To achieve the best cosmetic outcome, it is recommended that incision lines during nasal reconstruction are placed at the borders of these cosmetic units. The nasal cartilaginous structures, consisting of the lateral nasal and the lower lateral cartilage, are essential to the integrity of the nose (Figure 1.3a). Certain infiltrative tumors may infiltrate the lower lateral nasal cartilage, requiring its excision. Failure to properly repair the cartilage in this situation may result in the loss of alar support leading to collapse of the nasal ala and inhibition of air flow into the nose.

Vasculature

Similar to the forehead and scalp region, the vasculature of the nose is derived from both the internal and external carotid arteries.³ In fact, arteries supplying the nasal area make up one of the essential anastomosing sites between the internal and external carotid arteries. The dorsal nasal and external nasal branches of the ophthalmic artery, which branches off from the external carotid, supply the dorsal nose (Figure 1.3b). Vascular supply to the nasal sidewalls, columella, and nasal alae is provided by branches of the angular artery, a branch of the facial artery that originates off from the external carotid (Figure 1.3b).

Nerves

Motor innervations to the procerus muscle at the nasal root, depressor septi nasi and nasalis muscles are

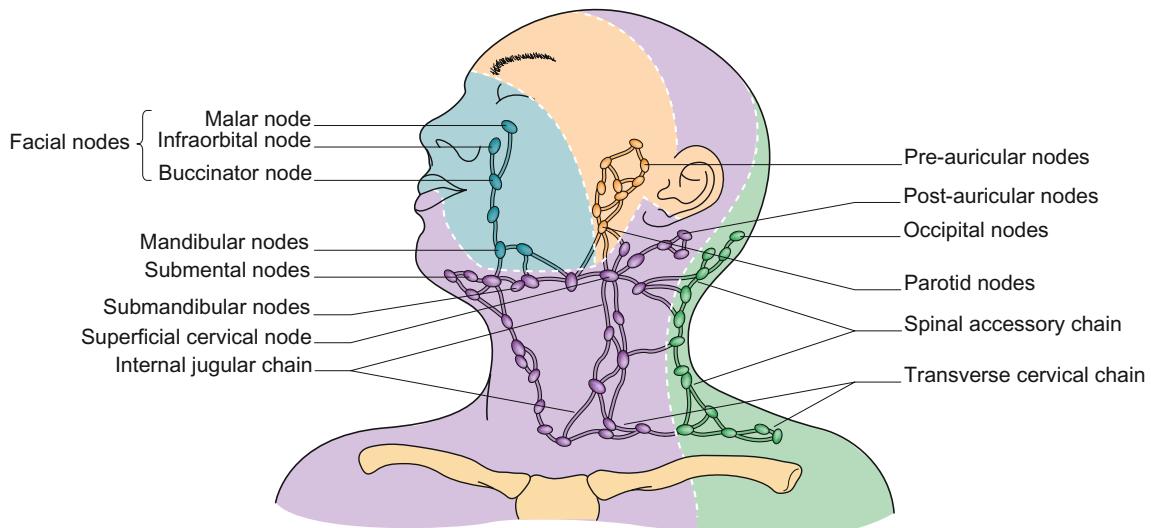


Figure 1.2 Lymphatic drainage of the head and neck.

provided by the zygomatic and buccal branches of the facial nerve (CN VII) (Figure 1.4). The ophthalmic and maxillary divisions of the trigeminal nerve provide sensory innervation to the nose. The infratrochlear and external nasal branches of the ophthalmic division (CN V1) and the infraorbital branch of the maxillary division (CN V2) are the primary sources of sensory innervation for this subunit.

Lymphatic drainage

Lymphatic drainage from the nose is collected primarily by the submandibular lymph nodes (Figure 1.2).

Perioral

The surface anatomy of the lip is divided into the lateral wings of the cutaneous upper lip, philtrum, lower lip and the vermillion border which demarcates the red and white portion of the lips (Figure 1.5a).⁴ The underlying musculature includes the orbicularis oris, zygomaticus major and minor, levator anguli oris, depressor anguli oris, levator labii superioris, depressor labii inferioris, risorius, mentalis, and the buccinators (Figure 1.5b). The nasolabial crease is formed by the cutaneous insertion of lip elevator musculature.

Vasculation

Vascular supply to the lips is provided by the labial arteries that branch off the facial artery. Labial arteries are frequently resected during biopsies and lip surgery. Intraoperative ligation or electrosurgery is usually sufficient to prevent excessive bleeding.

Nerves

Perioral musculature is innervated by the zygomatic, buccal, marginal mandibular, and cervical branches of the facial nerve (CN VII) (Figure 1.4). The maxillary division (CN V2) provides sensory innervations to the upper perioral region via the infraorbital nerve. The mandibular division (CN V3) contributes to the sensory innervation of the lower lip via the mental nerve.

Lymphatic drainage

The primary site of lymphatic drainage from the perioral region is the submental lymph nodes (Figure 1.2).

Chin

The cosmetic subunit of the chin is demarcated from the cheek and lip subunits by the mentolabial crease. Surgeons must be aware of the location of the mental

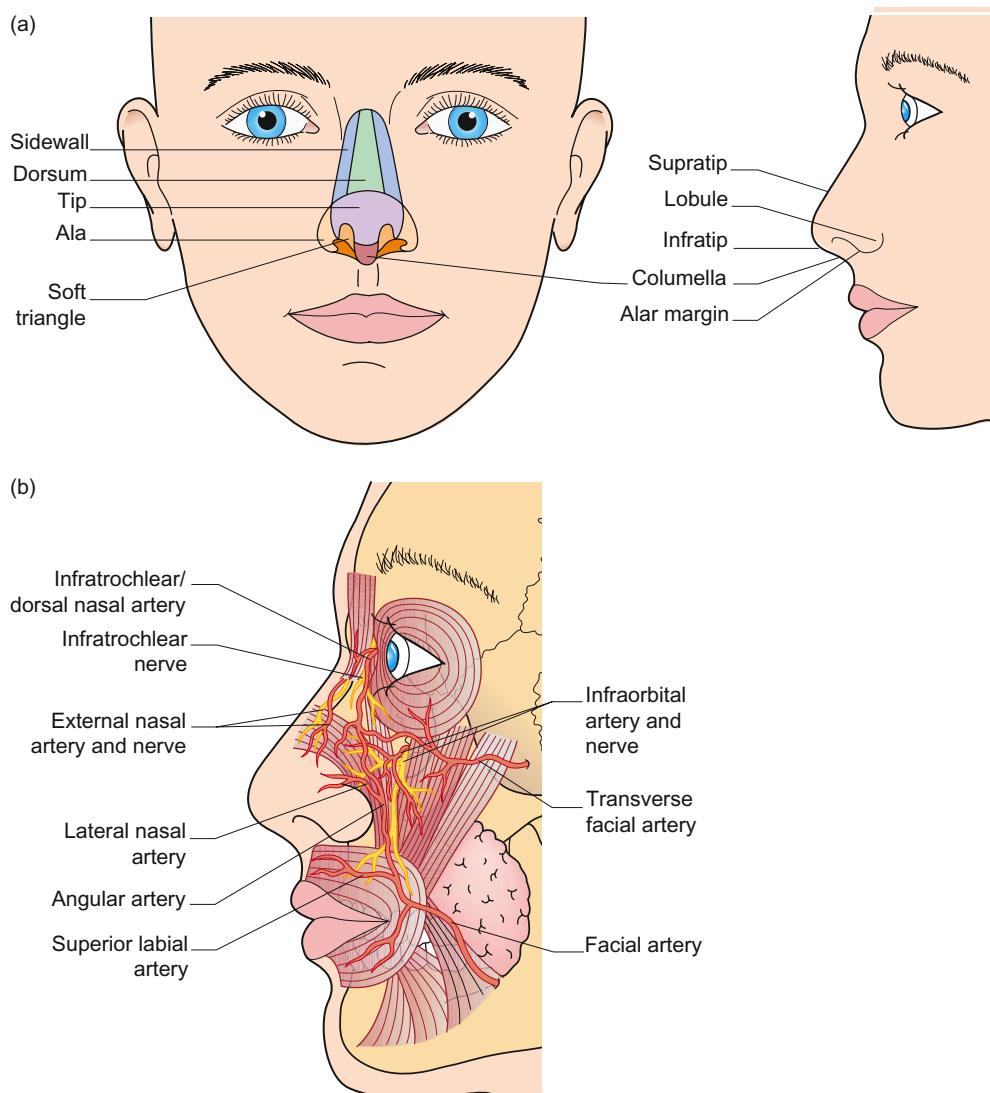


Figure 1.3 (a) Landmarks in nasal anatomy; (b) nasal vasculature and sensory nerves.

foramen that carries the mental nerve and vessels to the chin, and is located below the second mandibular premolar tooth in the majority of the population. Musculature of the chin consists of the mentalis, depressor anguli oris, and depressor labii inferioris (Figure 1.5b).

Vasculature

The mental and submental arteries branch off the external carotid artery to form the vascular supply of the chin.

Nerves

Motor innervation to the chin is provided by the marginal mandibular branch of the facial nerve (CN VII). Injury to this nerve may occur as it crosses the mandible at the medial edge of the masseter muscle within the superficial soft tissue (Figure 1.4). Marginal mandibular injury is manifested as ipsilateral asymmetry of the lip and chin during smiling. The mental nerve, entering via the mental foramen, provides the sensory innervation to the chin subunit.

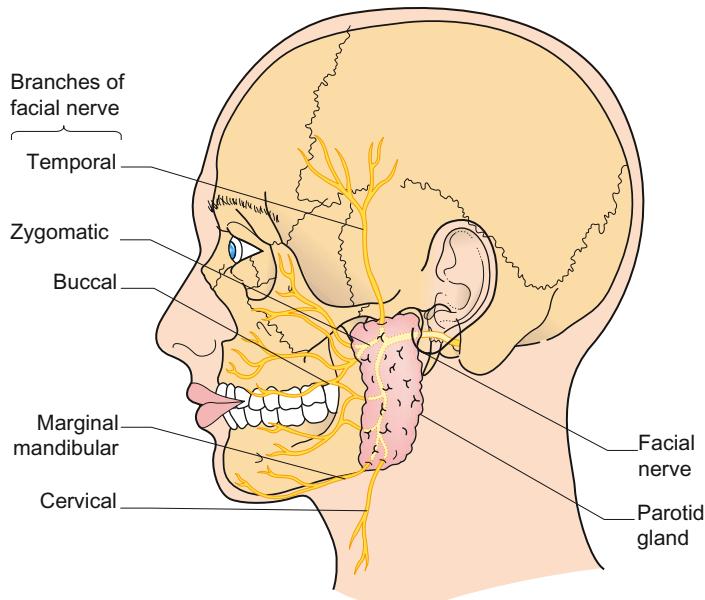


Figure 1.4 Branches of the facial nerve (CN VII).

Lymphatic drainage

The submental lymph node basin collects lymphatic drainage from the chin subunit (Figure 1.2).

Periorbital

An understanding of periorbital anatomy is key to avoidance of ectropion and entropion complications of cutaneous surgery in this region. The eyelids are made up of the skin, orbicularis oculi muscle, the tarsus, and the conjunctiva.⁵ Overall structural support to the eyelids is provided by the medial and lateral canthal tendons. The superior and inferior lacrimal canaliculi are enveloped by the medial canthal tendon and are the means of passage of tears to the lacrimal sac. Disruption of the canaliculi will lead to a defect in tear drainage. Glands of Zeis and meibomian glands are large sebaceous glands that reside in the eyelids (Figure 1.6a). Glands of Moll are apocrine glands of the eyelids (Figure 1.6a).

Vasculature

The internal and external carotid arteries provide a vascular supply to the periorbital area. The dorsal nasal

branch of the internal carotid system anastomoses with the angular branch of the facial artery in the vicinity of the medial canthus (Figure 1.6b). Supraorbital and supratrochlear artery branches of the internal carotid system also supply the upper eyelid area (Figure 1.6b). The external carotid artery supplies vasculature to the lower eyelid by the infraorbital branch of the maxillary artery and to the lateral periorbital area via the superficial temporal artery.

Nerves

Knowledge of neural anatomy of the periocular region is crucial both to proper anesthesia and to botulinum toxin treatment of the motor component of the eyelid region. Sensory innervation is provided by the ophthalmic division (CN V1). The glabella is innervated by the supratrochlear branch of the ophthalmic division. Sensation to the lower eyelid is mediated by the infraorbital nerve. The zygomatic branch of the facial nerve (CN VII) provides motor innervations to the orbicularis oculi, levator palpebrae superioris, and parts of the procerus muscles (Figure 1.4). The temporal branch of facial nerve is responsible for motor innervations of the corrugators and procerus.

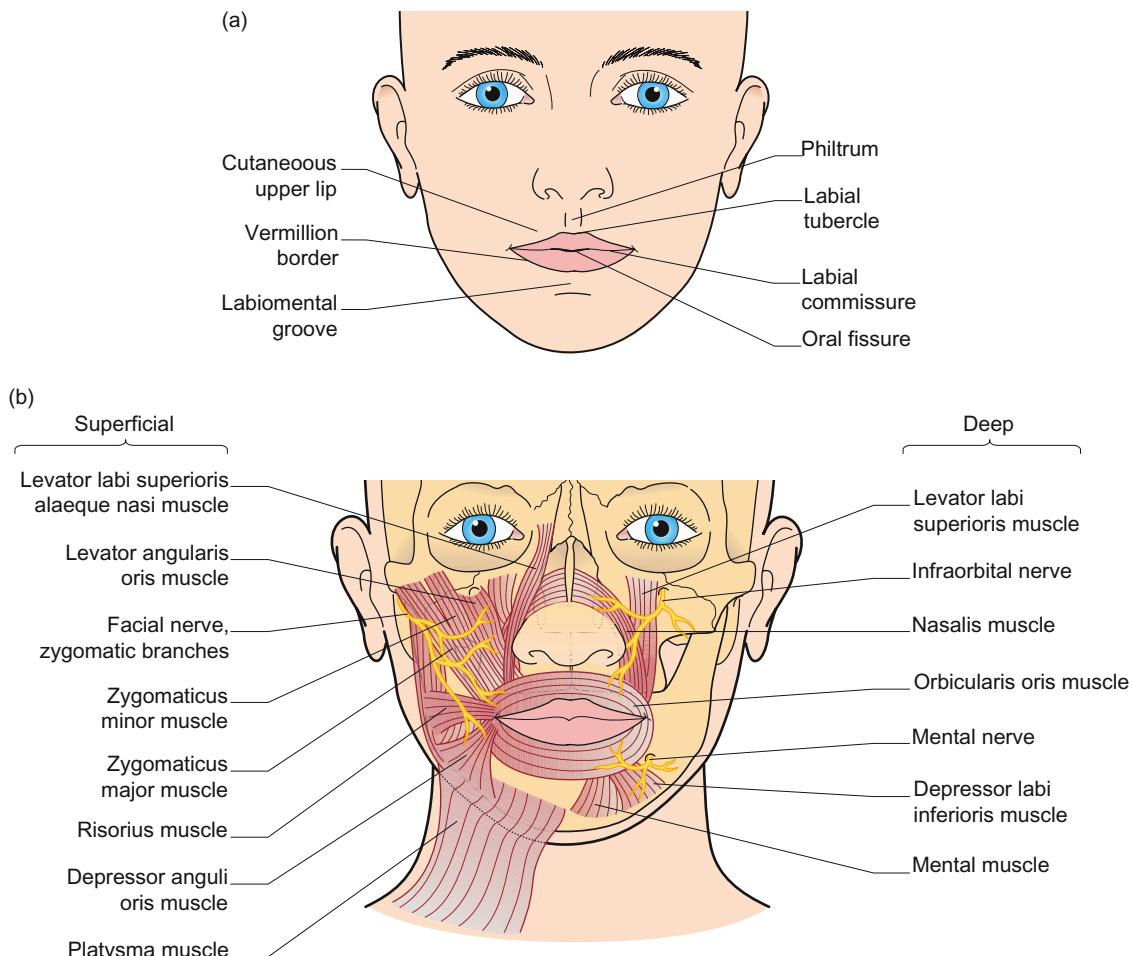


Figure 1.5 (a) Perioral anatomic landmarks; (b) perioral musculature.

Lymphatic drainage

The lymphatic drainage basin of the lateral eyelid area lies primarily within the parotid lymph nodes. Medial canthus lymph drains to the submandibular lymph node basin.

Cheeks

The cheek is the largest facial subunit. Its superior border is made of the infraorbital rim and zygomatic arch. The nasolabial and melolabial folds mark the medial border and the pre-auricular crease makes up the lateral border of the cheek. The cheek subunit can be further

subdivided into the medial, zygomatic, buccal, and lateral cheek units. Each of these has unique surface characteristics and sebaceous nature that must be taken into account during reconstruction.⁶

Vasculation

Vasculation supplying the cheek subunit is derived from the external carotid artery system. The transverse facial artery supplies the lateral cheek. The angular branch of the facial artery and the infraorbital artery supply the medial aspects of the cheeks (Figure 1.1b). Multiple anastomotic connections within the cheek make this subunit a highly vascularized skin surface.

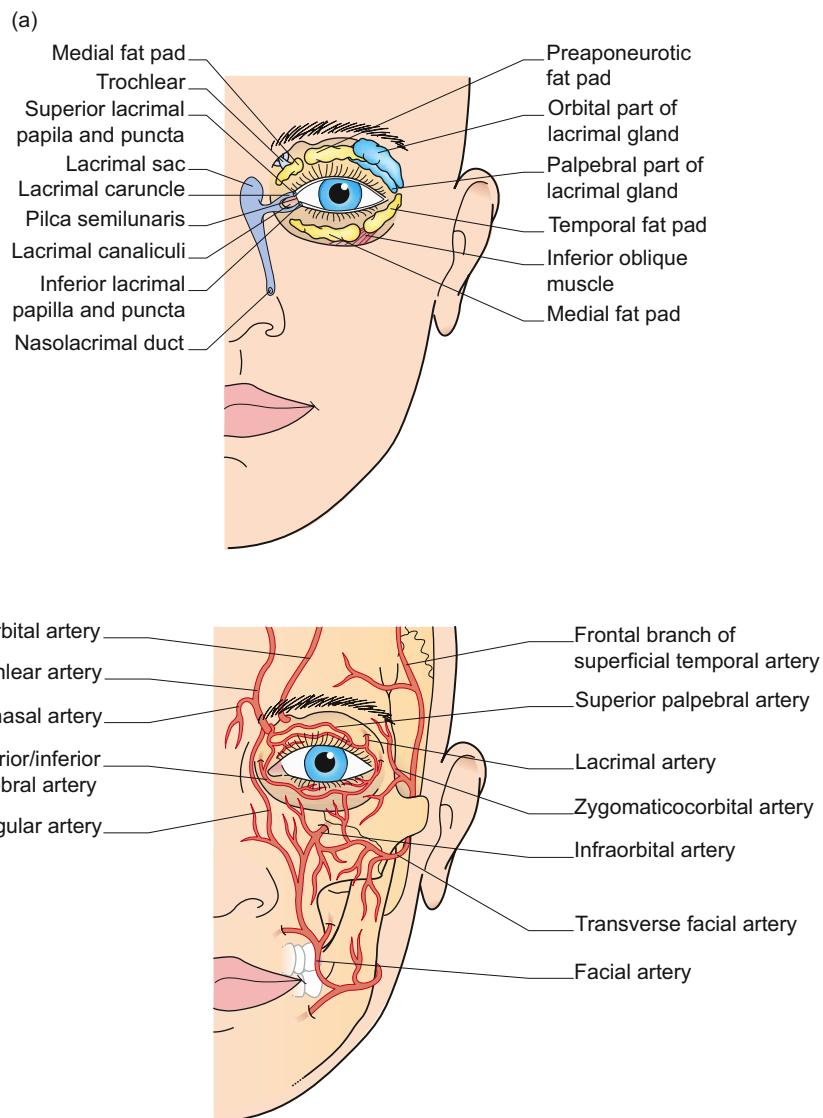


Figure 1.6 (a) Lacrimal glands and periorbital fat pads; (b) periorbital vascular supply.

Nerves

The muscles of the cheek are supplied with motor innervation by the zygomatic and buccal branches of the facial nerve (CN VII) (Figure 1.4). The infraorbital, zygomaticofacial, and zygomaticotemporal branches of the maxillary division of the trigeminal nerve supply sensation to the medial and zygomatic aspects of the cheek. Nerves emanating from the mandibular division of the trigeminal nerve provide sensation to the rest

of the cheek subunit. The auriculotemporal nerve innervates parts of the lateral cheek with the buccal nerve providing sensation to the lateral and buccal portions. The mental nerve innervates the inferior medial aspects.

Lymphatic drainage

The parotid and submandibular nodes collect the lymphatic drainage from the cheek subunit.

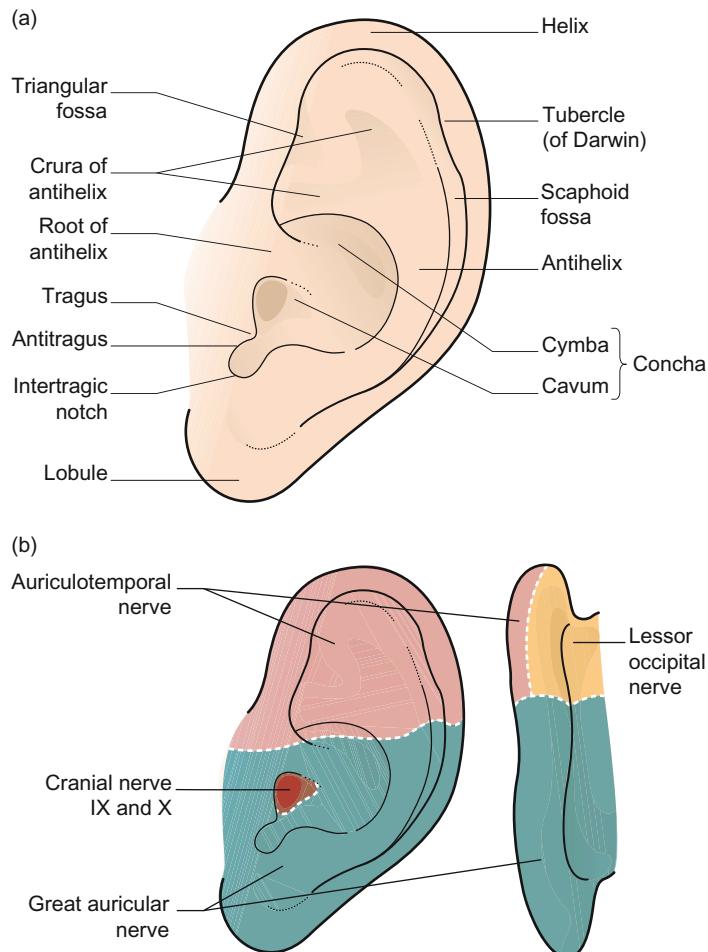


Figure 1.7 (a) Auricular anatomic landmarks; (b) Innervation of the ear.

Auricular

The surface anatomy of the ear is complex, with intermixing of multiple convex and concave surfaces.⁷ Notable anatomic landmarks of the ear include the helix, crura, scaphoid fossa, triangular fossa, conchal bowl, antihelix, tragus, antitragus, and lobule (Figure 1.7a). The auricular cartilage is found in the upper two-thirds of the ear.

Vasculature

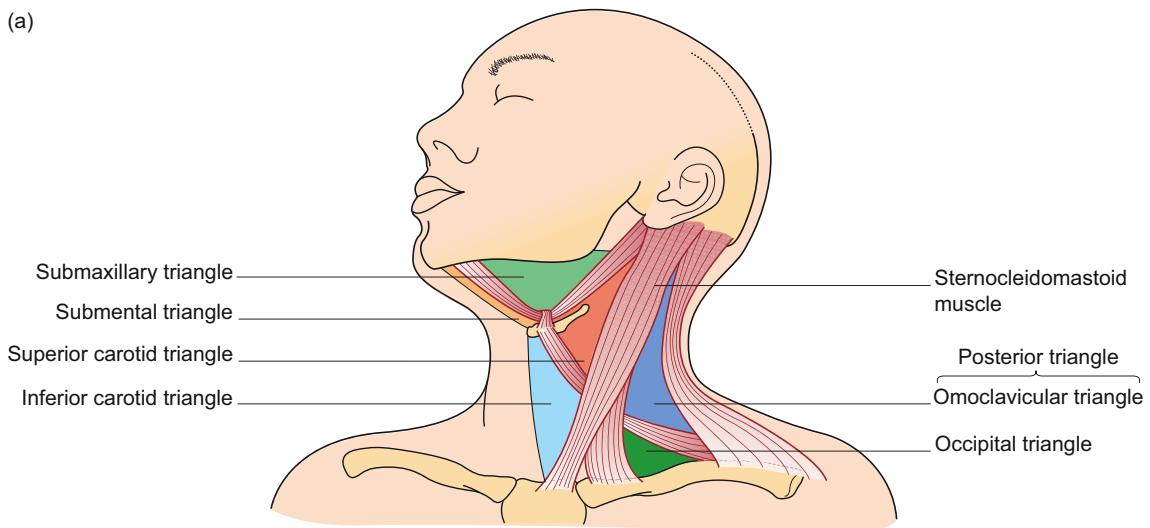
Blood supply to the auricle is derived entirely from the external carotid artery system.⁸ The lobule and posterior ear are supplied by the occipital and posterior auricular arteries. The conchal bowl is supplied by branches of the

posterior auricular artery. The anterior auricular artery, which branches off from the superficial temporal artery, supplies the anterior ear.

Nerves

Sensory innervation of the ear is complex, with the great auricular nerve (C2, C3) innervating the lower part of the lateral and posterior ear. The auriculotemporal branch (CN V3) innervates the superior lateral ear, and the lesser occipital nerve provides sensation to the superior posterior ear. The external auditory meatus and conchal bowl are supplied by fibers of the glossopharyngeal (CN IX), auricular branch of the vagus (CN X or Arnold's nerve), and facial (CN VII) nerves (Figure 1.7b).

(a)



(b)

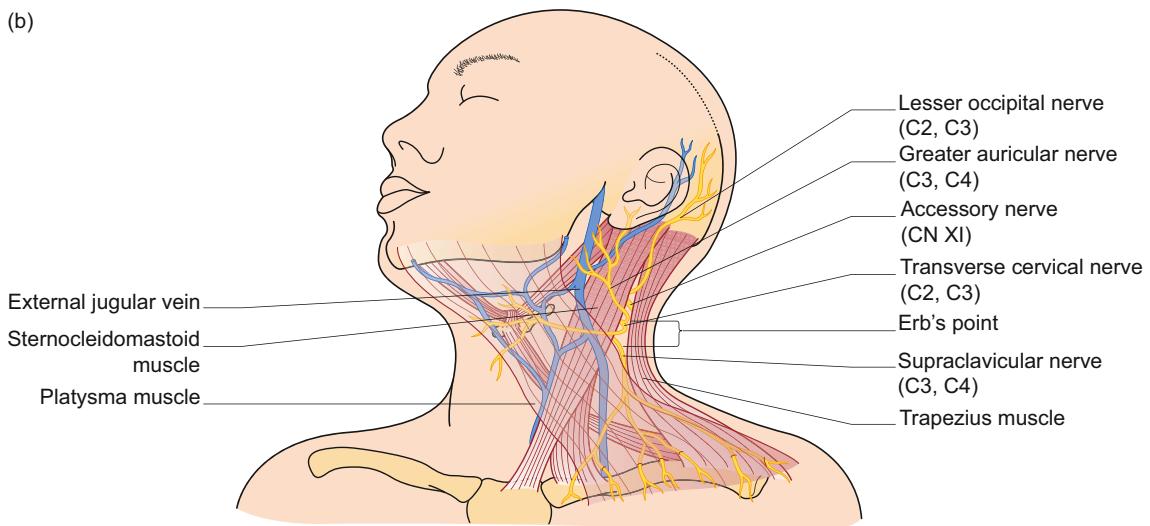


Figure 1.8 (a) Anatomic triangles of the neck; (b) Erb's point in posterior triangle of the neck.

Lymphatic drainage

The posterior aspect of the ear drains to the occipital and posterior auricular lymph nodes. Anterior ear lymphatic drainage proceeds to the parotid nodes.

Neck

The superficial anatomy of the neck requires anatomic landmarks indicated by the triangles of the neck to help

identify important underlying structures (Figure 1.8a). The superficial musculoaponeurotic system (SMAS) is a fibrous layer of fascia that envelops the platysma and the superficial facial muscles.⁹ The easily identified sternocleidomastoid muscle separates the anterior and posterior triangles of the neck. The posterior triangle contains Erb's point, a landmark of the exit of the spinal accessory (CN XI), lesser occipital, and great auricular nerves as well the transverse cervical rami (Figure 1.8b). Damage to the spinal accessory nerve may result in the inability

to raise the ipsilateral shoulder. The jugular and carotid vessels run through the carotid triangle (Figure 1.8a). The mental lymph node basin and lingual arteries occupy the submental triangle. The submaxillary triangle includes the lingual nerve, artery, and vein, and hypoglossal nerve.

Nerves

The cervical branch of the facial nerve (CN VII) provides the motor innervation to the platysma. Sensory innervation to this area is provided by the transverse cervical, supraclavicular, and great auricular nerves.

Lymphatic drainage

Lymphatic nodes of the neck region are the secondary lymph nodes that receive drainage from most nodes on the face. These eventually empty into the venous circulation via the thoracic duct.

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Surgical equipment and instrumentation

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Instruments

Scalpel handles and blades

The scalpel is one of the most essential pieces of equipment for the dermatologic surgeon. It comprises a handle that is gripped by the surgeon and a used to incise tissue. A variety of handles and blades exist from which to choose. Primarily, scalpels may be purchased in disposable or non-disposable forms. Those purchased to be thrown away after one use have a blade permanently mounted to the handle, whereas the non-disposable scalpel components are sold separately. Although the quality of disposable scalpels may be inferior to that of the reusable variety, it may be a convenient option for practitioners who do not possess an ability to sterilize surgical equipment.

A number of non-disposable scalpel handles exist that may be selected by the surgeon based on personal preference and the specific procedure to be performed. The no. 3 Bard-Parker flat handle is the predominantly used handle for cutaneous surgery. Made of stainless steel or chrome, this instrument is 12 cm long and often comes with a metric scale on its side. The portion of the scalpel distal to the gripped end has a bayonet locking

mechanism that accommodates the blade. No. 3 handles may be compatible with blade numbers 10, 11, 12, 15. A similar but larger handle, the no. 4, accommodates larger blades (numbers 20–25) that are not often used in cutaneous surgery. Some surgeons choose to operate with a no. 7 scalpel handle because they perceive that its long, thin, and textured shape allows for enhanced comfort and precision (Figure 2.1). The no. 7 handle may be used with the same blades used on a no. 3 handle. Also in the surgeon's armamentarium are Beaver handles, round or hexagonal in shape, which may be used for more delicate work around the eye. This handle has a threaded end that accepts a second piece (a collet) that screws into the handle. Prior to being screwed into the handle, a special blade (no. 64 or no. 67) is inserted into the collet. The rounded, knurled Beaver scalpels have the added advantage of being rolled easily between the fingers.¹

Surgical blades comprise two components, the tip and the belly, the latter of which is the chief cutting surface. The rear portion of the blade inserts into the oblique recess of the handle and is secured firmly in place with a light push. To remove the blade, a hemostat or blade remover should push up on the base of the blade and simultaneously pull away from the handle. Although stainless steel blades maintain their edge longer than carbon steel blades, they tend not to have as sharp a cutting surface.² The sizes of surgical blades are directly proportional to their corresponding number. General surgeons operate with blades numbered in the 20s,

Conflicts of interest: in the chapter the senior author (AH) discusses two instruments (skin hooks) which he helped design.

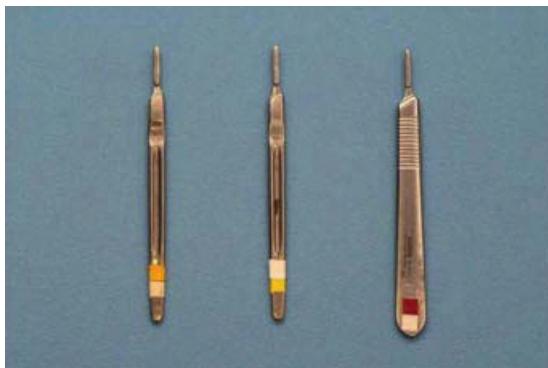


Figure 2.1 From left to right, no. 7, 9, and 3 scalpel handles.

whereas dermatologic surgeons most frequently use blade numbers 10, 11, 12, 15.

The no. 15 blade is the workhorse in cutaneous surgery with a curved edge and a flat back. A miniature variant of this blade, the 15c, may be used for fine tissue cutting along the eyelid or more intricate areas around the ear. The no. 10 blade is a larger version of the no. 15 blade, used for excisions on thicker skin such as the torso and scalp. The no. 11 blade is triangular in shape with a sharp point that is often used for stab incisions or procedures that require a sawing motion, such as cartilaginous wedge excisions from the ear. As mentioned above, the 67 and 64 blades are used with the Beaver handle. The no. 67 blade is analogous to the no. 15 blade, whereas the no. 64 blade has a rounded tip that allows for enhanced sawing motions.

With the scalpel in hand, most excisions may be performed by gripping the instrument like a pencil. This grip allows the scalpel to rest between the index and middle fingers with the thumb applying light pressure on the opposite side of the handle. With the fourth and fifth digits resting on the cutting surface to stabilize the hand, the scalpel may be wielded in a fluid motion to cut through the skin. Rounded handles such as the no. 7 scalpel facilitate rotating the blade with ease while cutting. This plays an important role during beveled excisions such as in Mohs surgery or while excising tissue in hard to reach areas such as the conchal bowl. Beveled cutting may also be performed by gripping the scalpel with the second through fifth digits with the thumb stabilizing the opposite side.



Figure 2.2 Pictured above are Adson 1 × 2 forceps; pictured below are Brown–Adson forceps.

Forceps

Gentle handling of tissue is an essential component of successful skin surgery. Forceps, or “pick-ups,” allow the surgeon to gently grasp tissue with the forceps held between the thumb and two or three fingers of the non-dominant hand. The many functions of forceps include grasping the suture needle after it has passed through tissue, grasping and evertting tissue while suturing, stabilizing tissue while cutting with scalpel or scissors. They may also be used as an electrical conduit for indirect electrocoagulation of bleeding vessels.

The proximal end of this lightweight instrument rests on the first webspace of the hand and has a spring tension device that holds apart the distal end until pressure is applied by the digits. The middle body of the forceps has a wide design and a textured feel that allows for easy manipulation. Lightweight forceps are signified with three circular holes on the body. The distal end of forceps, or the tissue-grasping portion, comes in three forms: toothed, smooth, and serrated.

Adson, Brown–Adson, and Bishop–Harmon forceps are the most common styles found on the trays of the dermatologic surgeon (Figure 2.2). For delicate handling of tissue, Adson 1 × 2 toothed forceps are preferred because of their one jaw into two teeth design. On the other hand, Brown–Adson forceps have an 8 × 9 row of gripping teeth that risk causing a crushing injury but are able to firmly hold on to slippery tissue.² Smaller, lightweight, and fine-tipped, the Bishop–Harmon forceps are the ideal instrument for grasping delicate, thin skin such as that encountered in the periorbital area. Some



Figure 2.3 Frazier skin hooks.

surgeons may find it useful to keep utility forceps on the surgical tray. In particular, some Mohs surgeons use this inexpensive instrument because it allows for delicate handling of Mohs layers. Because of the lightweight grip and lack of teeth of utility forceps, false positives can be avoided from tumor being pushed toward the tissue margin. Smooth-tipped Adson forceps are most often utilized for suture and dressing removals. Jeweler's forceps may be used for suture removal; however, their extra-fine tip also make them useful for grasping small vessels during indirect electrocoagulation.

Skin hooks

When used appropriately, skin hooks can supplant forceps for many surgical procedures (Figure 2.3). Most commonly, these single or double-pronged instruments can pull up on the subcutis from its undersurface and allow for maximum eversion of tissue while suturing.³ With the index finger and thumb holding the hook in a pincer fashion, the skin is lifted and pivoted over the fourth digit. This method avoids injury to the epidermis and facilitates the optimum path of travel for the suture through the dermis. Skin hooks may also be useful for skin flap elevation and for retraction of tissue, particularly when hemostasis must be performed deep underneath skin that has been undermined.⁴ Multipronged skin hooks are also available for assisting with skin retraction. Skin hooks with modifications such as the Hendi-Frazier and Hendi-Roth skin hooks are designed with grip points to help the assistant hold the hook in the correct position (Figure 2.4). Because of their design and sharp tip points some surgeons avoid hooks for fear of



Figure 2.4 Hendi-Frazier skin hooks with contour that facilitates easy gripping for surgical assistants.

accidental trauma to oneself or staff; thus, it is advisable to for all those near the operative site to have a heightened awareness of the presence of hooks, as one would with any other sharp item on the surgical tray. Blunt-tip skin hooks are also available, although their tissue grasping ability is suboptimal.

Scissors

Scissors comprise three components. There is a handle, or shaft, with rings for thumb and finger placement that allow the instrument to be handled easily. There are blades that allow for tissue cutting and undermining. And there is a fulcrum that connects the shaft and blades, allowing for pivoting of the blades and development of torque. Variation of these components creates a wide spectrum of scissors from which the dermatologic surgeon may choose (Table 2.1). Most scissors are constructed of stainless steel, although those with gold-plated handles signify blades that have been strengthened with tungsten carbide inserts.² Black handles, on the other hand, indicate Supercut blades that minimize trauma while cutting tissue (Figures 2.5 and 2.6).

One important facet of scissors that directly impacts their ability to cut tissue is the ratio of handle length to blade length. As this ratio increases so does the scissors' ability to generate force and thereby cut tissue. It should also be mentioned that most scissors are constructed in a manner such that shear and torque forces may be maximized with use by the right hand when the index finger pushes on the fulcrum. This technique must be



Figure 2.5 Suture-cutting scissors (left); iris scissors (right).



Figure 2.6 Gradle scissors with black handles denoting Supercut quality blades (left); Metzenbaum scissors strengthened with tungsten carbide and represented by gold handles (right).

Table 2.1 The various scissors available to the dermatologic surgeon and their characteristics

Scissors	Tips	Handle	Blades	Shaft:blade	Uses
Iris	Sharp	Short	Straight or curved; smooth-smooth or smooth-serrated	Less than gradle or tenotomy scissors	Blunt or sharp dissection; cutting tissue
Metzenbaum	Blunt	Long	Straight or curved;	High	Blunt or sharp dissection
Mayo	Blunt	Long	Straight or curved;	Approximately 1:1	Blunt dissection
Gradle	Sharp and tapered to fine tip	Short	Slightly curved	Greater than 1:1	Cutting tissue and blunt dissection
Stevens tenotomy	Similar to gradle but slightly wider, less delicate tip	Short	Straight or curved	Greater than 1:1	Cutting tissue and blunt dissection
Castroviejo	Sharp	Spring-loaded	Straight, angular, or curved	Greater than 1:1	Cutting delicate tissue
Westcott	Blunt or sharp; fine tip	Spring-loaded	Slightly curved	Greater than 1:1	Cutting delicate tissue
Northbent	Notched	Short	Curved	N/A	Cutting suture
Lister	Blunt	Long	Angled	Greater than 1:1	Cutting dressings and bandages

reversed, or the scissors must be held with the tips facing the palm, in order to generate the same forces with the left hand.

Needle holders

The design of needle holders is similar to scissors in that there are three main components. The handle portion

has rings that allow for easy insertion of the thumb and ring finger. A fulcrum connects the handle to the jaws and permits the instrument to load a needle and lock it into place so that it is stabilized while driving it through tissue. Jaws may be smooth or serrated, with the former being preferred with smaller, finer needles so as to prevent their damage. Serrated jaws may prevent the unnecessary



Figure 2.7 From left to right, Baumgartner, Titanium Webster, and Halsey needle holders.

turning of needles and work well with larger needles. Also like scissors, gold-plated handles signify needle drivers that have tungsten carbide inserts for enhanced jaw durability.⁵

Because of their small handle, narrow jaws, and smooth or delicate serrations, the Webster and Halsey needle holders are the preferred needle holder for operating on the face and hands, particularly with smaller needles (Figure 2.7). For procedures that require larger needles, such as those located on the trunk or extremities, the Baumgartner or Crile-Wood needle holders may be better suited. If larger needles are used on Webster or Halsey needle holders, their delicate grip and locking mechanism may be altered for future use with smaller needles. When suturing around the eye or on other fragile tissue, the spring-loaded Castroviejo needle holders may allow for enhanced precision and a more delicate feel.

Hemostats

Hemostats are a valuable instrument to keep on one's surgical tray in order to maintain meticulous hemostasis (Figure 2.8). The Jacobsen or Halstead Mosquitoe models are fine-tipped tools that allow the surgeon to grasp vessels that are encountered during surgery. Straight or curved hemostats may clamp vessels for ligation with sutures, as when performed on the labial artery during a wedge excision of the lip. They may also be used as a conduit during indirect electrocoagulation of bleeding vessels.



Figure 2.8 Halstead mosquito straight hemostat (left); Halstead mosquito curved hemostat (right).



Figure 2.9 Fox curettes of different sizes.

Curettes

Benign and low-grade malignancies may be treated by being “scraped” with a curette (this is often followed by electrodesiccation). Curettes have a keen ability to delineate the margins of a cutaneous neoplasm because of the textural contrast between normal skin and tumor. It is for this reason that some surgeons will curette a non-melanoma skin cancer prior to the first stage of Mohs micrographic surgery or before surgical excision.⁶ Curettes are stainless steel and shaped like a stylus with a somewhat sharp head at the distal tip (Figure 2.9). Fox curettes have a rounded head, measured in millimeters, while Piffard and Cannon curettes have a more oval head. Curettes should be kept sharp in order to allow for proper functioning. For those who practice in an office without

sterilizing capabilities, disposable curettes may be a preferred option.

Biopsy blades

The nature and anatomic location of the lesion to be biopsied, along with its suspected underlying pathology, all impact the surgeon's decision on the specific method of biopsy. Suspected non-melanoma skin cancers are often sampled via shave biopsy. Options available include no. 15 blade (\pm scalpel handle), Dermblade, or razor blade. The last two instruments may be flexed to match the size of the lesion and are rocked back and forth through the skin until the entire specimen is removed. These instruments may also be used to perform saucerization biopsies, such as for suspected melanocytic neoplasms. However, no. 15 blades can provide more precise depth and margin during shave removal. In experienced hands this can prevent positive margins after shave removal of atypical nevi, and hence prevent additional excision. Some prefer to fully excise melanocytic lesions in the form of an ellipse with the no. 15 scalpel. Trephines (hand-held punches) are also available in sizes that range from 1.5 mm to 10 mm and may be used for excisional or incisional biopsies.

Dermatome/Weck blade

Dermatomes produce split-thickness grafts for surgical defects that are often too large or complex to be closed primarily. They may be operated manually, such as seen with the Weck and Braithwaite knives. Air and electrically operated dermatomes with rapidly oscillating blades include the Zimmer and Padgett models. Prior to graft harvesting, it is essential that the dermatome blades be inserted with the proper orientation. Additionally, the donor site must be properly lubricated and countertraction applied by an assistant. Graft thickness settings range from 0.005 inches (0.127 mm) to 0.03 inches (0.762 mm), with most split-thickness grafts chosen between 0.012 inches (0.30 mm) and 0.018 inches (0.46 mm). An angle of 30–45° should be used to approach the skin and avoid creating an unwanted crateriform defect. As the

dermatome is applied to the skin, the harvested skin should be gently grasped by forceps and lightly pulled up until the dermatome motion is completed.

Chalazion

Chalazion clamps provide a unique function whereby the rigid plate that is attached to the forceps-like handle clamps down and stabilizes otherwise mobile structures such as the lip or earlobe. The instrument may be locked into place by tightening the nut on the threaded bolt. The added advantage of the chalazion is that it provides a bloodless operative field, which is particularly on locations such as the tongue.

Summary

The diligent surgeon must have a masterful understanding of all the tools at his or her disposal. Instruments that grasp, cut, and suture skin have been addressed in this chapter. Use of these materials in a manner that gently handles tissue is of utmost importance. Additionally, understanding the nuances between these various pieces of equipment may help enhance surgical outcomes.

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Anesthesia in dermatologic surgery

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Local anesthetics

Local anesthetics are drugs used worldwide in minor surgical procedures with the purpose of blocking conduction along peripheral nerves, and thereby inhibiting the sensation of pain. The first anesthetic discovered was cocaine, isolated from coca leaves in 1855 by the German chemist Frederick Gaedcke. In 1884, Kölle first introduced its uses in ophthalmology, and later that year Hall used it in dentistry¹. Procaine was the first synthetic derivative of cocaine developed in 1904 by the German chemist Alfred Eighorn. Lidocaine was originally produced under the name of Xylocaine by the Swedish chemist Nils Löfgren in 1943.

They exert their effects by binding reversibly to the fast voltage-gated Na⁺ channels located in the membrane of the postsynaptic neurons. This prevents neuronal cell membrane depolarization, and, consequently, the propagation of the action potential. The pharmacologic event interferes with the generation and propagation of the pain signal².

Local anesthetic classification

I. Amides

- a. Include lidocaine, bupivacaine, levobupivacaine, etidocaine, mepivacaine, and ropivacaine.
- b. Buvicaine is used in long-duration procedures².
- c. They are metabolized by cytochrome P450 3A4 and should be used carefully in patients with liver disease or those taking medications that act as an inhibitor of this microsomal enzyme.

- d. Inhibitors include azole antifungals, macrolides, calcium channel blocker, and protease inhibitors.

II. Esters

- a. Include cocaine, chloroprocaine, procaine, and tetracaine.

III. Lidocaine^{2–4}

- a. Is the most commonly used local anesthetic. Can be used with or without epinephrine.
- b. Epinephrine produces local vasoconstriction which decreases bleeding and systemic absorption. It also reduces the pH of lidocaine, which may increase the pain after injection.
- c. Epinephrine can be administered in safe doses of 1.5–2 mg/kg and 7 mg/kg of plain lidocaine and lidocaine with epinephrine, respectively.
- d. The use of lidocaine with epinephrine in the fingertips, the tip of the nose, and the ears is controversial.

Key features

- I. Confirm the lesion location with a body map and outline it with a skin marker.
- II. Obtain informed consent.
- III. Ask about past medical history, current medications, and allergies to anesthetics, antibiotics, or antiseptics.
- IV. Prepare the surgical site with antiseptic swaps.
- V. Select the appropriate anesthetic technique.
- VI. Always pull back the plunger of the syringe after inserting the needle, to ensure that there is no intravascular injection.

Additives

- Epinephrine: decreases bleeding and enhances anesthetic effect.
- Sodium bicarbonate (8.4%): 1 part + 10 parts of anesthetic, reduces the burning sensation; reduces anesthetic effect 25%.
- Hyaluronidase: better anesthetic diffusion, less tissue distortion, reduces the anesthetic effect.

Choosing the appropriate anesthetic technique

- I. Topical: for shaves or infiltration of anesthetic with less pain.
- II. Infiltrative: for shaves, punches, curettage, and excisional biopsies.
- III. Nerve blocks: for larger procedures and more sensitive areas.

Instruments

- I. Non-sterile gloves
- II. Antiseptic swaps
- III. Lidocaine (most commonly used) with/without epinephrine
- IV. Syringes (3, 5, and 10 mL)
- V. Syringe needles (25, 27, and 30 gauge)
- VI. Gauze pads

Step-by-step anesthetic techniques**Topical anesthesia**

- Topical agent that decreases cutaneous pain sensation³.
- Cryoanesthesia: refrigerant sprays (dichlorotetrafluoroethane and ethyl chloride)
 - Topical anesthetic compounds: EMLA, S-Caine Peel, LMX, and Tropicaine among others.

EMLA

- I. Clean and dry the site. Shave the area if necessary.
- II. Apply EMLA 1–3 hours before the procedure. Do not spread out the cream.

- III. Cover with an occlusive dressing, getting a thick layer underneath.

- IV. Write the time of application on the dressing.

Infiltrative anesthesia

- I. Hold the skin taut, insert the needle in a 10° angle (intradermal) or a 30° angle (subcutaneous) into the skin.
- II. Inject the anesthetic smoothly.
- III. If additional needle sticks are needed, place them in an already anesthetized area.

Nerve blocks

Classified into ring blocks and peripheral nerve blocks^{5–7}.

Ring or field block

- I. Hold the skin taut, insert the needle in a 10° or a 30° angle into the skin.
- II. Pull back the plunger of the syringe to ensure that there is no intravascular injection.
- III. Inject the anesthetic smoothly.
- IV. Repeat the injection process in a circumferential pattern around the marked surgical site.

Scalp block

- I. Hold the skin taut, insert the needle in a 10° angle into the skin.
- II. Inject small wheals of anesthesia, 5 cm apart from each other, starting on the mid-forehead.
- III. Continue injecting above the eyebrows, follow across the superior auricular sulcus towards the occiput.
- IV. Proceed around the other side of the scalp back to the starting point, completing the ring.
- V. Further injections should be done at the subcutaneous and subfascial level.

Ear block

- I. Hold the skin taut, insert the needle in a 30° angle at the inferior auricular sulcus, next to the attachment of the ear lobe.
- II. Infiltrate in the direction of the tragus; withdraw the needle and redirect it in the posterosuperior direction along the post-auricular sulcus.
- III. Next, insert the needle at the tragus and in a superior direction. Infiltrate along the pre-auricular sulcus.

- IV.** Finally, infiltrate along the superior post-auricular sulcus, completing the ring.

Caution: Temporal arteries run 1cm anterior to the tragus.

Peripheral nerve blocks: higher anesthetic concentrations (e.g., 2% lidocaine) are recommended

Face

Supraorbital nerve block

- Anesthetizes the scalp and forehead above the eyebrow.
- I.** Locate the supraorbital foramen in the mid-pupillary line, along the supraorbital ridge (2.5cm lateral to the facial midline).
 - II.** Hold the skin taut, insert the needle perpendicular to the skin and infiltrate the site, generating a papule.
 - III.** Insert the needle into the anesthetized area and move forward to the bone.
 - IV.** Infiltrate 1–2 mL of anesthetic outside the foramen.

Supratrochlear nerve block

- Anesthetizes the glabella, and the forehead and scalp above it.
- I.** Hold the skin taut, insert the needle perpendicular to the skin at the junction of the supraorbital ridge and the nose root; 1 infiltrate the site, generating a papule.
 - II.** Insert the needle into the anesthetized area and move forward to the bone.
 - III.** Infiltrate 1–2 mL of anesthetic outside the foramen.

Both nerve blocks can be done at the same time, starting from either one and infiltrating along the eyebrow until the other is reached.

Infraorbital nerve block

- Anesthetizes lower eyelid, lateral part of the nose, upper lip, and medial part of the cheek
- I.** Locate the infraorbital foramen, at the mid-pupillary line, 10mm below the infraorbital ridge (2.5cm lateral to the facial midline); press the site with your third finger.
 - II.** Raise the upper lip with second finger and the thumb of the same hand.
 - III.** Insert the needle at the apex of the canine fossa; infiltrate 1–2 mL of anesthetic outside the foramen.

Mental nerve block

Anesthetizes lower lip and chin

- I.** Locate the mental foramen, at the mid-pupillary line, midway between the alveolar margin and the inferior border of the mandible (2.5 cm lateral to the facial midline); press the site with your third finger.
- II.** Retract the cheek laterally.
- III.** Insert the needle along the lower gum line between the two lower premolar teeth; infiltrate 1–2 mL of anesthetic outside the foramen.

Hand and wrist

Median nerve block

Anesthetizes lateral two-thirds of the palm, ventral side, and nail beds of the thumb, second, third and half of the fourth finger

- I.** Locate the palmaris longus and the flexor carpi radialis tendons.
- II.** Insert a 27-gauge needle at the proximal wrist flexion crease, between the tendons, in a 30° angle in direction of the ring finger.
- III.** Insert the needle until it pierces the fascia; infiltrate 5 mL of anesthetic.

Caution:

The radial artery runs lateral to the flexor carpi radialis tendon.

Radial nerve block

Anesthetizes lateral half of the dorsum of the hand, dorsum of the thumb, second, third, and half of the fourth finger

- I.** Locate the styloid process of the radius.
- II.** Insert a 27-gauge needle just above the styloid process of the radius in a 30° angle in medial direction; infiltrate 5 mL of anesthetic.
- III.** Withdraw the needle and redirect, infiltrating 5 mL of anesthetic in a lateral direction.

Ulnar nerve block:

Anesthetizes palmar and dorsal side of fifth and half of the fourth finger, medial third of the palm, and medial half the dorsum of the hand.

- I.** Locate the insertion of the flexor carpi ulnaris tendon at the styloid process.
- II.** Insert a 27-gauge needle transversally, below the insertion.

- III.** Advance the needle until it pierces the fascia; infiltrate 5 mL of anesthetic.

Caution:

The ulnar artery runs lateral to the flexor carpi ulnaris tendon.

Digital nerve block

- I.** Place the patient's hand with the palm facing downwards.
- II.** Insert a 25-gauge needle perpendicular to the skin onto the dorsolateral aspect of the base.
- III.** Advance with the needle until just below the ventral side; infiltrate 1 mL of anesthetic.
- IV.** As the needle is withdrawn, infiltrate 1 mL of the anesthetic.
- V.** Repeat the same process on the other side of the base of the finger.

Ankle**Sural nerve block**

Anesthetizes lateral edge of the foot and dorsum of fifth toe.

- I.** Position the patient prone.
- II.** Locate lateral edge of the Achilles tendon and the posterior border of the lateral malleolus.
- III.** Insert a 25-gauge needle between the two anatomical landmarks, toward the lateral malleolus.
- IV.** Advance with the needle, infiltrating 5–10 mL of anesthetic in a transverse line until the malleolus is reached.

Posterior tibial nerve block

Anesthetizes the heel, sole and plantar side of the toes.

- I.** Position the patient prone.
- II.** Locate medial edge of the Achilles tendon and the posterior border of the medial malleolus.
- III.** Locate the posterior tibial pulse behind the malleolus.
- IV.** Insert a 25-gauge needle 1 cm behind and above the pulsating artery toward the tibia in 45° angle.
- V.** Advance the needle, infiltrating 5 mL of anesthetic until the bone is reached.

Caution:

The posterior tibial artery runs medial to the nerve.

Saphenous nerve block

Anesthetizes medial edge of the foot.

- I.** Position the patient supine.
- II.** Locate the anterior border of the medial malleolus and the anterior tibial tendon by dorsiflexing the foot.
- III.** Insert a 25-gauge needle 1.5 cm in front and above the superoanterior border of the medial malleolus.
- IV.** Advance the needle transversely, infiltrating 5 mL of anesthetic toward the anterior tibial tendon.

Caution:

The great saphenous vein runs anterior to the nerve.

Superficial peroneal nerve block

Anesthetizes dorsum of the foot and digits, except for the first web space.

- I.** Position the patient supine.
- II.** Locate the medial and lateral malleoli.
- III.** Draw a transverse line from the medial malleolus to the anterior border of the lateral malleolus.
- IV.** Insert a 4 cm 25-gauge needle at the anterior border of either of the malleoli.
- V.** Advance the needle at the subcutaneous level, transversely, infiltrating 5–10 mL of anesthetic toward the anterior border of the opposite malleolus.

Deep peroneal nerve block

Anesthetizes dorsal aspect of foot's first web space.

- I.** Position the patient supine.
- II.** Locate the extensor hallucis longus and the extensor digitorum longus.
- III.** Search between the tendons for the anterior tibial pulse.
- VI.** Mark the site of the injection.
- V.** Insert a 27-gauge needle 5 mm lateral to the pulsating artery, perpendicular to the skin.
- VI.** Advance the needle until the bone is reached, withdraw the needle 1 mm; infiltrate 3 mL of anesthetic.

Caution:

The anterior tibial artery runs medial to the nerve.

Penile block

- I.** Position the patient supine.
- II.** Locate the dorsal superficial penile vein.

III. At the base of the penis, insert a 27-gauge needle lateral to the vein and just below the skin, inject 2 mL of the anesthetic without epinephrine.

VI. Repeat on the other side of the vein.

Complications

I. Vasovagal response: due to anxiety, producing diaphoresis, dizziness, bradycardia, hypotension, and syncope.

II. Toxicity: the patient can present with different symptoms depending on the blood concentrations, ranging from tinnitus, lightheadedness, circumoral numbness and nystagmus to generalized tonic-clonic seizures and respiratory depression at very high levels.

III. Allergic reaction: rare, less than 1%. Type I (usually with ester type anesthetics) and IV reactions could occur.

IV. Vascular injury: prolonged bleeding and hematomas can develop. Apply continuous pressure in this situation.

V. Nerve injury: transient neuritis, paresthesias, or motor deficits can develop. Infection: can occur if aseptic measures are not taken before starting the procedure.

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CHAPTER 4

Suturing techniques

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Introduction

The goals of proper suturing techniques are:

- Eliminating dead space.
- Providing support to the wound so that the healing process can strengthen the wound.
- Approximating the cutaneous edges so that cosmesis and function are preserved.
- Minimizing the risk of infections and bleeding.¹

Besides considering the conditions that affect wound healing, the repair of wounds should always be preceded by an evaluation of wound characteristics, their anatomic location, thickness of the skin, degree of tension, and desired cosmetic results.

Instruments

The instruments tray is set containing the following items. Afterwards, a photograph should be taken;

- appropriate suture material
- surgical needle
- needle holder
- fine suture scissors
- toothed tissue forceps ± skin hook
- anesthetic solutions.

An adequate light source is important to perform wound closure appropriately.

Choosing appropriate suture materials (Table 4.1)

A good suture material must have tensile strength to resist breakage, good knot security, workability in handling, low tissue reactivity, and the ability to resist bacterial infection. The two main classes of suture materials are:

- absorbable
- non-absorbable.²

Absorbable

Those sutures that are absorbed by tissue enzymes or hydrolysis by the body's cells and tissue fluids that they are embedded in, during, and after the healing processes.

They are used as deep sutures and do not need to be removed postoperatively.

I. Surgical gut: tensile strength is maintained for 7–10 days post implantation and absorption is complete within 70 days:

- a. indicated for epidermal use (required only for 5–7 days)
- b. not recommended for internal use.

II. Dexon (polyglycolic acid): absorbable suture material of a synthetic braided polymer:

- a. has low rate of reactivity and infection, as well as excellent knot security and tensile strength.
- b. disadvantage: high friction.

III. Chromic gut: types A–D with increasing absorption times.

Table 4.1 Types of sutures

Suture types		
Location	Subcutaneous	Cutaneous
Material	Usually absorbable Organic: catgut-plain or chronic Synthetic: polyglycolic acid (dexon, vicryl)	Non absorbable: nylon (dermalon) Absorbable: fast-absorbing catgut
Advantages	Decreased dead space Decreased tension Homeostasis	Good approximation of tissue, good eversion of wound edges, minimal tissue reaction to nylon and no need to remove if using catgut suture
Disadvantages	Introducing foreign body Risk of scar if suturing near skin surface Risk of splitting of the suture	Nylon sutures require removal and can leave a mark after removed, plus more time consuming than other methods (staples and glue)

Non-absorbable

Those suture materials that cannot be absorbed by the body's cells or fluids.

They are used for surface suturing and requires manual removal postoperatively.

I. Nylon (Ethilon): most commonly used of all non-absorbable suture materials.

- a. Possesses minimal tissue reactivity, resists infections, high tensile strength, and good wound security.
- b. Drawback: difficult to achieve a good knot (needs four or five "throws" to get a secure knot).

II. Prolene

- a. Stronger than nylon and better overall wound security.
- b. Has greater memory and hence is difficult to work with.

III. Braided: includes cotton, silk, braided nylon and multifilament Dacron.

- a. Most workable and has excellent knot security.
- b. Soft, pliable, good to use around the eyes, lips
- c. Disadvantages: high reactivity and absorption of body fluids by the braided fibers.

The choice of suture material also greatly depends on which area is being considered for suturing. The suture size, which is measured by its width or diameter, is determined accordingly:

- 1-0 and 2-0: for strong retention in high stress areas, e.g., deep fascia
- 3-0: areas requiring good retention, e.g., scalp, torso, hands
- 4-0: for areas that need minimal retention and superficial closure, e.g. extremities

- 5-0: For closure on face, nose, ears, eyebrows and eyelids
- 6-0: For areas which need little or no tension, e.g., cosmesis.³

Surgical needles

The needle has three sections: point, body and swage.

- The point is the sharpest portion which is used to penetrate the tissue.
- The body is the mid-portion.
- The suture material is attached at the swage, which is the thickest portion.
- Curved needles with two basic configurations are used in suturing: tapered and cutting. The former is used on soft tissue, and when the smallest diameter hole is desired. A cutting needle has a sharp edge directed towards the wound edge (inner curve). A reverse cutting needle is similar but has the sharp edge directed away from the wound edge (outer edge) and allows for a smooth and atraumatic penetration of tough skin and fascia. Hence, it is used more often than the cutting needle in cutaneous surgery.

Needle holders

Needle holders come in different shapes and sizes. The larger and deeper the wound, the bigger the size of the needle holder required. It is used to grasp the needle at the distal portion of the body. It is then tightened by

squeezing it until the first ratchet catches. Excessive tightening can damage the needle and the needle holder. The needle is held vertically and longitudinally perpendicular to the needle holder to avoid difficulty in penetrating the skin, bending of needle and undesirable angle of entry into the tissue.

The needle holder is held with the thumb and fourth/ring finger into the loops and the index finger on the fulcrum of the needle for better stability. Alternatively, it may be, held in the palm for an improved dexterity.

Suture scissors

Three main types of scissors are generally used:

- Iris scissors: mainly used for wound debridement and revision. These are very delicate, and are not recommended for cutting sutures except very small sutures.
- Dissection scissors: used for undermining the wound.
- Suture removal scissors: used for cutting sutures and other dressing materials. These are single blunt-tip standard scissors which are 6 inches in length and durable to use.

Forceps

For proper suture placement, grasping and controlling the tissue with forceps is essential. At the same time, gentle handling of the tissues is necessary for avoiding tissue strangulation and necrosis. Toothed or untoothed forceps or skin hooks are the available options for the surgeon. The forceps are also useful in grasping the needle, as it exits the tissue and lessens the risk of losing the needle in the dermis and subcutaneous fat.

Important points for suturing

- I. Gathering is a maneuver that should be used for every suture to get excess line out of the way and off the table.
 - a. Push the needle through the skin with a needle holder.
 - b. Then with the thumb and the index finger grasp the needle and pull the suture through.
 - c. Now using the fifth digit pull the suture into your hand as you re-grab the suture with your thumb and index finger.
 - d. Repeat.

II. Wound eversion

- a. Essential for good epidermal approximation and reduces the risk of scar depression secondary to tissue contraction during healing.
- b. The needle should always penetrate the skin at 90° angle to minimize the size of entry wound and promote eversion.

III. Wound layers should be placed in close approximation.

IV. Minimize the amount of tension across the suture line.

V. Equal bites, horizontally and vertically result in a flask shaped configuration, i.e., the stitch is wider at its base (dermal side) than its superficial portion (epidermal side).

VI. Small bites can be used to precisely co-aptn wound edges. Large bites can be used to reduce wound tension.

VII. Debride devitalized tissue.

Step-by-step suturing technique

I. Apply the needle to the needle holder one half to three quarters of the distance from the tip of the needle.

II. Stabilize the wound edge and apply gentle traction with either toothed forceps or a skin hook.

III. Insert the needle 1–3 mm from the wound edge at 90° angle to the skin surface.

IV. The needle should traverse downwards through the epidermis and dermis and take a small bit of subcutaneous tissue.

V. Turn your wrist to get the needle through the tissues.

VI. Release the needle from the needle holder and reach into the wound and grasp the needle tip with the needle holder and pull it free, so that you have enough suture material to enter the opposite side of the wound.

VII. Insert needle on the opposite wound edge at an equivalent depth to the initial placement to avoid mismatched wound-edge heights (i.e., stepping). The needle should follow a reverse path exiting the skin equidistant to the opposite side, perpendicular to the skin.

VIII. Pull the needle through the skin until you have approximately 1 inch suture strand protruding from the bite sites.

IX. Release the needle from the needle holder and wrap the suture around the needle holder twice.

X. Grasp the end of the suture material with the needle driver (instrument tie) and pull the two lines across the wound site in opposite directions. This is called a throw. It can be done using one's hands too.

XI. Do not position the knot directly over the wound edge.

XII. Two throws make a "knot". Repeat three or four throws to ensure knot security. Over each throw, reverse the order of the wrap (squaring). Proper squaring of successive ties prevents creation of a granny knot which tends to slip and is inherently weaker than a properly squared knot.

XIII. Cut the ends of the suture one-quarter inch from the knot.

Types of suturing technique

Simple interrupted sutures

- Interrupted sutures are individually placed and tied.
- The technique involved is mentioned above and needs to be repeated for however many times is required depending on wound length.
- Sutures should be placed 0.5–cm apart.
- Less potential for causing wound edema.
- Allow the surgeon to make adjustments as needed to properly align wound edges.
- Technique of choice, if cleanliness of wound is doubtful. If the wound appears to become infected, a few sutures can be removed without interrupting the entire closure.
- Disadvantage: more time required to place interrupted sutures and more risk of crosshatching (train tracks) across the suture line. The latter can be minimized by early suture removal.¹

Running sutures

Simple running sutures

- Uninterrupted series of simple interrupted sutures.
- Suture is started by placing a simple interrupted stitch which is tied but the line leading to the needle is not cut.
- Reinsert the needle the same distance from the wound. Once inserted, push the needle perpendicular to the wound and out of the other side.

- Instead of tying, reinsert the needle down the wound and so that the suture crosses over the top of the wound. Now, go through the wound perpendicular again.
- Repeat until the end of the wound, then tie off (like mentioned in the technique).
- Useful for long wounds in which tension has been minimized with already placed deep sutures, and in which wound approximation is good.
- Can be used to secure a split- or full-thickness skin graft.
- Causes lesser scarring due to lesser number of knots than interrupted sutures.
- Advantage: quicker placement
- Disadvantages: wound dehiscence if suture material fails, can cause crosshatching, adjustments along the suture line can be difficult, puckering of suture line can occur in patients with thin cutaneous tissue.¹

Running locked sutures

- Also known as baseball sutures due to its final appearance.
- The first knot of a running suture is tied as mentioned earlier and is then locked by passing the needle through the loop preceding it as each stitch is placed.
- Useful in wounds that need more hemostasis (oozing from skin edges), e.g., scalp and post-auricular sulcus.
- Can impair microcirculation and cause strangulation.
- Should only be used in areas that are adequately vascularized.¹

Mattress sutures

Vertical mattress sutures

- Variation of simple interrupted sutures.
- Goes both deep and superficial, and constrains minor blood vessels.
- For placing this suture go in and out of the wound, narrow and shallow. Then reinsert needle on same side as the exit, but further from the wound. Push needle back to the other side of the wound going deeper than the first pass. Pull suture tight, and tie the ends as before.
- The width of the stitch should be made directly proportional to the amount of tension on the wound.
- Useful in achieving maximum wound eversion, reducing dead space and minimizing tension across the wound.

- Disadvantage: cross-hatching
- Early suture removal (5–7 days), should be done to reduce scarring.¹
- Pulley suture/far-near near-far modified vertical mattress sutures: variation of vertical mattress suture. Facilitates greater stretching of wound edges. Useful when additional wound closure strength is desired.

Horizontal mattress sutures

- Begins as a deep simple interrupted stitch by entering the skin 5 mm to 1 cm from the wound edge, passing through the dermis and exiting on the opposite side at an equidistant point. Now, the needle is re-inserted on the same side of suture line 5 mm to 1 cm lateral to the exit point emerging from the opposite side. The ends are tied to complete the knot.
- Useful for wounds under high tension, and can be used as a stay stitch where risk of dehiscence is high. Improved wound strength and wound eversion.
- Disadvantage: high risk of tissue strangulation.¹

Buried sutures

Buried sutures are a useful technique for wide gaping wounds and wounds where eversion is difficult. The purpose of this stitch is to line up the dermis and thus enhance healing. The knot needs to be as deep into tissues as possible (buried), so that it does not present through the epidermis and cause irritation and pain.

Variations of running sutures

Running horizontal mattress sutures

After placing a simple suture, the horizontal mattress is placed. The final loop is tied to the free end of the suture material.

Useful at places where wound inversion chances are high, e.g. neck, and also useful for reducing spread of facial scars.¹

Running subcuticular sutures

- Useful in situations with minimal wound tension and dead space, and when the best cosmetic result is desired.
- Can result in minimal visible suture marks, little cross-hatching, as well as closely approximated wound edges.
- Does not contribute to wound strength.¹

Table 4.2 Length of suture maintenance, by body region

Region	Approximate number of days for suture removal
Face	5–7 days
Scalp	10 days
Neck	7 days
Trunk and upper extremities	10–14 days
Lower extremities	14–21 days

Running subcutaneous sutures

- Begins as a running subcutaneous suture. The knot is tied but not cut. The suture is looped through the subcutaneous tissue by successively passing through the opposite sides of the wound.
- Next, the knot is tied at the opposite end of the wound by knotting the long end of the suture material to the loop of the last pass that was placed.
- It is used to close deep portion of surgical defects under moderate tension.
- Disadvantages: suture breakage can create dead space underneath the cutaneous surface.¹

Suture removal

- Rule: the greater the tension across a wound, the longer the suture needs to be left in place (Table 4.2).
- Buried sutures that utilize absorbable suture material are dissolved by tissue fluids and do not require removal.

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CHAPTER 5

Electrosurgery

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Introduction

Electrosurgery is defined as the application of a high-frequency electric current to biological tissue as a means to cut, coagulate, desiccate, or fulgurate tissue. Electrosurgery refers to the following modalities which are used in the management of many benign and malignant conditions (Table 5.1):¹

- electrofulguration
- electrodessication
- electrocoagulation
- electrosection
- electrocautery
- electrolysis.

Electrosurgical equipment works by using either direct or alternating current. The direct current consists of electrons flowing in one direction whereas alternating current comprises flowing electrons that regularly reverse direction. Most electrosurgical equipment works by using high-frequency alternating current. Electrocautery and electrolysis are the only techniques that utilize direct current. Alternating current produces two types of waves.¹

- *Damped waves:* this type of wave current emits a strong initial electrical burst of waves followed by diminishing waves. The faster the waves return to zero, the more damped is the current. These waves coagulate tissue and cause more tissue damage. As current dampening increases so does hemostasis. Most of the electrosurgical

devices that use alternating current have a damped waveform.

- *Undamped waves:* Electrosection utilizes undamped current composed of a purely sinusoidal wave. Undamped current cuts tissue without hemostasis.¹

Principles of electrosurgery

- The electrosurgical generator is the source of the electron flow and voltage.²
- The circuit is composed of the generator, active electrode, patient, and patient return electrode.
- Pathways to the ground can be the operating room (OR) table, stirrups, staff members and/or equipment.
- The patient's tissue provides the impedance thereby producing heat as the electrons overcome the impedance.
- The electrosurgical generators take a current at a frequency of 60Hz and increase it to over 2kHz, to achieve a high enough frequency at which electrosurgical energy can pass through the patient with minimal neuromuscular stimulation and no risk of electrocution.²

Electrical current may be transferred to the patient through a single treatment electrode with (biterminal) or without (monoterminal) the use of a dispersive electrode. The biterminal method may be either unipolar or bipolar.²

Table 5.1 Types of electrosurgery

Modality	Definition	Tissue reaction/effect	Uses	Other comments	Trade names
Electrofulguration	Use of a single treatment electrode capable of producing a spark without touching the tissue. Current: 0.5–0.75 A Voltage: >2000 V	The electrode is held at a distance from the tissue and the spark generated crosses the gap. Monoterminal: the amount of heat produced varies with the power setting Reticular dermis remains unaffected as carbonization of the skin surface forms an insulating barrier.	Tissue heals with no or minimal scarring or hypopigmentation	Removal of benign epidermal lesions such as verrucae, acrochordons, seborrhic keratoses, sebaceous hyperplasia	Conmed Hyfrecator 2000 Ellman Hyfrecator Aaron Bovie 900 Hyfrecator
Electrodessication	Similar to electrofulguration except that the treatment electrode is in contact with the tissue and no spark is produced. Current: 0.5–0.75 A Voltage: >2000 V	The tip of the electrode is either moved gently across a lesion surface or inserted into a thick hyperkeratotic lesion for deeper penetration of the current. Treated tissue shrivels and can be removed with a gauze or curette.	Benign epidermal lesions and telangiectasias	Light touch and minimum pressure applied when performing electrodesiccation. Treatment cycle is usually repeated three times	Conmed Hyfrecator 2000 Ellman Hyfrecator Aaron Bovie 900 Hyfrecator
Hemostasis		Hemostasis is achieved by placing the treatment tip directly over the bleeding vessel or by touching the treatment tip to forceps grasping the bleeding vessel.		1% lidocaine with epinephrine is used for local anesthesia for treating cutaneous lesions. Electrosurgery is performed on the lesion surface until dermoeidermal separation has been achieved, followed by curettage	Conmed Hyfrecator 2000 Ellman Hyfrecator Aaron Bovie 900 Hyfrecator
Electrocoagulation	A technique used to achieve hemostasis in vessels <2 mm and treatment of some skin lesions using moderately damped monopolar or bipolar current	After the surgical site has been dried using a gauze pad, an activated electrode at low power is touched to the forceps holding an interrupted vessel Current is removed when a wisp of smoke, discoloration or pop occurs at the site	Hemostasis	The process is repeatable until all the friable tissue is removed and normal, firm pale dermis is reached	(Continued)

Table 5.1 (Continued)

Modality	Definition	Tissue reaction/effect	Uses	Other comments	Trade names
Electrosection	Electrosurgical technique that uses undamped current and cuts tissue in a manner similar to the scalpel but with less bleeding	Reserved for surgery in highly vascular areas such as nose and scalp or in patients with coagulopathy		Disadvantage of lateral heat spread that causes peripheral tissue damage. Also smoke plume produced has a potential to transmit infectious or carcinogenic particles-this can be avoided by using face masks and smoke evacuators. Pure undamped current produces very little coagulation, hence the "Bovie" named after its inventor William Bovie, was developed which is a blended damped and undamped wave that provides both cutting and coagulation at the same time.	Conmed Hyfrecator 2000 Ellman Hyfrecator Aaron Bovie 900 Hyfrecator
Electrocautery	Use of either direct or low-frequency alternating current with low voltage and high amperage which heats a treatment filament.	The tissue to be treated is anesthetized and the tip of electrocautery is applied to the tissue producing a charred layer which is removed using a gauze or gentle curettage	Superficial benign lesions such as verrucae and acrochordons	Use in patient with cardiac pacemaker or implantable defibrillator No dispersive electrode required No risk of interference with implanted cardiac devices Available in small disposable pen-sized battery-operated version Hemostasis with electrocautery is less effective than with electrocoagulation while the zone of thermal damage may actually be greater	Conmed Hyfrecator 2000 Ellman Hyfrecator Aaron Bovie 900 Hyfrecator
Electrolysis	Electrosurgical technique using direct electrical current in which the flow of electrons is from anode to cathode. It is the only truly bipolar electrosurgical procedure.	For treating hypertrichosis: the anode, which is in the form of a very thin needle, is inserted into a hair follicle under magnification. The current is increased gradually until sodium hydroxide and hydrogen gas are generated and the protein in the follicle is liquefied.	Used to coagulate very fine telangiectasias and for treating hypertrichosis	The patient holds the cathode in his/her hand to complete the circuit. The process is slow taking between 30 seconds to 1 minute for each follicle.	Apilus-S Platinum Clareblend-Nova2000 Multi-Needle, Ultrablend, Thermolysis Generator Fischer Hinkel Instantron Silhouette-Tone

The unipolar method allows the current to flow between a single hand-held treatment electrode and the dispersive electrode, which is attached to the skin at a site distant from the treatment area. This method is the most commonly used electrosurgical modality because of its versatility and clinical effectiveness. The active electrode is in the surgical site and the patient's return electrode is elsewhere on the patient's body. The current passes through the patient as it completes the circuit from the active electrode to the patient return electrode.²

The ideal return electrode safely collects current delivered to the patient during electrosurgery and carries it away. The pad should provide a large contact area with low impedance to avoid current concentration. It should be placed on conductive tissue, such as well-vascularized muscle mass, close to the operative site. Areas of vascular insufficiency, irregular body contours and bony prominences should be avoided because these areas may facilitate current collection. The difference between the "active" electrode and the patient return electrode is their relative size and conductivity.²

- Bipolar forceps refer to the current flowing between the two prongs of a forceps. The active output and patient return functions are both accomplished at the site of surgery. The path of the current is confined to the tissue grasped between forceps tines. The patient return electrode should not be applied for bipolar only procedures, as the return function is performed by one tine of the forceps.²
- Electrosurgical generators can produce a variety of waveforms. Changing the waveforms can change the device's effect on the tissues.
- A constant waveform helps to vaporize or cut tissue as it produces heat very rapidly.
- An intermittent waveform reduces the duty cycle and helps perform coagulation due to low heat production.
- There can be other modifications of the duty cycle, known as "blended current." Moving from blend 1 to blend 3, there is a reduction in the duty cycle with lesser heat produced. Thus, while blend 1 can vaporize tissue with minimal hemostasis, blend 3 has less effective cutting but maximum hemostasis.²
- Hence, the only variable that determines whether one waveform vaporizes tissue and another produces coagulum, is the rate at which heat is produced; high heat

produced rapidly causes vaporization and low heat produced slowly creates a coagulum.²

Cardiac pacemaker and defibrillator interference

- Modern pacemakers are synchronous demand-type units that have protective mechanisms to shield from outside electrical activity.³
- For patients with implanted cardioverter defibrillators and pacemakers, a prior consultation with the patient's cardiologist should be made in order to clear all the electrosurgical procedures.
- There should be access to cardiologist and resuscitative drugs and equipment in case a complication arises.
- Unstable patients, who are highly dependent on their pacemakers, should not undergo electrosurgery.
- Bipolar forceps should be used when treating patients with cardiac pacemakers; however, electrocautery is an acceptable alternative.
- The dispersive electrode site should be far from the heart and the pacemaker. The current path between the treatment and the dispersive electrodes should not cross the pacemaker and all the electrosurgical equipment should be grounded properly.
- Continuous cardiac monitoring with electrocardiogram (ECG) or pulse oximetry should be performed.
- Current should be delivered in short bursts under 5 seconds with the lowest possible current setting.
- Instant response technology: by measuring the tissue impedance/resistance at the electrode contact site, computer-controlled output is automatically adjusted providing instant response to changes in tissue impedance/resistance.
- Vessel sealing technology: vessel sealing technology is an electrosurgical technology that combines pressure and energy to create a seal. It is advantageous because of the following properties:
 - reliable, consistent permanent vessel wall fusion
 - minimal thermal spread
 - reduced sticking and charring
 - seal strength higher than other energy-based techniques
 - seal strengths comparable to existing mechanical based techniques

- It applies a unique form of bipolar electrosurgery in combination with optimal pressure delivery by the instruments in order to fuse the vessel walls and create a permanent seal.³
- The feedback-controlled output produces a reliable seal in minimal time, independent of the type or amount of tissue in the jaws. Vessels 7mm in diameter or tissue bundles can be sealed with a single activation. The thermal spread is significantly reduced compared to traditional bipolar systems and is comparable to ultrasonic coagulation. The seal site is often translucent, allowing evaluation of hemostasis prior to cutting.³

Radiofrequency ablation system

- Alternating current through the tissue creates friction and thus increased intracellular temperature causing localized interstitial heating. At temperatures above 60°C, cellular proteins rapidly denature and coagulate, resulting in a lesion. The Cool-tip system's generator feedback algorithm senses tissue impedance and automatically delivers the optimum amount of radiofrequency energy. It also eliminates tissue charring and allows for maximum current delivery, resulting in a larger ablation zone in less time.³
- The generator software monitors tissue impedance and adjusts the output accordingly.
- The electrode's internal circulation of water cools the tissue adjacent to the exposed electrode, maintaining low impedance during the treatment cycle. Low impedance permits maximum energy deposition for a larger ablation volume.

Complications

- Burns: although modern equipment is very safe, using a dispersive electrode with defective contact between the electrode and the patient can result in burns. During electrodesiccation and electrofulguration, a dispersive electrode is not used, but a burn can still occur if the patient is accidentally grounded (such as if the patient's body part is touching a metallic object that is in contact

with the floor). Also, excessively high power settings can produce burns in the tissue adjacent to the treatment site.

$$\text{Burn} = (\text{Current} \times \text{Time})/\text{Area}$$

- Return electrode monitoring (REM) was developed to protect patients from burns due to inadequate contact of the return electrode. REM-equipped generators actively monitor the amount of impedance at the patient/pad interface because there is a direct relationship between this impedance and the contact area. If the system detects a dangerously high level of impedance at the patient/pad interface, it is designed to deactivate the generator before an injury can occur.
- Channeling: this is the conduction of high-frequency current along neurovascular bundles, producing pain and tissue damage at distal sites. It occurs most often when operating around a nerve and can be avoided by using a bipolar forceps or electrocautery, or using low energy settings.
- Fire: during electrosurgery the skin should be cleaned with nonflammable substances such as povidone – iodine or chlorhexidine and flammable substances such as alcohol should be avoided. High-tension oxygen can be hazardous making it important to keep nasal prongs, masks, etc. away from the operative field. A fire extinguisher and emergency training come handy in case of fire.
- Infection: human papilloma and herpes virus have been demonstrated to exist in the smoke produced during electrocautery. Hepatitis B virus also has been found residing in electrode tips. No reports of HIV or hepatitis B infection are known from exposure to plumes. Face shields and use of smoke evacuator at <2 cm from the operative site should be used.

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6

CHAPTER 6

Biopsy techniques

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Preoperative care

I. Determine the appropriate biopsy technique depending on the type of lesion. Items necessary for any biopsy include the consent form, histopathology form, and specimen container.¹

II. Outline the lesion with a marker, document its location on a body map, and take pictures of it so that follow-up evaluation is possible. One suggested method for specifying the exact location of a lesion is triangulation, in which three anatomical parts (such as the tragus of the ear, the lateral canthus of the eye, and the corner of the mouth) can be used to measure the various distances from the lesion. Another method uses a clock face on a single anatomical location (such as the tragus of the ear) to create a landmark for the lesion.

III. Choosing the appropriate type of biopsy:

- a. A shave biopsy with a scalpel should be used for exophytic lesions or epidermal tumors.
- b. Saucerization should be used for deeper-seated lesions that extend into the upper to mid-dermis.
- c. A punch biopsy should be used for hair disorders, uniform skin lesions, or deep lesions that extend into the mid-dermis to subcutaneous tissue.
- d. An incisional biopsy should be used for larger specimens or nail matrix disorders.
- e. A wedge biopsy should be used to examine ulcers while also including normal skin margins.
- f. An excisional biopsy should be reserved for total removal of the skin lesion with or without normal skin margins. For example, removal of a mole that is suspicious for melanoma.

Instruments

- Sterile gloves (not needed for shave biopsies)
- Antiseptic agents
- Scalpel, blade
- Razor blade
- Punch (available in 2 mm, 3 mm, 4 mm, and 6 mm diameters); the 6-mm punch is also available in an elliptical shape
- Scissors
- Smooth and toothed Adson tissue forceps
- Suture kit/set
- Cauterizing agent
- Gauze pads and bandages
- Specimen container with formalin

Key techniques

- I. Ask about a history of bleeding problems. Ask about current medications the patient is using and any allergies to anesthetics, antiseptics, and antibiotics. Also, obtain an informed consent.
- II. Confirm location of skin lesion with body map and pictures, and outline the lesion with permanent ink.
- III. Prep the skin using antiseptic wipes.
- IV. If deemed necessary, use a sterile draping to surround the lesion.
- V. Anesthetize the affected area.
- VI. Perform the appropriate biopsy to obtain a specimen.
- VII. Gently handle the specimen while transferring it to the container.
- VIII. To stop bleeding, a cauterizing agent or suture can be used depending on the type of biopsy and depth of the lesion.

- IX. Apply petrolatum or antibiotic ointment topically and dress the wound appropriately.
- X. Advise the patient on proper wound care techniques to avoid complications.
- XI. Schedule a follow-up appointment.

Step-by-step surgical techniques

Shave biopsy with scalpel¹

- I. Infiltrate the lesion with local anesthesia, usually lidocaine with or without epinephrine.
- II. Slide the scalpel horizontally across the base of the lesion.
- III. A chemical hemostatic agent or electrical cautery may be used to achieve hemostasis.

Saucerization¹

- I. After infiltration of local anesthesia, the razor blade is bent in a U-shaped manner and the lesion is scooped out according to the depth desired. The more the blade is bent, the deeper the biopsy will be.
- II. A chemical hemostatic agent or electrical cautery may be used to achieve hemostasis.

Punch biopsy¹ (Video 6.1)

- I. After infiltration of local anesthesia, make the skin taut by applying pressure on the surrounding skin downward and outward with the thumb and the index finger of the non-dominant hand.
- II. Using the dominant hand, insert the punch into the lesion in a rotating fashion.
- III. To grasp the tissue specimen, gently use a skin hook or forceps with teeth.
- IV. If the lesion is 3 mm or greater, closure of the wound with a suture is suggested.

Incisional biopsy¹

- I. Anesthetize the area of the lesion, usually with lidocaine with or without epinephrine.

- II. Perform the incision in a fusiform fashion in the middle of the lesion. Normal skin is not required for this type of biopsy. The depth should reach the subcutaneous tissue and should be the same throughout the incision.
- III. Place the specimen in the biopsy container and suture the wound.

Wedge biopsy

- I. Appropriately anesthetize the affected area with the lesion.
- II. Unlike an incisional biopsy, normal skin is obtained in this procedure. Starting with normal skin, an incision is made toward the middle of the lesion in a wedge or pie-shaped manner.
- III. Remove the specimen with forceps, and close the wound with sutures, if necessary.

Excisional biopsy¹ (Video 6.2)

- I. If possible, outline the area of excision in an elliptical shape with a 3:1 ratio.
- II. If not, outline the lesion with an appropriate margin or normal skin.
- III. Follow the markings with a scalpel to obtain the full thickness biopsy.
- IV. Putting a suture at 12 o'clock can help to mark the upper margin of the lesion.

Reference

1. Perez M, Lodha R, Nouri K. Skin biopsy techniques. In: Nouri K (ed.). *Techniques in dermatologic surgery*. Edinburgh: Mosby, 2003:75–9.

Video list

[Video 6.1 Punch biopsy](#)

[Video 6.2 Excisional biopsy](#)

Mohs micrographic surgery

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Mohs micrographic surgery is a subset of staged surgical excision, whereby removal of tissue in each stage is driven by the histological findings from the previous stage.¹ The most common technique is the fresh frozen tissue technique. Horizontal sections instead of traditional vertical sections are taken from the specimen and mapped. Another method utilizes fixed tissue with zinc chloride paste (fixed tissue technique). Horizontally sectioning the specimen allows for 100% margin evaluation compared with vertical sectioning, which allows for approximately 1% margin evaluation² (Video 7.1).

Preoperative care

I. The medical history should take note of how long the patient has noticed the lesion, along with any previous treatment or pathological results. Allergies to medications, especially to local anesthetics, should be documented.

II. Physical examination should include measuring the size of the lesion and documenting its location. A lymph node examination should be performed, checking for nodal metastases.

III. The patient should be properly informed regarding the details of the Mohs procedure, the reconstruction plan, and the risks associated with this surgery. Risks of Mohs micrographic surgery include infection, scarring, bleeding, and tumor recurrence. As part of a proper informed consent, alternative treatments should also be offered based on the etiology of the lesion.

Indications for Mohs micrographic surgery

I. Basal cell carcinoma (BCC): indications include recurrent or primary tumors with poorly defined clinical margins; BCCs in high risk areas including the eyes, nose, ears, and scalp; size greater than 2 cm; morpheaform,¹ metatypical including basosquamous¹ and keratinizing, adenoidal, infiltrating,¹ or micronodular¹ BCCs; any tumor exhibiting perineural, periappendageal, or perivasculär invasion; BCCs in areas where tissue conservation is of importance such as the external auditory meatus, nostril, eyelid, genitalia, fingers, or toes; and BCCs occurring in previously irradiated skin.

II. Squamous cell carcinoma (SCC): indications include recurrent or primary tumors with poorly defined clinical margins; mucocutaneous lesions;¹ SCCs in high risk areas including the eyes, nose, ears, scalp, large size; and evidence of perineural invasion.¹

III. Rare tumors, such as melanoma *in situ*, dermatofibrosarcoma protuberans (DFSP), verrucous carcinoma,^{3,4} keratoacanthoma (KA), extramammary Paget's disease (EMPD), sebaceous carcinoma, microcytic adnexal carcinoma (MAC), and adnexal carcinoma.

In the case of rare tumors, many Mohs surgeons send the last stage or an additional layer (if concerned) for permanent paraffin section. In the case of melanoma, immunostaining is used to confirm negative margins.

IV. Histopathological evidence of aggressive tumor subtypes.

V. Cutaneous tumors greater than 2 cm on the trunk or greater than 1 cm on the face.

- VI.** Clinical margins that are poorly defined.
- VII.** Cutaneous tumors developing from previously irradiated skin.

Step-by-step surgical procedure

Fresh frozen tissue technique⁵

I. Prior to anesthetic infiltration, the tumor is outlined with a marking pen to avoid losing the exact tumor site due to tissue distortion. The tumor location should also be verified with pictures that had been previously taken and triangulations documented during the consultation visit.

II. The tumor and surrounding area is infiltrated with anesthesia, using lidocaine with or without epinephrine.

III. Curettage is used to debulk the tumor.

IV. The tumor is excised using a scalpel angled at 45° with 2–3 mm margins. It is beveled upwards and goes below the estimated tumor level. For large tumors and tumors on the trunk, back, or scalp, a no. 10 blade is used. A no. 15 blade is used for smaller tumors.

V. Prior to removing the tumor, hatch marks are made for properly orienting the lesion.

VI. The “disk-like” tissue is excised, leaving behind a defect in the form of a saucer.

VII. The excised tissue is placed on a gauze pad and oriented in accordance with the patient.

VIII. A “map” of the excised tissue is drawn on a piece of paper and oriented with the hatchmarks.

IX. The excised tissue is transported to the histopathology laboratory.

X. In the histopathology laboratory, the excised tissue is cut into four quadrants.

XI. Each of the four quadrants is marked with a different color of dye.

XII. The color of the dye is mapped on paper.

XIII. The quadrants are also numbered, often in a clockwise direction.

XIV. Each quadrant is transferred to the cryostat and compressed with the epidermal side facing downwards.

XV. Optimal cutting temperature is used to freeze the edges and depth of tissue in the same plane.

XVI. The histopathologist sections the tissue with 5- to 7-µm cuts from the bottom of the sample upwards, in a manner that allows for the depth and two margins to be processed in the same section.

XVII. The sections are placed on a slide and stained, most often with hematoxylin and eosin. A glass coverslip is placed on top of the section.

XVIII. The staining can be carried out in a manual fashion or by using an automatic staining device.

XIX. The slides are placed on a tray with the “mapped” paper.

XX. The slides are read under the microscope, starting at 4× and progressing to 40× as needed.

XXI. If residual tumor is viewed under the microscope, a note is made on the mapped section of the paper card.

XXII. More local anesthesia is given to the patient if necessary.

XXIII. Tissue noted on the mapped paper is removed in 2–3 mm margins, and histopathologic analysis with further mapping is carried out again as described above until no residual histopathological evidence of tumor exists.

XXIV. The defect is surgically reconstructed if indicated, or it may also be left to heal by secondary intention.

Zinc chloride paste technique

I. This technique is useful when tumors extend to the bone.

II. Prior to anesthetic infiltration, the tumor is outlined with a marking pen to avoid tissue distortion by local anesthetic infiltration.

III. The tumor and surrounding area are infiltrated with anesthesia, using lidocaine with or without epinephrine.

IV. Curettage is used to debulk the tumor.

V. Dichloroacetic acid is applied to the lesion in order to promote hemostasis, and to encourage better penetration of the zinc chloride paste.

VI. The zinc chloride paste is applied to the affected area with pressure so that it will penetrate the lesion, and care is taken so that it does not spread to adjacent tissue. The amount of zinc chloride paste can also affect how much penetration occurs.

VII. The zinc chloride paste remains in place for 6–24 hours, depending on the tumor location; i.e. a shorter time interval in areas where more tissue preservation is desired or required.

VIII. Surgical excision and histological examination are carried out in the same manner as in the fresh frozen tissue technique.

IX. Following histological examination with findings marked on the paper map, additional zinc chloride is

applied to areas of residual tumor, and the same process is repeated every 6–24 hours until no residual tumor is observed under the microscope.

X. The necrotic tissue sloughs from the wound in approximately 2–3 days, and the defect can be surgically repaired or left to heal by secondary intention.

Limitations of Mohs micrographic surgery

- I. Labor intensive
- II. Requires histotechnician
- III. Time consuming
- IV. Frozen sections lend themselves to artifact.¹

Equipment for the Mohs micrographic surgery laboratory

- Cryostat
- Automatic slide stainer or manual stainer kit
- Grossing board
- Slide warmer
- Mounting media
- Embedding agent
- Tissue marking dyes
- Blank cards for mapping specimen
- Microscope
- Slide tray
- Slides
- Coverslips
- Marking pencil
- Chemical reagents including:
 - fixative
 - hematoxylin and eosin stain
 - bluing reagent or lithium carbonate
 - alcohol
 - xylene

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Video list

Video 7.1 Mohs micrographic surgery

CHAPTER 8

Skin grafts

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Introduction

A skin graft is a fresh-tissue skin specimen that has been completely separated from its native vascular supply. Skin grafts are typically divided into split-thickness skin grafts (STSGs) and full-thickness skin grafts (FTSGs). STSGs are composed of epidermis and superficial dermis and contain few or no adnexal structures. FTSGs, on the other hand, are composed of epidermis and the full thickness of the dermis, and preserve the dermal adnexal structures. FTSGs modified to include underlying structures such as adipose tissue or cartilage are referred to composite skin grafts. Skin grafts are also classified as autografts, in which skin is taken from a donor site on the individual patient; homografts, in which skin is taken from one individual and transplanted onto another member of the same species; and xenografts or heterografts, in which skin is transplanted across species. This chapter will discuss surgical design and clinical considerations pertaining to full-thickness and split-thickness autografts.

Full-thickness skin grafts

Preoperative care

Proper selection of defects and donor sites is critical for successful outcomes with skin grafts. FTSGs are indicated for reconstructing surgical defects that cannot be apposed primarily or with a flap, and where healing by second

intention is likely to result in a poor cosmetic outcome or functional deficit. Sites where FTSGs are commonly utilized include the nasal tip and ala, lower eyelid, medial canthus, ear helix, digits, and hands. In addition to these classical sites for FTSGs, the use of such grafts has extended to include practically every area of the body where a proper recipient bed exists and there is lack of lax adjacent local skin, thereby making primary linear and local flap repairs challenging, as well as sites bordering free margins where not using a graft may result in anatomic distortion in the final cosmetic outcome (Figure 8.1a). FTSGs, however, have a significant nutritional requirements and require a rich vascular supply to promote capillary regrowth. Consequently, when possible, FTSGs should be avoided on large avascular areas such as exposed cartilage. In such circumstances, the placement of the FTSG may be delayed, allowing for granulation tissue to cover the defect. When exposed nasal tip cartilage is present, subcutaneous or myocutaneous hinge flap may also be used to fully occupy the base of recipient site with well-vascularized tissue while reducing the depth of the defect. Exposure or addition of vascularized tissue to a wound bed may also improve graft survival in certain cases. For example, on the leg, the excision of underlying adipose tissue and fascia to expose skeletal muscle improves graft survival by providing a far more vascular recipient site.

For defects covering a portion of a cosmetic subunit, the surgeon should consider complete removal of the subunit prior to graft placement. This is particularly



Figure 8.1 (a) Large surgical defect on the forehead not amenable to primary closure or local flap reconstruction; (b) Fenestrated full-thickness thickness skin graft from the abdomen at the time of suture removal one week after being placed on the defect recipient bed; (c) Long-term follow-up of the skin graft.

useful on the nasal tip and ala, where grafting a portion of the cosmetic subunit may result in a clear step-off in terms of skin thickness, consistency, color, or texture that can be reduced or eliminated by placing a graft over the entire cosmetic subunit.

Careful attention to matching the donor and the recipient sites is essential for a good cosmetic outcome. When selecting a donor site, the primary goal is to best match the donor skin with the skin surrounding the recipient site. Several factors contribute to the selection process, including skin color, texture, amount of photodamage, and presence or lack of hair. Skin taken from the same anatomic region generally provides the best donor skin for defects in that anatomic region. However, donor sites in less conspicuous regions that are able to provide a sufficient surface area of lax skin are more frequently used. Common donor sites include pre-auricular,

post-auricular, clavicular, inner arm, concha, and upper eyelid skin. Larger defects, for instance on the scalp, require large donor grafts and the supraclavicular region, inner arm, or abdominal skin can be used as donor sites.

Surgical technique (Video 8.1)

The first step in approaching skin graft should be creating a template for the graft. This is easily accomplished by pressing non-stick gauze against the defect and cutting along the borders of the blood-inked area. In general, skin grafts should be cut to size and undersizing and oversizing are to be avoided. Exceptions include grafts used to repair lower eyelid defects where grafts may be oversized to allow for contraction, which can occur and lead to a possible ectropion formation, as well as in grafts covering creases, where the effective surface added by the

crease must be taken into account. It is also critical that the graft be sized to fit the maximal defect site size on areas such as the inner canthus and fingers, where stretching the skin with facial or musculoskeletal movement results in a significantly larger defect than the defect size at rest. For the inner canthus, the template should be created with the patient's eyes open, eyebrows elevated, and mouth wide open in order to prevent webbing due to undersizing of the graft. On the fingers, the template should be created while the patient is making a fist.

The cut out template should then be laid over the donor site and a surgical marking pen should be used to outline the size of the defect on the donor site. The donor site should be anesthetized in a regular fashion using lidocaine with epinephrine. The graft should then be excised from the donor site. Tissue should be handled gently to cause minimal trauma to the graft tissue. The graft should then be quickly transferred to a sterile saline-containing container. The donor site should be reapproximated with sutures, usually using the layered closure, or left to heal by second intention healing depending on the thickness of the graft, donor site, and overall patient characteristics.

Prior to transfer of the graft to the recipient site, grafts must be trimmed to remove adipose tissue until the white glistening surface of the dermis is seen on the undersurface of the graft. The dermis may further be trimmed to match the thickness of the donor site. The graft should then be placed in the recipient site, with its dermis side facing down and epidermal side facing outwards. Trimming of the graft should be performed, as necessary, to ensure exact fit of the graft to the donor site.

The graft is then sewn into place using either simple interrupted or running sutures or a combination of the two. Both absorbable and non-absorbable sutures may be utilized. Basting sutures, gut suture, may be used in conjunction with perimeter sutures to stabilize and support the graft, particularly in concave surfaces and deep defects where the graft has a tendency not to adhere to the recipient site. A bolster or tie-over dressing may also improve graft adherence and provide constant, direct pressure to the graft (Figure 8.2d). Petrolatum-impregnated gauze can be used to both provide pressure and prevent desiccation of the graft. The bolster is typically tied down with one or a series of sutures as necessary.

Postoperative care and follow-up

To cover the graft, a pressure dressing consisting of non-stick gauze, covered with gauze pads, and dressing retention sheets are placed typically over the bolster dressing. The dressing is left in place until suture removal, which usually takes place 1 week after the graft placement. The dressing should be removed slowly, by gently elevating one edge of the dressing and then carefully removing the rest of the dressing, to avoid lifting the graft off its base. After suture removal, the area of the skin graft can be cleansed with water, as soap might irritate the new skin, followed by application of petrolatum ointment to the site, and covered with non-stick gauze and adhesive tape to minimize any disturbance to the graft for the next 1–2 weeks.

Split-thickness skin grafts

Preoperative care

Split-thickness skin grafts (STSGs) consist of a full-thickness epidermis and a variable portion of the dermis. Compared with FTSGs, STSGs are more versatile and are more likely to survive under conditions of vascular compromise and can be used to cover large defects. STSGs are usually harvested from a matching broad area of skin that can be concealed beneath clothing. Common donor sites for large STSGs include the anterior, medial, and lateral portions of the upper thigh, lateral hips, inner aspect of the upper arm and the forearm, lower back, and abdomen, with the most commonly used donor site being the anteromedial thigh.

Surgical technique

To harvest STSGs, both electric dermatomes, air-driven or electrically powered, and freehand devices, such as scalpel blades, double-edge razor blades, flexible blades (Figure 8.2b), and knives, such as the Weck blade, can be used. Using the free-hand knife, the graft is obtained by holding the donor skin taught and then performing a sawing motion while placing moderate downward and forward pressure across a blade that is held virtually parallel to the skin surface. Electric dermatomes enable harvesting of uniform grafts of predetermined width and thickness, with thickness adjusted by a control lever on the side of the dermatome.



Figure 8.2 (a) Defect on the helical rim of the ear; (b) Split-thickness graft being harvested; (c) Skin graft attached to the defect recipient bed; (d) Bolster dressing holding skin graft in place; (e) Skin graft at the time of suture removal at one week.

After the donor site is marked, anesthetized, prepped, and draped, it is lubricated with mineral oil, ointment, or other skin lubricants to ensure a smooth and steady pass of the dermatome over the skin. The assistant applies tension to the donor area to create a flat, taught surface while the surgeon guides the unit forward at a 30–45° angle with respect to the donor skin and applies persistent downward and forward pressure to the dermatome. As the graft emerges, it should be gently lifted away from the machine with light tension using forceps or hemostats, thus preventing it from folding on itself. After the

graft is obtained, the dermatome is lifted from the skin, and the graft is promptly placed into sterile saline solution or directly onto the recipient site.

Although meshing or fenestrating a graft to create slits, which allow for drainage of accumulated serosanguinous fluid that can impair vascularization of the graft, is sometimes performed with larger FTSGs (Figure 8.1b), it is more necessary with the STSGs given the typically larger size of these grafts. Meshing also allows for expansion of the surface area of the graft and increases the flexibility of the graft so it can be used over mobile surfaces such

as joints. A mesher contains a flat bed with a roller that compresses the harvested skin on a plastic carrier with a predetermined “grid” pattern etched into the plastic. Once the plastic carrier is compressed between the steel roller and its bed, the graft emerges on the opposite side with uniform fine fenestrations. However, mechanical meshing often results in honeycomb graft appearance not seen with hand-meshing using a scalpel blade. Trimming of the graft is then performed, and the graft is secured in place using absorbable or non-absorbable sutures or staples. Basting sutures are recommended to ensure central adherence of the graft to the recipient bed. A bolster followed by a pressure dressing are often placed for added security.

Postoperative care

Sutures or staples are removed after about 1 week. The re-epithelialization of fenestrations of extensively meshed graft can require up to 8 weeks. STSGs also have a tendency to become dry and hyperkeratotic, so liberal use of emollients is recommended. Donor sites for the STSGs are usually left to heal by second intention, a process that is often associated with some pain. Depending on the thickness of the graft, healing of the STSG donor site will take anywhere from a week to a month. Transparent vapor-permeable polyurethane dressings allow drainage at the donor site to collect and keep the wound moist, thereby shortening healing times and improving overall healing. Other dressings include moist occlusive dressings, antibiotic ointment or petrolatum, and polymer film dressings. Moist occlusion significantly decreases postoperative pain at the site and promotes re-epithelialization. The donor site typically remains pink for several months and later becomes hypopigmented.

Complications

Early complications of all skin grafts include graft failure due to formation of hematomas, seromas, infections, or presence of the shearing forces on the graft. At the time of suture removal, the ideal color of the graft is pink (Figure 8.2e), but a variety of colors, ranging from faint pink to purple can be acceptable. Frequently, at 1 week, FTSGs can appear violaceous due to ecchymosis. Truly necrotic grafts, however, are patently black and their surface will have a “dummy” feel upon gentle pinching



Figure 8.3 Example of superficial necrosis.

of the surface with toothed forceps. White grafts may signify ischemia and necrosis or fibrin deposition, but whiteness can also be caused by maceration. If a graft looks necrotic (Figure 8.3), it should not be debrided. The presence of necrosis does not necessarily signify a poor aesthetic outcome. Following superficial necrosis and sloughing of the epidermis, re-epithelialization over the healthy dermis may produce an excellent final cosmetic result.

Long-term complications include poor color and texture match, contour changes, pin-cushioning, contracture, and hypertrophic scar formation. In the long term, STSGs provide a more noticeable cosmetic outcome than FTSGs, with less color and texture match with the surrounding skin. STSGs tend to be pale or white, hairless, smooth, and with impaired sweating since adnexal structures are not harvested in their entirety or are frequently found below the level at which these grafts are harvested.

Conclusion

This chapter tries to deliver a basic overview of skin grafts, and to provide a step-by-step guide to using skin grafts in dermatologic surgery. Overall, FTSGs have long been established as a good cosmetic and functional repair choice for many well-vascularized defects, whereas STSGs have their niche in providing coverage to a large defect, while being able to survive on recipient beds with

limited vascularity. Grafting may be an option in a multitude of different situations, and solid knowledge of the applications, advantages, and disadvantages of each type of skin graft is an invaluable tool for the dermatologic surgeon.

Video list

Video 8.1 Full-thickness skin graft technique

Nail unit surgery

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Preoperative care

Before a nail unit surgical procedure, a thorough preoperative evaluation is important. A complete history must be obtained to identify factors that increase the risk of complications, such as diabetes, peripheral vascular disease, peripheral neuropathy, immunocompromised states, scleroderma, and coagulopathies.¹ If possible, medications such as salicylates or anticoagulants should be discontinued 7–10 days prior to the procedure, to reduce perioperative bleeding.² Informed consent is obtained after a detailed discussion of risks, benefits, and alternatives of the procedure. It is important to explain and document the possibility of a permanent post-procedure nail dystrophy.

Preoperative care

The patient should be placed in the supine position. Prior to delivering anesthesia, antiseptic agents are used to clean the operative field and create as sterile environment an environment as possible.

Several techniques may be utilized for delivering anesthesia, including the distal digital block, wing block, proximal or traditional digital nerve block, transthecal blocks, and other regional blocks.³ The distal digital block is considered the preferred technique for anesthesia for nail unit procedures.⁴ Anesthesia is directly delivered to

periungual tissues and the digital tip, allowing for immediate anesthesia and compression hemostasis with fluid volume. Caution should be used to avoid use of a larger quantity than is required. Buffered 1% lidocaine without epinephrine is used and prepared in a 3-mL syringe with a 30-gauge needle.⁴ To decrease the pain of injection, cryogen spray or a massager can be used on the digit to be anesthetized.⁴

To perform a distal digital block, the anesthesia is first inserted into the superficial skin over the lateral aspect of the proximal nail fold, approximately 3 mm proximal to the junction of the proximal and lateral nail fold, and a dermal wheal is created (Figure 9.1). Without removing the needle, anesthesia is slowly injected and diffused to the lateral nail fold, blanching the skin. This process is repeated with injection at the opposite lateral edge of the proximal nail fold, anesthetizing the opposite lateral nail fold. The proximal nail fold is then anesthetized by inserting the needle into already anesthetized areas and orienting the needle across the proximal nail fold. Finally, the hyponychium is anesthetized by inserting the needle at the distal aspect of the digit. Slow administration of anesthesia throughout helps minimize pain.^{1,4} Each injection site generally is anesthetized with 0.3–0.5 mL of anesthetic with a total of 1.5–3 mL total of anesthesia required, depending on the size of the digit.^{4,5}

The use of epinephrine in digital blocks and nail unit surgery has been debated. The use of buffered epinephrine 1:200 000 in patients without comorbidities and



Figure 9.1 Wing block. Insertion of the needle into the superficial skin at the junction of the lateral and proximal nail folds.



Figure 9.2 The use of a sterile glove as a tourniquet helps create a bloodless and sterile field for a procedure.

without a ring block is considered safe with minimal risk of digital gangrene.⁶ Alternative anesthetics such as bupivacaine 0.5% added to lidocaine to lengthen the postoperative anesthesia up to 8 hours are also used. Ropivacaine, which has similar onset to lidocaine, can provide postoperative anesthesia up to 9 hours.⁵

After delivering anesthesia, the digit and respective hand/foot are cleansed with a sterile surgical preparation. A tourniquet may be required to keep a bloodless field, particularly in the evaluation of pigmented lesions and kept in place for no more than 15 minutes, if possible.⁷ A Penrose drain or sterile surgical glove cut with a small hole, placed on the target digit, and rolled back over it are both effective⁴ (Figure 9.2). Additional hemostasis may also be achieved with manual pressure on the digital arteries during a procedure.

Step-by-step surgical techniques

Punch biopsy

To access the nail bed, partial or full nail plate avulsion is sometimes necessary. Soaking the digit in warm water and antiseptic for 15 minutes will soften the nail plate and allow easier sampling and passage of the punch.⁵ A “two-punch set technique” is another effective technique to sample the nail bed through the nail plate. A 6-mm punch is made through the nail plate only, and the circle of nail plate is removed. A smaller 3- to 4-mm punch is then inserted with a twisting motion until the periosteum is reached (Figure 9.3a,b).^{4,5} Fine-tipped gradle scissors are then used to gently snip the base by holding them perpendicular to the nail bed and elevating the specimen. Forceps use is not recommended because it may damage the specimen. The punch instrument should be examined after every biopsy to look for retained nail plate, and, if present, submitted as a separate specimen. Gel foam should be inserted to decrease any bleeding, and further repair is usually not required. Dystrophy after this procedure is uncommon.

A punch biopsy of the nail matrix is occasionally necessary to diagnose inflammatory lesions or for longitudinal melanonychia less than 3 mm originating in the distal matrix.^{4,8} The proximal nail fold and cuticle is inspected for any pigment, and, if present, is shaved and submitted as a separate specimen. The proximal nail fold is first incised with a scalpel blade to make two oblique incisions surrounding the biopsy area, followed by gentle undermining with a nail elevator. The area is reflected with a skin hook, exposing the matrix and proximal plate. Care is taken to avoid crush artifact of the matrix tissue. After obtaining the sample, gel foam helps for hemostasis. The proximal nail fold is returned to its anatomic position and secured with simple sutures, or Steri-strips. A dressing is applied as described below.^{4,9} After obtaining a punch biopsy specimen, inking of the superior portion is recommended to ensure proper orientation in the histopathology laboratory.

Lateral longitudinal excision

Lateral longitudinal excision or biopsy is the preferred technique for longitudinal melanonychia or erythronychia on the lateral 30% of the nail unit as well as for the occasional diagnosis of inflammatory conditions.^{3,8–11}

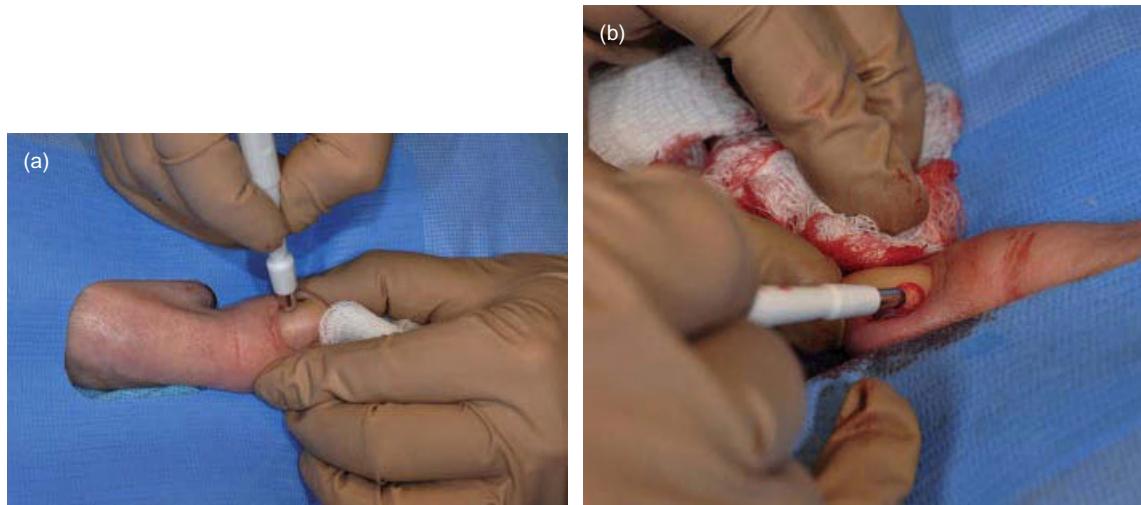


Figure 9.3 (a) Double punch biopsy of a subungual hematoma involving the nail bed. First the nail plate is removed with a 6-mm punch. (b) After using the 6-mm punch to remove the nail plate, a smaller 3- or 4-mm punch is used to obtain a specimen containing epithelium and dermis. This technique allows for easier removal of the nail bed with the fine tip grable scissors through the larger hole in the nail plate.



Figure 9.4 An example of a fusiform shape outlined prior to a lateral longitudinal excision.

Soaking the digit is recommended to soften the nail plate. The excision is then outlined to create a fusiform shape (Figure 9.4).^{5,9} Anesthesia is delivered, and a tourniquet is placed. A scalpel is used to incise the area to the level of the bone and fine-tipped scissors to remove the specimen from the distal to proximal portion with gentle use of forceps. The specimen is inked for orientation. The defect is reconstructed with simple interrupted sutures, including sutures through the nail plate. The digit is dressed, and the tourniquet is removed.⁵

Complications of this technique include acquired nail malalignment, postoperative cyst formation, and spicule formation. To avoid postoperative cysts and spicules, a small curette may be used to debride any matrix remnants in the region of the matrix horn.⁸

Matrix shave

The matrix shave is a relatively recent technique to sample longitudinal melanonychia. Although this procedure is technically more difficult, scarring of the distal and proximal matrix, with subsequent nail plate dystrophy, is minimized.^{1,8}

The proximal nail fold is reflected as described above. The matrix is subsequently exposed with a partial nail plate avulsion. After the matrix is visualized, the pigmented band is identified, and a scalpel is used to score a 1–2 mm margin around the longitudinal band origin. The blade is then oriented almost parallel to the matrix epithelium and passed superficially beneath the scored specimen until the tissue is removed using a gentle gliding motion to remove a thin specimen of less than 1 mm. No forceps are used in the process (Figure 9.5).¹ To avoid curling, the specimen is placed flat on a piece of paper (preferably with a nail map), inked, and submitted for processing. The defect heals by secondary intention.



Figure 9.5 Matrix shave biopsy: The proximal nail fold had been reflected and held with a skin hook, and the matrix was exposed with a partial nail plate avulsion with the nail plate being held with a hemostat. The biopsied area was scored, and the blade was oriented almost parallel to the matrix epithelium to remove the specimen.

The partially avulsed plate is trimmed at its lateral edges and returned to its anatomic position. The incisions in the proximal nail fold are sutured, and a dressing is applied.¹

Nail plate avulsion

When feasible, partial nail plate avulsions are preferred to total nail avulsions to promote better healing. Many approaches are described elsewhere for partial nail avulsions, and distal and proximal approaches are used for total nail plate avulsion.^{9,10} The distal approach is described here because of its utility in both total and partial nail avulsions.

After anesthesia is delivered, a nail elevator is introduced under the nail plate at the level of the hyponychium and pushed gently but firmly toward the lunula. It is withdrawn, moved laterally, and the procedure is repeated until the attachments are loosened. An antero-posterior motion is repeated to avoid injuring the fragile longitudinal nail bed ridges. The lateral horns of the nail plate are detached with caution by firmly pushing the instrument in the posterolateral angles. After firm attachments are loosened, one lateral portion of the nail plate



Figure 9.6 Nail surgery dressing and taping: small gauze pads have been folded over and secured with tape to avoid a circumferential tourniquet (taped side-to-side and top-to-bottom).

is grasped with a hemostat, and nail plate is removed with an upward, rotating motion.^{3,5} (Video 9.1).

Postoperative care and follow-up

Petrolatum should be applied to the wound first and then a balled up pressure dressing consisting of gauze is applied over the wound^{4,5} (Figure 9.6). The dressing should be secured with tape in a manner to avoid circumferential taping and a postoperative tourniquet effect. The patient should be monitored for 10–15 minutes to ensure return of blood flow without excessive bleeding. This original dressing is left in place for 24–48 hours after which the patient provides routine wound care.⁴

Use of postoperative antibiotics should be considered on an individual case basis. For foot procedures, opened mucous cysts, or infected nails, antibiotics are appropriate. If warning signs such as increased redness, purulent drainage, and increased pain outside of the initial 24–48 hours occur, patients should seek prompt evaluation, and the addition of antibiotics considered if medically necessary for an infection.³

Postoperative pain and swelling are expected to be worst in the first 24–48 hours after a procedure, and analgesia is often necessary. Analgesia should be prescribed for more intensive procedures for 1–3 days postoperatively, after which non-prescription medications should be adequate. Patients also should be instructed to elevate their limb for 48 hours to ease throbbing and facilitate healing.⁵



Figure 9.7 A subungual hematoma as a complication of a procedure of the distal nail bed.

Prevention, and management of complications

With proper technique and training, postoperative complications for nail procedures can be minimized. Nail plate dystrophy, onycholysis, spicule formation, scarring, or altered sensation may be possible sequelae, depending on the type of procedure performed, and the patient should be warned of this prior to the procedure.^{3,12}

Postoperative bleeding and hematomas are painful and could lead to secondary infection. They can be avoided with appropriate hemostasis, nail plate repositioning, and compressive dressings to avoid dead space (Figure 9.7). Postoperative necrosis has been reported if a tourniquet was not removed or with high-tension sutures. Infections also may occur as a consequence of a hematoma or necrosis.³ Reflex sympathetic dystrophy has been reported rarely after nail procedures and biopsy. It is a chronic pain disorder with burning pain and stiffness, often out of proportion to the inciting event, and allodynia; it is a poorly understood condition that is a

diagnosis of exclusion, but steroids have helped improve symptoms.³

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Video list

Video 9.1 Nail plate avulsion performed for treatment-resident onychomycosis.

Cryosurgery

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Preoperative care

Regarding the patient

Lesion selection

There is a whole array of benign, premalignant or malignant lesions that can be treated with cryosurgery (see Table 10.1).¹ This table includes the most commonly seen lesions in which cryosurgery stands as the first or second option of treatment. The following points should be taken into account:

- *Diagnosis:* The first golden rule is to know the exact diagnosis of what you are about to freeze. Melanocytes are very sensitive to cold; you do not want to mistakenly freeze a melanoma. In general, benign conditions require more superficial freezing than malignant lesions. It is better to undertreat a benign lesion than to leave an undesired hypopigmentation or acromia.
- *Size:* Lesions larger than 1.5 cm should be treated by sections either by segmental (Figure 10.1) or fractional cryosurgery (Figure 10.2). By freezing large lesions, the center can be overtreated and an undertreated periphery.
- *Location:* Lesions located in the face heal faster than in the trunk, which in turn heal faster than in legs. As a general rule, superficial cryosurgery in the face heals in 5–7 days; 10–12 days in the trunk, and over 2–3 weeks in the legs. The scalp can be treated just as any other area, avoiding deep freezing in hairy areas because hair follicles will be destroyed, leaving an alopecic area. Loose skin areas will swell the most (i.e., face more than legs).
- *Thickness:* Keratin is a bad cold conductant; therefore, thick lesions need longer freezing times. One option,

whenever possible, is reducing keratin by prior shaving. It is also convenient to debulk nodular lesions as basal cell carcinomas² or a large tumoral mass (palliative treatment), keeping in mind that these tumors are rich in vessels and debulking can result in profuse bleeding.

- *Temperature:* Destruction of malignant cells requires temperatures or –40°C to –60°C. Make sure to achieve those temperatures at the periphery of the malignant tumors that you are treating with cryosurgery.

Skin type

In general, white skins tend to swell more than darker ones but with less risk of pigmentation sequela. Whenever treatment of multiple lesions for cosmetic reasons is required, begin with a less visible area and check for results.

Pretreatment information and consent

Ask the patient about bleeding and clotting problems, intolerance to cold, current medications, allergies to anesthetics, antiseptics, and antibiotics.

Give careful written instructions on the procedure and its expected side effects. Spend some extra time explaining and making sure the patient understands how much edema and oozing can occur, especially when treating malignant lesions. Deeper freezing equals larger side effects. Occasionally, it might help to exaggerate the expected side effects to assuage any worries.

Explain how much time will be required for total healing. Here is the choice: a fast to do and bloodless procedure with a long healing period versus a long bloody procedure with a short healing time. The bloodless aspect will be an important consideration when

Table 10.1 Skin conditions most commonly treated with cryosurgery

Skin condition	Pretreatment (optional)	Post treatment	Procedure	Duration (s)
Benign lesions				
Macular (lentigines, lentigo simplex, etc.)	Retinoic acid/glycolic acid	Minimal	Spray	5–10
Popular lesions (molluscum contagiosum)	None	Minimal	Mostly spray Probe/cone	10–20 5–15
Dermatofibroma	None	AO	Probe	10–15
Verrucous warts	Salicylic acid/lac acid/shaving, wetting	AO	Spray/cone	10–15
Condilomas	Immunomodulators	AO	Spray	10
Seborrheic keratosis	None	AO	Spray	10–20
Tumoral keloids	None	AO	Intralesional/spray/probe	30
Premalignant lesions				
Actinic keratosis	5FU/exfoliating treat/diclofenac/immunomodulators	Minimal	Spray	15–20
Actinic cheilitis	Same	Minimal/AO	Spray	15–20
Malignant lesions				
Superficial BCC	5FU/Imiquimod/diclofenac Shaving/C&E		Spray	20–30
Nodular BCC	Shaving/C&E	AO	Spray/probe Cone	2 × 30
CEC (<i>in situ</i> , well differentiated) Bowen	Debulking/C&E	AO	Spray/Probe Cone Chamber	2 × 30 1 × 30
Lentigo maligna	Optional: immunomodulator	AO	Spray	2 × 30
Metastasis/palliative tto	Debulking if possible	AO	Spray/probe/ chamber	2–3 × 30

Minimal care: water and soap.

AO, antibiotic ointment; C&E, curettage and electrocoagulation.

treating patients with coagulation disorders, phobia to surgery, or bloodborne infections.

Obtain informed consent.

Preparation for cryosurgery

Pretreatment options

Most lesions do not require previous treatment. Nonetheless, in some cases, cure rates and cosmetic results can be improved by pretreatment with keratotic substances or immunomodulators (for warts), topical retinoids (in

lentigos, in flat verruca), topical chemotherapy agents like 5% 5-fluorouracil (FU), topical diclofenac, and immunomodulators (for field cancerization, premalignancies, or superficial basal cell carcinomas).³

The following guidelines might help decide length of pretreatments:

- keratolitics plus shaving (3–4 weeks)
- topical retinoids (3–4 weeks)
- 5% 5FU (4 weeks)
- imiquimod (3–4 weeks)
- topical 3% diclofenac gel (3 months)

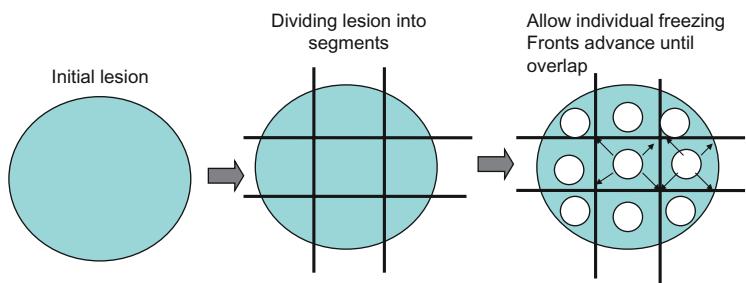


Figure 10.1 Segmental cryosurgery. Divide a large lesion in small segments; freeze each with great precision. Take care with the honeycomb effect: do not leave untreated areas.

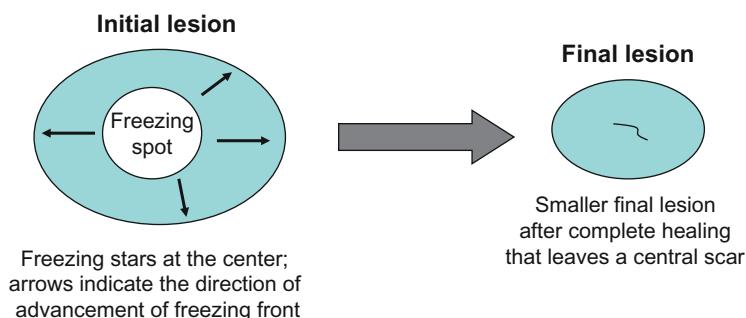


Figure 10.2 Fractional cryosurgery. Treat the center and let it heal completely. The remaining section will be smaller and easier to fit in a probe. Reproduced from Goncalves (1997) Dermatol Surg 1997; 23: 475–481 with permission from Blackwell Publishing.

- simple wetting with humid gauze (1–2 minutes before freezing)
- shaving (the same day).

Debulking of large tumoral masses and combining with electrocoagulation/curettage improves cure rates.

Pretreatment

- Reduces the size of the original lesion for the final freezing procedure.
- Reduces thickness leaving a more penetrable to cold skin.
- Eliminates many lesions that would unnecessarily be frozen if pretreatment were not applied.

Regarding the surgeon

Instruments (Figure 10.3)

- Sterile gloves
- Antiseptic agents
- Local anesthesia and syringes
- A 4-, 5-, 10-, 25-, 30-, 35- or 50-L LN dewer (LN evaporates faster from smaller tanks and larger ones are cumbersome; ideally use a 25- to 30L).
- Hand-held unit (preferably devices with temperature monitoring like Cry-Ac® Tracker® Cam)



Figure 10.3 Tray with basic cryosurgical equipment.

- Minor surgery equipment with suture kit/set; curettes; Teflon tweezers
- High resolution ultrasound imaging system (above 22 Mhz, commercially available in very compact fit-in-one-hand units like 22 MHz US TPM®): for non invasive measurement of tumours and control freezing front extension.
- Cauterizing agent (20–35% aluminum chloride or silver nitrate sticks) (care should be taken with aluminum

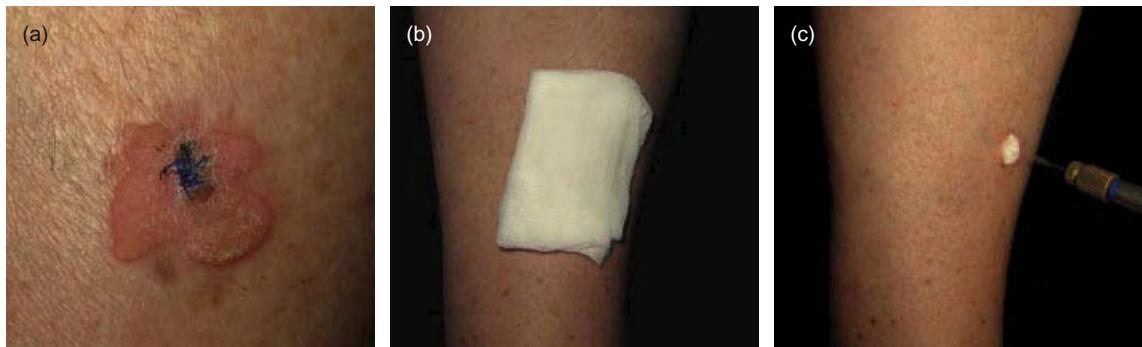


Figure 10.4 Spraying a verruca. The lesion is wet for 5 minutes with a humid gauze and then frozen, starting at the center and allowing the freezing front to advance gradually to the periphery (up to 1 mm from the outer border).

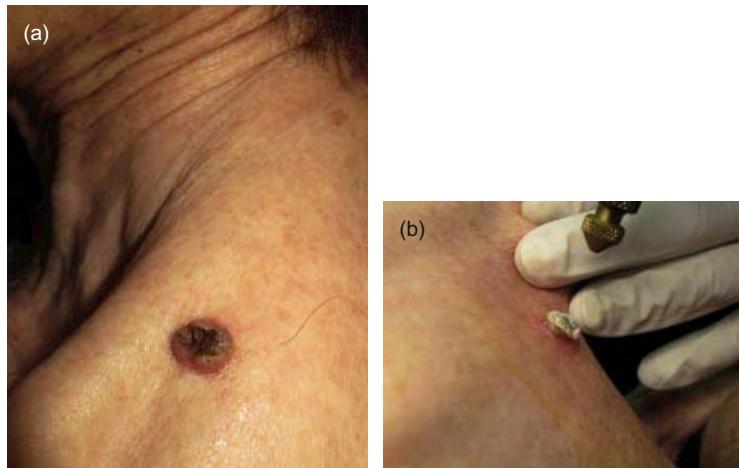


Figure 10.5 For a bulky lesion, the freezing front has to reach the bottom vertically and then extend peripherally to the external margin.

chloride, which leaves a whitish area that can be confused with the freezing front)

- Gauze and bandage; antibiotic creams (optional)
- Specimen bottle with formalin
- A small container with warm water, in case a probe gets stuck to the skin

Techniques

I. Open or spray technique is the most commonly used (Figures 10.4–10.6). It consists in applying LN from the unit through tips or adapted needles. Commercially available tips come in different diameters: A through D, where A has the largest orifice and D the smallest. A larger

orifice releases a larger amount of LN thus causing faster freezing. The most commonly used tip is the C.

Spraying can be delivered in an intermittent or in a continuous manner. The first allows better control due to the slow advancement of the freezing front (Videos 10.1–10.4).

It is very useful for bulky malignancies where previous curettage cannot be performed nor probes applied due to the irregular surface.

II. Cones (neoprene, rubber or plastic) help contain the sprayed LN within a defined area (Figure 10.7). Useful for small bulky lesions (Video 10.5)

III. Close or probe technique delivers LN through a close system. Probes are made out of metal and are available in different sizes. They should fit the lesion (Figure 10.8).

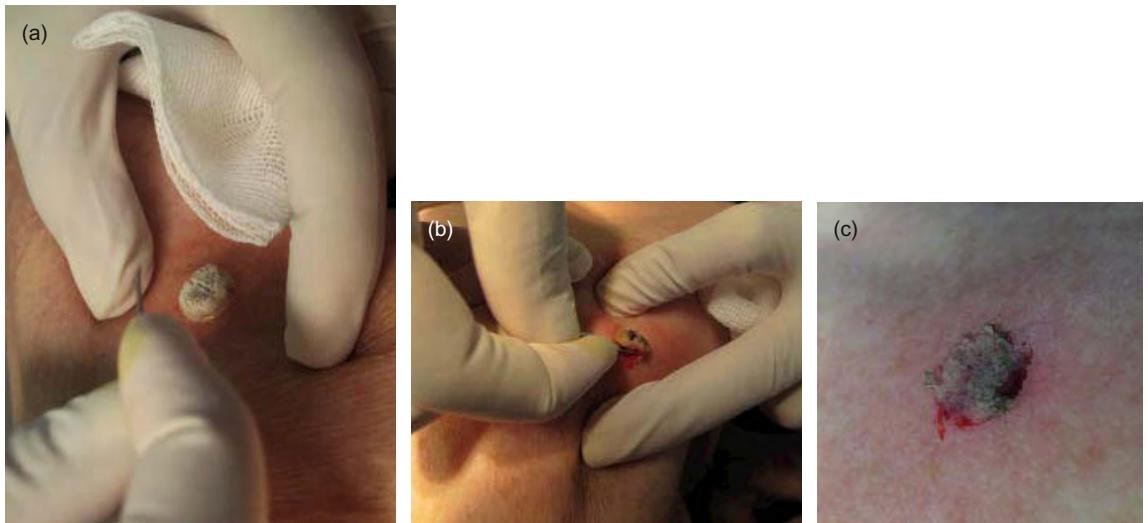


Figure 10.6 To hasten healing, a recently frozen lesion is curetted as soon as it starts thawing.

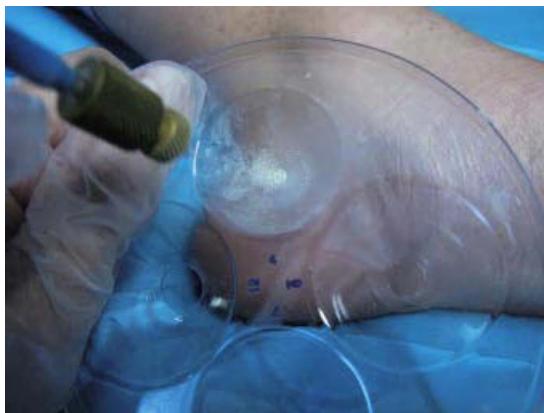


Figure 10.7 Plastic disk with four cone-shaped openings used in a verruca.



Figure 10.8 Close system or probe cryosurgery of a keratoacanthoma on dorsum of hand. The probe is firmly applied in a perpendicular manner.

If the exact size is not available, is preferable to use a smaller one and allow the freezing front advance until the desired margin is achieved (Video 10.6–10.9).

The main uses are:

- *Vascular lesions* (hemangiomas, vascular malformations, venous lakes): were they have to be previously frozen before firmly applied to surface (to avoid sticking). Compression empties the tumor form blood (which otherwise raise local temperature). One cycle is usually sufficient.
- *Skin cancers*, especially keratoacanthomas and nodular basal cells (BCCs) and squamous cell carcinomas (SCCs).

IV. Others: Teflon tweezers – ideal for filiform lesions like some verrucae, skin tags, etc (Videos 10.10–10.13).

V. Chamber is a variation of the spray technique. A metal chamber is attached at the releasing end of the unit and firmly applied to the skin. LN stays trapped in the chamber, generating turbulence and lower temperatures. It is a technique that should be limited to malignancies such as SCC or in palliative treatments (Video 10.14).

VI. Intralesional cryosurgery⁴ is a method for deep freezing a lesion (such as a keloid) and it is ideal for voluminous or deep seated lesions. It consists of inserting a

sterile open cannula or thick and large needle into one side of the tumor and letting it run interstitially until it appears on the other side of the tumor. LN will run through the cannula or needle, freezing the tumor from the center towards the periphery, in a centrifugal manner. Its main advantage is the superficial skin preservation with better cosmetic results.

Step-by-step surgical technique

I. Local anesthesia: for most conditions, anesthesia is not required. The topical one may be sufficient. Consider local infiltrative anesthesia in:

- a. very apprehensive patients
- b. young ones
- c. people with low pain threshold to extreme low temperatures
- d. people with past bad experiences with cryosurgery
- e. deep freezing (probe and chamber technique)

II. Choose the proper cryosurgical technique (Table 10.1)

III. Freezing time and cycles (Table 10.1). For benign lesions: one cycle; for malignancies: two freeze-thaw cycles. Palliative treatment: several treatment sessions. Freezing should include adequate margin (1 mm in benign lesions; 4–6 mm for malignancies).

Postoperative care and follow-up

Immediate

- In superficial spraying, there is no need to cover the lesion. For deep freezing, cover with gauze for 48 hours. An antibiotic ointment is optional.
- There will be a cold sensation, followed by a local tingling sensation (intensity is dependent on location and personal sensibility). It can last 20 minutes to 1.5 hour. Rarely requires analgesic.
- Local redness and edema gradually appear.
- Regular washing with water and soap is sufficient.

After 24–48 hours

The patient will have local redness, larger edema (proportional to depth of freezing) and no pain. A blister or bulla will appear (in 1–2 days), which some prefer to eliminate while others just leave. Local antibiotics are suggested.

After 48 hours

With bulla removal or breakage, daily cleaning becomes essential. Water and soap, disinfection, and antibiotic ointment should be used until complete healing. For deep freezing, proper debridement and hydrocolloid dressings hasten healing.

Complications

- *Expected occurrences:* edema, vesicle, or bullae formation, exudation, tissue sloughing, eschar formation (in probe procedures); hypopigmentation in deep procedures; hypo- or hyperpigmentation in relation to skin type (tends to improve with time).
- *Occasional occurrences:* secondary infection is a possible event after 1 week of procedure and occurs whenever the treated area has not been properly cleaned. It can be recognized because a lesion in process of healing suddenly becomes painful and redness reappears. Exudation is substituted by suppuration.
- *Permanent events:* permanent hypochromia (more frequent in deep freezing); retraction or notching (when working close to orifices); alopecia (in deep freezing of hairy areas); nail dystrophy (when treating periungual warts in an inadequate manner) and atrophic scars.

Prevention and management of complications

- Be sure of the diagnosis of the lesion you intend to treat: never treat a lesion if you are not certain of the diagnosis.
- It is safer to undertreat benign lesions and repeat the procedure than to overtreat them and leave an unwanted hypopigmentation.
- Be readily available for your patients. Let them know that they can come to you if they feel they might have a complication.

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Video list

Video 10.1 Cryosurgical technique: spraying

Video 10.2 Cryosurgical technique: small lesions best to freeze individually

Video 10.3 and 10.4 Cryosurgical technique: removal of large seborrheic keratosis

Video 10.5 Cyrosurgical technique: spraying bulky lesions like warts

Video 10.6 Cyrosurgical technique: vascular lesions or skin cancers, the use of probes

Videos 10.7 Cyrosurgical technique: treating cherry angioma

Video 10.8 Cyrosurgical technique: some tips for the probe technique

Video 10.9 Cyrosurgical technique: observation of thawing

Video 10.10 Cyrosurgical technique: how to use the tweezers

Video 10.11–10.13 Cyrosurgical technique: treatment on pedunculated lesions

Video 10.14 Cyrosurgical technique: treating with the chambers

Dermatologic surgery in ethnic skin

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Introduction

Dermatological procedures in ethnic skin require special precautions in order to achieve result and avoidance of complications.

Preoperative care

For superficial procedures, such as chemical peels and microdermabrasion in skin of color, the expert should routinely follow a checklist including a history of keloidal tendency and scaring, recent isotretinoin therapy, photosensitizing drug intake along with radiation history and herpes simplex virus infection history.¹ It is essential to take a detailed history, including dermatological conditions, current treatments, and any past reactions to cosmetic procedures. It is recommended to prime the skin with fruit acids, salicylic acid, or retinoic acid for about 1–4 weeks prior to the procedure along with sunscreen of at least SPF 30. However, these topical medications should be discontinued at least 3 days before the procedure to minimize irritation reactions. Education on the use of daily broad-spectrum sunscreen and sun-protective measures, such as sun avoidance and protective clothing, is essential. It is not uncommon for darker phototypes to develop transient postinflammatory hyperpigmentation (PIH) after chemical peeling. However, this sequela can be anticipated and pretreated with hydroquinone to minimize its intensity.²

The preprocedure consultation for any laser treatment should include history of any hereditary hemolytic diseases which may affect any postoperative healing; history of sickle cell anemia, thalassemia, and glucose-6-phosphate dehydrogenase deficiency.³ Pigmentary disorders can always be treated with some lightening agents for a couple of weeks before procedures to minimize rebound pigmentation.

Before treating benign cutaneous tumors or laser skin rejuvenation, skin of color patients should be extensively counseled to ensure realistic expectations and occurrence of possible side effects.

Care during procedure

While treating skin of color, the experts must find a balance between aggressive early interventions to target the lesions, and gentle treatments to increase tolerability and avoid side effects.

Most superficial chemical peeling agents are well tolerated by Fitzpatrick skin types IV–VI. Apart from the common side effects, the complications in regards to skin of color include PIH, hypopigmentation, hypertrophic scarring, and keloid formation.⁴ The selection of the chemical peel must be done with caution after cleaning the face with pre-peel cleanser as the response to chemical peels may vary accordingly. It is wise to start at lower peel concentrations and titrating up based on response, performing peels at less frequent intervals (2–4 weeks),

and stopping retinoid therapy 5–7 days prior to the peel procedure.² Feathering can be done at the junction of the face and the neck to prevent demarcation lines of treated and untreated areas; spot-treatment can be done for acne papules, acne scars, melasma, and other focal dyschromias.¹ It is difficult to assess the end point of the peel by observing the erythema during the peel procedure in colored skin as erythema is not easily discernible in skin of color. Thus, timing is essential in peels in these situations. In addition, minimal or no frost is desirable in phototype IV–VI patients. This will assist in preventing PIH and keloidal scarring.

There should be a balance between effective treatment and the minimal complications while treating the ethnic patient with lasers and light sources.^{3,5} A test patch is advisable prior to formal laser procedure with the safest settings, that is, lower fluences and longer pulse durations with a minimal 48-hour wait before determining the safe treatment fluence.³ Owing to the wide absorption spectrum of melanin (250–1200 nm), laser energy intended for deeper targets can be absorbed within the pigmented epidermis, which can lead to complications such as dyschromias, blistering, and scars.⁴ Possible side effects of laser procedures on ethnic skin can be PIH, mottled hyperpigmentation, keloidal scarring, rebound hyperpigmentation, relapse of melasma, darkening of dyschromias post-laser treatment, unmasking of previously subclinical melasma, hypo/depigmentation, and punctate leucoderma.⁶ The use of longer pulse durations, more conservative parameters, low-energy settings, appropriate wavelengths, and cooling techniques can provide a greater margin of safety while still maintaining efficacy in darker skinned individuals.^{4,5} Immediate cooling of laser-treated areas with an ice pack and use of a moisturizer and sunscreen after treatment will promote better healing of the sites with minimal side effects.

In case of aesthetic procedures, like dermal filler injections, it is better to inject the filler in the deeper dermis, with as few points of injection as possible, so as to minimize the risk of PIH.⁷

Laser therapy for hair reduction in pigmented skin poses several challenges because of the constant competing chromophore of melanin. The choice of laser technology and laser settings are the most important factors to be considered while treating skin of color patients. Performing the test sites in inconspicuous areas prior to

the procedure is highly appreciated and helps in determining the maximum tolerated fluence. It is recommended to use the largest spot size and the highest tolerable, safe fluence to obtain the best results.⁸ The hair structure and pigmentation in ethnic skin may make the laser procedure painful and uncomfortable. This can be addressed by application of topical anesthetic cream for about 45 minutes and applying a thick layer of cooled gel prior to each procedure. It is also recommended to use longer pulse durations with an optimal cooling device during the procedure.⁸ Diode lasers at 800 nm and 1064 nm Nd:YAG lasers are most useful in darker skin types, as these devices have considerably less melanin absorption.³ These measures will help in minimizing the side effects like dyspigmentation and scarring. In general, lower laser fluences should be implemented by more conservative parameters with the cooling device that is recommended for ethnic skin.

The patients with ethnic skin while undergoing temporary hair reduction methods such as waxing and epilation should take precautions against the possibility of recurrent folliculitis, ingrown hairs, hypertrophic scarring or keloids, and PIH. Similarly, there may be blistering with subsequent PIH and sometimes scarring in skin of color patients while treating with cryotherapy for any indications. Thus, therapy should be carried out with caution, especially on the face.

Hypertrophic scars and keloids can occur in all races, but they occur much more frequently in ethnic skin, ranging from 3 to 18 times higher incidence than Caucasians. The incidence has been reported to be between 4.5% and 16% in African Americans, Chinese, and Hispanics.⁹ The treatment of hypertrophic scars and keloids is challenging in regards to ethnic skin as there is a high rate of recurrence (around 50%) after surgical excision and a high risk of complications after treatments such as pigmentary alterations. Hypopigmentation and telangiectasia are common side effects if high doses of intralesional steroids or superficial injections are installed. Similarly, higher skin phototypes have a high chance of epidermal burns from laser/light treatments or pigmentary changes after treatment. Hence, the need to select lower parameter settings and titrate accordingly with around 10% overlap.⁹ It is suggested to start the treatment for the scar as early as possible because new lesions have numerous capillaries and give a better result.

Postoperative care and follow-up

Immediately after chemical peels, the skin should be wiped with the cold water till the tingling subsides, followed by application of moisturizer and broad-spectrum sunscreen. Patients should be advised to strictly apply the sunscreen and to avoid direct sunlight for about 1 week and to avoid other treatment products to avoid side effects such as PIH and skin irritation. PIH can largely be prevented by strict adherence to use of broad-spectrum sunblock and sun avoidance while undergoing microdermabrasion.¹

Most of the laser treatments for both therapeutic and aesthetic indications such as acne scars, pigmentary disorders, and skin rejuvenation should be followed immediately by cooling the treated areas with an ice pack to reduce erythema and oedema and to minimize epidermal injury. Application of moderate potency topical steroid immediately after laser treatment may reduce the risk of PIH.⁵ It is also important to use topical lightening agents after laser treatment of pigmentary conditions to decrease the risk of PIH and to reduce recurrence of lesions. Patients should be instructed to apply a sunscreen containing physical blocking agents at least three times a day to avoid irritation. Patients should also be advised to avoid phototoxic drugs, like tetracycline, 2 weeks before and after laser treatment to decrease the risk of PIH.⁵

In case of ablative lasers, such as CO₂ lasers for DPNs, syringomas, wart removal, acrochordon removal, xanthelasma, and seborrheic keratosis topical antibiotics cream is applied twice a day for 1 week. It is essential to educate the patients to allow scabs to fall down on their own and avoid picking. It is also important to emphasize on sunscreen application three times a day from day 1, especially for lesions on the face and neck. PIH, if any, should be treated with Kligman's formula as early as possible for better outcome.

Laser-assisted hair reduction treatments may be immediately followed by ice packs to reduce post-operative pain and minimize oedema. Post-treatment care should include topical antibiotic cream applications, should be applied twice a day for 3–7 days along with broad-spectrum sunscreen daily usage and avoidance of direct sun exposure. Routine skin care and make-up regimen may be resumed the day following treatment unless blistering or crusting develops.⁸ The damaged hair is often

shed during the first weeks after treatments. Patients should be reminded that this is not a sign of hair growth.⁸

Conclusion

It is prudent to be cautious while performing dermatological procedures in skin of color to avoid untoward side effects. A detailed history, thorough clinical examination and adequate preparation of skin prior to all procedures will minimize any complications. A conservative approach during procedures such as selecting an appropriate concentration of acid, low fluence parameters of lasers with cooling devices, and titrating upward according to the response is preferable. Post-procedure care should be properly communicated to patients, including the regular use of moisturizer, broad-spectrum sunscreen and antibiotic creams or lightening creams wherever essential. Ethnic populations have skin with unique properties and characteristics; professional expertise and physician training is mandatory to enhance patient and physician satisfaction while performing dermatologic surgeries in ethnic skins.

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Complications and emergencies in dermatologic surgery

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Introduction

Hematoma, infection, dehiscence, and necrosis, are an interrelated group of surgical complications that can compromise patient outcome. Called the “terrible tetrad” by some, these complications are infrequently associated with long-term sequelae since dermatologic surgery enjoys a very low complication rate. Most complications can be avoided with careful pre-operative assessment, thorough patient education, meticulous intra-operative technique, and appropriate post-operative care. Optimal management of complications when they do occur is essential to mitigate adverse outcomes. Additionally, due to risk of considerable morbidity or mortality, special attention should be given to prevention of perioperative thrombotic events, infectious endocarditis and total prosthetic joint infections.

Management of life-threatening emergencies, such as allergic reactions, arrhythmia, myocardial infarction, and stroke requires advanced planning. Their rareness in the dermatology office requires heightened diligence against complacency; the correct and rapid response may well be the difference between a minor event and a catastrophic one. Emergency preparedness is the key and will be discussed in this chapter.

Interrelated mechanisms of complications: the “terrible tetrad”

The “terrible tetrad” of hematoma, infection, dehiscence, and necrosis are so called because of their relationships with each other as cause and effect. Hematoma acts as a

nidus of infection; it can also lead to dehiscence from increased wound tension and necrosis as the increasing tension causes ischemia of the wound edges, flap, or graft. Infection, which will be discussed further, may be from devitalized necrotic skin, hematoma, or a contaminated wound. Necrosis often leads to infection. Ischemia in a flap can result from tension or inadequate blood supply (pedicle is too narrow or flap too long). Serum or blood collecting below a skin graft may cause necrosis. Smoking has been associated with flap and graft ischemia leading to necrosis.

Hematoma with active bleeding requires that the entire wound be opened and hemostasis achieved. If the hematoma is stable and beginning to organize, it will be coagulated and too thick to drain without removing sutures. A decision not to drain the hematoma may be appropriate if the collection is small.

Necrosis of a skin graft or flap is always disconcerting; however, the outcome is often better than expected. With gentle wound care, application of copious ointment, and antibiotics, the necrotic area will heal as a second intention wound. Debridement is used judiciously as it may extend the wound and delay the healing.

Hemostasis and anticoagulation

Bleeding complications are overall rare in cutaneous surgery, but a thorough preoperative assessment may predict a disposition for bleeding. Excessive intraoperative bleeding increases the complexity of the procedure, and although intraoperative hemostasis is achieved bleeding may resume postoperatively resulting in a hematoma.

A bleeding diathesis is often due to drugs, but may also be due to inherited or acquired deficiencies in the coagulation cascade or platelet dysfunction. Common drug culprits are aspirin, aspirin-containing preparations (such as Alka-Seltzer®; Bayer Health Care, LLC, Morristown, NJ), non-steroidal anti-inflammatory drugs (NSAIDs), clopidogrel, and warfarin. Ethanol and a vast array of nutritional supplements also dispose to bleeding, vitamin E, garlic, and fish oil are very commonly encountered. If a patient is anticoagulated with warfarin, the international normalized ratio (INR) can be tested within 7 days of the planned surgery to ensure the therapeutic window of 2–3 days has not been exceeded. It may be wise to postpone surgery if there is reason to believe the patient has not reached a steady therapeutic value; usually at the beginning of warfarin therapy or after a diet change, as often happens after hospitalization or vacation.

Use of epinephrine in the anesthetic can aid intraoperative hemostasis. A note of caution regarding the apparently “totally dry” wound: bleeding may begin as epinephrine wears off, thus even seemingly insignificant oozing vessels should be cauterized. In an excessively bleeding wound the anesthetic diminishes quickly; be prepared to reanesthetize often. It is prudent to minimize undermining even with linear closures. Use of imbrication or plication stitches can be helpful. Silver-tipped bipolar forceps (SILVERGlide®, Stryker Kalamazoo, MI) are particularly helpful as the char does not stick to the tips and thus does not disturb the hemostasis when pulling away. Holding pressure on the wound for a few minutes may assist hemostasis intraoperatively. A drain may be employed to avoid a hematoma. Hemostatic agents are infrequently employed; however, in an open wound a collagen product (Avitene®; Darvol a BARD Co, Warwick, RI, or Puracol®; Medline Industries, Inc, Mundelein, IL) may significantly aid hemostasis. Additionally, Gelfoam®; Pfizer Inc, NY, NY is frequently employed but dependent on functional clotting factors.

A growing trend to continue anticoagulation during dermatologic surgery followed reports of perioperative thrombotic events^{1,2} temporally related to discontinued anticoagulation.³ In 2002, 80% of Mohs surgeons discontinued warfarin prior to surgery and compelling data regarding the risk of perioperative thrombotic events after discontinuation of anticoagulation was reported.⁴ Five years later, fewer than half (44%) of Mohs surgeons still discontinue warfarin.³ The risk of thrombotic events

with interruption of warfarin and aspirin, NSAIDs (especially in rheumatoid arthritis and systemic lupus) as well as clopidogrel is increasingly documented.^{1,5–7} It is suggested that during platelet recovery, a rebound phenomenon occurs in which the platelets are hyperthrombotic.⁷ The mechanism is unknown, however, there is one compelling hypothesis. Many biological systems upregulate in response to chronic inhibition. Thus, as cyclooxygenase-1 (COX-1) is inhibited on both platelets and the megakaryocytic precursor, the latter having a nucleus has the ability to upregulate COX-1 in response to the inhibition. As such, new platelets are released from the megakaryocytes with increased production of COX-1 thus leading to the prothrombotic state.⁷

Perioperative anticoagulation has been documented to be safe with an equivalent complication rate to non-anticoagulated patients. Severe complications occurred in only 1.6 % of patients.⁸ Therefore, due to the high risk associated with thrombotic events, interruption of anti-coagulation is not recommended.

No studies have assessed the safety of interrupting daily non-medically necessary aspirin or NSAIDs. Given the concern of a rebound hyperthrombotic state, perhaps consideration should be given to continuing all daily aspirin and NSAID regimens, even in the “non-medically necessary.”

Anticoagulated patients are counseled regarding the risk of severe repercussions from interruption of anticoagulation, even though this may limit reconstructive options to the simplest possible. When collaborating with plastic or other surgical specialists, communication regarding management of perioperative anticoagulation is important. Postoperative application of a high-quality pressure dressing with instructions to the patient to ice the wound, rest, and leave the dressing in place for 48 hours is usually sufficient to prevent oozing and hematoma.

Infections

Dermatologic surgery is known to have a low postoperative infection rate ranging from 1% to 4%.⁹ Patients at risk for postoperative infection are diabetic,¹⁰ immunosuppressed (renal disease, transplant, HIV) and/or obese (defined by percent body fat).¹¹ Some surgical sites have been reported to be prone to infection: surgery below the knee was associated with a 6.92% risk of infection, groin 10%, skin grafts 8.7%, and wedge excision of the lip or

Box 12.1 High-risk cardiac conditions for which antibiotic prophylaxis is indicated for patients undergoing dermatologic surgery on infected skin or that involves breach of oral mucosa

Prosthetic cardiac valve

Previous infective endocarditis

CHD

Unrepaired cyanotic CHD, including palliative shunts and conduits

Completely repaired congenital heart defects with prosthetic material or device, whether placed by a surgical or catheter intervention, during the first 6 months after procedure

Repaired CHD with residual defects at site or adjacent to site of prosthetic patch or prosthetic device (which inhibits endothelialization)

Cardiac transplantation recipients who develop cardiac valvulopathy

Source: Wilson *et al.*¹³.

CHD, Congenital heart disease.

ear 8.57% and flaps 2.94%.⁹ These situations may merit prophylactic antibiotics; however, this should be individualized rather than routine.

Antibiotic prophylaxis is also warranted in high-risk patients to prevent infective endocarditis (IE) or hematogenous total (prosthetic) joint infection (HTJI). Guidelines for antibiotic prophylaxis in these situations have changed significantly recently. Although the recommendations for HTJI have since changed, an excellent summary on the topic, as it pertains to dermatologic surgery, was produced by Wright *et al.* in 2008.¹²

In 2007 the American Heart Association produced new guidelines based upon the knowledge that everyday activities such as brushing teeth cause bacteremia, and therefore routine antibiotic prophylaxis for surgery on low risk sites was no longer recommended. The statement identifies a significantly constricted cohort at high risk for IE (Box 12.1)¹³ for which prophylactic antibiotics are only recommended when the surgical site involves oral mucosa and infected skin or the site is at high risk for infection. A single oral dose of cephalexin 2 g 1 hour prior to surgery is the standard regimen, which provides excellent coverage against staphylococcus, is appropriate

Box 12.2 Antibiotic regimens

Prevention of surgical site infection

- Wedge excisions of the lip and ear, skin flaps on the nose, and skin grafts
 - Cephalexin 2 g p.o.
 - If PCN allergic, Clindamycin 600 mg p.o. or Azithromycin/clarithromycin 500 mg p.o.

Lesions in the groin and lower extremity

- Cephalexin 2 g p.o.
- If PCN allergic, TMP-SMX DS one tablet p.o. or Levofloxacin 500 mg p.o.

Prevention of IE, HTJI

Non-oral surgical site

- Cephalexin 2 g p.o.
- If PCN allergic, clindamycin 600 mg p.o. or azithromycin or Clarithromycin 500 mg p.o.

Oral surgical site

- Amoxicillin 2 g p.o.
- If PCN allergic, clindamycin 600 mg p.o. or azithromycin or clarithromycin 500 mg p.o.

AHA recommends 30–60 minutes preoperative dosing.

ADA-AAOS recommends 60 minutes preoperative dosing.

For patients with PCN allergy and unable to take PO medication refer to Wright *et al.* Tables III and VI.

Treat any skin infection or surgical site infection (SSI) aggressively

- We do not recommend prophylaxis for curettage and cryotherapy or electrodesiccation and cryotherapy.
- Be familiar with the risk of MRSA in your community.
- If you are in community with increased risk of MRSA, consider SSI/IE/HTJI prophylaxis with: combination of TMP/SMX DS one tablet and PEN VK p.o., OR clindamycin 600 mg p.o.

except for oral sites, in which case a single dose of amoxicillin 2 g is used to cover streptococci species. Alternatives for penicillin allergic patients are listed in Boxes 12.2 and 12.3, along with an algorithm for appropriate prophylaxis (Figure 12.1).¹²

The American Association of Orthopedic Surgeons produced an information statement in 2009 in which they now recommend antibiotic prophylaxis for all patients with a total joint replacement, regardless of how long it has been from the replacement¹⁴ (Box 12.4). This is a significant departure from the previous guidelines for

Box 12.3 High-risk indications**For surgical site infection**

- Lower extremity, especially leg
- Groin
- Wedge excision of the lip or ear
- Skin flaps on nose
- Skin grafting
- Extensive inflammatory skin disease

For infective endocarditis

- Prosthetic cardiac valve
- Previous infective endocarditis

Congenital heart disease (CHD)

- Unrepaired cyanotic CHD, including palliative shunts and conduits
- Completely repaired congenital heart defects with prosthetic material or device, whether placed by a surgery or a catheter intervention, during the first 6 months after the procedure
- Repaired CHD with residual defects at the site or adjacent to the site of a prosthetic patch or prosthetic device (which inhibit endothelialization)
- Cardiac transplantation recipients who develop cardiac valvulopathy

For hematogenous total joint infection

- All patients with prosthetic joint placement
- Previous prosthetic joint infections
- Immunocompromised/immunosuppressed patients
- Inflammatory arthropathies (e.g., rheumatoid arthritis, systemic lupus erythematosus) Drug-or radiation-induced immunosuppression
- Patients with comorbidities (e.g., diabetes, obesity, HIV, smoking)
- Insulin-dependent (type 1) diabetes
- HIV infection
- Malignancy
- Malnourishment
- Hemophilia
- Megaprostheses

antibiotic prophylaxis during the first 2 years after the replacement. That recommendation was based on only one study and because the risk of morbidity and cost of having to replace an infected prosthetic joint is so high they believe that prophylaxis is a cost effective way to prevent HTJI. A single dose of cephalexin 2 g 60 minutes prior to surgery is appropriate for most cutaneous sites; however, this should be modified for oral, nasal, or genital sites to appropriately cover typical flora.

Emergency preparedness

Emergencies happen: having a plan in place and rehearsed with the clinic staff will prove invaluable. The algorithm for addressing medical emergencies has long been “ABC” (airway, breathing, circulation). Fader and Johnson¹⁵ also used this acronym to categorize the three basic areas of emergency in the dermatology office, allergy, brain, and circulation in a comprehensive review that is abbreviated below.

General considerations

The most important emergency supply is the telephone, for dialing 911. Emergency medical services (EMS) should be contacted as soon as an emergent situation is recognized. For most clinics the emergency plan is only necessary to bridge the time lapse until the arrival of EMS. An automated external defibrillator (AED) is next in importance. An exhaustive inventory of emergency supplies is unnecessary if EMS response is rapid. A shortlist of suggested supplies includes epinephrine 1:1000, oral or nasopharyngeal airway, a portable oxygen tank and tubing, nitroglycerin tablets, aspirin, diphenhydramine, and possibly lorazepam and dextrose 50% as well as IV access.¹⁵

Allergy

Anaphylaxis is a life-threatening situation that may arise from food, a dose of antibiotics or other drugs, exposure to latex, and, rarely, from administration of anesthetics (the last one may be an allergy to preservative methylparaben). Administration of 0.3–0.5 mL of epinephrine 1:1000 subcutaneously every 5–10 minutes as necessary until EMS arrives is standard.

Pseudoallergy (vasovagal syncope) is a relatively common occurrence, frequently after injection with

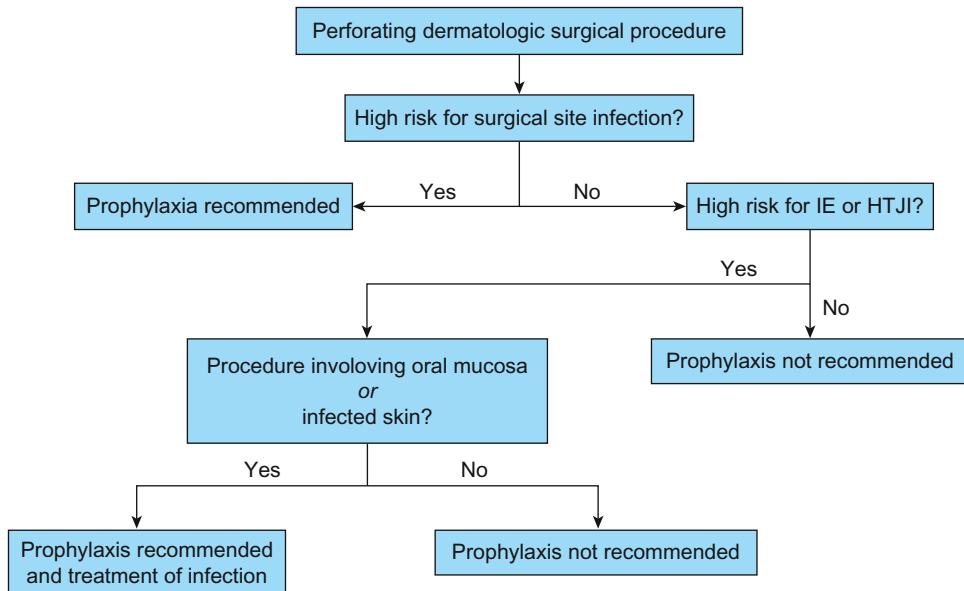


Figure 12.1 Recommended antibiotic prophylaxis in dermatologic surgery. IE, infective endocarditis; HTJI, hematogenous total joint infection. Modified from Wright et al. 12 with permission from Elsevier.

Box 12.4 Patients at potential increased risk of hematogenous total joint infection

- All patients with prosthetic joint replacement
- Immunocompromised/immunosuppressed patients
- Inflammatory arthropathies (e.g., rheumatoid arthritis, systemic lupus erythematosus)
- Drug-induced immunosuppression
- Radiation-induced immunosuppression
- Patients with comorbidities (e.g., diabetes, obesity, HIV, smoking)
- Previous prosthetic joint infections
- Malnourishment
- Hemophilia
- HIV infection
- Insulin-dependent (type 1) diabetes
- Malignancy
- Megaprostheses

anesthetic. It is good practice to always recline the patient prior to administration of local anesthesia, even if the patient has no prior history. Also, draping the patient's eyes and distracting them with "talkesthesia" can be effective. Vasovagal reactions may be potentiated by

hypertensive medications such as beta-blockers. Occasionally, hypotension may evoke a seizure, in which case the patients should be placed in Trendelenburg position with oxygen supplementation, and vital signs should be monitored while EMS is summoned.

Brain

Stroke and status epilepticus are two conditions that are infrequently encountered. Both require immediate EMS activation and attention to the ABCs and prevention of trauma. If EMS takes longer than 10 minutes to arrive, lorazepam may be administered 1–2 mg IV in an attempt to control seizure activity.

Circulation

Myocardial infarction requires immediate activation of EMS and prompt attention to relief of chest pain. MONA (morphine, oxygen, nitroglycerin, aspirin) is a useful acronym; all but the morphine are readily available and should be administered prior to EMS arrival. As most myocardial deaths occur due to arrhythmia, an AED should be employed to cardiovert an arrhythmia if necessary.

Arrhythmias may be iatrogenic with the use of electro-surgery in patients with pacemakers. Use of bipolar

forceps for hemostasis will avoid interference with pacemakers.¹⁶ A more thorough discussion is found in Chapter 5.

There are no firm guidelines on a “safe” preoperative hypertensive level, and it is left up to the surgeon to decide their threshold for preoperative control. Hypertension increases intraoperative bleeding and thus an increased risk of postoperative bleeding, hematoma, and flap and graft necrosis. This highlights the importance of preoperative assessment and addressing identified elevated blood pressures. The patient’s primary care physician should be enlisted to control hypertension prior to surgery.¹⁷

Conclusion

Dermatologic surgery is safe, enjoying a low risk of complications and adverse events. Successful and safe cutaneous surgery requires a thorough preoperative assessment. Attention to appropriate antibiotic prophylaxis, and meticulous hemostasis is the key to prevention of the majority of complications. Rehearsal of an emergency response plan can ensure that your medical team is ready for any life-threatening situation.

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2

PART 2

Reconstructive Surgery

Secondary intention healing

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Introduction

The main function of the skin is to serve as a physical barrier separating the internal milieu of the body from the external environment of the world.¹ There are four categories of wound healing: primary intention healing, delayed primary healing, secondary intention healing, and re-epithelialization for partial thickness wounds.² Primary intention healing occurs when a full-thickness wound has its edges approximated, and often is held in place by artificial means (i.e., sutures). Delayed primary healing occurs when the edges of a full-thickness wound are not immediately re-approximated. Healing by secondary intention occurs when a full-thickness wound is left to heal by itself without any attempt to close it surgically. Secondary intention healing typically results in a formation of significantly more granulation tissue than primary intention healing because the body attempts to close the wound. Healing of a partial thickness wound is the fourth category of wound healing and is characterized by migration of the epithelial cells traversing the wound.

The healing process is complex,³ orchestrated by many growth factors, cytokines, and proteases at the molecular level that can be affected by numerous systemic factors. The skin begins healing immediately after injury and

encompasses three phases: inflammation, proliferation, and maturation.¹

The stages of healing

- I. The inflammatory stage
 - a. The cutaneous surface is incised.
 - b. The keratinocytes produce interleukin (IL)-1 and tumor necrosis factor (TNF)- α .
 - c. IL-1 and TNF- α promote migration of neutrophils into the wound.
 - d. The blood clot forms a scaffold for the inflammatory cells.
 - e. The platelets in the blood clot begin secreting epidermal growth factor (EGF), platelet-derived growth factor (PDGF), and transforming growth factor (TGF)- β .
 - f. EGF, PDGF, and TGF- β act to encourage epithelial cells to dissociate from their cell-extracellular membrane and cell-cell connections and instead to migrate the wound, where they begin to proliferate.
 - g. During the next few days, neutrophils are replaced by macrophages.
 - h. The macrophages stimulate granulation tissue production via vascular endothelial growth factor (VEGF), and more IL-1 and IL-6.

II. Proliferative stage

- a. Neovascularization occurs during this stage and is instrumental to forming new extracellular matrix.¹
- b. PDGF, fibroblast growth factor (FGF), and TGF- β promote fibroblastic migration into the wound.
- c. Collagen is initially deposited vertically followed by horizontal deposition.
- d. TGF- β and PDGF promote fibroblastic differentiation into myofibroblasts near the edges of a wound.
- e. The myofibroblasts express α -smooth muscle actin that will assist to contract the wound.

III. Maturation stage

- a. The granulation tissue is remodeled into elastin and collagen, forming a framework.
- b. Collagens are synthesized and degraded. This process is modulated by TGF- β , matrix metalloproteinases, and tissue inhibitors of matrix metalloproteinases.
- c. A scar is formed from the remaining collagen and elastin.

In 1983, Dr. Zitelli⁴ suggested that wounds heal better by secondary intention in certain anatomical locations than others, such as the head and neck region. Surgical wounds are known to heal better in concave areas, especially in the areas of the nose, eye, ear, and temple (NEET), than the convex surfaces of the nose, oral, cheek, or chin (NOCH) areas.⁴ Areas that typically heal FAIRly well include the forehead, antihelix, eyelid, and the remainder of the nose.⁴

Secondary intention healing for surgical wounds offers a number of advantages. For instance, management of the wound is straightforward. An occlusive or semi-occlusive dressing is used and requires daily changes. Wounds encompassing a large surface area do not exhibit a slower healing rate than smaller wounds because they heal logarithmically.⁴ Also, surgical wound complications such as flap/graft necrosis, hematomas, or seromas do not occur in secondary intention healing.⁴

Skin color is also an important consideration in healing because scar tissue can be hypopigmented in darker skinned individuals. The size of wounds can also affect the cosmetic outcome of the scar. Larger wounds heal with a more irregular surface than smaller wounds.⁴ In addition, superficial wounds are known to heal better than deeper wounds.⁴

The overall goal in treating wounds healing by secondary intention is to reduce drying and subsequent crust

formation.⁴ By doing this, healing is less painful and re-epithelialization is increased.⁵⁻⁷

Management of secondary intention wound healing

- I. Hemostasis is achieved via suturing, electrocoagulation, or use of oxidized cellulose cotton.
- II. A pressure dressing is applied for 24–48 hours.
- III. After 48 hours, the pressure dressing is removed and the wound is cleaned with mild soap and water.
- IV. An ointment such as petrolatum ointment is spread over the wound. In certain circumstances, an antibiotic ointment may be prescribed for application on wounds located in areas prone to a higher risk of infection (genital areas, under the nose, etc.) and for immunocompromised or diabetic patients.
- V. The wound is covered with a bandage.
- VI. The bandage is changed and the process is repeated on a daily basis.

Guiding sutures may be used to “guide” the process so that contraction occurs in the desired direction.⁴ In situations where bone or cartilage is exposed, petrolatum or antibiotic ointment should be applied more frequently.⁴ If the exposed bone/cartilage is less than 1 cm, granulation tissue usually develops rapidly enough to cover the wound.⁴ Wounds with larger bone/cartilage exposure require extra treatment.⁴ In concave areas, tiny 1- to 2-mm holes can be punched into the exposed cartilage to enable migration of skin from the other side and enhance wound healing.⁴ On convex areas, the cartilage should not be excised, otherwise the wound may heal with a depression.⁴ It may help to expose the perichondrium of these surfaces with a 3-mm dermal punch, which assists in the formation of granulation tissue.⁴ For cases involving approximately 1–10 cm of exposed bone, a bone chisel can be used to strip the outer cortex.⁸ This also assists in the formation of granulation tissue. The granulation tissue is known to protect the bone from desiccation necrosis, and hence decreases the risk of osteomyelitis.^{9,10}

The patient and physician must be patient when using secondary intention as the wound’s appearance continues to improve for 6 months to 1 year.⁴ The patient should also be made aware of the potential complications of secondary intention wound healing, including

infection, hemorrhage, telangiectasias, ectropion, retraction, delayed wound healing, and scar depression.¹¹

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CHAPTER 14

Side-to-side closure

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Introduction

Side-to-side closure of wounds can serve both functional and aesthetic purposes. The purposes of closure include

- elimination of dead space by approximating the subcutaneous tissues
- minimization of scar formation
- careful alignment of epidermis
- avoidance of a depressed scar by precise eversion of skin edges.¹

Wounds, which may be either surgical or traumatic, can heal by primary intention when clean and possessing apposable edges. The edges of such wounds are held in place by mechanical means (adhesive strips, staples, or sutures) which allow wounds to heal and develop enough strength to withstand stress without support.

Traumatic wounds which can be closed primarily should be closed promptly after injury. Extremity wounds left open for more than 6 hours have an increased risk of infection when closed.

The principles of wound closure

- *Minimization of bacterial contamination:* large amounts of sterile saline or Ringer's solution using intermediate pressure with a 50-mL syringe and an 18-gauge needle can be used to irrigate the wound.
- *Removal of dead tissue and/or foreign bodies:* sharp debridement of necrotic tissue is effective and can be

carried out in a painless manner because this tissue is insensate.

- *Hemostasis:* electrocautery is most commonly used in surgical wounds.
- *Avoid iatrogenic injury:* use fine-toothed forceps.
- *Approximation without strangulation:* the wound should be approximated. Sutures that have too much tension can worsen cross-hatching, wound ischemia, and increase infection risk.²

Advantages of primary side-to-side closure

- Simplifies wound care for the patient, who simply needs to keep suture line clean and dry.
- Facilitates the biological event of healing by joining the wound edges.
- Heals much more quickly and with less pain.
- Involves fewer problems with abnormal scarring and has better cosmetic result.
- All vital underlying structures are covered.

Contraindications to primary side to side wound closure

- An acute wound >6 hours old, except facial wounds.
- Foreign debris in the wound that cannot be completely removed.

- Active oozing of blood from the wound.
- Skin closure with underlying dead space.
- Excessive tension on the wound.

Preoperative care

- Local injection or Nerve block using lidocaine, bupivacaine, or both can be used to achieve anesthesia which may last 4–8 hours.
- Epinephrine is sometimes added to anesthesia to control bleeding, but this should be avoided in areas of compromised circulation or partially devitalized tissue.
- The maximum dose of lidocaine is 4.5 mg/kg when used alone, while the maximum dose when used along with epinephrine is 7 mg/kg.
- To diminish discomfort of anesthetic injection, use a small-gauge needle and a slow rate of injection. Also, lowering the acidity of the local agent by buffering it with sodium bicarbonate may also lessen pain.
- Topical agents can be highly effective in well-vascularized areas (e.g., face).
- Inject enough anesthetic to make tissues swell just a little. Pinch the tissues with a pair of forceps or gently touch the skin edges with a needle. If the patient feels “sharp” pain, more anesthetic should be given.
- Wait 5–10 minutes for the anesthesia to take effect.

Step-by-step technique

Side-to-side closure using sutures

I. Once the area seems to be anesthetized and hemostasis is achieved, start suturing the wound. The technique and all details related to types of suture materials have been discussed in Chapter 4. The choice of suture and the type of suturing technique to be used is made as per need and indications.

II. Surgical pearl: Before placing the sutures, use two skin hooks at the tips of the defect and apply tension along the proposed line of closure so that the skin edges approximate. The skin edges can be marked using a surgical marker perpendicular to the line of closure at points where the suture are intended to be placed. The skin hooks can now be removed. Any redundant folds of tissue can be excised if required and remainder of the defect can be closed. This helps attain excellent approximation and prevention of dog ears.

III. Small sutures such as 5-0 and 6-0 should be used for repair of facial lacerations to have decreased scarring. In other areas, where cosmesis is not of top priority, 3-0 or 4-0 sutures can be used for their strength.

IV. The most common type of excision is an elliptical excision designed such that the resulting scar runs parallel with existing skin creases. A spindle-shaped or elliptical excision leaves a defect that is closed by bringing the wound edges together with single or running skin sutures. This is easier if subcutaneous stitches are used first.

V. To prevent occurrence of dog ears, an optimal elliptical defect should be attempted.

VI. Larger elliptical defects require undermining before closure can be done. This implies separation of the adjacent tissue from its subcutaneous connections so that the skin moves freely over the fat. This not only makes the approximation easier but also prevents overstretching during later stages of healing.

Complications

Correction of dog ears

After a wound is closed, swellings or folds of tissue are occasionally created at one or both ends. These folds are known as “dog ear” and are the result of a wound which is too wide for its length, or the wound edges are of unequal length. Dog ears can be corrected by elevating the fold with a wound hook and then excising it with a scalpel. This helps the two edges to gain comparable lengths and can now be approximated without folds.

Postoperative care and follow-up

Care of stitches and advice to patient

I. After suturing the wound closed, apply a small amount of petrolatum ointment over the suture line and cover the area with a dry gauge. Head and facial wounds are often left uncovered.

II. The wound may become painful 1–2 hours after suturing when the local anesthetic wears off. Painkillers such as acetaminophen can be used for the control of pain. Avoid painkillers that increase the chance of bleeding such as aspirin and anti-inflammatory medications.

III. After 24 hours, remove the original dressing.

IV. Avoid strenuous exertion and stretching of the area until the stitches are removed and for sometime afterwards.

V. The suture line should be kept clean and dry

VI. The patient can wash the area with gentle soap and water the day after the repair. the sutured area, however, should not be allowed to soak in water for more than a few minutes.

VII. A small amount of petrolatum ointment can be applied daily for the first few days followed by covering the wound.

VIII. If the injured area is on the hand, foot or calf, have the patient elevate the affected extremity. The elevation is to reduce swelling.

IX. Small amount of bleeding may stain the dressing. This is not unusual and needs no action. However, if the bleeding persists, apply another dressing on top of the original one and apply firm pressure for 20–30 minutes.

X. Do not shave over the stitches if they are around the beard area.

XI. Do not apply make-up to the operation site until it is healed.

XII. Avoid clothing that is going to rub on the suture line.

XIII. Contact the doctor if the suture line becomes red, inflamed, increasingly painful, has any discharge or bleeds persistently.

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General

Tri H. Nguyen and Jamie L. McGinnes

Introduction

A flap is a partially detached section of tissue that is moved to reconstruct a surgical defect. Flaps are frequently used in reconstructive surgery, especially when simpler repairs are not appropriate (second intention, linear closures, skin grafts). Familiarity with flap terminology, biomechanics, and vascular supply is essential to proper flap design and application.

Flap biomechanics

It is essential when designing flaps for reconstruction that the surgeon understands the biomechanical properties of

the skin, as these properties will affect flap blood supply and survival. The mechanical properties of the skin are defined by *stress*, *strain*, *creep*, and *stress relaxation*. *Stress* is the force applied per cross-sectional area, and *strain* describes the change in length versus the original length for a given applied force. The stress – strain relationship refers to how the length of a flap (strain) changes as the force (stress) varies for a given cross-sectional area. It can be understood from the stress – strain relationship that the skin is not truly elastic.¹ As can be observed in Figure 15.1, as the stress is increased the lengthening or strain of a flap goes through three separate regions. In region I considerable lengthening occurs with little increase in applied stress. Region II shows a rapid transition, and region III demonstrates the point where additional stress

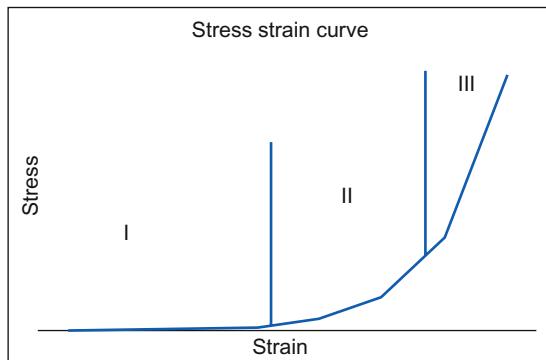


Figure 15.1 The stress–strain curve demonstrates as the stress is increased the strain of the flap goes through three separate regions. In region I considerable lengthening is acquired with very little increase in applied stress. In region II a rapid transition occurs. In region III additional stress produces very little addition strain of the skin.

produces very little elongation (strain) of the skin. In region I there is a large change in strain with a small change in stress. This is related to the initial deformation of the elastin fibers.² As continued stress is applied to the skin, the collagen fibers start to reorient in the direction of the force, which is seen in region II.² In region III as the force continues to increase, most of the collagen fibers are recruited, fully extended, and reoriented parallel to the direction of stress, and are unable to deform further.^{3,4} With aging the stress – strain curve is shifted to the right, secondary to a degradation of the elastin network.⁵ This phenomenon is important for reconstructive surgeons to remember, as increasing stress on a flap beyond a certain point will produce very little additional lengthening of the flap. However, it has been noted that increased incidence of flap necrosis and decreased blood flow is seen with an increase in closure tension.⁶

Creep describes the phenomenon of an increase in skin lengthening (strain) when skin is placed under tension at a constant force (stress). This phenomenon, which is time dependent, is likely secondary to the straightened collagen fibers displacing interstitial fluid.^{3,4} When skin is held under a constant strain, it will undergo a decrease in stress, and this is referred to as *stress relaxation*. This occurrence is beneficial to the surgeon when using intraoperative temporary sutures to stretch the skin, such as sutures used to close or partially close a

wound while processing and reading a Mohs layer or during a delayed repair while permanent pathology is being processed.

Flap movement is restricted by two types of restraints: lateral and vertical. *Lateral restraint* refers to a flap's attachments to its periphery, which are released by well-placed relaxing incisions. *Vertical restraint* is the fibrous attachments of a flap to its base. The skin, for example, is adherent to the underlying fascia by collagenous interlobular septae that run from the deep reticular dermis to the underlying fascia (the superficial musculoponeurotic system (SMAS) on the face).⁷ Relaxing incisions alone do not affect vertical restraints. Only proper undermining can loosen vertical restraints and allow flap movement.⁷

Flap vascular supply

A flap's survival depends on a robust vascular pedicle. The vascular supply to the skin originates from one of two main routes: the musculocutaneous arteries that traverse the underlying muscle before supplying the overlying skin and the septocutaneous arteries that traverse the fascial septa before supplying the overlying skin.⁸ The cutaneous portion of the septocutaneous arteries typically run parallel to the overlying skin and supply a larger area in contrast to the musculocutaneous arteries, which leave the underlying muscle and enter the subcutaneous tissue, supplying a smaller area of skin.^{8,9} These arteries then empty into interconnecting vascular plexi that form the subdermal plexus, located within the deep part of the dermis and superficial to mid-subcutaneous fat, and the intradermal plexus, located within the reticular dermis.^{8,10} The vessels then finally empty into capillaries making up the subepidermal plexus, located at the junction of the papillary dermis and superficial reticular dermis.¹⁰

It is important to be aware of the concept of perfusion pressure in relation to flap viability. The perfusion pressure of a vessel is the force of blood flow through that vessel and this pressure must be high enough to overcome the capillary resistance of the distal capillaries within the flap.¹ If the perfusion pressure of the vasculature in the flap's pedicle is higher than the capillary resistance at the flap's distal tip, then this pressure will maintain

patency of the capillaries, blood supply, and viability of the distal portion of the flap. The farther the vessels traverse from the pedicle base, the lower their perfusion pressures become; and beyond a certain length the perfusion pressure will fall below the critical closing pressure leading to a halt of blood flow and distal flap necrosis.¹¹ When perfusion pressure is below the critical closing pressure, it is irrelevant how many additional vessels are recruited by a wider pedicle if the additional recruited vessels have the same perfusion pressures, since the outcome of distal flap necrosis will be unchanged.^{9,12} Therefore, a wider pedicle will not always produce a more viable flap. However, lengthening of a flap can occur if the perfusion pressure of the vessels within the flap's pedicle is increased. This concept can be illustrated when forehead flap design is evaluated. The length to width ratio of a forehead flap can be increased with a decreased risk of distal flap necrosis given that it is based on the supratrochlear artery, which has an increased perfusion pressure. Most local cutaneous flaps have a vascular supply based on the subdermal plexus, which contains arterioles and capillaries with perfusion pressures high enough to sustain a cutaneous flap.¹ A flap based on the intradermal plexus alone is less likely to survive due to low perfusion pressures of these vessels.¹³ Therefore, it is necessary that cutaneous flaps be undermined at least below the subdermal plexus in order to increase the chance of flap survival and viability.

Flap terminology

Flap terminology should be clearly defined to avoid confusion. The *primary surgical defect* is the defect created by the surgeon when removing a tumor (Video 15.1). The *secondary surgical defect* is the defect created when a flap is excised and the mobilized tissue is moved to close the primary defect (Figures 15.2 and 15.3). *Primary tissue movement* is the movement of the flap into the primary defect. *Secondary tissue movement* is the movement of tissue both around the primary and secondary defect to complete closure (Figure 15.3). A flap's *pedicle* is the area of the flap that is still connected to the skin adjacent to a surgical defect containing the vascular supply of the flap (Figure 15.2). The *tip* of a flap is the area of the flap that is farthest from the vascular pedicle (Figure 15.2).



Figure 15.2 The primary surgical defect is the defect created by the surgeon when removing a tumor and is depicted by the blue arrow. The secondary surgical defect is the defect created when a flap is excised and the excised tissue is moved to close the primary defect. The secondary surgical defect is indicated by the red arrow. Primary tissue movement is the movement of the flap into the primary defect and is indicated by the large black arrow. Secondary tissue movement is the movement of tissue both around the primary defect to close the primary defect as well as the movement of tissue around the secondary defect to close the secondary defect and is depicted by the small arrows.

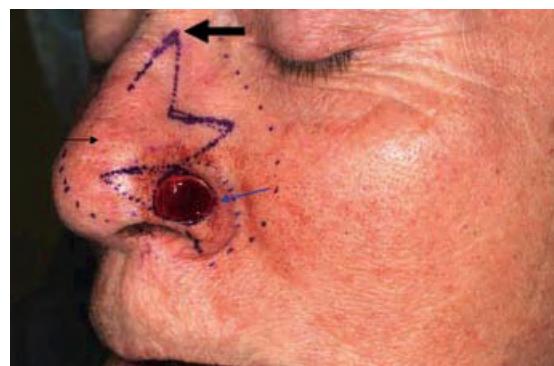


Figure 15.3 The large arrow in this bilobed transposition flap represents the tip of the flap and the small arrow demonstrates the flap's pedicle. The blue arrow represents the primary surgical defect.

Flap classification

Flaps have been described by several methods based on movement, vascular supply, location, stage, configuration, and flap eponyms (Table 15.1). The most useful terminology is based on movement. When describing

Table 15.1 Flap classification

Flap classification	Examples of flaps
Movement	Advancement – O-T, A-T, O-U, O-H, Burow's wedge advancement Rotation – dorsal nasal rotation, O-Z, single rotation flap Transposition – rhombic, bilobed, trilobed Interpolation – cheek to nose, paramedian forehead flap, lip switch
Vascular supply	Random pattern – no named artery Axial – named artery
Location of donor site	Local – donor tissue is adjacent and contiguous with the defect Regional – donor tissue is nearby but not contiguous with the defect Distant – distant donor site
Stage	Single – no additional procedures Multi-staged – additional procedures
Configuration	Note, bilobed, trilobed, rhombic, hatchet
Flap eponym	Reiger, Abbe, etc.

flaps based on movement the terms *advancement*, *rotation*, *transposition*, and *interpolation* are commonly used (Video 15.1). *Advancement flaps* describe the reconstruction of a primary defect by the use of direct linear movement of skin adjacent to a primary defect. When a surgeon closes a primary defect by the use of rotational movement of skin adjacent to the primary defect, the flap is defined as a *rotation flap*. These definitions are straightforward; however, when flaps are designed for reconstruction of surgical defects, a large number of flaps consist of both advancement and rotational movement and are not neatly defined as just advancement or rotation. A *transposition flap* consists of advancement and rotation of tissue over an island of adjacent normal tissue and into the surgical defect. The *interpolation flap* is similar to a transposition flap in that it consists of movement (advancement and rotation) of tissue over adjacent normal tissue and into a surgical defect; however, the vascular pedicle is left attached initially in stage I and taken down at a later date during stages II or III of the procedure.

When describing flaps based on the vascular supply of the flap the terminology of *random pattern*, *axial pattern*, and *microvascular flaps* are used. *Random pattern flaps* are flaps without a large named vessel and rely on the subdermal vascular plexus for survival. In contrast, *axial pattern flaps* are based on a named artery. A common example of an axial pattern flap is the paramedian forehead flap where the pedicle and flap contain and depend on the supratrochlear artery for survival. However, the majority of skin flaps are random pattern cutaneous flaps.

Advancement (Video 15.1)

As this section discussed previously, advancement flaps involve linear movement of adjacent tissue into the surgical defect. In a true advancement flap there is no component of rotation. Advancement flaps do not redistribute or redirect tension but do allow for repositioning of the Burow's triangle at any point along the line of advancement. Advancement flaps can be subdivided into unilateral and bilateral advancement flaps. Examples of the unilateral advancement flaps include the O-U, Burow's wedge advancement flap, and V-Y advancement flap (formerly known as island pedicle flap) (Figures 15.4 and 15.5). Examples of the bilateral advancement flap include the O-T, A-T, and O-H. The incision lines should be hidden within relaxed skin tension lines or cosmetic subunit boundaries, if possible. The advantages of advancement flaps include the ability to decrease wound closure tension, move adjacent skin with similar characteristics into the surgical defect, displace the Burow's triangle to a better location, and if the procedure is planned appropriately, the ability to hide surgical scars within relaxed skin tension lines and cosmetic subunit boundaries. The disadvantages include large scars sometimes difficult to conceal and the relatively small amount of movement when it is compared with other flaps.¹⁴

Rotation (Video 15.1)

Rotation flaps involve adjacent tissue movement that moves along an arc into the surgical defect. Unlike advancement flaps, rotation flaps redistribute and redirect both the tension and the standing cutaneous cone away from the surgical defect. The Burow's triangle can be placed anywhere along the arc of rotation. Rotation flaps have a component of pivotal restraint (tethering of the flap's movement) at their pivot point (point



Figure 15.4 (a–c) A Burow's wedge advancement flap is used to reconstruct this dorsal nasal defect. The Burow's triangle is displaced to an area of laxity on the medial cheek and positioned to be concealed in the melolabial fold. The primary linear movement is represented by the arrow.



Figure 15.5 (a–c) Island pedicle advancement flap is used to reconstruct this cheek defect. Skin laxity is recruited from the inferior cheek and advanced superiorly. The primary linear advancement can be observed.



Figure 15.6 (a–c) A rotation flap is used to reconstruct this pre-auricular defect. The laxity of the inferior cheek is recruited and rotated superiorly. The surgical incision is strategically placed along the pre-auricular and tragus areas to conceal the surgical scar. The Burow's wedge is removed from the anterior inferior pre-auricular area.

of rotation), for which the surgeon must compensate in the design of the flap in order to prevent unwanted flap tension or tissue displacement.¹⁵ Rotation flaps generally are very robust due to their broad vascular pedicle. Examples of rotation flaps include the O-Z, single rotation flap, and the dorsal nasal rotation flap (Figure 15.6).

Transposition (Video 15.1)

The transposition flap's tissue movement consists of both advancement and rotation of adjacent skin over an area of normal skin and into the surgical defect. Like the rotation flap, redistribution of tension away from the surgical defect is obtained with the transposition flap. Pivotal restraint will also have to be accounted for when designing the transposition flap.¹⁵ Examples of transposition flaps include the rhombic flap, bilobed flap, and trilobed flap (Figure 15.7).

Staged (Video 15.1)

Staged flaps can be both axial and random pattern flaps and involve two or more stages to complete. Interpolated flaps are staged flaps that involve both advancement and rotation of adjacent skin over an area of normal skin and into the surgical defect while leaving the pedicle attached during stage I and then divided at a later stage. The stages are most commonly separated by 2–3 weeks. Stage I consists of creating and transferring the flap into the surgical defect with an attached pedicle. The pedicle may be axial (i.e., supratrochlear artery in the pedicle of a paramedian forehead flap) or random based (unnamed arterial perforators in a cheek to nose melolabial interpolation flap). In stage II, the pedicle is divided and the flap finalized in 3 weeks. Occasionally, an intervening stage occurs at 3 weeks where the flap is elevated and sculpted but the pedicle remains. Pedicle division then occurs at 6 weeks rather than at 3 weeks. Staged flaps



Figure 15.7 (a–c) Trilobed transposition flap was used to reconstruct this surgical defect. The tissue movement consists of both advancement and rotation of adjacent skin over areas of normal skin and into the surgical defect. Redistribution of tension away from the surgical defect to the lateral cheek is obtained with this transposition flap.

include Lip-switch (Abbe) flaps, paramedian forehead flaps, and cheek-to-nose melolabial interpolation flaps (Figure 15.8).

Preoperative care

Optimal functional and cosmetic results require thoughtful planning in design, execution, and postoperative care. Preoperative planning is critical and should address several factors: surgical defect analysis, relevant anatomy, adjacent skin and structures, and patient factors.

Surgical defect analysis

Before any repair option is considered complete tumor extirpation with clear margins is necessary. The surgical defect is analyzed evaluating the size and depth with attention placed on the layers (epidermis, dermis,

subcutaneous fat, muscle, fascia, etc.) of tissue that are absent. Structures that may have been exposed during surgery, such as tendon, bone, cartilage, nerves, etc., are evaluated. The lack of structural support is assessed, and, if missing, it is important to consider a means of replacement in order to restore function and form.

Relevant anatomy

The patient is assessed for injury to vital structures that may have occurred during tumor removal (temporal nerve, nasal valve collapse, etc.). The surgeon should evaluate for possible danger areas that can be injured during further reconstruction of the surgical defect. Relaxed skin tension lines and cosmetic units should be observed and assessed for the ability to camouflage scars. If more than 50% of a cosmetic subunit is missing, consideration should be given to complete subunit removal during reconstruction.

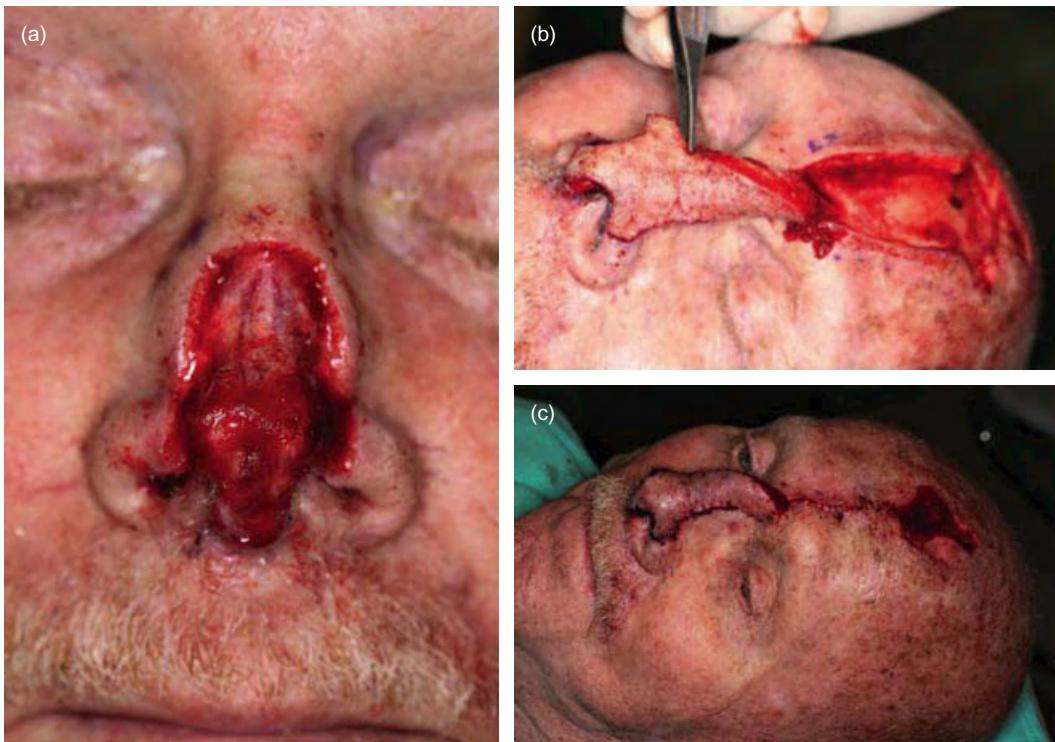


Figure 15.8 A paramedian forehead flap is used to reconstruct this nasal defect. The interpolation flap is a axial pattern flap based on the supratrochlear artery. Since the flap is an axial pattern flap the length to width ratio can be increased without decreasing flap viability. The pedicle is left attached and is divided at a later stage.

Adjacent skin and structures

Care should be taken to evaluate nearby free margins that could be distorted during repair of the surgical defect. Maximum skin laxity and tissue reservoirs are important to evaluate prior to any repair design. The pinch technique where the index finger and thumb are used to pinch adjacent skin together will often show where maximal skin laxity is present. The quality of adjacent skin should be evaluated not only for mobility but also for color and texture match. It is also important to examine the donor skin thoroughly for additional skin cancers to avoid the inadvertent transfer of malignant tissue.

Patient factors

Every patient undergoing wound reconstruction is not equal; therefore, each patient should be evaluated individually for his or her aesthetic expectations. Two patients with the same surgical defect may have vastly different

expectations on outcome. Some patients may not want additional surgery or a two-staged procedure and are willing to accept a less cosmetically acceptable result. Comorbidities, including diabetes, smoking, immunosuppression, venous stasis, etc., will need to be evaluated as they may affect wound healing and reconstructive choices. The ability of a patient or his or her caregivers to care for a wound as well as the ability to follow wound care instructions should be considered when addressing repair options. For patient safety, anticoagulation should not be discontinued for dermatologic surgery. Even staged flaps and complex repairs may be safely performed in anticoagulated patients. However, extra intraoperative (suction, extra-meticulous hemostasis) and postoperative (longer monitoring before discharge) precautions may be necessary for these patients.

Following a methodical algorithm for closure (from simple to complex) will usually narrow the one or two best options for each patient. In order of simple to

complex, general options include: second intention, primary closure, skin grafts, single stage flaps, and multi-staged flaps.

Step-by-step surgical technique

Several attributes are common to excellent reconstructive outcomes include: attention to detail, respect for the tissue (gentle tissue handling, precise coagulation), and tension reduction. Tissue should be handled delicately with small single or double skin hooks or small fine-toothed forceps to avoid excessive trauma or maceration of the tissue.¹⁶ Careful undermining in the appropriate tissue plane can release lateral restraints, reduce tension, and preserve an adequate vascular pedicle. Care should be taken to avoid excessive twisting of the vascular pedicle, which could compromise blood supply and flap viability. Precise suturing technique should be used and the flap closed in a layered fashion taking care to obtain perfect skin edge approximation. Finally, prior to dressing, the flap should be evaluated for adequate vascular supply. If the flap appears dusky or white then the sutures are removed and the flap is evaluated for possible causes of vascular compromise.

Postoperative care and follow-up

Detailed verbal and written postoperative wound care instructions are provided to the patient prior to being

discharged home. Ice and elevation can be considered to reduce postoperative swelling. Pain control should be discussed and addressed with either over-the-counter medications or prescription pain medications if more severe pain is anticipated. Care should be taken to ensure that the patient fully understands when, how often, and how to clean and bandage the wound. Initially a pressure bandage is applied to the wound, which is removed 24–48 hours after the procedure. The wound is then cleaned, ointment reapplied, covered with a non-stick pad, and tape reapplied twice daily. It is essential to educate the patient and his or her care givers on postoperative wound-healing expectations and potential postoperative complications such as postoperative bleeding or suspected infection. Follow-up instructions and emergency contact information should be given to the patient in case postoperative complications would occur.

Conclusion

Knowledge of the basics of flap biomechanics, vascular supply, and design combined with meticulous preoperative, operative, and postoperative care is necessary for the reconstructive surgeon to achieve superior and cosmetically ideal reconstructive results. These building blocks can be applied to all flaps used in reconstructive surgery allowing the reconstructive surgeon to further expand his or her skill set and armamentarium offering his or her patients the best surgical repair options and outcomes.

Advancement flaps

Francis Hsiao and Summer R. Youker

Preoperative care

Preoperative care is similar for all flaps. A review of this subject can be found in Chapter 7. A wide area surrounding the operative field must be prepped and draped in a sterile fashion.

Step-by-step surgical technique, crescentic advancement flap

I. Flap is designed and drawn with skin marking pen (Video 15.2)

- a. Design is lateral to the apical triangle of the lip (colored solid with marker in clip) in this location.



II. Defect is undermined in the submuscular plane (skeletonize nose) in this location (Video 15.3). The depth of undermining is dependent upon the location of the defect. For instance, when working on the ear, undermining is generally performed at the level of the perichondrium.

III. Flap is incised with a scalpel (Video 15.4)

- a. Scalpel should be perpendicular to skin surface to avoid bevel
- b. Note that, at this location, incision is in melolabial fold lateral to apical triangle of lip

IV. Flap is undermined using primarily sharp dissection technique (Video 15.5)

- a. Care is taken to maintain consistent thickness of flap
- b. When undermining on the nose, the plane of dissection continues to be submuscular
- c. When undermining is continued out onto the cheek, the plane of dissection shifts to a mid subcutaneous one to maintain consistent thickness of flap
- d. Maintain proper hemostasis throughout procedure to aid in visualization and to avoid intra- and postoperative complications
- e. Tethering often occurs at inferior portion of lateral nasal bone (Video 15.6)
- f. Intermittently assess flap movement and need for further undermining

V. Debevel wound as necessary (Video 15.7)

VI. Key suture placed in primary defect (Video 15.8)

- a. This suture sets the course for the rest of the flap and its proper placement is "key" in the success of the flap. Although there is a modest amount of inferior motion to this flap, the majority of the movement is medial.
- b. A temporary simple interrupted suture is used as an efficient tack. It will be replaced with a buried suture once flap placement is certain.
- c. In this location, one must ensure that the alar rim will not retract.

VII. Suture that will clarify potential for free margin distortion (alar retraction at this location) is placed next so that adjustments can be made at this stage, if necessary (Video 15.9)

- a. Check for alar retraction by placing a horizontal straight edge under columella and view patient from directly above. This allows the surgeon to compare contralateral (native) alar height.

b. For flaps on the nose, all dermal (buried) sutures should incorporate the muscle. It is important to remember that the muscle retracts when incised, making it essential to "reach" for the muscle to incorporate it into each dermal suture.

VIII. Excise crescent along lateral edge of flap to "fit" flap into alar groove. This is the "crescent" of the crescentic advancement flap (Video 15.10). For advancement flaps at other locations, a Burrow's triangle may be excised in lieu of the crescentic excision to address length discrepancies after flap placement.

- a. Note the incised edge of the alar groove is visualized multiple times before crescent is incised (measure twice, cut once).
- b. Again, incisions are made with scalpel perpendicular to skin surface.

IX. Restoration of nasal valve

a. This is an essential part of any flap in this location. Without restoration of the valve, the patient will experience permanent, noticeably decreased air flow through the ipsilateral nasal airway.

b. The first demonstrated attempt at valve restoration is too lateral. When asked to inspire with the contralateral nasal airway obstructed, the patient still experiences ipsilateral compromised flow. The suture was removed, as was the more medial buried suture to allow adequate access to the valve area (Video 15.11).

c. The second demonstrated attempt at valve restoration is in the appropriate location (Video 15.12). It is accomplished with a "three-bite" suture placement that combines a traditional buried dermal suture with a bite of the floor of the defect at approximately the posterior border of the juncture of the upper lateral cartilage (lateral process of septal nasal cartilage) and the lower lateral cartilage (lateral crux of major alar cartilage). This essentially reattaches the lateral wall of the nasal vestibule to the overlying skin, thus re-establishing the valve function.

d. Test the valve function by having the patient inspire through his nose while obstructing the contralateral nasal airway. You can also visualize the valve function by observing the nasal vestibule during inspiration from the swimmer's (worm's eye) view.

X. Cutaneous "tacking" suture is removed and replaced by a dermal suture. Notice the muscle is incorporated into the stitch (Video 15.13).

- XI.** The ala and apical triangle of the lip are lifted back into position using dermal sutures. These should be placed such that the lateral (flap) bite is shallower than the medial (alar/lip) bite to facilitate this “lift” (Video 15.14).
- a. Further dermal suture placement with attention to re-establishing muscle apposition (Video 15.14).
- XII.** Superior standing cone excision and repair followed by trimming of tip (Video 15.15).
- XIII.** Cutaneous suture placement
- a. Flap tip should be sutured using simple interrupted technique. Superior and lateral/inferior incisions may be sutured with a running or running-locked technique.
 - b. All sutures should be placed to finesse the skin edges into perfect approximation with an emphasis on eversion of edges.
- XIV.** “Milking” of flap to express any collected blood and ensure flap apposition to wound bed (Video 15.16).
- XV.** Immediate postoperative views of the repair (Video 15.17).

Postoperative care and follow-up

Postoperative care is similar for all flaps. A firm pressure dressing is critical in reducing complications. Patients are instructed to remove the dressing gently after few days, and apply petroleum jelly to the wound daily. An exhaustive review of this subject can be found in Chapter 58. Generally, follow-ups are scheduled in few weeks and then few months postoperatively.

Prevention and management of complications

Complications, and their prevention and management are similar for all flaps. Hematoma/bleeding, infections, dehiscence, flap necrosis, and distortion of regional anatomy are potential complications. Given the broad pedicle of an advancement flap, necrosis is less likely in comparison to other flaps. An exhaustive review of this subject can be found in Chapter 12.

Rotation flaps

Bichchau Michelle Nguyen and S. Brian Jiang

Rotation flap is one of the three major types of random-pattern flaps useful for repair of wounds in areas with limited elasticity that are not well suited for granulation, linear closure, or graft. This flap is most commonly used in the reconstruction of defects on the scalp, lateral forehead, temples, middle portion of the cheek, and nose. The advantages of a rotation flap include (a) low rate of flap failure; (b) decreased risk of “trap-door” effect compared with transposition flaps; and (c) simple flap design that can be modified as needed to recruit more tissue movement. However, rotation flap can produce long curvilinear scars that, unless hidden in cosmetic unit lines or resting skin tension lines (RSTL), can be more obvious than linear or angulated scars on the face.

Classic rotation flap

In a classic rotation flap design, the incision line is created along an arc to repair the primary defect. The curvature and length of the arc depend on several factors including defect size, elasticity and mobility of donor skin, and overall cosmesis and function of repaired structure. In general, the designed arc should be three to four times the area of the primary defect.¹⁷ The design may also be modified to respect cosmetic units, to hide incisions within available RSTL or a junction line, or to avoid tension on free margins such as the eyelid or nasal ala.

In Figure 15.9, ABC represents the primary defect, arc BD represents the arc of the flap, and DE represents the

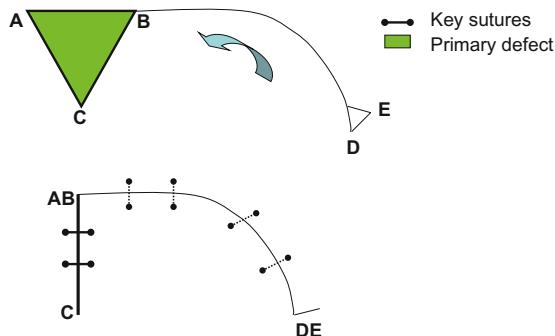


Figure 15.9 Classic rotation flap.

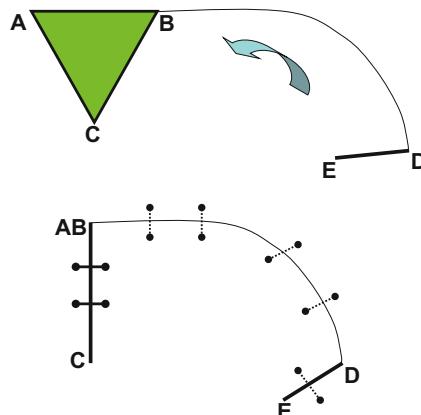


Figure 15.10 Rotation flap with a back-cut.

Burow's triangle necessary to remove the standing cone at D. Note that the flap BCD is three to four times the size of the primary defect.

After an incision is made along arc BD, undermining is performed along the arc and the primary defect. The flap is elevated and rotated toward primary defect ABC. With appropriate flap design and adequate undermining, point A and B should meet under minimal tension. Key sutures approximate AC and BC. The secondary defect created by rotation of the flap can then be repaired with simple side-to-side closure. Puckering can be reduced with rule of halves suturing or removal of Burow's triangle at any point along arc BD. Finally, a tip stitch is used to secure AB. Usually, the flap and primary defect do not match up in shape perfectly, requiring some trimming of the flap to fit the primary defect.

Rotation flap with a back-cut

If there is inadequate tissue movement, arc BD may be extended along the same curvature or back-cut into the pedicle. As shown in Figure 15.10, back-cut DE will facilitate increase rotation and advancement of the flap CBDE without further extension of arc AD. However, increasing lengths of back cut will lead to decreasing size of pedicle CE and thus increase the risk of flap failure. In addition, the back-cut will also alter the shape of the secondary defect and will lead to more complex closure of this defect.¹⁷

Dorsal nasal flap

The dorsal nasal flap utilizes the tissue reservoir at the glabella to cover the primary defect at a more distal site on the nose dorsum and tip.¹⁸ The arc incision often starts beyond the edge of the primary defect to ensure adequate tissue movement and coverage. It is then extended proximally along the lateral bridge of the nose up to the vertical glabella rhytides, where a back-cut is made to facilitate tissue rotation. The glabellar defect can be closed first to help push the tissue distally into the primary defect. Key sutures approximate primary defect with tip of flap, which may require trimming and thinning to fit the contour of the nose dorsum or tip.¹⁹ Remaining secondary defects are closed side-to-side. Final scars are often hidden in the glabellar folds and shadows of the lateral nasal bridge, shown in Figure 15.11.

Bilateral rotation flap

In contrast to the classic rotation flap, the bilateral rotation flap (Figure 15.12) recruits tissue from two separate sides of the primary defect.²⁰ The design of each arm in the bilateral rotation flap is based on the same principles as designing a single rotation flap. In some cases, difference in tissue elasticity and mobility of the two donor

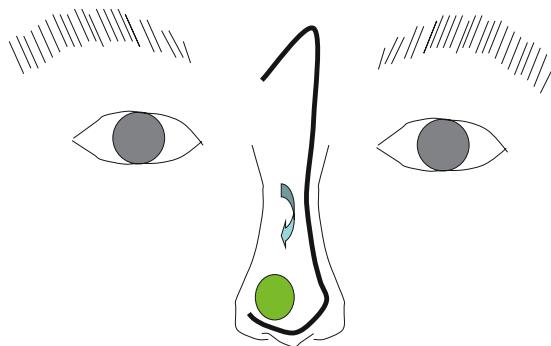


Figure 15.11 Dorsal nasal flap or Rieger's flap.

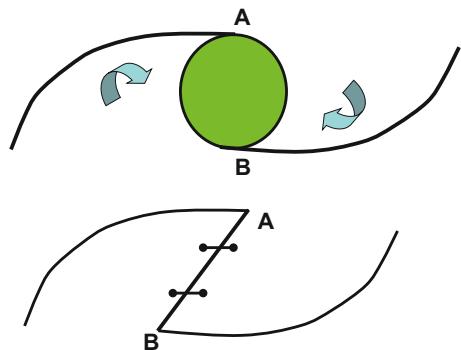


Figure 15.13 O-Z rotation flap.

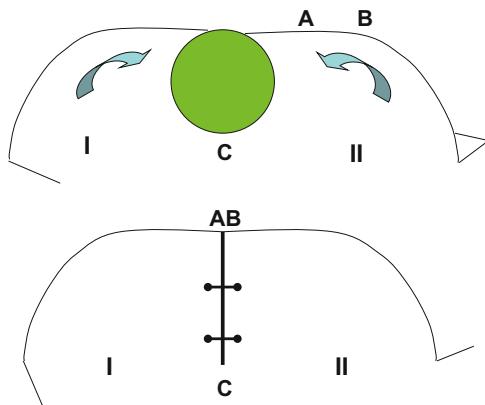


Figure 15.12 Bilateral rotation flap.

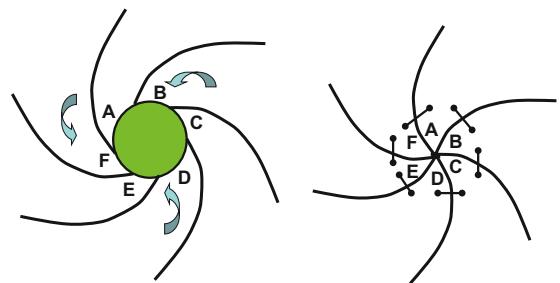


Figure 15.14 Pinwheel rotation flap.

sites may lead to differing size and curvature of each half of the bilateral rotation flap. The resulting secondary defects will also differ in size, shape and methods of closures.

Incisions are made along the two arcs with appropriate undermining. Flaps are elevated and brought together centrally with key sutures placed to approximate AC with BC. Repair of the two secondary defects follow.

O-Z rotation flap

In an O-Z rotation flap (Figure 15.13), a modified version of the bilateral rotation flap, the flap pedicles are

positioned on opposite sides of the central defect. Location of the tips along the circumference of the central defect determines the degree of rotation and advancement of the two resulting flaps, and placement of the final central scar limb. If the tips are placed at 12 and 6 o'clock on a circular defect, the central limb will be oriented more vertically. If the tips are placed 3 and 9 o'clock, the flaps undergo more rotation and result in a more horizontally oriented central limb. Another consideration in designing the flap is the size of the tips, which is dictated by the curvature of the arc at its initiation point on the circumference of the primary defect. Narrow tips have increased risk of tip necrosis.

After the flaps have been incised, undermined and elevated, key sutures are placed to approximate AB on opposite sides of the primary defects. Secondary defects are closed with side-to-side closure. Excessive tip tissue is trimmed off.

Pinwheel rotation flaps

For large defects, particularly those on scalp, more than two rotation flaps may be needed to increase tissue mobility.²¹ A pinwheel rotation flap is a version of O-Z rotation flap where multiple arcuate incisions are made,

resulting in three or more flap segments that can be brought together to close the primary defect, shown in Figure 15.14. Key sutures bring together the tips of opposing flap segment with excessive tip tissues trimmed off. Side to side closures approximate neighboring flap segments.

Transposition flaps

Katharine Arefiev and Hayes B. Gladstone

Introduction

Transposition flaps are random pattern flaps (do not rely on a named artery for perfusion) that make use of adjacent skin laxity to close a defect. They differ from rotation flaps due to the fact that the flap is rotated over an intact area of skin (i.e. transposed) to close the primary defect.

Transposition flaps take advantage of adjacent laxity thereby redirecting, redistributing and reducing tension vectors. Compared to rotation or advancement flaps, transposition flaps can take skin further away from the primary defect and thus take advantage of laxity not directly adjacent to the defect.

The most frequently utilized transposition flaps are the rhombic and bilobed flaps. The rhombic flap was first described by Limberg in 1946²² and since then variations have been introduced including the Webster and Dufourmental rhombic flaps. These flaps take advantage of shorter pivotal angles thereby reducing tension. A further practical modification of the rhombic flap^{23,24} does not require converting the primary defect into a rhombus and thus avoids removal of tissue from the primary defect, and with its circular design it does not limit you to the eight flap positions of the traditional rhombic flap (Figure 15.15a–d).

The bilobed flap was initially described by Esser in 1918 but not until 1989 was it modified and popularized by Zitelli.^{25,26} Since then it has become a staple in facial reconstruction, especially in the repair of defects on the lower third of the nose (Figure 15.16a–c). The concept of the bilobed flap has further been expanded to the trilobed flap²⁷ allowing the recruitment of potentially more mobile skin distal to the defect.

Preoperative care

It is important to anticipate and prevent complications that may impair flap viability and cosmetic outcome. Postoperative bleeding and hematoma formation can cause dehiscence, delayed healing and increased risk of infection, all of which may lead to further complications and a poor cosmetic outcome. Tobacco use increases the risk of tissue ischemia and is associated with delayed wound healing. Therefore it is important to be aware of tobacco use and all medications your patient is taking and advise them to stop smoking and avoid all non-medically necessary medications and herbal supplements with anticoagulant activity (e.g., aspirin, NSAIDS, vitamin E) at least 7 days prior to the planned procedure. Knowledge of patient comorbidities such as diabetes, coagulopathy, immunosuppression, and prior surgical or radiation treatment of the surgical site allows anticipation of potential impaired wound healing and thus may affect the choice of repair.

Step-by-step surgical technique

The cornerstone to designing a transposition flap is to understand the tension vectors. It must be designed so that the main tension vectors do not distort a free margin such as the nasal ala, eyelid or lip. The key to executing the transposition flap is excising the Burow's triangle which will aid in mobilization of the flap, and wide undermining which will also promote movement, but also reduce the risk of the trapdoor deformity. Making



Figure 15.15 (a) Mohs defect on the right temple. (b) The design of the rhombic flap. (c) Rhombic flap completed. (d) Three months postoperative.

the flap slightly smaller than the defect – as long as there is not distortion of adjacent skin or structures – may also reduce pincushioning.

Rhombic flap

I. Determine the reservoir of skin that will enable closure of the flap's secondary defect

II. The limbs of the flap can be drawn at any point along a circular defect as long as the resulting tension vector does not distort a free margin

III. The initial limb is the same length as the diameter of the defect, and should bisect the defect

IV. The second adjoining limb that constitutes the flap is drawn at a 60° angle from the first limb. The limbs are of equal length.

V. A Burow's triangle should be drawn at the opposite pole of the defect from where the flap will move into the defect

VI. Two small triangles should be drawn at each corner of the circular defect in order to "square" the defect, This



Figure 15.16 (a) Mohs defect on right ala. (b) Bilobed flap completed. (c) Three months postoperative.

maneuver will enable the flap to fit into the defect, and may reduce trapdooring due to unequal wound contraction rates.

VII. The flap is incised and the burrows triangle and corners are excised.

VIII. Wide undermining is performed

IX. The key buried suture at the base of the secondary defect created by the flap is performed. This represents the greatest tension of the flap. It also helps in the movement of the flap into the defect.

X. The next buried suture will be placed into the distal corner.

XI. The distal side is then sutured which serves to position the flap and reduce potential trimming of the proximal side.

XII. The proximal (to the incised flap) corner is then sutured, and buried sutures are placed around the flap.

XIII. A running epidermal suture is then placed.

Postoperative care and follow-up

Provide detailed written postoperative instructions including specifics regarding dressing changes, cleansing, and when to seek medical attention. Most surgeons advise leaving the initial pressure dressing in place for 24–48 hours then change the dressing (liberal layer of ointment, non-stick dressing, then adhesive layer) daily for 2 weeks. If non-absorbable epidermal sutures have been placed, they should be removed in 5–7 days to avoid tram-track scarring on the face. Sutures on the trunk and scalp may be left in place for 10–14 days.

Prevention and management of complications

Careful planning including selection of appropriate flap for anatomic area with regards to fixed anatomic

structures and proper design and marking of the flap is of paramount importance in preventing complications. Despite this, complications occur to even the most experienced surgeons, therefore knowing how to manage complications is essential. Table 15.2 contains a brief

summary on the prevention and management of some common complications.^{28–30} Though scar revision has been advocated at two months, we wait 3 months to allow for further scar maturation. However, if there is obvious pincushioning which may occur as soon as one month, it

Table 15.2 A summary on the prevention and management of some common complications

Primary dehiscence	Ensure flap is sized appropriately for defect	If flap does not fill the primary defect despite wide undermining of wound edges and base of pedicle, you can leave a small area to granulate or place a FTSG.
Excessive tension along suture lines	Wide undermining of pivotal and lateral restraints	
Premature removal of sutures	Appropriate subcutaneous and epidermal sutures Minimize rotation angles	Allow dehisced area to heal by secondary intent if >24 hours from surgery
Secondary dehiscence	Avoidance of non-medically necessary anticoagulants and alcohol a week prior to and post surgery	Early recognition and evacuation of hematomas is necessary to prevent dehiscence, necrosis, and infection. Small hematomas may be removed via a large bore needle with suction on a syringe, while larger hematomas may require taking down the flap to remove the hematoma and packing of the cavity. Empiric antibiotics should be considered. Allow secondarily dehisced areas to heal by secondary intent.
Hematoma	Sterile surgical technique	
Infection	Diligent intra-operative hemostasis of wound bed and all undermined areas	
	Perform a layered closure; close dead space	
	Apply a pressure bandage for 24 to 48 hours postop	
Necrosis (tissue ischemia)	No smoking at least one week prior and two weeks after surgery	Tissue necrosis frequently affects the tip/distal portion of the flap, and is often confined to the epidermal layer. If no clinical signs of secondary infection, the eschar can be left in place to act as a biologic dressing. Allow full thickness necrosis to heal via secondary intent. Necrosis of wound edges may be addressed by removing epidermal sutures
Hematoma	Handle tissue carefully to avoid crush injury	
Infection	Ensure base of pedicle appropriate for length (usually 1:2–4)	
Excessive tension	Minimize rotation/pivotal angle so not to compromise vascular supply in base	
Smoking	Ensure base has appropriate vascular supply (do not dissect superficially)	
Intraoperative tissue damage	Avoid tension in epidermal sutures	
Pincushion/trap door deformity	Wide undermining	Intralesional triamcinolone may be utilized to cause SQ atrophy and thus even out height discrepancy. Dermasanding may also be used, and is additionally useful for smoothing out surface irregularities. Massaging the affected area encourages lymphatic drainage and may help prevent excessive tissue contracture. Evacuate seromas with a large bore needle on a syringe
Oversized flap	Trim excessive SQ fat	
Excessive SQ fat	Trim oversized flaps	
Lymphedema	Consider using an absorbable buried tacking suture, especially if flap is positioned over a concavity	
Seroma	Design flap so that base of pedicle is inferiorly positioned to allow favorable lymphatic and venous drainage	
	Use geometric lines to prevent circumferential contraction and thus elevation of the flap	
Distortion of fixed anatomic structure	Wide undermining	Tissue swelling from local anesthetic and edema may temporarily pull on a free edge such as eyelid, lip, or nasal ala causing distortion but after this initial swelling goes down, the free edge is released. Gentle massaging of the affected area also helps to reduce swelling and encourage softening of scar tissue. Surgical revision (e.g., z-plasty) may be required, especially when ectropion occurs as aside from a cosmetic concern, there are adverse functional side effects
Tension vectors	Be aware of adjacent fixed anatomic structures and design flap to avoid tension vectors that pull/distort them	
Scar contracture		

FTSG, full-thickness skin graft; SQ, subcutaneous.

should be treated. Initial treatment may be with triamcinolone injections, but may require surgical intervention. Patients should be counseled that scars continue to improve, and not until 1 year can you final appearance.

Intralesional triamcinolone can be used for hypertrophic scarring. Pulsed dye laser can be used to reduce erythema. Widened scars may be excised or treated with fractional photothermolysis.

Subcutaneous island pedicle flap

Michael P. McLeod, Sonal Choudhary, Marilyn Zabielinski, and Keyvan Nouri

Introduction

An island pedicle flap, also known as the V-Y advancement flap, is a cutaneous flap in which the entire perimeter is incised and completely separated from the surrounding skin.³¹ A small vascular supply or in some circumstances underlying muscle, is left intact underneath or inferior to the flap. This is known as the pedicle.

It is especially useful for repairing defects in the perioral region, or more specifically the upper lateral lip and lateral nasal defects.³² In this region, the tissue is well vascularized allowing for a relatively small vascular pedicle. An understanding of the cutaneous anatomy as well as the anatomy of the surrounding area is essential.

The thicker the pedicle, the greater the flap can be mobilized due to the fact that the pedicle can be narrowed without decreasing the blood supply below a critical level at which the flap is undersupplied by blood.

Subcutaneous island pedicle flap

- I. An infralateral incision should be made in the shape of a triangle to the subcutaneous tissue.
- II. The area underneath of the flap is dissected so that a small vascular pedicle is supplies the flap.
- III. The next step is to undermine the flap, donor skin, and defect so that the wound edge can be easily everted during closure.
- IV. A circular defect should be squared before the triangular flap is advanced so that the edges evenly line up. For repairing Mohs' defects, the beveled edges should be removed.
- V. The triangular flap is advanced into the defect
- VI. The flap and secondary defect is sutured into place in a layered fashion

Cutaneous anatomy pertinent to performing a subcutaneous island pedicle flap

- I. Vertical perforators originate from the muscle and supply the axial blood vessels
- II. Axial blood vessels form a horizontal network located in the superficial fascia as well as the subcutis tissue
- III. Subdermal plexus is supplied by the axial blood vessels and perforates upwards through the subcutis to the skin

Preoperative considerations

The length of the pedicle flap should be at least three times greater than the diameter of the defect being repaired.

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Video list

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Video 15.2 Flap design

Video 15.3 Undermining the defect

Video 15.4 Flap incision

Video 15.5 Undermining the flap

Video 15.6 Tethering may occur at the lateral nasal bone

Video 15.7 Debeveling the defect

Video 15.8 Key suture

Video 15.9 Evaluation for free margin distortion

Video 15.10 Excision of the crescent

Video 15.11 Attempt to restore nasal valve

Video 15.12 Restoration of nasal valve

Video 15.13 Removal of a cutaneous tacking suture

Video 15.14 Placement of dermal sutures

Video 15.15 Excision of the superior standing cone and trimming of tip

Video 15.16 “Milking” the flap

Video 15.17 Immediate postoperative views of the repair

CHAPTER 16

Reconstruction of the nose

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Introduction

The importance of the nose to facial harmony has been well recognized throughout history, and nasal mutilation as a form of humiliation or punishment dates back to 1500 BCE, when Prince Lakshmana in India deliberately amputated the nose of Lady Surpunakha. King Ravana arranged for the reconstruction of Lady Surpunakha's nose by his physicians, documenting one of the earliest accounts of nasal reconstruction in India.¹ The historical account of nasal reconstruction in premodern times is well established, and myriad advancements have been made during the last few decades. This chapter will focus on repair of superficial nasal defects following extirpation of cutaneous malignancies; however, the principles discussed can often be applied to other forms of nasal surgery.

Cutaneous restoration for nasal defects that result from the removal of skin malignancies can be addressed through a number of options, including healing by secondary intention, primary closure, local and regional flaps, skin grafts, and composite grafts. Occasionally, cartilage grafts or subcutaneous augmentation flaps are also necessary to establish appropriate framework support and contour match with the tissue surrounding the defect. Selection of the optimal reconstructive method is influenced by the size, depth, and location of the facial defect. Finally, paramount to a successful reconstruction is appropriate assessment and treatment of any existing or potential functional compromise. As the gateway to the respiratory system, the nose warms, humidifies, and

filters the air while allowing inhaled particles to come into contact with olfactory epithelium. Disruptions of normal nasal anatomy can impair nasal function and lead to complaints of nasal obstruction, nasal drainage, and compromised olfaction.

Nasal Anatomy

Addressing deficiencies of the external soft-tissue envelope, nasal framework, and internal mucosal lining is an important part of achieving an optimal aesthetic and functional outcome, and a thorough understanding of nasal anatomy is essential to successful nasal reconstruction. Given that the focus of this chapter is on restoration of superficial nasal defects, the anatomic discussion will concentrate on the relevant cutaneous, structural, and functional anatomy.

Cutaneous layer

The external nose consists of overlying skin, soft tissue, blood vessels, and nerves. Understanding the variations in skin thickness between different regions of the nose is an essential aspect of reconstructive nasal surgery. Skin thickness varies widely between individuals and between aesthetic units in any given individual. Lessard and Daniel² analyzed 60 cadaver dissections and 25 patients undergoing septorhinoplasty and found the average skin thickness to be greatest at the radix (1.25 mm) and least at the rhinion (0.6 mm). Skin is thinner and more mobile over the dorsum, while it is thicker and more adherent to

the underlying nasal framework at the nasal tip and alae. Despite thicker skin at the nasal tip, the skin rapidly transitions to very thin skin covering the nostril margins and columella. The close approximation of the dermis of the skin lining and covering the nostril margins makes these areas especially vulnerable to notching and contour irregularities following reconstruction.³

Subcutaneous layer

There are four layers composing the soft tissue between skin and the bony cartilaginous skeleton of the nose. These are the (1) superficial fatty panniculus, (2) fibromuscular layer, (3) deep fatty layer, and (4) periosteum/perichondrium.⁴ The superficial fatty panniculus is located immediately below the skin and consists of adipose tissue with interlacing vertical fibrous septae running from the deep dermis to the underlying fibromuscular layer. This layer is thicker in the glabellar and supratip areas. The fibromuscular layer contains the nasal musculature and the nasal subcutaneous muscular aponeurotic system (SMAS), which is a continuation of the facial SMAS. Histologically, the nasal SMAS is a distinct sheet of collagenous bundles that envelops the nasal musculature. The deep fatty layer located between the SMAS and the thin covering of the nasal skeleton contains the major superficial blood vessels and nerves. This layer of loose areolar fat has no fibrous septae; as a result, immediately below it is the preferred plane for undermining nasal skin. The nasal bones and cartilages are covered with periosteum and perichondrium, which provide nutrient blood flow to these respective tissues. The periosteum of the nasal bones extends over the upper lateral cartilages and fuses with the periosteum of the piriform process laterally.⁵ Perichondrium covers the nasal cartilages, and dense interwoven fibrous interconnections can be found between the tip cartilages.

Muscles

The nasal musculature has been described and classified by Greisman and Letourneau.⁶ The greatest concentration of muscle is located at the junction of the upper lateral and alar cartilages. This allows for muscular dilation and stenting of the nasal valve area. All nasal musculature is innervated by the zygomaticotemporal division of the facial nerve.⁷

The elevator muscles include the procerus, the levator labii superioris alaeque nasi, and the anomalous nasi.

These muscles rotate the nasal tip in a cephalic direction and dilate the nostrils. The procerus muscle has a dual origin. The medial fibers originate from the aponeurosis of the transverse nasalis and the periosteum of the nasal bones. The lateral fibers originate from perichondrium of the upper lateral cartilages and the musculature of the upper lid. The procerus inserts into the glabellar skin. The levator labii superioris alaeque nasi originates from the medial part of the orbicularis oculi and ascending process of the maxilla while inserting into the melolabial fold, ala nasi, and skin and muscle of the upper lip. The anomalous nasi originates from the ascending process of the maxilla and inserts into nasal bone, upper lateral cartilage, procerus, and the transverse part of the nasalis.⁷

The depressor muscles include the alar nasalis and the depressor septi. These muscles lengthen the nose and dilate the nostrils. The alar nasalis muscle originates from the maxilla above the lateral incisor tooth and inserts in the skin along the posterior circumference of the lateral crura. The depressor septi nasi originates from the maxillary periosteum above the central and lateral incisors and inserts into the membranous septum and the footplates of the medial crura. A minor dilator muscle is the dilator naris anterior, a fanlike muscle originating from the upper lateral cartilage and alar portion of the nasalis before inserting into the caudal margin of the lateral crura and lateral alar skin.

The compressor muscles rotate the nasal tip in a caudal direction and narrow the nostrils. These muscles include the transverse portion of the nasalis and the compressor narium minor. The transverse portion of the nasalis muscle originates from the maxilla above and lateral to the incisor fossa. Fibers from the transverse portion insert into the skin and procerus, while some fibers join the alar portion of the nasalis muscle. The compressor narium minor arises from the anterior part of the lower lateral cartilage and inserts into the skin near the margin of the nostrils.⁷

External blood supply

Both the internal and the external carotid arteries contribute to the superficial arterial supply of the nose and adjacent area. The angular artery arises from the facial artery and provides a rich blood supply for the melolabial and subcutaneous hinge flaps. A branch of the angular artery, the lateral nasal artery, supplies the lateral surface of the caudal nose. The lateral nasal artery passes deep to

the nose in the sulcus between ala and cheek and is covered by the levator labii superioris alaeque nasi. The artery branches multiple times to enter the subdermal plexus of the skin covering the nostril and cheek.

The dorsal nasal artery, a branch of the ophthalmic artery, pierces the orbital septum above the medial palpebral ligament and travels along the side of the nose to anastomose with the lateral nasal artery. The dorsal nasal artery provides a rich axial blood supply to the dorsal nasal skin, and serves as the main arterial contributor to the dorsal nasal flap.

The nostril sill and columellar base are supplied by branches of the superior labial artery. A branch of the superior labial artery, the columellar artery, ascends superficial to the medial crura and is transected with a transcolumnellar incision during an external rhinoplasty approach.

In addition to the columellar artery, the nasal tip is supplied by the external nasal branch of the anterior ethmoidal artery. The anterior ethmoidal artery, a branch of the ophthalmic artery, pierces bone on the medial wall of the orbit at the point where the lamina papyracea of the ethmoid bone articulates with the orbital portion of the frontal bone (frontoethmoid suture). The vessel enters the ethmoid sinuses to supply the mucosa and sends branches to the superior aspect of the nasal cavity. The external nasal branch of the anterior ethmoidal artery emerges between the nasal bone and the upper lateral cartilage to supply the skin covering the nasal tip. The nasal tip blood supply also has contributions from the lateral nasal artery, a branch of angular artery.

The venous drainage of the external nose consists of veins with names that correspond to the associated arteries. These veins drain via the facial vein, the pterygoid plexus, and the ophthalmic veins.

External sensory nerve supply

The sensory nerve supply of the nasal skin is supplied by the ophthalmic and maxillary divisions of the fifth cranial nerve. Branches of the supratrochlear and infratrochlear nerves supply the skin covering the radix, rhinion, and cephalic portion of the nasal side walls. The external nasal branch of the anterior ethmoidal nerve emerges between the nasal bone and the upper lateral cartilage to supply the skin over the caudal half of the nose. The infraorbital nerve provides sensory branches to the skin of the lateral aspect of the nose.

Nasal skeletal anatomy

The nasal framework consists of both bony and cartilaginous components. The caudal third of the nose consists of the lobule (tip), columella, vestibules, and alae. It is structurally supported by paired alar (lower lateral) cartilages, the caudal septum, accessory cartilages, and fibrous fatty connective tissue. The variable configuration of the nasal tip is dependent on the size, shape, orientation, and strength of the alar and septal cartilages, and by the quality and thickness of overlying soft tissue and skin. The alar cartilages are attached to the upper lateral cartilages and the septum, and they provide the majority of support for the tip. The vestibule is bounded medially by the septum and columella and laterally by the alar base. It contains a protruding fold of skin with vibrissae, and terminates at the caudal edge of the lateral crus.

The alar cartilage is subdivided into medial, intermediate, and lateral crura. The medial crus consists of the footplate and columellar segments. The footplate is more posterior and accounts for the flared portion of the columellar base. The columellar segment begins at the upper limit of the footplate and joins the intermediate crus at the columellar breakpoint. The breakpoint represents the junction of the tip with the columella. The appearance and projection of the columella are influenced by the configuration of the medial crura as well as the caudal septum. Intervening soft tissue between the columellar segments of the medial crura may fill this space; however, patients with thin skin may have a bifid appearance of the columella.

The intermediate crus consists of a lobular and domal segment. In the majority of noses, the cephalic borders of the lobular segment are in close approximation and the caudal margins diverge.⁸ The intermediate crura are bound together by the interdomal ligament, and lack of intervening soft tissue may give the supratip area a bifid appearance. On lateral view, the internal structure responsible for the prominence of the tip defining point or pronasale is the cephalic edge of the domal segment of the intermediate crus. Thus, the shape, length, and angulation of the intermediate crura determine the configuration of the infratip lobule and the position of the tip defining point. The supratip breakpoint represents the junction between the intermediate crus and the lateral crus.

The lateral crus is the largest component of the alar cartilage and provides support to the anterior one half of

the alar rim. Resection or weakening of the lateral crus predisposes to alar retraction and notching, an important consideration in nasal reconstruction. Laterally, small sesamoid cartilages are interconnected by a dense, fibrous connective tissue that is contiguous with the superficial and deep perichondrium of the upper lateral cartilage and lateral crus. Inferolaterally, the ala contains fat and fibrous connective tissue, but no cartilage. The shape and resiliency of the nostril depends on the dense fibrous fatty connective tissue located within the confines of the ala, and the integrity of this area should be restored with cartilage grafting when necessary.

The cartilaginous dorsum consists of paired upper lateral cartilages and the cartilaginous septum. The upper lateral cartilages are overlapped superiorly by the bony framework for a variable distance. The free caudal border of the nasal bones has fibrous connections to the cephalic margin of the upper lateral cartilages. The cephalic two thirds of the cartilaginous dorsum is a single cartilaginous unit. However, caudally there is gradual separation of the upper lateral cartilages from the septum. The lateral borders of the upper lateral cartilages are rectangular in shape and are connected to the piriform aperture by an aponeurosis.⁸ The lateral border of the upper lateral cartilage creates a space known as the external lateral triangle. This space is bordered by the lateral edge of the upper lateral cartilage, the extreme lateral portion of the lateral crus, and the edge of the piriform fossa. The space is lined by mucosa and covered by the transverse portion of the nasalis muscle. It may contain accessory cartilages and fibrous fatty tissue that contribute to the lateral aspect of the internal nasal valve. Nasal obstruction may occur from medialization of this space by scar tissue and/or cartilage grafts used in nasal reconstruction.

The bony dorsum consists of paired nasal bones and paired ascending processes of the maxillae. The bony vault is pyramidal in shape, and the narrowest part is at the level of the intercanthal line. The bony dorsum is divided approximately in half by the intercanthal line, and the nasal bones are much thicker above this level.⁹ The sellion is the deepest portion of the curve of soft tissue between the glabella and nasal dorsum and marks the level of the nasofrontal suture line. The nasion is approximately at the level of the supratarsal fold of the upper eyelid. Laterally, the nasal bones articulate with the ascending processes of the maxillae.

Internal nasal anatomy

A brief description of the internal nasal anatomy pertinent to nasal reconstruction is provided below. Partitioned by the septum, the nose provides two independent passages between the nostrils and the nasopharynx. Each passage is circumferentially lined with ciliated pseud stratified columnar epithelium.

The nasal cavities begin at the limen nasi, which represents the junction between the vestibule, lined with squamous epithelium, and the nasal cavities, lined with respiratory epithelium.

Along the lateral aspect of the nasal passages, the turbinates create a complex of mucosally lined peaks and valleys into which drain the ostia of the paranasal sinuses and the nasolacrimal duct. The superior aspect of the hard palate creates the floor of each nasal passage. The nasal roof is the underside of the nasal pyramid and increases in vertical height anteroposteriorly from the nostril to skull base. From this point, it decreases in height as it extends posteriorly along the face of the sphenoid to the choanal opening of the nasopharynx. The narrowest portion of each nasal passage is at the caudal margin of the upper lateral cartilage, an area referred to as the internal nasal valve.

The septum is constructed of bone posteriorly and cartilage anteriorly. Septal cartilage can be harvested for use as a cartilage graft in nasal reconstruction. The septum provides support to the nasal dorsum and tip, and a supporting L-shaped strut of caudal and dorsal septum should be preserved to maintain this support. The cartilaginous septum is covered on both sides by a thin but highly vascular layer of mucoperichondrium. An ideal plane of dissection is located between the cartilage and mucoperichondrium. The septal cartilage is however dependent on the mucoperichondrial lining for its blood supply. Septal cartilage lacking mucoperichondrium on both sides will eventually undergo necrosis. When mucoperichondrium is present on one side of the septal cartilage, the cartilage is likely to survive.

The blood supply to the septum consists of the septal branch of the superior labial artery, branches of the anterior and posterior ethmoidal arteries, and the posterior septal branch of the sphenopalatine artery. Arising from the facial artery, the superior labial artery travels through the orbicularis oris at the level of the vermillion border roll. Lateral to the philtrum column, it gives off a septal branch that passes almost vertically upward and enters

the nasal septum lateral to the nasal spine. It may travel on the cartilaginous septum as a discrete vessel before finally dispersing into the anterior septal vascular plexus. Given this arterial supply, a flap of septal mucoperichondrium can survive based on a pedicle located in the area between the anterior plane of the upper lip and the lower edge of the piriform aperture. This hinged mucoperichondrial flap may extend from the nasal floor superiorly to the level of the medial canthus and posteriorly to beyond the junction of the cartilaginous septum with the bony septum. Septal flaps based on the septal branch of the superior labial artery may be used to line full-thickness ipsilateral lower nasal vault defects.¹⁰

The internal nasal valve is the cross-sectional area bordered by the septum and the caudal margin of the inferior turbinate and upper lateral cartilage. This area may be compromised during cutaneous tumor resection by removal or weakening of its structural components. In addition, scar contracture resulting from nasal reconstruction may contribute to partial valve collapse unless preventive measures are performed at the time of surgery. If valve compromise is anticipated, structural cartilage grafts and/or suspension sutures are employed to reinforce and support the valve.

Nasal aesthetic units

The nose may be divided into aesthetic units by contour lines which mark zones of transition between nasal skin of differing texture and thickness. Aesthetic units consist of the nasal dorsum, sidewalls, tip lobule, nasal facets, alae, and columella. These units are highlighted when incident light is cast upon the nasal surface creating shadows along the borders of each unit and topographic landmark.¹¹ The framework underlying the nasal skin is primarily responsible for these variations in light reflections. Therefore, precise restoration of the framework is important in reconstruction of the nose to avoid contour irregularities and asymmetries. In addition, repair of nasal skin defects with a covering flap of appropriate thickness and orientation will help maintain the definition of aesthetic units and anatomic landmarks.

Patient preparation

Systemic diseases such as diabetes, malnutrition, arteriosclerosis, hypertension, and collagen vascular disease can

compromise flap vascularity and lead to necrosis and impaired wound healing during nasal reconstruction. Consulting with the patient's personal physician is important to ascertain that the patient's medical condition is optimized during the perioperative period.

Patients with a history of irradiation have subcutaneous scar tissue and decreased vascularity of the skin in the irradiated area. Cutaneous flaps from adjacent non-irradiated tissue are preferred, but even then healing may be compromised leading to poor outcome. When interpolated flaps are transferred to an irradiated area, detachment of the flaps is best delayed until revascularization of the flap is certain. For suitable candidates, consideration is given to hyperbaric oxygen treatment to optimize tissue oxygenation levels prior to reconstruction.

Patients are questioned preoperatively concerning their use of tobacco and alcohol. Heavy alcohol consumption will dilate blood vessels, predisposing to hematoma formation. Avoidance of alcohol during the perioperative period is recommended. Ideally, tobacco and nicotine products should be avoided, at least 8 weeks before and after surgery. Nicotine causes systemic vasoconstriction through activation of the adrenergic nervous system which lowers tissue oxygenation pressure. Smoking also produces carbon monoxide which has a higher affinity for hemoglobin than oxygen, thereby producing high levels of carboxyhemoglobin. Although smoking cessation is not always possible, consideration should be given to delaying complicated surgical reconstructions until smoking cessation can be assured.

Healing by secondary intention

Small superficial cutaneous defects involving concave nasal surfaces may granulate and epithelialize with an acceptable aesthetic result. Ideal locations for healing by secondary intention include the boney nasal sidewall and the lateral alar groove, where the force of wound contracture is stabilized by the underlying soft tissue and nasal framework. It is imperative to keep wounds moist during the healing phase. Wounds are cleaned twice daily, removing fibrinous debris during each cleaning. Wounds are then covered with a topical water-based ointment containing mupriocin and non-adherent gauze for the initial 2 weeks, followed by a topical petroleum-based ointment and non-adherent gauze until complete

re-epithelialization occurs. For patients with larger defects or concerns for slower wound healing, wet to dry dressings are employed daily. These patients are instructed to place a moist, but not dripping wet, gauze to the wound in the evening, followed by removal in the morning. The morning wound care is as previously described, with topical ointment application and non-adherent gauze. Patients are counseled that wounds often take 4–6 weeks to heal, and massage or other treatments may be indicated to address any contour irregularities. Patients may be offered resurfacing procedures if surface irregularities are persistent.

Defect analysis and preparation

Analysis of a facial defect includes determining the depth of the wound, the color and texture of the missing skin, and the extent of involved aesthetic units and adjacent facial regions. In addition, the defect is inspected for any missing muscle, cartilage, or internal lining, and the thickness, texture, and mobility of remaining adjacent skin are important in determining reconstructive options. Finally, paramount to a successful reconstruction is appropriate assessment and treatment of any existing or potential functional compromise, especially nasal airway obstruction related to nasal valve collapse (Box 16.1).

Defects occasionally involve more than one region of the face. When planning reconstructive options, it is helpful to demarcate the division between the primary location of the defect and the surrounding facial regions such that defects involving multiple facial regions are repaired with separate methods addressing each region. Adhering to this principle places eventual scars along lines that separate each aesthetic region, which helps preserve the natural contours of the face.

Box 16.1 Nasal defect analysis

- Nasal aesthetic units and landmarks
- Depth, size, and location of defect
- Contour and strength of underlying nasal framework
- Color, thickness, laxity of adjacent skin
- Nearby structures that cannot be distorted
- Existing or potential functional compromise

Within each region, individual aesthetic units should be identified. For example, the aesthetic units of the nose are based on variations in skin thickness and texture, as well as variations in nasal contour created by the underlying nasal framework. Optimal repair of a nasal defect may require repositioning of skin and soft tissue within an involved aesthetic unit; thereby, allowing eventual scars to lie within zones of transitions between adjacent units. In addition, small defects are often enlarged to facilitate repair of an entire aesthetic unit by a single regional flap. Often, the contralateral aesthetic unit is used for template design, to ensure appropriate symmetry after inset of the flap.

Assessment of skin thickness and mobility is another critical concern. As described earlier, the nasal skin has topographic variations in cutaneous thickness, and the location of the defect in relation to these differences is an important consideration. Defects located in areas of thinner nasal skin tend to be more amenable to local tissue advancement, given increased cutaneous mobility. Defects located in areas of thicker nasal skin tend to have decreased mobility of surrounding tissue, and are a greater concern for adjacent anatomy distortion with local tissue movement. In these situations, consideration is given to recruiting tissue from areas of greater tissue laxity to assist with cutaneous restoration.

Establishing uniform depth, while maintaining symmetry with contralateral facial units, is equally important. Beveled tissue at the periphery of the Mohs defect is removed if flaps are planned, in order to optimize eversion of skin edges at closure. In addition, cutaneous edges of the flap and the recipient tissue are trimmed appropriately to establish uniform thickness at the line of closure. Whenever possible, the primary defect should be deepened to establish uniformity rather than thinning the flap. Additional techniques helpful in optimizing repair may include angulation of curvilinear defects, since round defects are more likely to undergo concentric scar contraction and result in trapdoor deformity. Modifying the periphery of the defect by creating more acute angles often reduces the risk of this deformity. Finally, wide undermining of the recipient site is also performed to help avoid trapdoor deformity. Undermining is performed in a submuscular plane, immediately above the nasal perichondrium and/or periosteum.

For defects involving the nose, a careful assessment for nasal lining deficiencies is essential. Nasal lining

restoration can be achieved with multiple methods, and usually involves transfer of local flaps and/or grafts. Furthermore, existing or potential compromise of the nasal framework should be noted, since maintaining an appropriate cartilaginous framework is an essential component of both aesthetic and functional restoration. Plans for nasal lining and structural framework restoration need to be established prior to elevation and transfer of any cutaneous flaps, and the author's preference is to perform lining and cartilaginous restoration prior to creating a template for any anticipated interpolation flap.¹²

Anesthesia

The majority of nasal reconstruction procedures for cutaneous restoration can be performed using local anesthesia with or without intravenous sedation. All skin marking is performed prior to injection, while skin laxity can be easily determined. Subsequently, regional nerve blocks are usually employed, using a control syringe with 30 gauge needle and slow injection of anesthetic. After regional nerve block, minimal anesthetic is placed beneath the submuscular layer of the cutaneous cover, avoiding excessive injection that could lead to distortion of anatomic landmarks. Typically, 1% lidocaine with 1:100 000 epinephrine is used for anesthesia, and placement of anesthesia within the proper tissue plane is especially important to optimize hemostasis and minimize tissue distortion.

Reconstructive methods

Nasal defects are repaired using a number of options, including healing by secondary intention, primary closure, local and regional flaps, skin grafts, and composite grafts. Occasionally, cartilage grafts or subcutaneous augmentation flaps are also necessary to establish appropriate support as well as contour match with the tissue surrounding the defect. As previously mentioned, selection of the optimal reconstructive method is influenced by the size, depth, and location of the nasal defect, and this chapter concentrates on the restoration of superficial cutaneous nasal defects.

Cutaneous grafts

Occasionally, superficial nasal defects can be repaired with a cutaneous graft. Placement of a graft obviates the need for additional scars on the nose as is seen with other reconstructive methods; however, most grafts have a "patched" appearance with discrepancies in color and texture between native and grafted nasal skin. There are occasions when skin grafts are used to repair defects of the nose even when it is anticipated that the graft will result in a contour depression or noticeable color discrepancy. These situations arise when debilitated patients that have life-threatening illnesses may prefer simpler methods of reconstruction, including skin grafting. In addition, in patients that have malignancies showing aggressive growth patterns and tumor persistence or recurrence is a primary concern, skin grafts may be used as a temporary covering for a specified time interval to facilitate tumor surveillance.

Viability of skin grafts depends on several factors: blood supply and surface microcirculation at the recipient site, vascularity of donor graft tissue, contact between graft and recipient site, and presence of certain systemic illnesses. Contact between the skin graft and recipient site is essential, and a bolster dressing prevents fluid collections and shearing forces from disrupting connections between graft and wound bed. Systemic illnesses that may compromise graft survival, and use of tobacco products is also detrimental to the survival of skin grafts. Recipient site conditions that are not favorable to graft survival include irradiated tissue, excessive fibrosis, exposed bone, cartilage, or tendon. Grafts placed over avascular defects smaller than 1 cm² may survive through nutritional support via wound edges; however, grafting over avascular wounds larger than this is unlikely to succeed.¹³

For deeper wounds, skin grafting may be delayed until granulation tissue has filled the wound bed; thereby, reducing the likelihood of a contour deformity at the wound edge. In addition, delay provides an improved vascular recipient site for the graft,¹⁴ which is especially important in areas of exposed periosteum or perichondrium. The wound is cared for in a similar fashion as healing by secondary intention. Development of sufficient granulation tissue may be improved by initial placement of an acellular dermal graft wound matrix to facilitate healing of the wound bed. The acellular dermal graft wound matrix may be placed at the time of tissue

resection, and wound care is dependent on the type of acellular dermal graft employed. After development of sufficient granulation tissue, any epithelium on the surface of the granulation tissue is removed prior to grafting, and the tissue is crosshatched so that myofibrils are released. Granulating wounds normally contain bacteria, and bacterial counts greater than 10^5 organisms per gram of tissue often leads to graft loss.¹⁵ When delayed grafting is planned, the patient is started on a course of an antistaphylococcal antibiotic several days prior to grafting.

Split thickness grafts consist of epidermis and typically minimal to no underlying dermis. Split thickness grafts are typically harvested using a dermatome, and the donor site heals by secondary intention. Because of their poor color and texture match with normal skin and their tendency to contract, split thickness skin grafts are rarely used for nasal cutaneous restoration. Rather, full-thickness grafts are typically employed. Compared with split thickness, full-thickness grafts have the advantage of better color and texture match, less contour irregularities, and easier donor site wound care since the donor area is closed primarily. Disadvantages of full thickness grafts include reduced survival rate for larger grafts, especially in situations with compromised vascularity.¹³

Full-thickness skin grafts consist of epidermis and usually full-thickness dermis, although the dermal component is typically contoured based on the anatomy of the recipient site. They resist contraction, have texture and pigmentation similar to normal skin, and require a well-vascularized, uncontaminated wound site for survival. Full-thickness grafts survive initially by diffusion of nutrition from fluid in the recipient site, a process known as plasma imbibition. This is followed by vascular inoculation, which usually occurs during the first 24–48 hours. After 48–72 hours, capillaries in the recipient site begin to grow into the graft to provide new circulation. By 3–5 days, a new blood supply has been established. Initially, full-thickness skin grafts appear blanched; however, over 3–7 days a pink color develops signaling neovascularization. After 4–6 weeks, the pink color begins to fade, but the graft may remain lighter than the surrounding skin, depending on the solar exposure of the donor site.

The ideal nasal defect to repair with a full thickness skin graft is superficial, with loss of skin, but not underlying tissue. The vascularity of shallow wounds is greater

than that for defects extending through the muscle to the underlying cartilage or bone. The ideal defect is well separated from the free margin of the nostril and is located in thin-skinned areas of the nose. Shallow wounds in these areas are typically completely filled by a full thickness skin graft, thereby establishing confluent contour with the surrounding skin.

The areas of the nose covered with thicker skin include the tip, ala, nasion, and caudal aspect of the sidewalls and dorsum. Full thickness skin grafts used to repair defects of the nose in regions of thicker nasal skin tend to heal with a contour depression and noticeable textural discrepancies between graft and adjacent nasal skin. This is because the nasal skin in these areas tends to have a more sebaceous nature than the graft.

There is a wide variation of nasal skin thickness among individuals, and the overall thickness of the nasal skin is an important preoperative consideration. For similar nasal defects, a skin graft may provide a perfect match in terms of thickness for one person and a poor match for another. If a full thickness graft has been performed and a contour depression exists, the appearance may be improved by subsequent augmentation with a dermal fat graft after the skin graft has healed.

A number of donor sites for skin grafts are available in most individuals, including the upper eyelid, forehead, melolabial fold, pre-auricular, post-auricular, and supraclavicular areas. When selecting the donor site, the thickness and color of the recipient site skin is assessed, and the most optimal match in donor skin is determined. Skin from the post-auricular area is preferred in men with skin defects of limited size because it is hairless and tends to have a similar thickness to the facial skin. Because men tend to have shorter hair than women, the post-auricular skin is likely to have solar aging, which provides an improved skin color match with the facial skin. In contrast, pre-auricular skin is a better source for grafts in females (Figure 16.1). Pre-auricular skin in females is hairless and has more solar aging compared to post-auricular skin, which is often covered by hair. The supraclavicular region is an excellent source for skin grafts, especially when a large graft is required. However, the supraclavicular skin is usually less sun exposed, creating a color discrepancy between the recipient skin and the skin graft. In addition, the supraclavicular skin can be much thicker than most facial skin, and judicious thinning of the graft is usually required.¹⁶



Figure 16.1 Cutaneous graft. Patient status post glabellar flap prior to presenting to our facility. (a) Open nasal defect following Mohs excision of skin cancer — no nasal laxity; (b) pre-auricular donor site delineated; (c) wound site preparation with angulation and beveling of wound edges; (d) cutaneous graft inset; (e) graft bolster; (f) 1-year postoperative result.

In general, cutaneous flaps from the nose, forehead, or cheek are often the preferred method of resurfacing cutaneous defects of the nose. However, the infratip lobule is one site where a full-thickness skin graft is likely preferred to a cutaneous flap. Provided the defect does not involve the margin of the nostril and there is no loss of

the intermediate crura, cutaneous defects of the infratip lobule are best covered with a full thickness skin graft harvested from the peri-auricular skin.

Defects located on the lateral nasal ala immediately adjacent to the nasal facial sulcus can be repaired with a number of options. If the defect extends into the cheek,

the cheek component of the defect is usually repaired with a cheek advancement flap. The alar component can be repaired with a cheek or paramedian forehead flap if the defect is large. For smaller defects, especially in very young patients where preservation of regional flaps is desired, full-thickness skin grafts and composite grafts are considered. Full-thickness grafts are best suited for superficial defects not extending to the nostril border. In the case of deep alar defects, skin grafts do not lend any structural support, and subsequent nasal valve collapse may lead to compromise of the nasal airway. One option for patients with deep alar defects is the transfer of subcutaneous cheek tissue in the form of a subcutaneous hinge flap. The flap partially fills the defect and facilitates placement of an alar batten graft deep to the hinge flap. A full thickness graft can then be placed as external covering over the hinge flap, thereby completing a single stage reconstruction.

When defects of the nasal sidewall that extend to the medial cheek are repaired with a skin graft, the cheek component of the defect is reconstructed with a cutaneous advancement flap developed from the remaining cheek skin. The flap is advanced and anchored in place at the nasal facial sulcus with deep sutures that pass from the medial border of the flap to the periosteum of the nasal sidewall. A full thickness skin graft can be used to resurface the sidewall. The cheek advancement flap facilitates positioning scars along the junctional zone between the aesthetic regions of the cheek and nose.¹⁶

Step-by-step surgical technique: cutaneous grafts

All patients undergoing skin grafting receive preoperative intravenous antibiotics, followed by 1 week of oral antibiotics. The bevel of the defect after Mohs excision is freshened, taking care to maintain a bevel to the skin edge, thereby smoothing the transition between the graft and recipient skin and lessening any contour deformity. Additional beveling of the defect may be performed if the skin graft is substantially thinner than the depth of the recipient site.

A template is made of the recipient site by outlining the periphery of the wound with a surgical marker and pressing a non-adherent dressing pad over the marking. If the defect is round, the shape is often modified by excising skin to create angulated borders, which improves the contour outcome (Box 16.2). In addition, movement

Box 16.2 Nasal Cutaneous Grafts

- Optimize vascularity of wound bed
- Angulate recipient site borders
- Bevel wound edges
- Consider benefit of delayed graft

and transfer of adjacent nasal or facial skin is performed, especially if this is helpful in isolating the defect to a single facial aesthetic unit. Using the template, the configuration of the graft is determined. The graft is excised and all subcutaneous tissue is removed using curved scissors. This is best accomplished by placing the graft over an index finger, epidermal side down, and trimming off excess fat until shiny dermis is visible.

The graft is transferred to the recipient site and secured with absorbable sutures as well as a bolster. The bolster is removed after 5 days, and any type of sheering motion is avoided as it may disrupt vascularization of the graft. After removal of the bolster, the patient is instructed to keep the graft dry and apply topical ointment to the graft's edges. A week or two later, when the graft has survived and is well adhered to the recipient site, the patient is allowed to bathe the area.

The graft may appear bruised during the first few days following transfer. It then transitions to a hyperemic stage, which eventually fades. If the entire graft dies, it will separate from the recipient site within several weeks. More commonly, the deeper portion of the graft will survive while the more superficial portion forms an eschar, which remains fixed to the wound bed. When this occurs, re-epithelialization will occur from the wound edges and from the viable deeper dermal component of the graft. Often sufficient dermis survives to prevent the development of a depressed scar following complete healing; however, color and textural differences between facial skin and the graft are usually more apparent than when the graft survives completely.

Adjunctive procedures to optimize aesthetic appearance may be performed after grafting. Trapdoor deformities usually resolve over time with appropriate massage. Grafts rarely require a surgical contouring procedure, but sometimes z-plasties may be performed at the border of the graft to enhance the transition between graft and native facial skin. Resurfacing procedures for full

thickness skin grafts are an option, although rarely performed by the author.

Composite grafts

Composite grafts contain two or more tissue layers, and often are unsuccessful secondary to high metabolic demands. They obtain their nourishment through plasma imbibition during the first 24 hours after transfer, followed by vascular inosculation. Ingrowth of capillaries from the edges of the graft begins by the third day.^{17,18}

Composite grafts were first described by Konig,¹⁹ who used composite auricular grafts to repair alar defects, noting a 53% graft survival. Composite grafts have been used to repair nasal columellar defects^{20,21} and deficiencies in nasal lining.²² During the first half of the twentieth century, Limberg²³ advocated the cavum and cyma of the concha as the preferred donor site for repair of the nose. Symonds and Crikelair²⁴ also used composite auricular grafts for nasal reconstruction, reporting an 89% graft survival rate.

The auricle is an excellent source for composite grafts for facial reconstruction, especially for nasal defects, because it provides a contoured graft of skin and cartilage. Certain segments of the auricle loosely replicate the delicate topography of the columella, facet, and nostril margin where composites grafts are commonly employed. For both anatomic sites, the skin is tightly adherent to the underlying cartilage and/or fibrofatty tissue. Common auricular donor sites are helical crus, helical rim, antitragus, and fossa triangularis. The helical crus provides a good contour match for small alar rim defects and provides the option of incorporating in the graft a segment of pre-auricular skin.

The traditional recommendation is to limit the size of composite grafts to one centimeter or less.²⁵ Considerably larger grafts may be successful if they are placed in a vascular recipient site and the graft is designed so that no portion is more than 1.0 cm from a wound edge.²⁶⁻²⁸ Skouge¹⁵ advocated a tongue and groove technique when using composite grafts. This technique involves insetting the border of the graft between two layers of tissue at the recipient site. This method of graft attachment has the effect of increasing surface contact between graft and recipient site by 50%.²⁹ A hinge flap developed at the

recipient site also increases the surface area for attaching a composite graft.³⁰

The use of perioperative corticosteroids is beneficial in enhancing survival of composite grafts in animals. Rabbits treated with preoperative and postoperative methylprednisolone demonstrated improved graft survival compared with animals receiving no steroids or postoperative doses only. Attempts to salvage compromised grafts with delayed administration of steroids were not successful.^{31,32} Cooling of composite grafts has also been demonstrated to improve survival. Cooling reduces biological requirements and improves graft survival in irradiated, atrophic, or scarred recipient sites. Conley demonstrated that constant application of ice compresses for 14 days effected a fall in skin temperature from 38°F to 17°F (3.33°C to -8.33°C). Grafts ranged in size from 1 × 1 cm to 2 × 2 cm. Of 12 composite grafts transferred to the nose and treated with ice compresses, 10 survived completely. Five of the grafts had been placed in recipient sites with scarring or post-irradiation fibrosis.³³

An ideal defect for a composite auricular graft is a small (1.0 cm or less) full-thickness defect of the nasal facet or columella. The nasal skin in these areas is extremely thin, lacking subcutaneous fat, and is tightly adherent to the underlying cartilage or fibrous connective tissue. Composite auricular grafts obtained from the helical crus provides a graft with thin skin attached to a delicate segment of cartilage, providing structural support and skin that closely resembles the adjacent nasal skin of the columella and facet.

Perhaps more commonly, composite grafts are used to repair small defects of the nasal ala, especially those extending to the alar rim. Composite grafts can be used to maintain structural integrity at the nasal valve and provide a smooth continuous border to the alar rim. Weisberg and Becker³⁴ describe the use of auricular composite grafts with stabilizing struts for repair of such defects. The stabilizing struts are extensions of cartilage that are placed beneath the adjacent nasal skin in a tongue and groove fashion similar to Skouge's original description.

Step-by-step surgical technique: composite grafts

Patient selection is an important consideration. The use of composite grafts is generally limited to small defects

in patients that do not use tobacco and have no systemic illnesses that would compromise graft revascularization. Patients receive antibiotics and wound preparation similar to that described when performing skin grafts. In addition, prednisone is administered on the day of surgery and a steroid taper is provided postoperatively.

Improved survival rate is noted if grafting is delayed until the facial defect has partially healed by secondary intention. The facial defect is then prepared by removing any epithelium and subepithelial scar tissue, and a template is created which measures several millimeters larger than the defect in all dimensions. Harvesting a graft which is slightly larger than the defect accommodates for the inevitable contraction of the graft. Whenever possible, a flap of soft tissue hinged on a border of the defect is developed to enhance surface contact with the graft. A composite graft containing skin and cartilage is harvested from the region of the auricle that most closely matches the contour and thickness of the nose at the defect site. The graft is placed in cold saline, and the donor site is closed primarily using 5-0 polydioxanone or poliglecaprone sutures to approximate the edges of the auricular cartilage and 6-0 polypropylene sutures for the skin. The graft is transferred to the recipient site and secured in place with simple absorbable sutures, limiting the degree of manipulation of the graft.

Ice-saline compresses are applied for the first 3–5 days. Successful grafts transition in color during the first week: blanched at initial transfer, pink color at 6 hours, darker by 24 hours, and gradual return of a pink color by 3–7 days. Complications include partial or complete graft loss, contracture, pigmentary changes, and contour abnormalities. Contour abnormalities may be addressed with debulking or scar revision procedures.

Primary closure

Adjacent nasal tissue provides the ideal color, thickness, and texture for repair of nasal defects. Unfortunately, scars associated with primary closure or local flaps do not always fall along borders between aesthetic units; nonetheless, the benefits gained in establishing appropriate contour and skin color usually outweigh this potential disadvantage. Small defects, usually less than 1.0 cm, may occasionally be closed with primary closure, depending

on the mobility and relative size of the remaining skin compared with the overall surface area of the nose. In general, oval and linear defects in a patient with redundant skin are best suited for primary closure. Modification of underlying facial tissue or framework may facilitate wound closure (i.e., dorsal nasal framework modification), and suspension sutures may be indicated to prevent distortion of mobile structures (i.e., nasal valve suspension sutures).¹²

Wide undermining of the skin adjacent to the defect is performed in a plane deep to the nasal vasculature, just superficial to nasal periosteum or perichondrium. Dissection below the nasal musculature and accompanying fascia minimizes bleeding and postoperative bruising, and wide undermining helps avoid trapdoor deformity. The effect of primary closure on surrounding structures such as the nasal tip, alar margin, eyelid, and canthus should be evaluated, and the method of repair reconsidered if there is concern for significant distortion that is not expected to resolve with time and postoperative massage.

Defects of the caudal and middle third of the dorsum may be repaired in a transverse fashion if cephalic rotation of the tip is desired; otherwise, these defects are approximated in a vertical fashion or along lines separating nasal aesthetic units. Small defects located near the glabella are best closed in a horizontal fashion, with scars within or parallel to transverse folds created by the procerus muscle. Finally, reduction rhinoplasty (when indicated) can reduce the volume of the nasal skeleton, thereby facilitating closure of overlying skin by providing a relatively greater amount of skin redundancy. Reduction of the dorsal skeleton is accomplished directly through the skin defect using rhinoplasty techniques and instrumentation. If indicated and accessible, a concomitant septoplasty can be performed. If osteotomies are indicated to medialize the nasal bones after dorsal reduction, these are best performed through an endonasal approach.

Cutaneous flaps

When primary wound closure is not possible, local flaps from adjacent nasal skin may be used to repair nasal defects. Repair with local flaps is limited by the laxity of

the nasal skin, and is generally restricted to defects less than 1.5–2.0 cm. Thorough analysis of blood supply, wound closure tension, and strength of underlying nasal framework should be performed prior to the transfer of a nasal flap. Cartilage grafting may be necessary to prevent distortion of nasal structures such as the alar margin or nasal tip. Standing cutaneous deformities should be anticipated, and incisions should be placed along aesthetic borders or relaxed skin tension lines when possible. The nasal cutaneous flaps that are most commonly used in reconstruction of small nasal defects include single and bilobed transposition flaps, rotation flaps, and advancement flaps.

Transposition flaps are pivotal flaps with a linear axis, and are occasionally used to repair nasal defects. These flaps are best suited for small defects within the thin skin zones of the nose. Transposition flaps created from thick skin have limited mobility, produce large standing cutaneous deformities and excessive wound closure tension. Design of transposition flaps with angulated borders reduces the likelihood of trapdoor deformity which is commonly seen with curvilinear scars (Figure 16.2).

Repair of defects of the caudal third of the nose is often achieved by borrowing tissue from the nasal sidewalls. This is best accomplished with a bilobed pivotal flap, which is ideal for defects of the nasal tip and adjacent areas. The bilobed flap is a double transposition flap. The primary lobe, usually the same size as the defect, is used to restore the defect and the secondary lobe, generally 75–85% the size of the defect, is used to repair the donor site of the primary lobe. The donor site of the secondary lobe is closed primarily. Variations in the size of each lobe is based on differences in nasal skin thickness. If the lobe is located within an area of thick, noncompliant, immobile nasal tissue, it is imperative to make the lobe the same size as the defect since limited mobility and stretch is expected. Undersizing of the primary or secondary lobe will result in increased wound tension, poor scarring, and distortion of surrounding nasal structures. In addition, oversizing of the flap predisposes to trapdoor deformity and uneven contours. Hence, judicious sizing is necessary, and is dependent of the texture and thickness of the skin and tissue being transposed. In general, ideal patients have thin, mobile skin, while patients with thick, sebaceous skin have less mobility for transfer, increased risk of developing necrosis, trapdoor deformity, and depressed scars. An anticipated standing cutaneous deformity is

removed, whenever possible, with the incisional line hidden within the alar crease.

Bilobed flaps are ideally based laterally, and are best used to repair defects located on the central or lateral nasal tip that are less than 1.5 cm in diameter. When possible, the axis of the secondary lobe is placed perpendicular to the alar rim. In so doing, displacement of the alar rim by closure of the secondary lobe donor site is minimized.³⁵ An ideal defect location for this technique is the zone of transition between the tip, ala, and sidewall. Use of the bilobed flap for alar reconstruction is avoided because crossing the alar groove with the pedicle causes distortion of this nasal landmark (Figure 16.3).

Rotation flaps are best used to repair small triangular defects of the nose. The flap is designed so that the length of its curvilinear border is four times the width of the defect. Maintaining this ratio and performing a z-plasty at the pivotal point minimizes wound closure tension and decreases the likelihood of a standing cutaneous deformity. The ideal location for rotation flaps is similar to other types of flaps, with areas of the nose having thin skin providing the best location for use of this flap.

Island advancement based on a soft-tissue pedicle is helpful in repairing small defects involving the anterior portion of the alar groove. The triangular island advancement, with its inferior border resting in the alar groove, is best used for small defects of the alar groove or lateral nasal tip. Patients with moderate skin thickness and large nasal tips are the best candidates. Dissection is performed for the medial and lateral thirds of the flap, maintaining a central island pedicle with random arterial supply. Wide undermining of adjacent tissue decreases the likelihood of trapdoor deformity and alar rim deformation (Figure 16.4).

Step-by-step surgical technique: primary closure and cutaneous flaps

In preparation for local flaps, the nose is injected with local anesthetic containing epinephrine in a submuscular plane, just superficial to the nasal perichondrium and periosteum. The margins of the defect are freshened with a scalpel, removing the beveled edge from the Mohs resection. The flap is demarcated based on the size of the defect, and the flap and surrounding nasal skin are elevated in a plane immediately above the nasal perichondrium or periosteum, in the same fashion as an external rhinoplasty. Elevation in this plane maintains a



Figure 16.2 Glabellar flap. (a) Patient with nasal defect following Mohs excision of skin cancer; (b) glabellar flap designed; (c) wide undermining of flap across nasal framework; (d) wound closure; (e) 2-years postoperative result, oblique view; (f) 2-year postoperative result, lateral view.



Figure 16.3 Bilobed transposition flap. (a) Patient with nasal defect following Mohs excision of skin cancer; (b) bilobed transposition delineated, with arc of rotation 100°; (c) wide undermining of flap across nasal framework; (d) wound closure; (e) 1-year postoperative result.

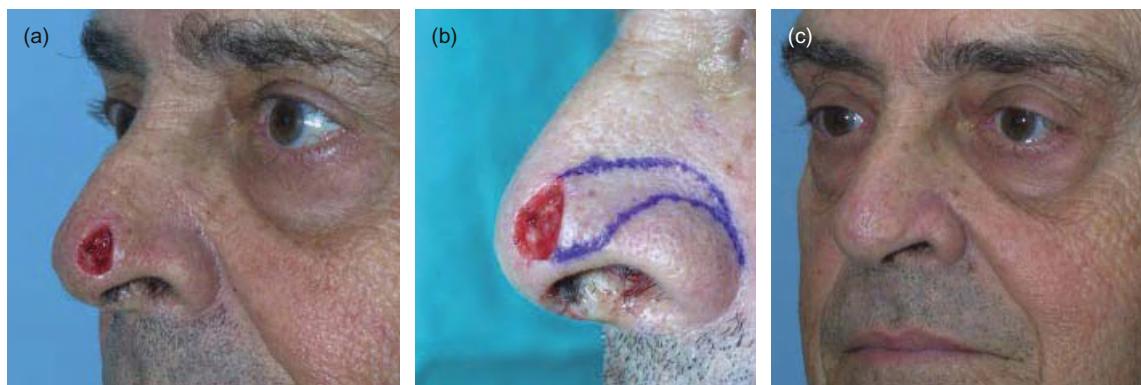


Figure 16.4 Island pedicle advancement. (a) Patient with nasal defect following Mohs excision of skin cancer; (b) island pedicle advancement delineated along alar rim; (c) 8-month postoperative result.

Box 16.3 Nasal Cutaneous Flaps

- Proper patient and defect selection
- Orient wound closure tension to minimize distortion
- Perpendicular incisions and appropriate undermining
- Meticulous closure

rich vascular supply to the flap, provides access to the underlying nasal framework for modification if needed, and decreases bleeding and associated bruising. Furthermore, wide undermining reduces trapdoor deformity and facilitates wound closure by reducing wound tension.

The donor site is closed first, followed by suturing the flap in place. 5-0 polydioxanone sutures are used for subcutaneous closure, and 6-0 polypropylene vertical mattress sutures are used for cutaneous closure. Topical ointment is applied and a compression dressing consisting of a non-adherent dressing, cotton balls, and elastic tape is placed for 24 hours. Cutaneous sutures are removed in five to seven days (Box 16.3).

Local cutaneous flaps have the potential to distort normal nasal anatomy, leading to anatomic asymmetries, potential alar retraction, and nasal valve collapse. Careful planning and selective use of flaps minimize these potential complications; furthermore, judicious use of cartilage grafting is recommended. Cartilage grafts can be harvested from septum or the conchal bowl, and grafts are sewn in place using 5-0 polyglactin mattress sutures through the graft and underlying nasal lining tissue. Cartilage grafts are commonly used along the alar rim to prevent notching, as well as over the sesamoid cartilages, spanning toward the pyriform aperture to address any potential lateral nasal valve collapse. Undermining of alar tissue adjacent to the defect is essential to facilitate a tongue-in-groove imbrication of cartilage graft into the adjacent intact alar rim. Suspension sutures may be used in the area of nasal sesamoid cartilages, spanning toward the pyriform aperture, to address any potential nasal valve collapse.

Adjunctive procedures to optimize aesthetic appearance may be performed after nasal reconstruction. Patients are encouraged to use scar minimization gels and ointments starting three weeks after surgery, mainly at night, for about three months. An appropriate moisturizer with sunscreen is applied during the day during this

same time period. Trapdoor deformities usually resolve over time with appropriate massage. Flaps rarely require a surgical contouring procedure, including flap debulking or z-plasties at the border of the flap to address persistent trapdoor deformities. Resurfacing procedures for incisions associated with cutaneous flaps are an option, although rarely performed by the author.

Interpolation flaps

Interpolation flaps are constructed from non-adjacent donor tissue, and they contain their own inherent blood supply. In many cases the vascular supply has an axial pattern (paramedian forehead flap); however, interpolated flaps may also have a random vascularized pedicle. Interpolation flaps generally require two stages, since the vascularized pedicle is transferred across normal adjacent skin, leaving a temporary bridge of tissue overlying the normal skin between the donor and recipient sites. Detachment of the flap pedicle is delayed until neovascularization from the recipient tissue render the distal flap independent of the vascularized pedicle.

Interpolated forehead flaps

Perhaps the most common interpolated flap used for repair of medium to large cutaneous defects of the nose is the forehead flap. Use of mid-forehead tissue (median forehead flap) for repair of the nose and mid-face is well established;^{36–38} however, refinement of the forehead flap over the past several decades has optimized the repair of nasal defects using forehead tissue. Labat³⁹ was the first surgeon to design a median forehead flap with the pedicle base over a single supratrochlear artery, and Millard shifted the complete vertical axis of the flap to the paramedian position. Compared to the original median flap, most authors prefer the paramedian forehead flap for restoration of nasal defects, secondary to its more axial design and narrower base which allows for a greater ease of rotation and overall more effective length.⁴⁰

The abundant blood supply to the paramedian forehead flap has been well described by multiple studies. Mangold, *et al.*⁴¹ demonstrated that the blood supply to the forehead skin includes: the dorsal nasal,

supratrochlear, supraorbital, and superficial temporal arteries. These injections studies determined that the paramedian forehead flap is primarily supplied by the supratrochlear artery and secondarily by other arteries. The secondary supply is significant, however, and studies have suggested that the paramedian forehead flap may survive even when the ipsilateral supratrochlear artery was occluded.^{42–45}

The forehead skin has an exceptional color and texture match with the cutaneous covering of the nose, especially at the lower third. The paramedian forehead flap is usually the preferred choice for full thickness nasal defects, unless they are isolated to the nasal ala or columella (in these cases, melolabial flap should also be considered). It is also a preferred method for restoration of partial thickness nasal defects that are too large to repair with adjacent tissue flaps, composite or skin grafts, or interpolated melolabial flaps (Figure 16.5).^{46,47} Nasal

defects with exposed bone and/or cartilage, lacking periosteum and perichondrium, are best repaired with vascularized tissue, and in these cases, the forehead flap is generally the preferred option. For patients with total or near-total nasal defects, the forehead flap can be used as internal lining.

Modifications to the paramedian forehead flap design and implementation are numerous, and well detailed in the literature.⁴⁸ Tissue expansion of the forehead tissue in anticipation of using a paramedian forehead flap has been reported; however, unless bilateral forehead flaps are required, tissue expansion is generally not recommended since the donor site usually has sufficient tissue and heals with an acceptable scar.^{49,50} Some authors have reported single-staged forehead flap, with tunneling of the flap pedicle under the dorsal nasal skin.⁵¹ Venous outflow obstruction was reported with single-staged flaps; however, Park⁵⁰ modified the technique and found



Figure 16.5 Interpolated flap — paramedian forehead flap.
 (a) Patient with a full-thickness nasal defect after Mohs excision of skin cancer; (b) paramedian forehead flap designed based on the supratrochlear artery; (c) flap in place after transfer; (d) 6-year postoperative result.

no difficulty with venous outflow obstruction. Menick reported his experience with the use of the folded forehead flap, requiring three stages. Menick describes folding of the distal forehead skin to serve as lining for nasal defects. The second procedure involves incising the flap at the nostril margin, allowing debulking and placement of cartilage grafts. At the third stage, the flap pedicle is detached.^{52,53}

The author has found folded forehead flaps particularly useful in patients with high hairlines and nasal defects adjacent to the alar margin. If the alar margin is intact, a portion of the folded flap can be de-epithelialized to allow for precise inset for repair of nasal fistulas.⁴⁸ Occasionally, the distal flap is modified to allow separation of the distal skin paddle from the underlying frontalis muscle. With this technique, two flaps are created, a muscle flap and a skin flap. Both flaps have a unified pedicle, but can be placed independently within the facial defect. The muscle flap is particularly useful for securing vascular supply to the undersurface of cartilage grafts when lining flaps are deficient and/or an open space is noted.

Preoperative assessment and planning is an essential aspect of forehead flap design. Attention is given to the height of the hairline, forehead tissue laxity, brow position, presence of temporal recession, skin thickness, and existence of previous scars. Special notice is given to the degree of sun damage, and prior biopsy, curettage, or ablative scars which may question the use of the forehead tissue secondary to concerns for malignancy. There is minimal long-term morbidity at the donor site; however, the presence of a vascularized pedicle across the nasal dorsum is temporarily required. Suitable candidates for reconstruction using a forehead flap should be shown pictures of patients having undergone forehead flap transfer, to allow for complete understanding of the anticipated appearance of the temporary vascular pedicle. Patients should be assessed for comorbidities that may complicate their ability to tolerate the surgical procedure and/or aftercare. Postoperative bleeding is expected, and the importance of assistance with wound care should be emphasized with elderly patients.

Step-by-step surgical technique: interpolated forehead flap

In preparation for a forehead flap, the nose is injected with local anesthetic containing epinephrine in a sub-

muscular plane, just superficial to the nasal perichondrium and periosteum. The margins of the defect are freshened with a scalpel, removing the beveled edge from the Mohs resection. The surrounding nasal skin is elevated in a plane immediately above the nasal perichondrium or periosteum. Elevation in this plane provides access to the underlying nasal framework and decreases bruising. Furthermore, wide undermining reduces trapdoor deformity and facilitates wound closure by reducing wound tension.

The preferred pedicle width for the paramedian forehead flap is generally 1.5 cm; however, pedicles as narrow as 1.0–1.2 cm have been reported.^{54–56} The 1.5-cm base allows for a greater ease of rotation and overall more effective length. The base of the pedicle is centered over the supratrochlear artery, which is usually located 1.7–2.2 cm from the midline. The template from the defect is applied to the forehead, with special consideration given to patients with short foreheads. Methods used to lengthen the flap include extending the pedicle incisions below the orbital rim, extending the flap into the hairline (combined with attempts to remove hair follicles from the distal flap), and extending the flap obliquely across the forehead, perhaps into a temporal recession.^{57–60} In general, the author's preference is to avoid extending the flap into the hairline, since removal of hair follicles is tedious and complex, and usually requires more than one treatment. When oblique flaps are performed, consideration should be given to placing a relaxing incision through the lateral cutaneous portion of the flap to release tension and allow lengthening of the flap.

The paramedian forehead flap is elevated in a subgaleal plane, and blunt dissection is used at the orbital rim to avoid injury to the arterial pedicle. Often, subperiosteal dissection is performed at the orbital rim, to ensure protection of the supratrochlear vessel. Adequate mobilization of the flap usually requires complete transection of the corrugator musculature, and extension of the incisions below the orbital rim. Prior to inset of the flap, muscle and subcutaneous tissue are removed from the distal portion of the flap. Modulating the thickness of the flap provides thin, pliable tissue that conforms easily to the intricate three-dimensional nature of nasal defects, thereby allowing appropriate visualization of the underlying nasal framework and tip definition. It is important to note that establishing an appropriate lining and nasal framework are essential for achieving a successful

aesthetic and functional reconstruction of the nose. The forehead flap pedicle is covered loosely with a petroleum gauze to avoid compression of the pedicle with anticipated swelling.

Wound closure is usually performed with 5-0 polydioxanone sutures subcutaneously, and 6-0 polypropylene vertical mattress sutures are used for cutaneous closure. At the recipient site, a light pressure dressing, usually consisting of topical ointment, non-adherent gauze, cotton, and retention tape, is applied for 48 hours.

Venous congestion of the flap is rare but can occur, especially if a tight dressing is placed around the vascularized pedicle. The congestion is generally self limiting, and when necessary can be treated with multiple needle perforations in the distal flap during early postoperative period. Small hematomas can occur between the inset flap and the recipient site, and these are related the abundant blood supply at the distal portion of the flap. Gentle and precise debridement of excessive scar tissue related to hematoma formation can be performed at the time of flap detachment.

The narrow pedicle allows for primary closure of the donor site at the time of flap transfer, and rarely alternative techniques are required for repair of the donor defect. Closure is facilitated by undermining bilaterally across the forehead to the conjoined tendons in a subgaleal plane, followed by advancement of tissue. After closure, a light pressure dressing, usually non-adherent gauze, cotton, and retention tape, is applied for 48 hours. With proper closure, the forehead scar generally heals with minimal visibility; however, more noticeable scars may be noted in patients with thicker skin, minimal tissue laxity, larger defects, and vascular compromise related to nicotine use, radiation, or systemic illnesses.

When used as an interpolated flap, paramedian forehead flaps require a second operation to detach the vascularized pedicle. The author's preferred timing for detachment is 3 weeks (4 weeks for patients that use nicotine and tobacco products). Thinning of the flap at the time of detachment is generally indicated, especially for the most proximal portion of large defects (smaller defects may likely be completely thinned and contoured as needed). Prior to wound closure, wide undermining is performed, in a submuscular plane on the nose and in a subgaleal plane on the forehead. Attention to brow position is essential, to ensure a symmetrical height and orientation.

Interpolated melolabial flaps

Melolabial flaps are an option for restoration of nasal alar and columellar defects. Multiple types of flap design have been described, including transposition, interpolated, and island pedicle.⁶¹ The transposition flap has a cutaneous pedicle immediately adjacent to the nasal defect, and the flap is pivoted and/or advanced toward the defect. This traditional flap design is useful for single-staged repairs; however, the flap is prone to trapdoor deformity and usually causes obliteration of the nasofacial junction.⁶² Although modifications of the single-stage melolabial flap have been developed to address these concerns, the author's preferred technique involves a two-staged interpolation melolabial flap.

The cheek skin has an exceptional color and texture match with the cutaneous covering of the lateral nose, especially the nasal ala. The melolabial flap may be recommended for partial and full thickness alar defects or columellar defect that cannot be repaired with local tissue and/or grafts. For patients with total or near-total nasal defects, the melolabial flap can be used as internal lining of the lateral nose. The vascularity of the melolabial region has been evaluated through a series of cadaveric dissections. Hynes and Boyd⁶³ demonstrated that the facial artery passes deep to the facial mimetic muscles, thereby suggesting that the artery is not included in the flap. However, the small vessels in the subdermal plexus were generally oriented along the long axis of the flap, suggesting a "degree of axiality", which likely contributes to the viability of the flap.

Preoperative assessment and planning is an essential aspect of melolabial flap design. Attention is given to cheek tissue laxity, lower eyelid and lip positions, skin thickness, presence and color of facial hairs, and existence of previous scars. Special notice is given to the degree of sun damage, and prior biopsy, curettage, or ablative scars which may question the use of the cheek tissue secondary to concerns for malignancy. Men with bearded skin are generally not good candidates for melolabial flaps; however, some patients prefer the anticipated transfer of hair bearing tissue from the cheek to more involved alternative reconstructive methods. There is minimal long-term morbidity at the donor site; however, the presence of a vascularized pedicle across the mid-face is temporarily required. Suitable candidates for reconstruction using a melolabial flap should be

shown pictures of patients having undergone melolabial flap transfer, to allow for complete understanding of the anticipated appearance of the temporary vascular pedicle. Patients should also be warned about potential long-term facial asymmetry, secondary to removal of unilateral mid-facial tissue. Patients should be assessed for comorbidities that may complicate their ability to tolerate multiple surgical procedure and/or aftercare. Minimal postoperative bleeding is expected; however, consideration should be given to obtaining assistance with wound care, especially with elderly or medically frail patients.

Step-by-step surgical technique: interpolated melolabial flap

In preparation for the melolabial flap, the nose is injected with local anesthetic containing epinephrine in a sub-muscular plane, just superficial to the nasal perichondrium and periosteum. The margins of the defect are freshened with a scalpel, removing the beveled edge from the Mohs resection. The surrounding nasal skin is elevated in a plane immediately above the nasal perichondrium or periosteum. Elevation in this plane provides access to the underlying nasal framework and decreases bruising. Furthermore, wide undermining reduces trapdoor deformity and facilitates wound closure by reducing wound tension.

The preferred pedicle width is generally 1.5–2.0 cm, and the medial border of the melolabial flap is aligned along the ipsilateral melolabial crease (the crease is usually marked with the patient in a sitting position, with ability to grimace if necessary). The template from the defect is applied to the cheek usually at the level of the oral commissure, and sufficient flap length is essential to avoid flap tension after transfer. The proximal aspect of the flap may be designed as a peninsula (interpolation flap) or based on a subcutaneous pedicle (island pedicle advancement). The interpolation flap is elevated in the subcutaneous plane, while preserving a generous thickness at the base to maintain perfusion. With island pedicle advancement, the cutaneous flap is incised on all cutaneous borders, while maintaining a vascularized subcutaneous and muscular pedicle at the central third of the flap. Dissection at the donor site is limited to tissues superficial to the underlying facial musculature. Thinning of the distal portion of the flap

prior to inset is usually recommended, while thinning of the proximal portion is generally reserved until flap detachment.

The melolabial flap pedicle is cauterized carefully along the lateral surface, and coverage of the pedicle with an external wrap is usually avoided. Cartilage grafting, when indicated, is placed in a non-anatomic position along the alar rim. Wound closure is usually performed with 5-0 polydioxanone sutures at subcutaneous level, and 6-0 polypropylene vertical mattress sutures are used for cutaneous closure. A light pressure dressing with topical ointment, non-adherent gauze, cotton, and retention tape is applied to the donor site for 48 hours. At the recipient site, a light dressing, usually non-adherent gauze and retention tape, is applied for 48 hours.

In most patients, donor site closure is usually uncomplicated because of cheek laxity; however, noticeable scars may be found in patients with thicker skin, minimal tissue laxity, larger defects, and vascular compromise related to nicotine use, radiation, or systemic illnesses. Wide undermining is performed, especially of the adjacent cheek tissue just lateral to the donor site. Attention must be paid to the closure vectors to prevent distortion of the lower eyelid, upper lip, and oral commissure.

When used as an interpolated flap, the melolabial flap requires a second operation to detach the vascularized pedicle. The author's preferred timing for detachment is 3 weeks (4 weeks for patients that use nicotine and tobacco products). Thinning of the proximal flap at the time of detachment is generally indicated. Wide undermining of the recipient and donor sites is performed, and usually an extension of the donor site incision medially is required to allow excision of redundant cheek tissue at the superior aspect of the melolabial crease. Hemostasis at the donor site is essential to avoid small hematoma formation and trapdoor deformity superior to the melolabial crease.

Adjunctive procedures to optimize aesthetic appearance of interpolated flaps may be performed, usually several months after flap detachment. Surgical contouring may be required, especially if the alar groove needs to be re-established because of obliteration by the interpolation flap. Dermabrasion and/or laser treatment of the flap and surrounding nasal skin is rarely used, but can be employed to address any telangiectasias or textural irregularities.

Postoperative care and follow-up

Patients undergoing local tissue flaps, regional flaps, and linear repairs receive a pressure dressing consisting of non-adherent gauze, loosened cotton balls, and a non-irritating, stretchable, retention tape. Application of ice to adjacent tissue is recommended when reconstruction involves dissection near the eyelids and lips. The pressure bandage is removed after 48 hours, and patients are instructed to apply liberal ointment (topical mupriocin antibacterial ointment or petrolatum), a non-adherent gauze with brown paper tape, changing once to twice daily for about 3 weeks. Sutures are removed within 5–7 days. Scar minimization gels and ointments are initiated about 3 weeks after surgery and continued for 3 months postoperatively. Patients are seen for two additional follow-ups over the next 6 months. Flap contouring procedures and laser scar treatments are options, although rarely performed by the author.

Patients undergoing skin grafts receive a bolster consisting of impregnated petrolatum gauze, loosened cotton balls, and permanent tie over sutures. The bolster is removed after 5–7 days, and patients are instructed to apply ointment (topical mupriocin antibacterial ointment or petrolatum) along wound edges, followed by a non-adherent gauze and brown paper tape on a daily basis for about 3 weeks. Sutures are removed within 5–7 days. Patients are seen for two additional follow-ups over the next 6 months, although superficial graft epidermolysis may require earlier visits for wound care with discrete debridement. Staged augmentation, laser scar treatments, or resurfacing procedures are options.

Complications

It is essential that facial surgeons become familiar with the potential complications associated with facial reconstructive surgery, anticipate these undesirable events, and take proper measures to help prevent their occurrence. Establishing a consistent perioperative routine, including immediate and regular postoperative evaluations, will facilitate early recognition and treatment of complications. Some complications are reversible, and expeditious treatment may prevent a reversible complication from becoming an irreversible one. Some complications that may be associated with nasal reconstruction include

Box 16.4 Complications: nasal cutaneous flaps and grafts

- Distortion of Adjacent Anatomical Structures
- Trapdoor Deformity
- Bleeding
- Abnormal Scarring
- Ischemia
- Infection

injury or distortion of adjacent anatomical structures, trapdoor deformity, bleeding, abnormal scarring, wound dehiscence, ischemia, infection, and unsightly scars (Box 16.4).⁶⁴

Avoiding injury to the nasal cartilaginous framework is important for maintaining nasal symmetry and function. Inadvertent injury to these structures may lead to obvious nasal deformities including alar retraction, nasal valve collapse, saddle nose deformity, and tip asymmetries. Repair of such is best addressed at time of injury, since delayed repair may require more complicated rhinoplasty techniques. Occasionally, pre-existing structural abnormalities of the nose are corrected during reconstructive surgery of the nose, when the exposure of the nasal framework is sufficient to allow alterations which could provide potential improvement in aesthetic and functional outcomes.

Trapdoor deformity may result from persistent edema and poor lymphatic drainage of flaps with incisions on three borders. Flaps with curvilinear borders are particularly prone to develop trapdoor deformity, where concentric contraction combines with contraction of the scar sheet beneath the flap to push the skin upward in a mushroom effect.^{65–67} Bilobed flaps of the nasal skin are particularly susceptible to trapdoor deformity because of the two circular lobes used for construction of the flap. The deformity is more common with patients having thick skin and sebaceous gland hypertrophy. Proper flap design and adequate tissue undermining reduces the incidence of trapdoor deformity. Presumably wide undermining reduces scar contractile vectors toward the center of the flap by enlarging the area of the underlying sheet of scar. Flaps that are superiorly based are more prone to develop trapdoor deformity than inferiorly based flaps because

lymphatic channels of the face drain in an inferior direction.

Trapdoor deformity usually improves with time, and rarely steroid injections into the subcutaneous tissue plane beneath the flap may be required. If time and steroid injections are not successful, contouring of the flap with or without scar revision is necessary. This involves incising the flap along one of the borders, removing subcutaneous fat and scar tissue beneath the flap and redraping the skin. Excess skin is trimmed as indicated. z-plasties performed along the incision are helpful in preventing recurrence of the trapdoor deformity by preventing a concentric scar from redeveloping.

Hematomas may cause compromise of local flap vascularity by inducing vasospasm, stretching the subdermal plexus, or separating the flap from the surface of the recipient site.⁶⁸⁻⁷⁰ Furthermore, iron compounds in a hematoma may promote free-radical production leading to flap necrosis.^{71,72} Hematoma formation also predisposes to infection, which may compromise flap vascularity secondary to inflammatory edema.⁷³ If a hematoma occurs, the wound may appear mottled, pale, or bluish, and palpation of the skin in the area of the hematoma usually reveals a tight, tense flap with oozing of blood from the suture lines. Small hematomas may sometimes be aspirated through the suture line using a large syringe attached to an 18-gauge needle. A compression dressing is then applied and the patient is re-examined in 24 hours. If the hematoma recurs, it may be necessary to return the patient to the operating room for drainage. There, the wound is opened at a dependent portion, the hematoma evacuated, and bleeding vessels controlled. A drain may be placed with compression dressing, and the patient is seen within 24 hours. Expediency in treatment of large hematomas is essential to avoid compromise of flap vascularity and skin slough. Typically, within the first 48 hours after surgery, hematomas consist of fresh clot of gel or liquid consistency. As the clot matures over the next several days, it becomes firmer and adherent to the underlying wound bed and cannot be easily aspirated. After approximately 2 weeks, fibrinolysis begins, and the hematoma liquefies. At this point, a repeat aspiration or drainage may be necessary to facilitate adherence of the flap to the wound bed.

Patients with darker skin and those with a family history of excessive scarring are prone to the development of hypertrophic scars and keloids following surgery.

Although numerous treatment modalities have been proposed, there is no definitive method of managing or preventing these problems.⁷⁴ Intralesional steroids are often helpful in reducing the volume of scar tissue within a hypertrophic or keloid scar. If the scar is responsive to the injections, surgical excision may be performed following a preoperative injection 1 week prior to surgery. Several injections are usually required postoperatively every 6–12 weeks for an indeterminate time interval.

Scar hyperpigmentation may be seen in patients that tan easily, particularly if the patient is exposed to excessive sun exposure during the immediate postoperative period. Hyperpigmentation improves over time and with sun avoidance. Use of topical hydroquinone gel with or without an anti-inflammatory component may be helpful in preventing permanent discoloration of the scar.

Ischemia is defined as vascular perfusion insufficient to provide the required oxygenation of tissue.⁷⁵ Cutaneous flaps are more vulnerable to tissue ischemia than wounds closed primarily given that the vascularity is isolated to the pedicle of the flap used for repair of the wound. This is especially true in the distal portion of the flap.^{76,77} Dissection of flaps causes release of catecholamines from severed sympathetic nerves, thromboxane A from platelet microthrombi, and oxygen free radicals. All of these substances cause vasoconstriction which can enhance tissue ischemia.^{78,79}

With proper technique, cutaneous flap necrosis is uncommon since most tissue can survive on a fraction of its average blood flow,⁸⁰ and eventual neovascularization reduces flap dependency on the pedicle's blood supply.^{70,81-83} However, reversible ischemia may become irreversible if there is additional vascular compromise. Excessive flap thinning, aggressive electrocautery, crush injury with surgical instruments, and excessive wound closure tension may worsen flap ischemia.^{84,85} Injection of local anesthetic containing vasoconstrictor agents are used judiciously and avoided in wounds where vascular perfusion is a concern.^{86,87} Infection is treated expeditiously since edema from inflammation may decrease tissue perfusion. When flap ischemia is evident, local wound factors and factors related to the patient are assessed and medical conditions optimized. In such situations, use of nicotine by the patient must be avoided.

Ischemia of a skin flap is signaled by color changes of the flap. A pale flap with slow capillary refill when the

skin of the flap is compressed are signs of impending ischemia. A reduced flap temperature below ambience and the absence of bleeding following pinprick of the flap suggests arterial insufficiency. Flaps with edema, purple-blue color, and brisk bleeding of dark blood following pinprick suggest venous congestion. Flaps may survive arterial insufficiency for up to 13 hours, but venous congestion can cause necrosis as quickly as several hours.⁷⁵ No widely accepted methods of monitoring flap vascular supply have been established, and most surgeons rely on careful and frequent examinations of the flap when ischemia is a concern. Repeat pinpricks of the flap or a trial of medicinal leeches may be helpful in treating flaps with venous insufficiency.^{88,89} Aeromonas infection secondary to treatment with leeches may occur and should be treated promptly with appropriate antibiotic coverage.^{89, 90, 91}

Arterial insufficiency of a flap may be caused by kinking of the flap's pedicle, an excessively tight compression dressing or excessive wound closure tension. If these causative factors are corrected early in the postoperative period, the ischemia is usually reversible. Correction of these conditions should improve the vascularity of the flap. In the case of excessive wound closure tension, the flap may be returned to its donor site and allowed to remain *in situ* for a few days. This has the effect of delaying the flap which will cause an enhanced blood supply to the flap. The flap is then usually transferred to the recipient site without ischemia.⁹² There are numerous reported experimental treatments for flap ischemia using pharmacologic agents, such as vasodilators, sympatholytics, and free radical scavengers.^{93–96}

Skin blanching may become progressively prolonged with digital compression until capillary refill cannot be elicited, signaling flap failure.^{96, 97} When ischemia causes epidermolysis or skin necrosis, the tissue is allowed to demarcate since the more proximal portion of the flap is usually viable. Devitalized tissue that is easily removed from the wound bed is debrided. Tissue adherence signifies some underlying viable tissue and is left as a biologic wound dressing. Patients are instructed to keep the wound moist with petroleum or water-based antibiotic ointment, and the wound is allowed to heal by secondary intention. Frequent follow-up examination is essential for maintaining appropriate wound care and providing reassurance to the patient.⁹⁸

Summary

Nasal reconstruction is a challenging, yet rewarding endeavor. Repair of nasal defects requires an appreciation of variations in nasal skin thickness and contour, and the influence of these differences on potential reconstructive methods. Multiple factors help determine the optimal method of repair, including the size of the defect relative to the amount of remaining skin, the depth and location of the defect, and the strength of the underlying nasal framework. Maintaining symmetry, contour, and function are essential for a successful nasal reconstruction.

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Reconstruction of the lips

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Introduction

The first reports of lip reconstruction being performed date back to 3000 BCE by Susruta in India.¹ However, the basis of modern techniques did not begin to emerge until the middle of the nineteenth century. Lip reconstruction remains a challenge to the reconstructive surgeon because of the high specifications demanded for acceptable cosmesis and functional performance.

The most common reason for lip reconstruction is after carcinoma resection. The goal of reconstruction is a favorable cosmetic outcome with proper function of the oral sphincter. The latter is important for facial expression, speech, and food intake.

Anatomy and function

The lips are the primary aesthetic landmark of the lower central face. The upper lip is divided into three anatomic subunits: two lateral subunits and a medial subunit. The subunits are demarcated by the philtral ridges, which extend from the border of the vermillion inferiorly to the base of the columella superiorly. At the base of the philtral ridges is a mucocutaneous ridge known as “Cupid’s bow” (Figure 17.1). Between the two philtral ridges lie a depression known as the philtrum. The vermillion is the “red” or mucosal portion of the lip and is separated by the “white” or epidermal portion of the lip by a thin, faint line known as the border of the vermillion. The lower lip is composed of only one unit.

The underlying muscle of the upper and lower lips comprises mostly sphincteric orbicularis oris muscle. The orbicularis oris muscle merges with decussating fibers of the buccinators muscle at the oral commissures. The paired mentalis muscles are the main elevators of the lower lip. They are large trapezoidal/pyramid-shaped muscles that originate from the mandible below the attached gingiva and insert horizontally and inferiorly into the chin pad below the labiomental fold. Important elevator muscles include the zygomaticus major and the levator anguli oris. Important depressor muscles include the depressor anguli oris and depressor labii inferioris.

The arterial supply of the lips comes from the superior and inferior labial arteries, which are branches of the facial artery. Motor and sensory innervation of the lips is primarily derived from the trigeminal and facial cranial nerves. More specifically, the buccal branches of the facial nerve innervate the orbicularis muscle. The marginal mandibular branch supplies innervation to the mentalis muscle. Sensory innervation of the lip is provided by the mental and infraorbital nerves. The mental nerve is the terminal branch of the inferior alveolar branch, which is a branch of the mandibular division of the trigeminal nerve, V3. The mental nerve exits between the second and third premolars. The inferior orbital nerve, which is a branch of the maxillary division of the trigeminal nerve, V2. This nerve exits via the foramen rotundum in the skull. It then passes through the inferior orbital fissure and travels along the orbital floor before diving into the maxillary sinus and emerging out the infraorbital

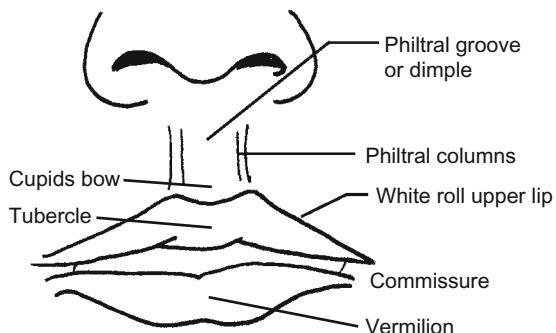


Figure 17.1 Anatomy of the lips.

foramen. It provides sensation to the upper lip, nasal sidewall, and ala.

Knowledge of the sensory innervation to the lips is important for local anesthesia. Low volumes of solution, placed accurately, provide total anesthesia. Intraoral injections are less painful and simpler to achieve based upon tooth landmarks. The needle should be placed at the level of the canine for both mental and infraorbital nerves, and directed inferolaterally (mental nerve) or superolaterally (infraorbital nerve). Only 1–2 mL should be required for each injection.

The lips perform a variety of functions and they should be kept in mind during the reconstructive process. Any disability in performing these functions can impact the quality of life. The lips are important in phonation, mastication, sensation, and oral competence.

Step-by-step surgical techniques

Upper lip reconstruction

Full thickness defects involving up to one-third of the upper lip can generally be closed primarily with acceptable results. Primary closure is also indicated for central defects involving up to one-half of the distance between the philtral columns.

For larger central defects (larger than half of the central lip), an Abbe flap is the best reconstructive option. The flap is harvested based on the labial artery from the central lower lip, ideally in the exact center. The flap should include the central raphe so that innervated orbicularis is intact on both sides of the closure. Closure

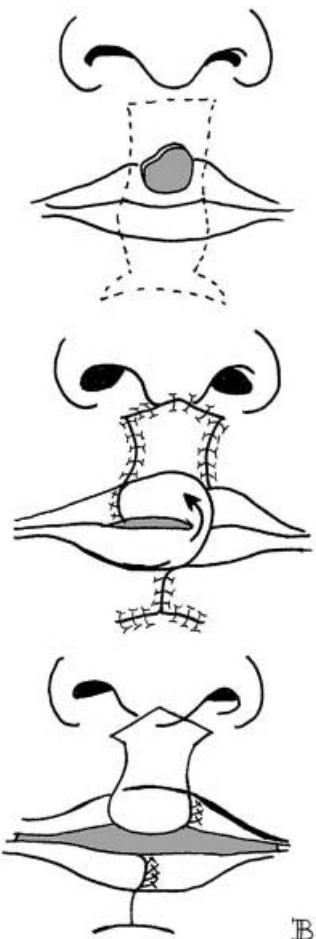


Figure 17.2 Abbe flap.

of the donor site may be done with Burrow triangles creating a small horizontal scar and a larger vertical scar in the midline. The flap is sutured onto the columella of the nose and is divided after a period of two weeks (Figure 17.2).

Lateral defects larger than one-third but less than three-quarters of the upper lip can also be repaired with the Abbe flap if the oral commissure is intact. Larger defects, defects greater than three quarters of the upper lip, require the use of the Gillies fan flap (Figure 17.3). First described in the 1920s, this classic fan flap uses a full-thickness pedicle that allows redistribution of the remaining lip. Karapandzic modified this technique by

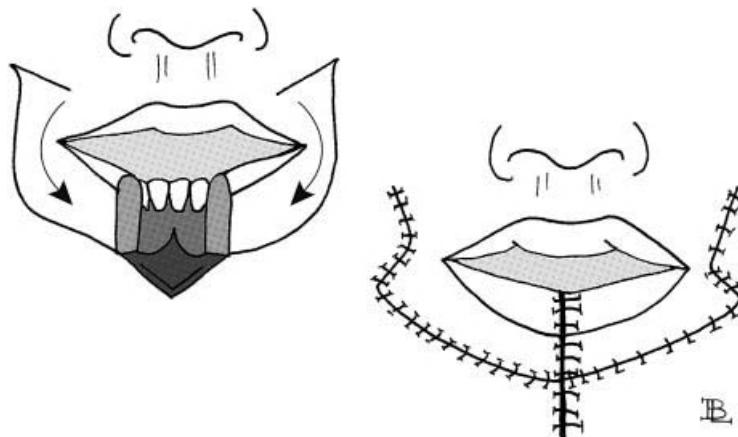


Figure 17.3 Gillies fan flap.

limiting the incision to only the skin and mucosa to preserve the musculature.²

Total upper lip defects greater than 80% are rare and reconstruction is a salvage operation.³ The radial forearm free flap is useful, and can provide adequate bulk of tissue with reasonable color match. The vermillion is reconstructed with either tattooing or with buccal mucosal grafting in a second stage procedure. Functional reconstruction is not as critical in the upper lip compared to the lower lip.

Lower lip reconstruction

Oncologic resection of the lip can usually be achieved using wedge or W-shaped excision with appropriate tumor-free margins.⁴ Although most can be done using local anesthesia, general anesthesia may be indicated depending upon tumor size and patient preference. Closure may be done at the time of index procedure (single stage), or delayed (two-stage). The delay is usually to await histologic confirmation of a tumor-free margin. The defect can be temporarily covered with a dressing while awaiting results.⁵

Defects should be classified into partial and full thickness. Full-thickness defects involve all three layers of the lip, including skin, muscle, and mucosa. Vermilion-only defects are a subset of partial-thickness defects. For full-thickness defects, further categorization may be done by width of defect into thirds: less than one-third, one- to two-thirds, and greater than two-thirds. Finally, location is of importance: central, lateral, or commissural.

Wedge resection is indicated for most defects incurred to the lower lip with repair using primary closure. For lower lip defects not amenable to wedge resection, usually the next option is the Schuchardt procedure (Figure 17.4). This is a sliding-lip reconstruction that advances the lower lip with labiomental incision to the mandibular border. The lip is then advanced centrally. Larger defects, those measuring one-third to one half of the lower lip, can be reconstructed using the Estlander flap (Figure 17.5) if the defect includes the oral commissure. The Estlander flap is a lip-switching flap that includes and rotates around the oral commissure. It results in a round commissure with a resultant loss of the normal taper of vermillion. The Abbe flap may be used if the defect does not include the oral commissure. A double central reverse Abbe flap can be used for large lower lip defects up to 80% (Figure 17.6).

For near-total lower lip defects, the Karapandzic flap remains the technique of choice (Figure 17.7). This has largely replaced the Gillies flap because the nerve supply is preserved. It is essentially a rotation–advancement flap along the nasolabial fold. The advantages of the Karapandzic flap is that the lip is innervated. The disadvantages of this flap is microstomia, rounding of the commissure, and misplacement of the modiolus.

For larger defects, non-lip techniques need to be employed. The Webster–Bernard procedure involves a medial advancement of the cheek tissue to create a new lower lip (Figures 17.8–17.11).³ Because non-lip tissue is used, often a bipedicled mucosal sliding flap may be

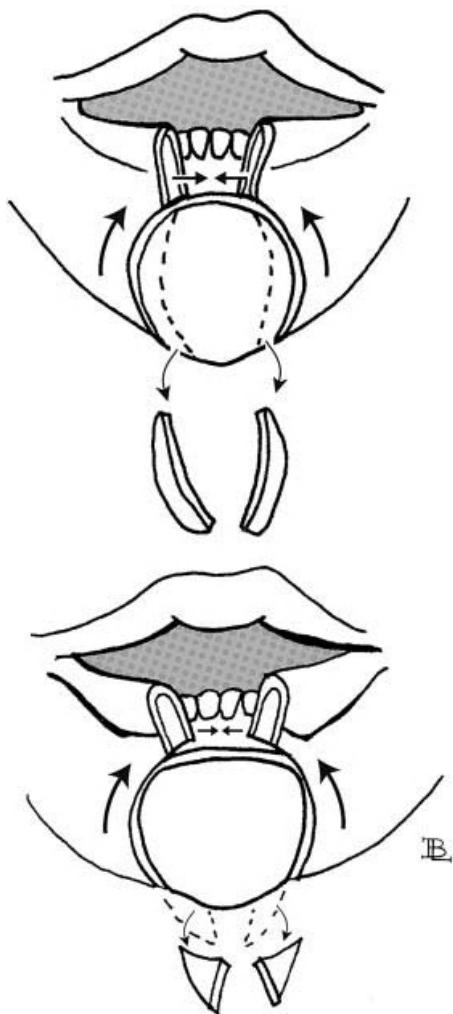


Figure 17.4 Schuchardt procedure.

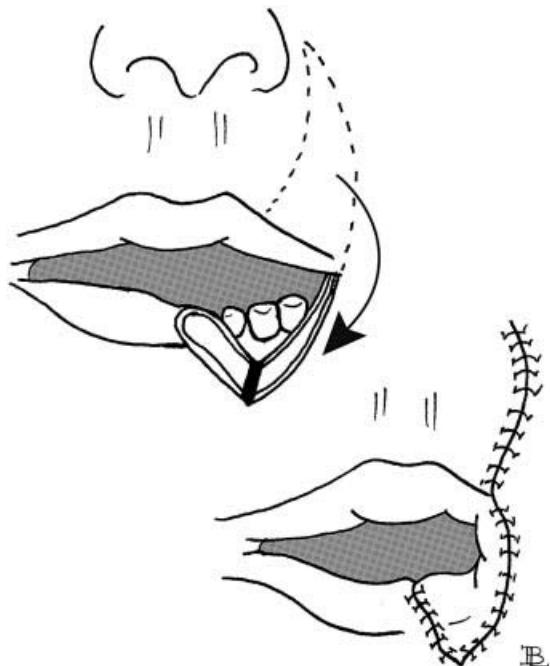


Figure 17.5 Estlander flap.

required to reconstruct the vermillion. The mucosal flap should be brought past the edge of the lip as contraction is expected. There is a significant amount of facial scarring associated with this technique. The free radial forearm flap is another reasonable option. A palmaris tendon may need to be included in the flap to be used as a sling to suspend the lower lip, and to provide oral competence. Other options include the Webster–Fries flap, Johanson stepladder flap design, and the Schuchardt flap.

Vermilion reconstruction

The vermillion is important in overall lip appearance deserves special importance. It is a thin layer of non-keratinized epithelium, without sebaceous glands or hair follicles. Its unique color and turgor is secondary to the underlying dense capillary network. Alignment of the vermillion is critical, as 1-mm step-offs are noticeable at conversation distance. Since it is difficult to identify the white roll after injection with local anesthetic, the white roll should be marked prior to infiltration. Methylene blue is oftentimes used for this. Excision of any portion of the vermillion is known as a vermillionectomy, or a “lip shave,” and is typically indicated for very superficial lesions such as in actinic cheilitis.

Small, superficial defects of the vermillion can be closed primarily with eversion of the approximated edges to prevent notching. Larger superficial defects necessitate the use of flaps, either from the lip or tongue. Lip flaps include vermillion advancement flaps for central defects (Figure 17.12) and mucosal flaps for defects that are distant from the vermillion border.

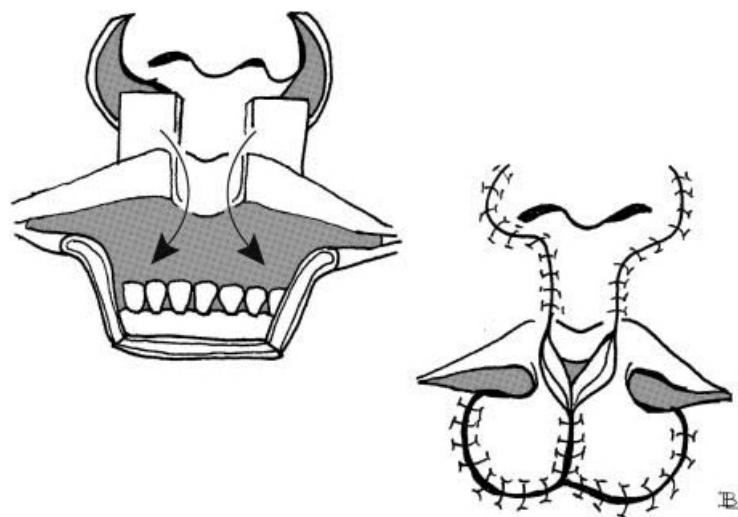


Figure 17.6 Double central reverse Abbe flap.

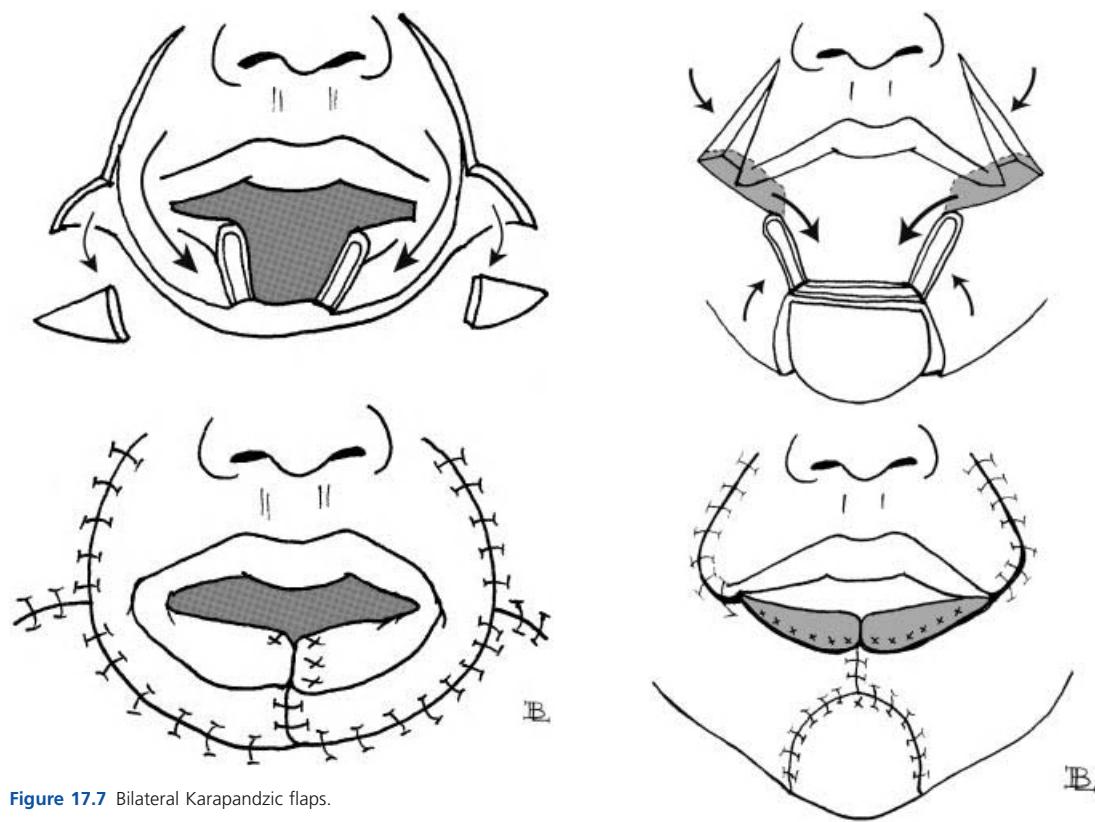


Figure 17.7 Bilateral Karapandzic flaps.

Figure 17.8 Webster–Bernard flap.

Other useful techniques include vermillion switch flaps (Figure 17.13), which can adjust the total amount of vermillion defect between both lips for optimal esthetic outcomes. The contralateral vermillion on the opposite lip is cut in a manner similar to an advancement flap but



Figure 17.9 Webster–Bernard flap, preoperative picture.



Figure 17.10 Webster–Bernard flap, intraoperative picture.

is flipped onto the lip of the defect and then divided accordingly after a period of 10–14 days.³

Postoperatively, patients sometimes complain of dryness and are advised to use moisturizing creams or balms.

Prevention and management of complications

Lip reconstruction often times requires revision procedures. Any lip-sharing procedure will have some degree of microstomia. Because it is best to replace like with like, an acceptable degree of microstomia is preferred over using non-lip tissue for reconstruction. One method to treat microstomia is with lip stretching, as some tribes in Ethiopia have done by serial placement of larger lip disks. Self-retaining spring dental retractors can be used, particularly for night-time wear. Hair transplants have also been used in an attempt to camouflage the scars of lip reconstruction.



Figure 17.11 Webster–Bernard flap, postoperative picture.

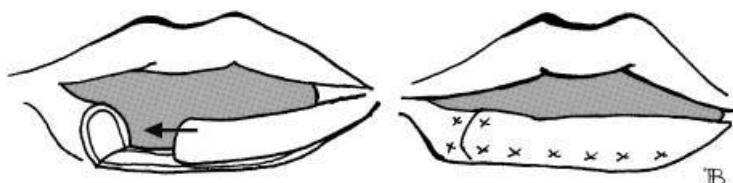


Figure 17.12 Vermilion advancement flap.

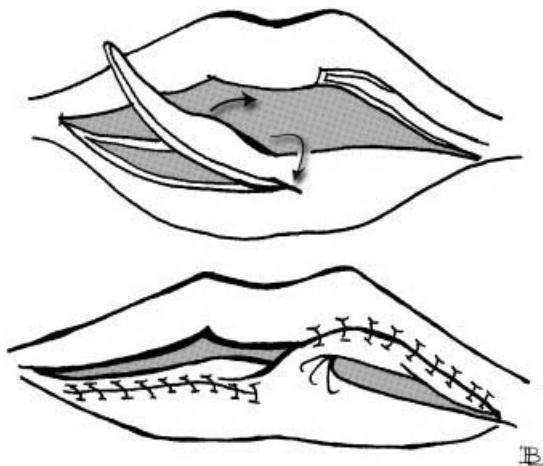


Figure 17.13 Vermilion switch flap.

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Reconstruction of the eyelids

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Preoperative care

The eyelid is reconstructed following definitive excision of the malignant lesion. Following excision of the tumor, the patient's wound should be dressed to prevent corneal exposure and trauma. Ophthalmic antibiotic ointment should always be placed over the cornea prior to any dressing application. Prior to reconstruction, the face may be prepped with 5–10% betadine solution.

Step-by-step surgical technique

Reconstructive methods are chosen based on the extent and location of the defect. The eyelid is composed of the anterior lamella (skin and orbicularis oculi) and the posterior lamella (tarsal plate and conjunctiva). Several principles must be taken into account when reconstructing an eyelid to achieve the optimum functional and cosmetic outcome. First and foremost, either the anterior or the posterior lamella must have an inherent blood supply. Two adjacent free grafts of anterior and posterior lamella will not survive. Next, horizontal stabilization should be maximized with minimal vertical tension, the lateral canthal area must be fixated properly, and an epithelialized internal surface must face the globe.¹ Finally, the transverse edge of the levator must be identified and addressed appropriately during upper eyelid reconstruction to ensure proper function.

Primary closure

Smaller defects in patients with sufficient horizontal laxity may be closed primarily. To avoid lid margin distortion, closure should be directed along a horizontal tension plane. A vertical incision and dissection are needed for subsequent undermining of skin and subcutaneous tissues along the horizontal plane in patients with deficient anterior lamella. These tissues may be undermined from the tarsal plate and then closed primarily with interrupted, superficial 7-0 vicryl sutures.

If insufficient anterior lamella remains or both lamellae are absent, a pentagonal wedge closure may be employed if there is sufficient horizontal laxity. A layered, primary closure provides the best tissue match, smooth lid margin and continuous lash line. A lateral canthotomy provides 5–6 mm of medial advancement of the temporal eyelid margin if tension precludes proper lid margin reapproximation.^{1,2} First, a 4–5 mm horizontal incision through skin and orbicularis muscle is made with Stevens or Wescott scissors from the lateral canthal angle and directed toward the orbital rim. The tips of the scissors are used to identify the lateral attachment of the lid. The superior/inferior crus of the lateral canthal tendon is cut with a vertical incision. The incision allows for medial mobilization of the wound without excess tension. The conjunctiva should not be disrupted during the cantholysis. The incision is then closed with interrupted 7-0 vicryl sutures (Figure 18.1 and Video 18.1).



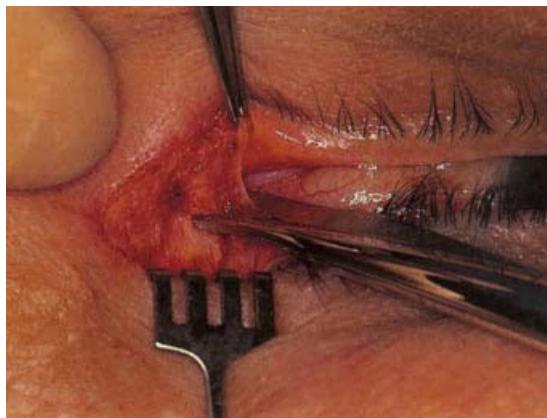


Figure 18.1 Lateral canthotomy. After a 4–5 mm horizontal incision is made through the skin and orbicularis muscle, Stevens scissors are placed at the lateral canthal angle and directed toward the orbital rim. The tips of the scissors are used to identify the lateral attachment of the lid to begin the lateral canthotomy, as outlined in this figure. Following this step, the superior/inferior crus of the lateral canthal tendon is cut with a vertical incision. The conjunctiva should not be disrupted during the cantholysis. The full details of this procedure may be viewed in Video 18.1.

Next, the wound edges are freshened and fashioned into a pentagonal shaped defect with the apex oriented inferiorly. The tarsal borders should be sharp and perpendicular to the lid margin. Three interrupted 5-0 vicryl sutures are placed at partial thickness depth through the tarsal plate. The lid margin is closed with a 4-0 or 5-0 silk vertical mattress suture that provides anteroposterior alignment. The suture is passed through the meibomian gland orifices. This vertical lid margin suture induces puckering of the wound edges, which prevents notching once the margin is healed. The orbicularis layer is closed with interrupted buried 6-0 or 7-0 vicryl sutures; the skin edges are closed with interrupted 7-0 vicryl sutures. The ends of the silk sutures are left long and secured away from the wound on the lid skin with a 7-0 vicryl suture (Figure 18.2a–c and Video 18.1).

Deficient anterior lamella

The anterior lamella may be reconstructed with primary closure, full-thickness skin graft, myocutaneous advancement flap, rotation flap, or unipedicle flap. Non-hair-bearing skin grafts may be harvested from the contralateral upper eyelid, retroauricular region,

supraclavicular region, or the upper inner arm. Skin grafts must be thinned of subcutaneous fat and connective tissue and sutured to the edges of the defect with interrupted 7-0 vicryl sutures. Two to three buttonholes should be made in the center of the graft to allow for egress of blood.

Deficient posterior lamella

Hughes tarsoconjunctival flap

In the lower lid, deficient posterior lamella not amenable to primary closure may be addressed with a Hughes tarsoconjunctival flap.² This flap provides an inherent blood supply. The main disadvantage is obscuration of the pupil by the tarsoconjunctival bridge for 4–8 weeks. To begin, the inferior border of the defect is squared off to create a rectangular defect with the lateral and medial edges perpendicular to the lid margin. The edges are advanced centrally with forceps and the horizontal defect is measured. A lateral canthotomy may also be employed.

The upper lid is everted over a Desmarres retractor using a 4-0 silk traction suture through the central upper lid margin. A three-sided flap is then harvested on the central tarsal conjunctival surface of the upper lid with a no. 15 blade. The incision should be at least 4 mm from the lid margin to minimize postoperative entropion, contour deformities, loss of lashes, and trichiasis. The vertical incisions are directed toward the superior fornix perpendicular to the lid margin and are made through conjunctiva and tarsus. The flap is undermined from the overlying levator aponeurosis and orbicularis muscle with Wescott scissors; the dissection is continued above the superior tarsal border between the conjunctiva and Mueller's muscle toward the superior fornix. Following mobilization of the tarsoconjunctival flap into the lower lid defect, the upper lid superior tarsal border should be aligned with the lower lid margin remnant. Interrupted 5-0 vicryl sutures passed through the anterior two-thirds of the tarsus secure the lateral and medial edges of the flap to the tarsal stumps. Finally, a running 7-0 Vicryl suture secures the inferior edge of the flap to the cut edge of the inferior fornical conjunctiva and lower lid retractors (Figure 18.3).

The second stage of the Hughes procedure is undertaken 4–8 weeks later. The second stage is delayed until the reconstructed lower lid has established its new blood supply and counteracted the downward contractile forces

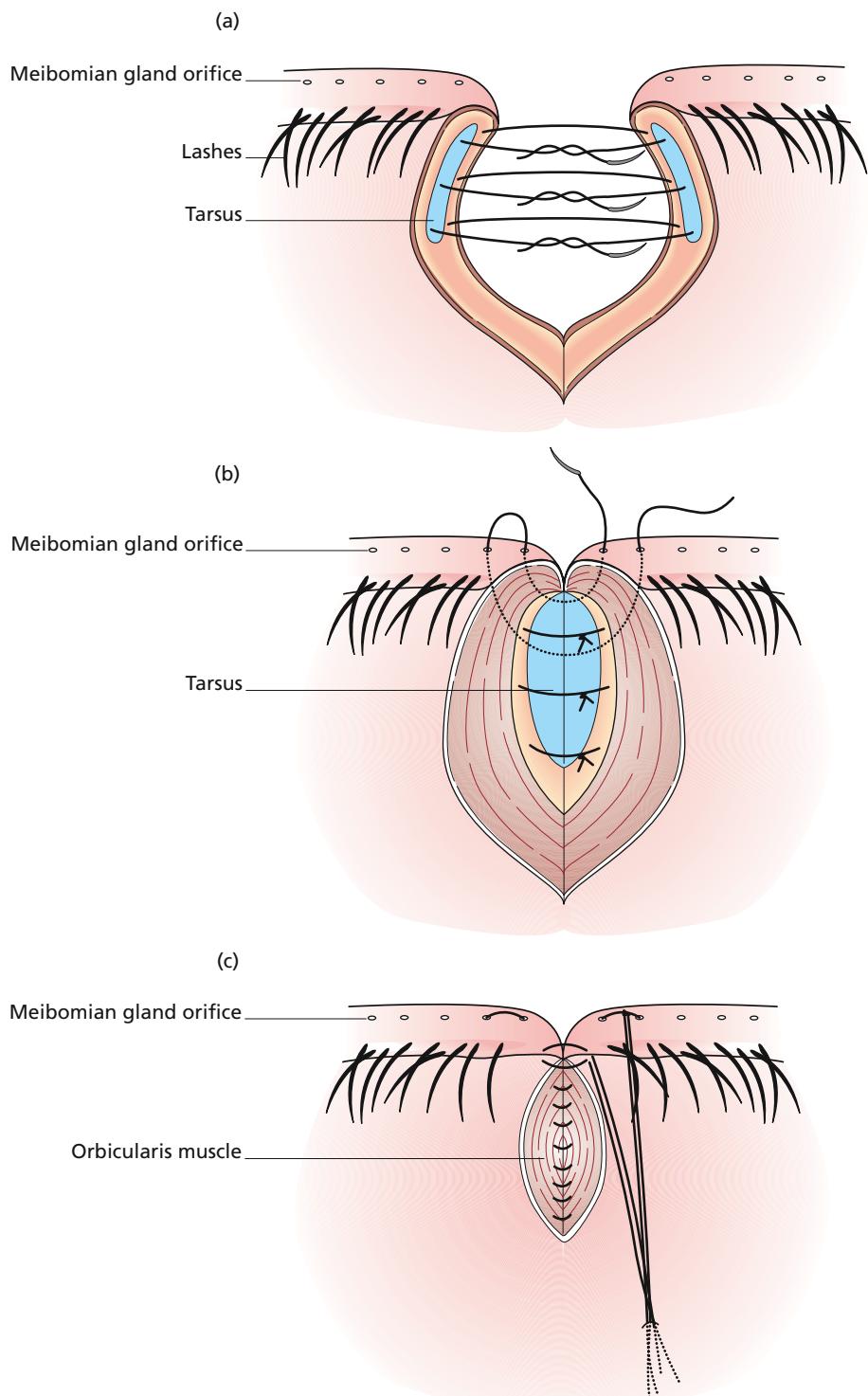


Figure 18.2 Primary eyelid closure. (a) Three interrupted 5-0 vicryl sutures are placed at partial thickness through the tarsal plate. (b) The lid margin is reunited anteroposteriorly with a 4-0 silk vertical mattress suture; the suture is passed through the meibomian gland orifices. (c) The ends of the silk sutures are left long and secured away from the wound on the lid skin with a 7-0 vicryl suture.



Figure 18.3 Hughes tarsoconjunctival flap from upper eyelid to lower eyelid. Following mobilization of the tarsoconjunctival flap into the lower lid defect, the upper lid superior tarsal border should be aligned with the lower lid margin remnant.



Figure 18.4 Second stage Hughes flap. The flap is incised 0.5 to 1.0 mm above the new lower lid margin with blunt Wescott or Stevens scissors while care is taken to avoid the underlying cornea.

of scar maturation and gravity. The flap is incised 0.5–1.0 mm above the new lower lid margin with blunt Wescott or Stevens scissors while care is taken to avoid the underlying cornea (Figure 18.4). A lacrimal groove director is an excellent tool for corneal protection while severing the bridge. The excess mucosa from the lower portion of the flap is left to retract or sutured to a skin incision made along the new lid margin with a running 7-0 Vicryl suture. This process establishes a new mucocutaneous border. The superior portion of the flap is allowed to retract under the upper lid.

Free tarsal graft

In the upper lid (or in cases of a lower lid defect with previous use of a Hughes flap), a free tarsal graft from the upper contralateral eyelid may be employed to reconstruct the posterior lamella. The lid is everted over a Desmarres retractor using a 4-0 silk margin suture. A graft of appropriate length is outlined and harvested with a #15 blade. The inferior border should be parallel to and no more than 4 mm from the lid margin. The vertical height of the graft is determined by the vertical height of the tarsus. The anterior tarsal surface is then dissected free from the levator aponeurosis. Conjunctiva and Mueller's muscle are severed from the superior tarsal border, leaving 2 mm of conjunctiva attached to the graft. The donor site is allowed to heal spontaneously.

The graft is secured with the conjunctival surface in apposition to the globe while the superior edge of the graft with the conjunctival remnant lies along the new lid margin. Interrupted, partial thickness 5-0 vicryl sutures are used to secure the graft. The anterior lamella is then reconstructed. To minimize postoperative retraction, the superior eyelid must be immobilized and kept on stretch with a temporary 4-0 silk frost suture.

Hard palate graft

Hard palate grafts are the method of choice to address deficient posterior lamella.^{3,4} They provide a long lasting, rigid, and epithelialized surface. The central palatine raphé, anterior palatine rugae and the area overlying the greater palatine foramen where the anterior palatine artery exits should be avoided. In most cases, rectangular-shaped grafts are harvested with a no. 64 or no. 66 blade. The palatal periosteum is left intact. Oxidized regenerated cellulose or microfibrillar collagen hemostat may be used to achieve hemostasis. The graft is soaked in antibiotic solution, trimmed to the appropriate dimensions, and secured to the defect with interrupted partial thickness 5-0 vicryl sutures.

Special circumstances

More involved methods of repair may be required for larger defects of the anterior lamella. Tissue expansion has been used with more extensive defects to provide vascularized skin that is similar in appearance, thickness and texture while preserving the maximal amount of normal tissue.⁵ Furthermore, tissue expansion enhances the vascularity of the skin flap. This provides for more

rapid vascularization of any free grafts beneath the flap. The creation of temporary disfigurement, however, is the main disadvantage.

Galeal and pericranial flaps may be used for large defects with an insufficient vascularized pedicle.⁶ A bicoronal incision is made over the vertex of the skull. A transcoronal incision is used to reach the forehead pericranium. The plane of dissection is between the subcutaneous tissue and the galea for a galeopericranial flap, and subgaleal for a pericranial flap. The loose areolar tissue and periosteum adherent to the frontal bone are not disturbed. Dissection is carried towards the supraorbital rim. The supraorbital and supratrochlear vessels are left intact. Dissection ceases where the vessels enter the flap base. It is important to avoid a transverse incision of the flap two finger breadths above the superior orbital rim, because the frontalis nerve enters the frontalis muscle in this area. The pericranium and galea are incised and elevated from the frontal bone with a periosteal elevator. The mobilized flap is turned down anteriorly through the skin defect. It may be turned to multiple arcs for reconstructive purposes. The length, width, angle and shape are tailored for the specific deformity. Once the flap is in place, it serves as a well-vascularized bed.

Postoperative care and follow-up

A pressure patch is placed over the reconstructed eyelids immediately postoperatively. The patch is angled inferolaterally, beginning at the central forehead (Figure 18.5). Benzoin or mastisol should be used in the forehead and cheek areas to secure the patch. Following installation of ophthalmic antibiotic ointment over the cornea, two sterile eyepads are placed over the *closed* eyelid. Next, two 4 × 4 gauze pads are unfolded and gently reformed into a round configuration. These pads are placed over the eyepads. Lastly, 2-inch paper tape is layered firmly over the dressings and benzoin/mastisol. The patient is instructed to keep the patch in place and dry for 1 week.

Complications

Wound infections may occur anytime after reconstruction. Postoperative antibiotics are prescribed if there is any concern for potential infection. Other complications



Figure 18.5 Pressure patch. The patch is firmly placed over the reconstructed eyelids.

include wound dehiscence and eyelid retraction. Care must be taken to minimize wound tension at the time of reconstruction. Eyelid retraction may also occur if there is insufficient anterior and/or posterior lamella. Both surfaces must be adequately restored to prevent this complication. Anterior lamellar shortage may also occur postoperatively as cicatrization occurs; in mild cases without corneal compromise, gentle massage of the deficient tissues to counteract the cicatrizing forces may alleviate the matter. However, if retraction persists with ocular compromise, further surgery may be indicated to augment the deficient tissues.

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Video list

Video 18.1 Lateral canthotomy and primary closure of a full-thickness lower eyelid defect

Reconstruction of the ears

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Introduction

The ears occupy an important functional and aesthetic part of the face. It is primarily cartilage covered by a soft tissue envelope that is thin and immobile (except at the helical rims and earlobe). With chronic sun damage or trauma, the ears can be highly calcified and difficult to incise or suture. One significant advantage is the lateral location of the ears; asymmetry is less noticeable and more easily camouflaged (hairstyle). Functionally, ears play two roles: support for glasses (superior crus of helix) and hearing conduit (external auditory canal (EAC)). A 95% loss of the ear can still be functional as long as a residual cartilage nub is present at the temporal scalp and the EAC is patent. As a last resort, ear prosthetics are exceptional and can be indistinguishable from a natural ear (Figure 19.1).

Principles of ear closure

The usual repairs of second intention (SI), skin grafts (SGs), primary closure, and single and staged flaps also apply to the ears.¹ The reconstructive goals are to cover exposed cartilage (especially if perichondrium is absent), prevent contractile deformities near the EAC, prevent notching of the helical dome convexity, and maintain the ear's height to width proportion of 2:1. Vertical shortening of one ear is not visually evident unless there is a 20% or greater discrepancy. If a 30% reduction in the ear

height is planned, then a similar narrowing in width should be considered to restore the 2:1 ratio. The many star shaped wedge closure designs aim to maintain this height to width proportion. Another consideration is whether the patient wears hearing aids. Altering the conchal bowl dimension may cause ill-fitting devices, and heroic repairs should be reconsidered. Whether it is realistic to preserve ear piercings and/or ear lobe position (attached or hanging) should also be discussed as part of the preoperative consultation. Resist the urge to close the entire wound. A defect involving the rim and antihelix, for example, may only need closure at the rim and SI for residual areas. A reconstructive algorithm based on location and depth is shown in Figure 19.2.

Suture techniques

Owing to its thin dermis, traditional buried vertical mattress sutures are difficult on the ear except for the more fleshy portions of the helical rim and earlobe. Ear cartilage can be easily fractured when handled and prevention strategies include grasping with Brown–Adson forceps (disperses pressure over wider area than single teeth), using a reverse cutting needle (inner curve flat, outer curve sharp), needle entry perpendicular to the cartilage and at least 2–3 mm away from the free edge, avoiding repeated needle passes, and using a figure-of-eight suture to approximate cartilage margins. Sharp or uneven cartilage edges should also be trimmed prior to suturing.



Figure 19.1 Ear prosthesis.



Figure 19.2 Repair algorithm for the ear.

The helical rims deserve special mention. With their convexity, the rims are prone to notching. Eversion here is critical with both buried and epidermal vertical mattress sutures.

Second intention healing

As a general rule, defects on the convex rims are best closed while SI is excellent elsewhere, provided that there is an intact cartilage and perichondrium. Owing to the substantial cartilage infrastructure, contour contracture is rare (even in large superficial defects) unless there is significant cartilage and perichondrial loss. For wounds without perichondrium, SI is still an option if the area is small (≤ 1 cm) and or if 2-mm punch adits are made to expose vascular tissue from the underside. Even large areas of denuded cartilage heal successfully by SI if covered by bovine dermal collagen (BDC) sheets² (Figures 19.3 and 19.4). Deep wounds near the EAC should be monitored closely for contractile narrowing during SI healing. Shallow post-auricular wounds, even large ones are SI candidates as long as occlusive wound care prevents cartilage desiccation.



Figure 19.3 Second intention healing.



Figure 19.4 Second intention healing with collagen matrix.

Skin grafts

Grafts on the ear are generally full thickness and should be thought of in the same settings as SI. Typically, thin full thickness skin grafts (FTSGs) are preferred. FTSG survival is dependent on an intact perichondrium, which provides vascular supply. However, inosculcation is less predictable given the thinness of the perichondrial layer. FTSG cover exposed perichondrium, minimize wound

contraction, and accelerate healing (1–2 weeks) relative to SI (4–6 weeks) (Figure 19.5). Ipsilateral pre- and post-auricular donor sites are ideal for match and ease of wound care. If the perichondrium is absent then FTSG survival is more tenuous. To optimize inosculation, punch-through adits or BDC will encourage granulation and FTSG may be deferred for 1–2 wks. The author finds that in such cases, grafts are often unnecessary as on follow-up, the healing progress is excellent with SI.

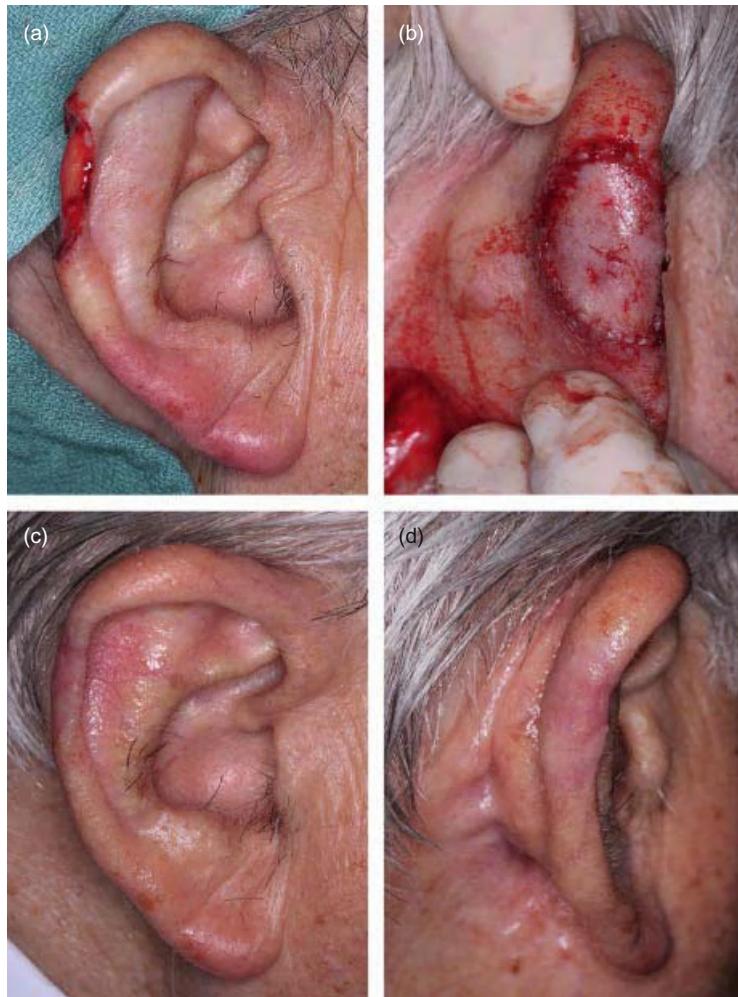


Figure 19.5 Skin graft.

Primary closure

Primary closure (PC) is ideal for helical rim defects, especially if there is partial cartilage loss. PC permits approximation of the residual cartilage and prevents contour notching. For most defects <1 cm, a wedge closure oriented perpendicular to the rim is adequate (Figure 19.6). Occasionally, orientation parallel to the rim is appropriate if the wound is superficial and if an S-plasty is applied (Figure 19.7). Larger excisions may require a geometric design. The design variations are numerous but the goals are identical: preserve height and width proportion and maintain the rim's contour and convexity. (Figure 19.8

and 19.9). Attention to suturing techniques as above is critical to successful closure.

Single stage flaps

Single stage flaps (SSFs) are best for long-rim contour defects (greatest defect dimension is along the rim) and are either transposition or advancement types. The ear skin itself has limited mobility. Flap donor tissue is either from the pre-auricular cheek or post-auricular mastoid for transposition designs. The former is more mobile and preferred for most wounds on the anterior ear or

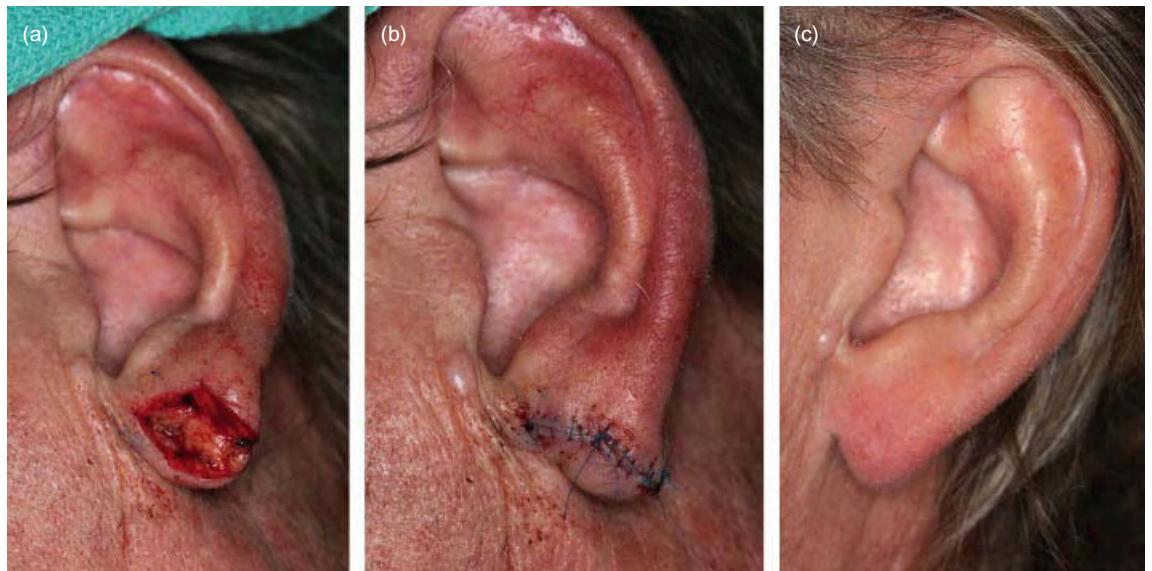


Figure 19.6 Primary closure of earlobe.



Figure 19.7 Primary S-plasty.



Figure 19.8 Geometric design closure.



Figure 19.9 Transposition flap: posterior.

superior dome. When transposing cheek skin to the ear, the pivot point should be mobilized slightly above the superior helical crus: to minimize twisting of the pedicle and blunting of the crus-cheek attachment (Figure 19.10). Further, the flap length should be 10–20% longer than the defect length to compensate for the three-dimensional rim contour. Auricular advancement flaps for helical rim defects can use just auricular tissue and are of two types: chondrocutaneous and cutaneous. Chondrocutaneous flaps incise and excise cartilage along the antihelix/rim junction to create composite flaps that are then redraped. Cutaneous designs create skin flaps only and full thickness cartilage incisions are avoided. However, there is more extensive dissection of the skin envelope in the post-auricular surface (Figure 19.11). In both versions, cartilage/skin at the scapha and or

antitragus may be excised for flap movement. A simpler alternative to the aforementioned flaps is the helical hinge advancement design (Figure 19.12). This repair for rim defects is least morbid, requiring less incisions and undermining. Pull through flaps are an option to resurface a composite (missing skin and cartilage) anterior ear defect. Flap tissue is mobilized from the post-auricular neck/sulcus area through a full thickness incision to the anterior defect.^{3,4} They may be either single or multi-staged depending on the design (Figure 19.13).

Staged flaps

Staged repairs are reserved for substantial composite wounds (usually along the rims) where aesthetic outcome



Figure 19.10 Transposition flap: anterior.

is crucial. A variety of staged flaps are available (Table 19.1). Pre-auricular cheek skin can resurface the upper or lower third of the ear while post-auricular flaps are best for middle or lower rim defects.⁵ Although staged, these flap pedicles are random pattern and are based on arterial perforators from the superficial temporal artery (front) or posterior auricular artery (back). Cartilage grafts may be inserted in stage I or if vascularity is fragile, then at an intervening stage before pedicle division. Figure 19.14 illustrates the post-auricular staged flap (Video 19.1).

A step-by-step plan of this flap is outlined in Box 19.1.

Perioperative care

Relevant issues to ear reconstruction include greater bleeding, challenging wound dressings, surgical pain due to chondritis, and infection. Bleeding and postoperative hematoma is mostly seen at the inferior crus and conchal bowl or post-auricular sulcus. These areas are highly vascularized by perforators from the posterior auricular artery. Further, pressure dressings are difficult. Meticulous hemostasis and basting (aka quilting) sutures reduce

bleeding. Quilting sutures (5-0 fast absorbing gut) sandwich the anterior and posterior ear skin flaps, especially when the cartilage layer is missing. Further, a tie-over bolster dressing provides added and even pressure on the ear's convoluted contours. Whenever possible, the author prefers to secure a one week dressing to simplify wound care. Table 19.2 outlines this method.

Pain is not uncommon with ear closures that resect cartilage. Analgesics are routinely prescribed for the ear. With significant cartilage excision, the author supplements with bupivacaine 0.5% + 1:200 000 epinephrine just before final dressing that serves two purposes: longer acting anesthesia and additional vasoconstriction for hemostasis. Unlike traditional teaching, pseudomonas ear infection or any infection is rare. Routine antibiotics are not given as any chondritis is often sterile and not infectious.

Conclusion

The ear is in a strategic position on the face. Individual variations and lateral location allows camouflage of mild to moderate imperfections between one ear and the

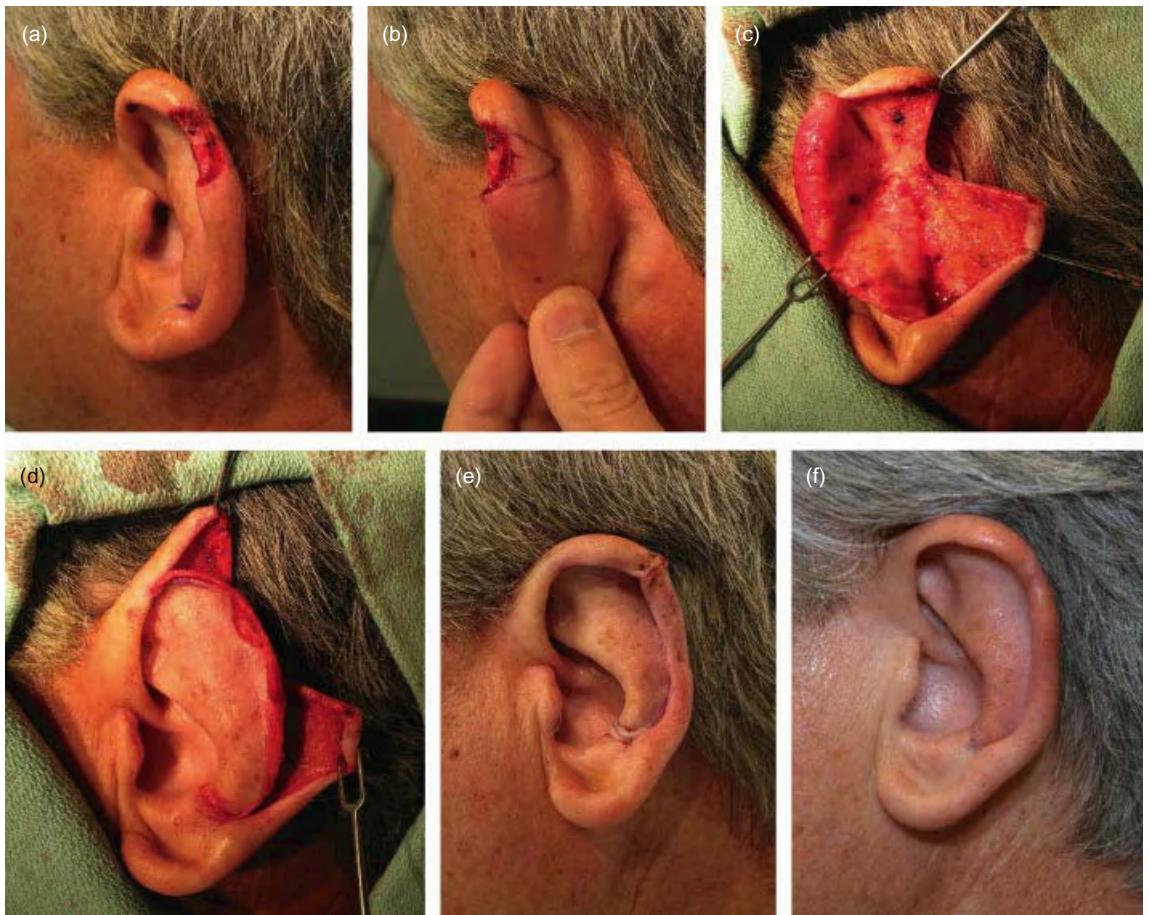


Figure 19.11 Chondrocutaneous advancement flap.



Figure 19.12 Helical hinge flap.



Figure 19.13 Retroauricular pull through flap.



Figure 19.14 Retroauricular staged flap.

Table 19.1 Staged auricular flaps

Design	Comment
Post-auricular staged flap	Post-auricular skin/mastoid flap is elevated to cover a helical rim or antihelix defect Ear is “pinned” posteriorly by flap until time of pedicle division
Post-auricular pull-through flap	Post-auricular skin flap pulled through an incision or existing defect to cover an anterior ear defect Some designs may be performed as one stage
Pre-auricular two-stage transposition flap	Pre-auricular cheek flap transposed onto a superior or lower helical rim or earlobe defect Pre-auricular donor skin is more mobile relative to post-auricular skin

Table 19.2 Ear postoperative care

Dressings	Comment
Plug the EAC with either a betadine soaked dental roll or Xeroform	Prevents any bleeding or serous drainage from entering EAC. Remove plug in 24–48 hours
Apply ointment to suture lines and cover with non-stick dressing.	Occlusive wound care promotes healing
Consider bolster dressings	Stabilizes closure and minimizes hematoma. Facilitates wound care for patient
Fluffed gauze or cotton to pad contours of both anterior and posterior ear	Prevents uneven pressure
Secure dressing with tape (Hypafix)	Creates a comfortable sandwich dressing that may be left for 7 days.

Box 19.1 Post-auricular staged flap

Stage I: Flap creation and inset

1. Measure the defect along the helical rim.
2. Outline the flap starting on the thin post-auricular skin of the ear itself.
3. Extend the flap posterior-laterally across the sulcus and back to the mastoid skin.
4. The flap shape should be trapezoid, with the anterior edge being smaller and the posterior pedicle wider.
5. Incise the flap above perichondrium at its anterior edge and dissect more deeply towards the pedicle (deep subcutaneous or just above fascia).
6. Critical step: Pin the ear back to the post-auricular neck skin with retention sutures (4 or 5-0 nylon); allows tension free flap closure of the helical rim defect and any antihelical portion.
7. If needed, cartilage grafting may be secured at this time.
8. Suture the flap to the defect (author prefers 5-0 or 6-0 Fast absorbing gut sutures) with epidermal sutures. Deep sutures are not needed except for at the rim itself.
9. Xeroform gauze and ointment packing for the exposed underside of the flap at the sulcus

Stage II: pedicle division

1. Divide the flap posteriorly, allowing adequate length to wrap around the rim in back.
2. Thin flap appropriately to match auricular contour.
3. Donor site heals by second intention.

other. The ear does have unique features that if attended to, will reward the patient and reconstructive surgeon in the majority of repairs.

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Video list

Video 19.1 Staged retroauricular flap

Reconstruction of the cheeks

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Introduction

The goal of cheek reconstruction is to restore facial appearance with symmetrical contour, uniform color, and even texture. There is abundant mobility and laxity in the cheek, allowing for linear side-to-side closures and flap repairs. These repairs result in fewer incision lines and a minimally noticeable scar. Secondary intention healing and grafts typically result in inferior cosmetic outcomes, and are only used in special circumstances.

Preoperative care

As with any cutaneous reconstruction, a number of factors must be considered before choosing a reconstructive technique including patient comorbidities, previous surgery in the area, anatomy, location of maximum skin tension lines, skin texture and color, and size, depth, and location of the defect.¹

The cheek is a large cosmetic unit delineated by the preauricular crease, superior aspect of the zygomatic arch and malar eminence, inferior orbital rim, nasofacial angle, melolabial crease, and inferior border of the mandible.² The cheek can be subdivided into seven subunits including the medial, anterior, infraorbital, zygomatic, buccal, preauricular, and mandibular cheek.³ In contrast to the subunit principle of reconstruction, it is generally acceptable to cross subunits in the cheek without significant consequence.⁴ Although there is abundant tissue

mobility in the cheek, special attention must be paid to avoid distortion of free margins at the lower eyelid, nasal rim, upper lip, and oral commissure. Topographically, the cheek is uneven and this must be considered when choosing a repair option. It is concave over the medial cheek, convex over the malar eminence, and flat at the lateral portion and pre-auricular region.

The relaxed skin tension lines run inferiorly and posteriorly over the surface of the cheeks.⁵ Ideally, scars are placed in these lines which will evolve into rhytides. It is also desirable to place scars in the boundaries of the cosmetic subunit, such as the melolabial fold, nasofacial angle, and pre-auricular crease if possible.

It is important to recognize what anatomic structures require special attention during cheek reconstruction. There is a good vascular supply through the facial artery which supports random flaps. Two motor nerves, the temporal and marginal mandibular branches of the facial nerve, have a superficial course in the cheek, and when damaged, can result in permanent loss of critical muscle function. The temporal branch is superficial as it crosses the zygomatic arch. The marginal mandibular branch travels along the edge of the mandible. The remaining branches of the facial nerve, the zygomatic, buccal, and cervical branches, have cross-arborization and paresis is typically temporary when these nerves are injured⁶ Stenson's duct, the primary drainage for the parotid gland, courses over the central buccal fat pad and descends anterior to it. Severing the parotid duct leads to salivary leakage through the surgical incision.

Choosing a reconstructive technique

Cheek reconstruction usually involves linear closures or flap repairs. Secondary intention healing leaves a noticeable scar, except in the alar–malar crease. Skin grafts are used in special circumstances when a defect resulted from excision of an aggressive tumor that requires surveillance and early detection of recurrence. Additionally, very large defects may require skin grafts, although cervicofacial flaps often are preferred.⁷

When deciding between a linear closure or a flap repair, one must consider whether a linear closure will lead to distortion of a free margin or excess tension. The most frequently used cheek flap options include rhombic transposition, rotation, and advancement flaps.

Repair by cheek subunit

Medial cheek

For small to medium wounds oriented along a vertical axis, linear closures along the melolabial fold or nasofacial sulcus are ideal. The use of periosteal sutures at the nasolabial fold helps to prevent distortion of the fold.² If the wound is too large for a linear repair, a rhombic flap can be performed. A double Z-plasty helps extension of the flap.¹

For small to medium horizontally oriented wounds, rhombic, rotation, and island pedicle flaps can be employed. The rhombic flap is usually inferiorly and laterally based, and the base should be perpendicular to maximum skin tension lines.⁸ Rotation flaps from the inferior tissue reservoir are also useful on the medial cheek (Figure 20.1). An incision is made inferiorly along the melolabial fold with a backcut if needed. Tissue is rotated superiorly. Techniques such as periosteal anchoring sutures, and de-epithelialization of the flap tip can help optimize surgical outcome (Video 20.1).⁹ Island pedicle flaps can be used, but often result in a puffy flap and suboptimal outcome.

Larger vertically oriented defects on the medial cheek can be repaired with a whole cheek rotation flap with a lateral and inferior base.¹⁰ The flap is designed with an arc of rotation two to four times longer than the arc of the defect.¹⁰ The initial incision is horizontal and lateral from superior aspect of the defect extending along the orbital rim. As it approaches the lateral canthus, it is often



Figure 20.1 Inferiorly based rotation flap utilized to repair a medial cheek defect.

curved superiorly above the zygomatic arch to reduce the risk of ectropion. For very large wounds, the incision can be carried over the zygomatic arch and down the preauricular crease to a point 2 or 3 cm below the earlobe where a Burow's triangle can be excised and hidden behind the earlobe.¹ The flap is undermined in the subcutaneous fat. The superior flap border should be thinned to match the skin thickness of the lower eyelid. The flap is then rotated medially and advanced superiorly. The key stitch is placed lateral to the lateral canthus, and is placed so the primary defect is filled with the leading edge of the flap and the lower lid is pushed superiorly. If placed correctly, it will be obvious that the weight of the flap is supported by the key stitch, and when remaining stitches have been placed the flap will not pull the lid downward.

Cervical-facial flaps and cerivopectoral flaps can be used for extensive cheek defects.² Similar to the cheek rotation flap, an incision follows the orbital rim laterally and continues along the temporal hairline and preauricular crease. At the inferior ear lobe, the incision is either continued inferiorly and anteriorly in a neck crease along the sternocleidomastoid muscle or posteriorly along the inferior hairline. In a cerivopectoral flap, the incision continues further along the posterior border of the trapezius and medially at the end of the clavicle. This extended incision allows for additional tissue recruitment to repair larger defects. Complications

of these more complicated reconstructions include anterior transfer of hair and ectropion.

Anterior cheek

Small to medium wound on the anterior cheek can be repaired with linear closures. Larger defects can be repaired with a rhombic or rotation flap.¹

Infraorbital cheek

When defects involve significant portions of the lower eyelid and the medial/anterior cheek, one may consider a flap closure for the cheek defect and a graft for the eyelid portion. If there is minimal involvement of the lower eyelid in conjunction with an infraorbital cheek defect, an inferiorly based rhombic transposition flap can push the lower eyelid up to relieve tension and reduce the risk of ectropion.

Malar cheek

Linear closures are optimal for the malar cheek. Incision lines should be placed within periorbital rhytides and along relaxed skin tension lines. Rhombic flaps and rotations flaps can be used for larger defects (Figure 20.2a,b). A laterally based Burow's advancement flap can be used for small defects. When performing surgery in the malar region, it is important to be wary of the temporal branch of the facial nerve. Additionally, tacking sutures should be placed if necessary to prevent lower lid ectropion.

Buccal cheek

The buccal cheek has much laxity. Defects can be repaired with linear closure, rhombic flaps, or rotation flaps (Figure 20.3a,b).



Figure 20.2 (a) Medium-sized defect on the malar cheek. (b) Laterally based rotation flap. A periosteal tacking suture was used to suspend the flap to avoid downward pull on the eyelid.



Figure 20.3 (a) Medium-sized defect on the buccal cheek. (b) A superiorly and laterally based rhombic flap.



Figure 20.4 (a) Large defect on the pre-auricular cheek. (b) An inferiorly based advancement flap with burow's triangle excised behind the ear. (c) Follow-up at 2 months demonstrates the scar line placed well in the pre-auricular crease.

Pre-auricular cheek

Linear closure or rotation flaps are optimal repair options for pre-auricular defects. Maintaining the hair bearing side burn requires horizontal or diagonal orientation of closures. Alternatively, a Burow's advancement flap is an option for small and medium defects (Figure 20.4a–c). An incision is made inferiorly along the pre-auricular crease and a Burow's triangle is excised inferior and posterior to the ear lobe. The flap is advanced superiorly and sutured in place. This repair option helps preserve the cosmetically hairless pre-auricular region in males.¹ Very large defects can be repaired using a cervical neck flap or post-auricular banner flap.¹

Mandibular cheek

Linear closures on the mandibular cheeks are used to repair small defects. An S-plasty can be designed to redirect wound contracture tension from going across the convex surface of the mandible.¹ A rhombic trans-

position flap, utilizing the excess tissue reservoir in the inferior and posterior submandibular and submental regions, can be used for small and medium-sized defects. When performing reconstructions along the mandibular cheek, one must avoid the marginal mandibular branch of the facial nerve which runs along the inferior border of the mandible.

Complications

Cheek reconstruction can result in the standard complications of any cutaneous surgery such as infection, necrosis, wound dehiscence, bleeding, and hematomas.¹¹ Often cheek surgery can result in significant ecchymoses that can extend down onto the neck. It is important to inform the patient that this may occur, especially if he or she is on anticoagulants. Flap necrosis is rare on the cheek because there is such a vigorous vascular supply

throughout the region. However excess flap tension can lead to necrosis. Also, patients on warfarin and smokers are at greater risk for flap necrosis.

Unique complications that can occur with cheek reconstruction include eyelid swelling, ectropion, medial canthal tenting, facial nerve deficit, and parotid fistula formation. Anterior and medial cheek surgery can result in significant eyelid swelling, especially in elderly patients. The lymphatic drainage is lateral and inferior on the cheeks. When the cheek is pulled upward, the tension results in a temporary blockage of lymphatic drainage. The swelling typically starts 1 day after surgery and peaks by postoperative day 2. Ice packs may help reduce the swelling.

Ectropion occurs when excessive flap tension pulls down the lower eyelid. Ectropion can be prevented by proper flap design and by placing tacking sutures from the flap to the periosteum, thereby redirecting flap tension away from the lower eyelid. If ectropion does occur, canthopexy or placement of a full thickness skin graft between the lid margin and flap may rectify the problem.

Medial canthal tenting results from tension in the vertical plane from poor flap design or excessive scar contraction in a downward direction. The tenting may improve or resolve with time. Intralesional steroid and massage can facilitate improvement. Surgical correction with a V-to-Y plasty or Z-plasty may be beneficial.

Motor deficits occur if the temporal or marginal mandibular branches of the facial nerve are severed. A temporal deficit results in an inability to raise the ipsilateral brow. A marginal mandibular injury results in a lip droop.

Parotid fistulas result from nicking Stenson's duct when working beneath the parotid fascia. Parotid fistulas result in salivary leakage through the flap incision site. Treatment options include cannulation and duct repair, duct ligation, irradiation of the gland, botulinum toxin injections, and pressure.

Conclusions

Cheek reconstruction requires knowledge of regional reconstruction principles, anatomy, and patient factors.

The aim is to create a closure with the fewest number of incision lines and a less noticeable scar. The abundant mobile tissue on the cheeks allows for most defects to be repaired with desirable cosmetic outcomes.

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Video list

Video 20.1 Inferiorly based rotation flap for closure of an infraorbital and medial cheek defect

Reconstruction of the forehead and temples

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Introduction

Reconstructions of defects involving the forehead and temples can range from simple linear closures to complex tissue transfers. Skin thickness, texture, and laxity can be highly variable, especially in the elderly patient. Given that tumors can grow quite large in these areas,¹ limited tissue motion can be problematic when designing appropriate repairs. Scars are generally well tolerated on the forehead and temples compared with the central face, and incision lines can often be disguised along anatomic boundaries. The surgeon's primary focus should be the preservation/restoration of position and functionality of nearby structures, primarily the eyebrows and hairline.

Preoperative care

Patient considerations

Appropriate matching of patient with procedure is critical to surgical success. Keeping functional and aesthetic concerns at the forefront, one must also consider the patient's desires and expectations. The optimal surgical reconstruction, from an aesthetic standpoint, may not always be feasible, nor in line with the patient's wishes. Conversely, some patients will have the unrealistic expectation that their postoperative appearance will be exactly the same as their preoperative appearance, minus the

tumor. Factors, such as tobacco use, previous surgical procedures in the area, and the patient's ability/willingness to tolerate substantial reconstruction, must also be considered.

Informed consent

It is important to document the discussion of informed consent prior to any surgical procedure. In the forehead and temple region, informed consent should include discussion of specific complications pertinent to the planned procedure, such as temporal nerve injury and brow distortion.

Tissue reservoirs

In general, defects of the temple will rely on tissue laxity from the pre-auricular cheek and neck being moved upward via direct or adjacent tissue transfer. Most asymmetry encountered with these repairs will generally resolve with time. Tacking sutures to the zygomatic periosteum may be necessary to minimize downward tension for larger flaps. Forehead defects will take most of their tissue from lateral aspects and, to a lesser extent, from the scalp. The glabella may also function as a reserve for small transposition flaps and for the placement of standing cones for more substantial repairs.²



Figure 21.1 Large defect of the left temple allowed to heal by second intention following removal of a squamous cell carcinoma. (a) Immediately postoperative with purse-string suture. (b) Defect well-healed at 1 year

Step-by-step surgical techniques

Second intention healing (granulation)

Second intention healing can be a viable option for defects of both the temples and forehead.³ The flat to concave nature of the temple will generally granulate well (Figure 21.1a,b). Purse-string sutures may be placed to make the overall surface area of the wound smaller, allowing for more rapid healing. If periosteum has been removed, exposing bone, it may be necessary to cover the wound bed with a muscle flap. Alternately, a dermabrasion tool can be used to burr the skull bone, exposing pinpoint bleeding, which will allow for more predictable granulation.

Primary (linear) closure

Historically, vertical closures on the forehead and scalp have been discouraged because they do not follow relaxed tension lines. However, vertical closures offer advantages of additional tissue laxity, minimal free margin distortion, and considerably less neurovascular compromise compared with horizontal repairs. For midline forehead defects, vertical closures are preferred. There is relatively little muscle contraction to cause distortion in this area due to the division of the bellies of the frontalis muscle. Horizontal closures work well for smaller defects high on the forehead, where they will be less likely to cause brow distortion.



Figure 21.2 Linear repair of the temple extending through the anterior hair line

In the temple region, skin tension lines of the orbicularis muscle favor linear closures radiating outward from the lateral canthus in a relatively horizontal plane.⁴ Vertical closures may be useful for small defects of the lateral temple, where the scar can be concealed along the hairline. When possible, it is advantageous to place scar lines along or behind the hairline, taking care to reapproximate the anterior hair junction so that no step-off is visible (Figure 21.2). Additionally, it may be useful to bevel incisions in hair-bearing areas to avoid transection of multiple hair shafts.



Figure 21.3 Advancement flap of inferior forehead, with displaced dog-ear to avoid disruption of an already sparse eyebrow. (a) flap design. (b) immediately postoperative

M-plasty

Repairs that may cross the margins of the brow, hairline, or orbital rim may be shortened by the use of a traditional M-plasty, where the redundant tissue cone at the affected end of the closure is taken with an M-shape back towards the original defect. However, in certain circumstances, it may be preferable to carry the incision through the hairline or brow.⁵

Local flaps

Advancement

Unilateral advancements can be quite useful for displacing dog ears on the forehead and brow to more favorable locations (Figure 21.3a,b). Undermining can be carried out just above the frontalis. The glabella and medial temple (crow's feet) offer convenient locations for redundant tissue cones in unilateral advancements of the brow. O-to-H bilateral advancement flaps are a tempting option, given that horizontal incisions can be placed in natural forehead wrinkles. However, given the multiple standing cones required, and extensive scar, we favor a simpler vertical closure for most defects amenable to this flap.

Unilateral advancement/rotation flaps utilizing cheek laxity are ideal for moderate to large defects of the lateral temple. The primary incision is made just anterior to the ear and redundant cones may be taken medially toward the lateral canthus, and inferiorly below the ear (Video 21.1).



Bipedicle flap

The bipedicle flap is a specialized advancement flap utilizing relaxing incisions to facilitate closure of the primary defect.⁶ It has limited use for forehead defects when a linear closure is preferred, but tension vectors are too great, or tissue is relatively immobile, despite wide undermining.

- I. Identify the preferred line of closure for the primary defect
- II. Make one or more relaxing incisions behind the hairline in the frontal scalp, parallel to the primary defect. Carry the incision(s) through the deep (galeal) fascia into the subgaleal plane.
- III. Undermine the primary and secondary defects widely, to connect the two defects in the undermined plane.
- IV. Obtain hemostasis
- V. Close the primary defect in a layered fashion
- VI. Close the secondary defect(s) in a layered fashion, taking care to not reapproximate the deep fascia.

Rotation

Rotation flaps may be useful for defects high on the forehead, near the midline. The central redundant tissue cone can be taken vertically in the midline, with the arc of the flap tracing along or just behind the frontal hairline. Lateral cones can be taken in the temple/sideburn or post-auricular areas. Bilateral rotation flaps may also be designed in this manner for large central forehead defects, and are generally preferred over O-to-Z opposing



Figure 21.4 Rhomboid transposition flap of lateral forehead. Horizontal tension vector of the secondary defect avoids distortion of the brow. (a) Immediately postoperative; (b) 6 months postoperative

bilateral rotations in this area. On the medial temple, rotation flaps with incision along the pre-auricular cheek can yield excellent results.

Transposition

Temple and lateral brow defects that cannot be closed linearly or with simpler flaps often will do well with rhomboid or bilobed transposition flaps (Figure 21.4a,b). Transposition flaps offer the advantages of moving more lax tissue from laterally and inferiorly into the defect, as well as redirecting tension vectors that may otherwise distort free margins. Banner flaps from the zygomatic area of the cheek can be used for lateral brow defects. Small rhomboid flaps from the glabella may also be used for lower forehead defects near the midline.

Regional flaps

Pedicled

Direct or tubed pedicle flaps may be used for specialized repairs of the lower forehead and brow. Pedicled flaps based off of the supratrochlear artery, or the frontal branches of the superficial temporal artery can be used to transplant intermediate hairs from the frontal hair line to recreate the brow.⁷

Distant/free flaps

Free flaps involve the transfer of tissue along with intact vessels to distant sites without a pedicle. They may be utilized for large defects extending to bone, where

periosteum has been removed, making skin grafting, alone, not possible.⁸ Microvascular reanastomosis is required.

Skin grafting

Full thickness

Full-thickness skin grafts may be used for small to medium-sized defects of the forehead and temples where other closure options are not feasible. Pre-auricular and neck skin will offer a reasonable tissue match for the temple. The more glabrous skin of the forehead is difficult to match, and grafting generally has a less acceptable cosmesis. Grafts require a well-vascularized bed in order to survive, and all adipose should be removed from the graft itself prior to suturing in place. If the lesion extends to bone and periosteum has been removed, a muscle flap may be created to cover the exposed bone⁹ or the wound may be allowed to partially granulate prior to grafting.

Split thickness

Split-thickness skin grafts are generally used for larger defects where harvesting adequate tissue by full-thickness methods are not feasible. Split grafts are typically obtained from the abdomen, buttocks, and proximal thighs, as these areas offer large, relatively flat surfaces, and the graft donor sites can be concealed by clothing. The harvesting of these grafts may be done with either a manual or powered dermatome and grafts may be fenestrated if a very large surface area requires coverage.

Skin substitutes

Skin substitutes may be used for areas where second intent or split-thickness grafts are considered but an open wound is not desired. A number of porcine products, both plain and fenestrated, are available at a reasonable cost. These are sutured in place and bandaged as with other grafts. They will generally slough at 1–2 weeks, leaving a bed of granulation for continued wound healing or another definitive repair.

Multiple closure (piecemeal) repair

Given the inherent lack of tissue mobility in the forehead and temple region, often multiple types of repairs will be employed simultaneously to close portions of the wound.¹⁰ Combinations of partial linear closure, opposing flaps, grafts, and second intention may be necessary to properly repair the wound while minimizing free margin distortion (Figure 21.5).

Prevention and management of complications

Nerve/muscle injury

Injury to the temporal branch of the facial nerve during tumor extirpation may result in a permanent unilateral brow ptosis. If the paralysis does not improve over time and the patient is sufficiently bothered by this disfigurement, surgical correction may be attempted via direct or indirect brow lift on the affected side.

Conclusion

While defects of the forehead and temples can be challenging from a reconstructive standpoint, appropriate closures can be extremely rewarding. A knowledgeable and careful surgeon should be able to avoid most complications and adequately manage those that do arise.

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Figure 21.5 Piecemeal repair for large defect of the lateral temple following removal of a Basal Cell Carcinoma. A portion of the wound, inferiorly, was closed linearly. A scalp rotation flap was performed for the superior medial portion. A regional full-thickness skin graft was used to cover the remainder of the wound at the helical root.

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Video list

Video 21.1 Unilateral advancement flap: temple

Reconstruction of the scalp

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Primary closures of the scalp

Primary closure is the simplest and most commonly used closure technique for scalp wounds arising after skin cancer surgery. The fundamental surgical techniques used in primary closures are the same as those used for more complicated flaps. Therefore, mastery of these techniques is essential.

Preoperative care

Surgical site preparation

I. If the procedure is being performed over hair-bearing skin, it is recommended that the surgeon shave or trim the hair surrounding the operative site. Although many patients will prefer that the surgeon avoid removing hair, doing this provides many benefits.

- a. It is much easier to obtain an aseptic surgical field. It is difficult to ensure the sterility of long hairs that are in the surgical field.
- b. It reduces the chances of hair being inadvertently trapped in the wound, which can cause foreign-body reactions.
- c. It allows the surgeon much better access to the surgical site, which should allow for more precise suture placement and a better ultimate result.

II. Hair that is outside of the surgical field should be secured with hair clips, hair bands, or tape, so that these hairs stay outside of the surgical field. These items need not be sterile, as they should be outside the surgical field.

III. The surgical field should be thoroughly cleansed with an antiseptic solution.

IV. The surgical field is then isolated with sterile towels or paper drapes.

VI. The area to be repaired is infiltrated with local anesthetic containing epinephrine. For most smaller reconstructive procedures, 1% lidocaine with 1:100 000 epinephrine is an excellent choice.

VII. Once the area to be repaired is infiltrated with anesthetic, the surgeon should wait for about 10 minutes before starting the surgery. This will give the epinephrine time to achieve the desired vasoconstrictive effect. This reduces intraoperative bleeding significantly and allows surgery to be performed more quickly and easily.

Step-by-step surgical technique (Video 22.1)

I. Orient the closure in the direction that allows for the wound to be closed under the least tension. This will vary with the size and shape of the defect as well as the elasticity of the surrounding skin (Figure 22.1a).

II. Excise Burow's triangles and the tissue at the base of the wound down to the galea. Then widely undermine the surrounding skin in the subgaleal plane.

III. As the Burow's triangles are removed and the skin is undermined, especially on hair-bearing skin, any electro-surgical means of controlling bleeding should be avoided.

- a. Using electrosurgical techniques (electrocoagulation, electrocautery, etc.) risks permanent damage of



Figure 22.1 (a) Scalp wound after Mohs surgery with planned Burow's triangles shown. (b) Burow's triangles are removed and wound is undermined. First deep suture is placed. (c) All deep sutures are placed prior to tying any knots. (d) The wound is completely approximated with deep sutures. (e) Cutaneous sutures are placed. (f) Patient at suture removal.

hair follicles, which may leave the patient with a poor aesthetic result.

b. Electrocoagulation of deep tissue is generally unnecessary, as all undermining takes place in the avascular subgaleal space.

c. The surgeon may encounter rather large vessels at the edges of the wound, but this bleeding invariably stops as the deep sutures are placed and the vessels are compressed when the skin is approximated. Occasionally, larger vessels can be ligated directly, if necessary.

IV. Approximate the wound with buried sutures (Figure 22.1b).

a. Scalp skin is often thick, so it is important to make sure that sutures are placed such that the deep and superficial tissue are both approximated.

b. In order to facilitate proper deep suture placement, place all of the deep sutures before tying any of the knots (Figure 22.1c). This technique keeps the wound completely open until all of the deep sutures are placed and allows deep sutures to be placed precisely and with ease.

V. A sufficient number of deep sutures should be placed so that the wound is completely approximated with deep sutures alone (Figure 22.1d). Failure to do this may result in spreading of the scar and possibly a noticeable bald strip several months after the wound has healed.

VI. Once the skin is approximated with deep sutures, the epidermis can be approximated with a layer of cutaneous sutures or staples (Figure 22.1e).

Postoperative care and follow-up

I. Once the surgery is complete, a pressure bandage is applied.

II. The patient is to wash the wound twice daily and keep it covered with petrolatum until suture removal.

III. Sutures are normally removed at 7–10 days (Figure 22.1f).

IV. Patients are normally seen again at 2–3 months to ensure that their wound has healed well.

Small local flaps to repair scalp wounds

For small to moderately sized wounds, direct primary closure may not be possible (especially for patients with

tight scalp skin). As a rule of thumb, in most cases, if one cannot push the edges of the wounds together (or get very close) prior to surgery, then primary closure is likely inadequate and a flap should be considered.

I. Surgical site preparation is exactly as described above for primary closures.

II. Flap design considerations

a. Since there are no relaxed skin tension lines on the scalp, incision lines can be placed in virtually any direction. This is especially true in patients with hair-bearing scalps. Incision lines should be placed in whatever location allows for the greatest reduction in wound tension.

b. Since scalp skin is often very inflexible, when performing rotation or advancement flaps on the scalp, the flaps often must be very large relative to the defect (Figures 22.2a,b).

c. Transposition flaps, which change the direction of the relevant tension vectors, may not need to be as large as a rotation flap would need to be for the same defect.

Step-by-step surgical technique

Once the flap has been designed, the surgical technique is as described for primary closures. The only additional considerations are as follows:

I. The skin should be undermined very widely. The inelasticity of the scalp requires significant undermining in order to generate even minimal tissue movement (Figure 22.2c).

II. Remove as little standing cone redundancy as possible (especially in patients with hair-bearing scalps).

a. The more redundant tissue one excises, the more hair-bearing skin is being sacrificed. This is counterproductive to the goal of causing as little hair loss/thinning as possible.

b. With liberal undermining, even significant amounts redundancy will spontaneously resolve (Figure 22.3a–c).

c. Even if minor redundancies remain, if they are covered by hair, they will not be perceptible.

d. Post-surgical care is as described for primary closures.

e. Examples of commonly used flaps

i. Rhombic transposition flap (Figure 22.4a–c)

ii. Rotation flap (Figure 22.5a–c)

iii. Advancement flap (Figure 22.6a–c)



Figure 22.2 (a) Scalp defect after Mohs micrographic surgery. (b) O-to-Z, double rotation flap performed to repair the defect. Note that the flap size is very large compared to the defect size on this patient's tight scalp. (c) Flap (from Figure 22.2b) reflected back to demonstrate the wide undermining required.



Figure 22.3 (a) Scalp defect after Mohs micrographic surgery. (b) O-to-Z, double rotation flap performed to repair the defect. No Burow's triangles were removed. Note the significant amount of redundant skin that is present along the margins of the flap. (c) Patient at 2 months after surgery. Note that all of the redundancies have disappeared.



Figure 22.4 (a) Scalp defect after Mohs micrographic surgery. Planned rhombic transposition flap is illustrated. (b) Rhombic transposition flap completed. (c) Patient at 2 months after surgery.



Figure 22.5 (a) Scalp defect after Mohs micrographic surgery. Planned O-to-Z rotation flap is illustrated. (b) O-to-Z rotation flap completed. (c) Patient at 2 months after surgery.



Figure 22.6 (a) Scalp defect after Mohs micrographic surgery. Planned advancement flap is illustrated. (b) Appearance of advancement flap at suture removal (7 days after surgery). (c) Patient at 2 months after surgery.

Small local flaps to repair scalp wounds

Very large flaps to close sizeable defects on hair-bearing scalps. When encountering very large defects of the scalp, often skin grafts or even second intention healing can provide very reasonable results with minimal morbidity. However, these techniques will not restore hair loss. For defects that involve up to 20% of the surface area of the scalp, multiple large rotation flaps can provide an excellent result without the aid of tissue expanders or other multi-stage procedures. While this type of reconstruction is very large, it can be safely, quickly, and comfortably be performed in an office-based setting.

I. Surgical site preparation (Figure 22.7a,b) is as described for primary closure, with the following modifications.

a. Shaving or trimming the hair from the entire scalp is recommended. Since the surgical field involves the entire scalp, doing this will allow for thorough aseptic preparation and give the surgeon the best access to the surgical site.

b. A dilute anesthetic solution must be used, so that toxic doses of local anesthetic solution are not administered to the patient. The following technique is recommended:

- i. The entire scalp is infiltrated with a solution that is made by mixing 30 mL of 1% lidocaine with 1:100 000 epinephrine with 250 mL of normal saline. Approximately 50–80 mL of this solution is sufficient to infiltrate the entire scalp. Since the solution is fairly dilute, it can be infiltrated quite painlessly.
- ii. The incision lines are infiltrated with undiluted 1% lidocaine with epinephrine:



Figure 22.7 (a) Scalp defect after Mohs surgery prior to surgical site preparation. (b) Scalp defect after surgical site preparation. The planned rotation flaps are illustrated. (c) The base of the wound is deepened down to the subgaleal plane. (d) The flaps are incised. (e) Undermining the flap in the subgaleal plane. (f) The flap is completely undermined. (g) The flaps are approximated under minimal tension. (h) The flaps are completely sutured in place. (i) Patient at 6 months after surgery.



Figure 22.7 (Continued)

II. Flap design

a. These types of flaps can be designed as multiple transposition flaps, multiple rotation flaps, or a combination of the two. Designing multiple rotation flaps in a “pinwheel” pattern (Figure 22.7b) is one useful approach.

b. However, no matter which flap design is chosen, it is important that the flaps are very large and recruit almost the entire scalp. This is the best way to ensure adequate tissue movement and a tensionless closure that will not spread over time.

III. Surgical technique

a. Excise tissue from the base of the wound down to the subgaleal plane. This tissue is unnecessary, as undermining will be carried out beneath it (Figure 22.7c).

b. Incise the flap (Figure 22.7d).

c. Undermine the flap in the subgaleal plane (Figure 22.7e,f).

d. Approximate the edges of the flap, and then suture the flap in place using the same technique described for a primary closure (Figure 22.7g,h).

e. As for smaller flaps, avoid excising tissue redundancies as much as possible.

IV. Post-surgical care is the same as described for primary closures, with the following considerations.

a. Ensure that the patient has an adequate pain control regimen. The patient can expect significant pain for the first 2–3 days that can be controlled with oral opioid analgesics.

b. The patient should be told to expect significant numbness over most of the scalp. This numbness may take 6–24 months to resolve completely.

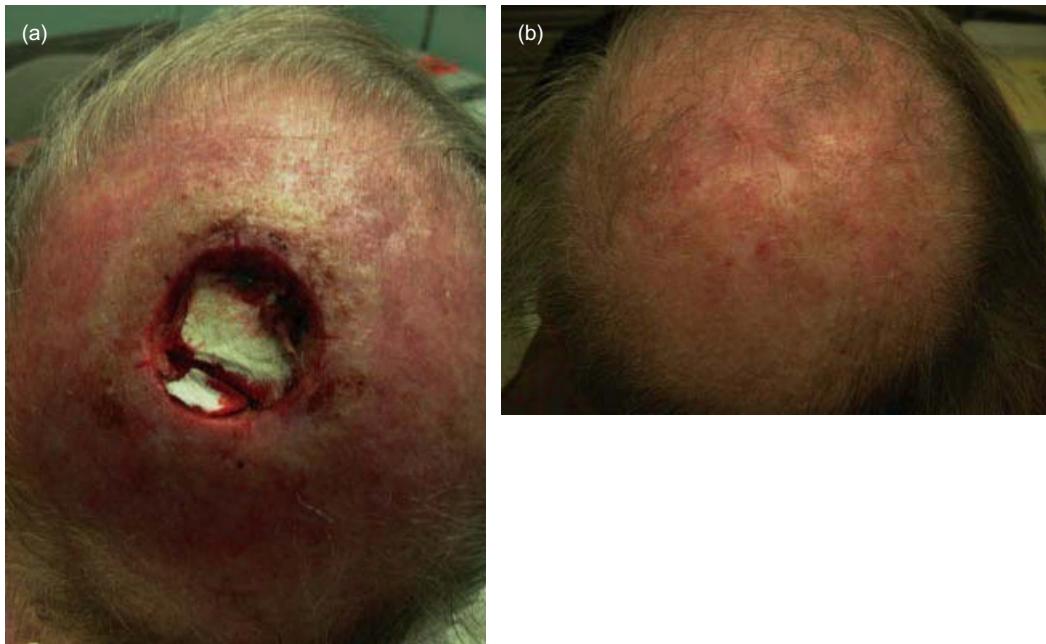


Figure 22.8 (a) Scalp defect after Mohs micrographic surgery. (b) Result at 8 weeks after second intention healing.

- c. Follow-up appointments are scheduled at 3 and 6 months (Figure 22.7i) to make sure that the scar has healed well and there is no evidence of the scar spreading.

Small local flaps to repair scalp wounds

Second intention healing. Since the scalp has an excellent blood supply, wounds on the scalp often heal extremely well by second intention. Second intention healing has limited utility when managing wounds on hair-bearing scalps. However, when managing large wounds on bald patients, second intention healing is an excellent option

I. Advantages of second intention healing

- a. It is virtually painless.
- b. Risk of complications such as infection, osteomyelitis, etc. are low even for deep defects going down to bone.¹

- c. Complications associated with surgery (bleeding, pain, numbness, paresthesias) are avoided.

- d. It is inexpensive.
- e. It can yield aesthetically excellent results (Figure 22.8a,b) in bald patients.
- f. Nothing is lost by a trial of second intention healing. If healing is not progressing as expected, then a reconstructive procedure, such as a flap or graft can always be performed in the future.

II. Disadvantages of second intention healing

- a. It normally does not restore hair growth.
- b. Healing takes a longer time than if a reconstruction is performed immediately.
- c. It requires that the patient be able to take care of the wound well at home. Some patients are unable to do this.

III. Regimen for management of second intention wounds

- a. Patient is instructed to wash wound twice daily and keep wound covered with thick layer of petrolatum at all times until healing is complete.



Figure 22.9 (a) Scalp defect after Mohs micrographic surgery. (b) Scalp defect after purse-string suture is placed. (c) Result at 8 weeks after second intention healing.

- b. Patient should be seen every 2–3 weeks until wound is healed.

IV. Second intention healing tips

- a. A purse-string closure can be performed to reduce the surface area of the wound and allow wound healing to take place more quickly (Figure 22.9a–c).

- i. This is done by passing a single absorbable suture (polyglactin, polydioxanone, etc.) through the dermis in a purse-string fashion around the edge of the wound. The wound is then cinched together and a knot is tied.

- b. Even wounds over exposed bone will heal well by second intention¹ (Figure 22.10a,c).

- c. A porcine xenograft or other wound matrix can be placed to increase the rate of healing.² This can be particularly useful for allowing defects with exposed bone to heal more quickly. This can be quickly performed as follows (Figure 22.11a–c):

- i. Remove xenograft from packaging and trim it to the appropriate size.
- ii. Affix it to the wound with tape or steri-strips.
- iii. Hydrate the xenograft with sterile saline.
- iv. Apply a bolster dressing.
- v. Repeat steps 1–3 above every week as long as necessary.



Figure 22.10 (a) Scalp defect after Mohs micrographic surgery. Patient refused reconstruction of his wound. (b) Result at 12 weeks after second intention healing. (c) Result at 12 weeks after second intention healing.

Small local flaps to repair scalp wounds

Skin grafts. Skin grafts are of limited utility in scalp reconstruction, since any patient who has a surgical defect that is well-vascularized enough to support a skin graft, could easily allow that defect to heal by second intention. Therefore, there are very few reasons to perform a skin graft on the scalp.

I. Disadvantages of skin grafts

- a. Donor site morbidity is an issue (split-thickness skin graft donor sites can often be exquisitely painful for weeks).
- b. Skin grafts will not restore hair loss.
- c. Skin grafts will not restore volume.
- i. Placing a skin graft on a deep scalp wound will leave the patient with a skin-covered crater that is aesthetically undesirable.

II. Reasons to perform a skin graft on the scalp

- a. Time
 - i. The patient desires a quicker result than what second intention healing can provide.
 - ii. The wound is extremely large and it would take an unreasonably long time to heal secondarily.
- b. The patient is unwilling or unable care for a second intention wound.

III. Performing a skin graft on the scalp is no different from performing a skin graft on any other anatomic site. Please refer to the chapter(s) on skin grafting for detailed descriptions of the proper technique. In short, the steps are as follows.

- a. Select an appropriate donor site.
 - i. The supraclavicular region is an excellent donor site for full-thickness skin grafts.
 - ii. The thigh is an excellent donor site for split-thickness skin grafts.



Figure 22.11 (a) Scalp defect after Mohs micrographic surgery.
(b) Fixation of porcine xenograft prior to bolster dressing application. (c) Final Result at 5 months.



Figure 22.12 (a) Scalp defect after Mohs micrographic surgery. (b) Full-thickness skin graft harvested from supraclavicular region has been sutured into the defect.

- b. Prepare the defect and donor site in the manner described above for primary closures.
- c. For a full-thickness skin graft (Figure 22.12a,b):
 - i. Make a precise template of the defect and use this to plan donor site excision.
 - ii. Excise skin from donor site and then close the wound primarily if possible.
 - iii. Thin the graft down to dermis.
 - iv. Suture the graft in place.
- d. For a split-thickness skin graft:
 - i. Make a precise template of the defect and use this to plan donor site excision.
 - ii. Harvest the graft from donor site using an electric dermatome or Weck blade.
 - iii. Suture the graft in place.

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Video list

Video 22.1 Primary closure of the scalp

Reconstruction and soft-tissue management of the trunk

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Introduction

Dermatologic tumor extirpation in the trunk (chest/abdomen) and extremities (upper/lower) can lead to a variety of post-surgical defects ranging from small to quite large. Utilizing the principle of the “reconstructive ladder,”¹ (Figure 23.1) small defects, typically, can be closed with primary closure, skin grafting, or adjacent tissue transfer (e.g., rotational flaps such as the rhomboid flap or the bilobed flap). Larger post-surgical defects can be treated with skin grafting, pedicle flaps of muscle, fascia, and/or skin, or free-tissue transfers (requiring microsurgical expertise). The free-tissue transfers can be muscular flaps, musculocutaneous flaps (comprising skin, fascia, and muscle) or fasciocutaneous flaps (comprised skin and fascia only). Determination of the type flap required depends upon multiple factors, including the size of the defect to be covered, depth of the defect, and exposure of vital structures such as blood vessels, nerves, tendon, or bone. Preoperative consultation with plastic surgeons well versed in microsurgical tissue transfer is recommended for planning of large, complex skin and soft tissue excisions in the trunk and extremities. Detailed description of the flaps available for reconstruction of large trunk and extremity defects is beyond the scope of this chapter. Rather, the focus will be placed upon a general overview of the approach that dermatologic surgeons should take when dealing with skin and soft-tissue defects of the trunk and extremities.

Chest reconstruction

The chest wall consists of a complex array of skin, muscle, cartilage, and bone which are integral for respiratory function. A variety of etiologies exist which account for most chest wall defects that will require reconstruction. These include infection, trauma, neoplasm,² congenital abnormalities, and acquired defects. Regardless of the etiology, all account for instances in which early and thorough communication between the dermatologic, plastic, and thoracic (oncologic) surgical services is needed to ensure the proper approach to reconstruction.

Neoplasm and the associated defects created by tumor extirpation account for the majority of chest wall defects. Often removal of tumors mandates resection of large amounts of involved skin and soft tissue. Additional resection of uninvolved tissue may be required to ensure negative pathologic margins. Reconstructive plans may be complicated by a prior history of radiation treatment, particularly in the elderly, debilitated patient.

Repair and management of extensive soft-tissue defects of the chest is dependent upon the size and dimension of the defect, exposure of underlying thoracic structures (rib and pleura), physiologic status of the patient, and projected donor site morbidity. For simple defects of the chest wall, primary closure in two layers can be used. Larger, more complex defects often require advanced reconstructive options such as adjacent tissue transfer,³

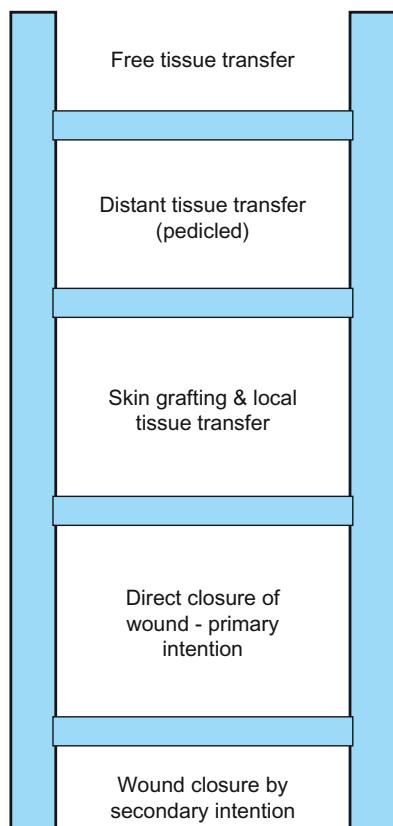


Figure 23.1 The reconstructive ladder. Adapted from Bennett and Choudhary Plast Reconstr Surg 1994;93:1503–4 with permission from Lippincott Williams & Wilkins.

fasciocutaneous or myocutaneous rotational (pedicle) flaps or even free-tissue transfers.⁴ The muscles most commonly used in flap reconstruction of the chest wall include the latissimus dorsi,⁵ trapezius, pectoralis,⁶ and rectus abdominus muscles.⁷ Pedicle flaps derived from these muscles can be raised as myocutaneous flaps or muscle only flaps that can be covered by split thickness skin grafts. Free flap coverage of chest wall defects is uncommon given the abundance of the large, well-vascularized regional flaps previously mentioned. However, free flap coverage of chest wall defects should be considered when (1) there is unavailability of appropriate local flaps (e.g., blood supply has been previously divided) or (2) when the defect is too large or extends beyond the coverage of local flaps.⁸

Full thickness chest wall defects (resection including rib and/or pleura) may require alloplastic reconstruction of the skeletal framework, in addition to flap coverage.^{9–11} Alloplastic materials such as Marlex mesh (Davol, Inc., Cranston, RI), Vicryl mesh (Ethicon, Inc., Somerville, NJ), Gore-Tex mesh (W.L. Gore & Associates, Flagstaff, AZ), and methylmethacrylate are commonly used in reconstruction of these full thickness complex chest wall defects.

Adjuvant therapies such as dermal matrix substitution can be of benefit in the approach to *staged* closure of complex wounds. For example, wounds requiring postexcisional irradiation can be covered with Integra (Integral Matrix Wound Dressing; Integra LifeSciences Corp., Plainsboro, NJ) followed by skin grafting after radiation treatment is completed.¹²

Abdominal wall reconstruction

Reconstruction of abdominal wall defects can be difficult and is often dependent upon the size and location of the defect that exists. Defects of the abdominal wall can be classified as partial or complete. Rohrich *et al.*¹³ provide an excellent set of algorithms for abdominal wall reconstruction of partial and complete (through-and-through) defects.

In general, basic principles of wound closure apply when small defects are encountered that can be closed primarily without tension. Larger skin-only defects can be treated with skin grafts or adjacent tissue rotation flaps. If rotational flaps are planned, care should be taken to design flaps that will survive on their random pattern blood supply. Alternative treatments include coverage with fasciocutaneous flaps,^{14,15} vacuum-assisted closure or VAC (KCI, San Antonio, TX), and/or tissue expansion. Complete defects of the abdominal wall with disruption of the abdominal musculature can often require complex repair including the use of prosthetic materials, components separation as described by Ramirez, *et al.*¹⁶ or pedicled or free-flap transfer.

A variety of prosthetic materials that are absorbable, non-absorbable or a combination may be used to successfully repair the abdominal wall. More recently, AlloDerm (LifeCell Corp., Branchburg, NJ) or acellular cadaveric human dermis has also been shown to be useful in contaminated¹⁷ or previously irradiated¹⁸ abdominal

wall reconstructions. In contrast to prosthetic material, AlloDerm promotes tissue in growth through the process of neovascularization.¹⁹ Pedicled myocutaneous flaps commonly used in complex abdominal wall reconstruction include the rectus abdominus,^{20,21} the gracilis,²¹ tensor fascia latae,²² and rectus femoris.²³ Free flaps may be indicated in extremely large, complete abdominal wall defects. Tensor fascia latae and anterolateral thigh (ALT) flaps have been used for complex abdominal wall reconstruction.²⁴

Upper extremity reconstruction

Management of upper extremity skin and soft-tissue tumors requires following the basic tenets of oncologic resection. Poorly planned and executed biopsies can result in poor outcomes.²⁵ Incisional and excisional biopsies should be oriented in an axial direction (along the long axis of the extremity). This allows a greater chance of primary closure when definitive wide excision of the lesion is performed.

Preservation of form and function is tantamount in upper extremity reconstruction. Exposure of neurovascular structures, tendon, and bone is likely with extensive tumor extirpation. Coverage of these structures by skin graft is possible when the associated paratenon and periosteum is preserved. If denuded tendon or bone is present, advanced flap coverage will be necessary.

Small and simple defects can be managed by primary closure, local soft-tissue arrangement or skin grafting. Soft-tissue defects that are not amenable to primary closure may be closed with techniques involving adjacent tissue recruitment such as rotation flaps, transposition flaps (e.g., rhomboid flap, Figure 23.2) and V-Y advancement flaps. Staged reconstruction can be considered when pathologic margin analysis is required (large or recurrent tumors). Negative pressure dressings and bilayer dermal matrix substitution have been used successfully in staged reconstructions of complex upper extremity defects.

Full-thickness and large complex defects of the upper extremity may require pedicle flaps or free-tissue transfer to provide adequate coverage of vital structures.²⁶ Common pedicled flaps in upper extremity reconstruction include the radial or ulnar forearm flaps, the lateral arm flap,²⁷ or the latissimus dorsi with or without a skin



Figure 23.2 Rhomboid flap design for excision of a recurrent squamous cell carcinoma of the left hand.

paddle. Free flaps commonly used in upper extremity reconstruction include the rectus abdominis muscle or musculocutaneous flap,²⁸ the latissimus dorsi muscle or musculocutaneous flap,²⁹ the gracilis muscle flap, the radial forearm fasciocutaneous flap, the lateral arm fasciocutaneous flap,³⁰ and the anterolateral thigh fasciocutaneous free flap.

Lower extremity reconstruction

Melanoma and non-melanotic skin tumors can be found on the lower extremity. Often these tumors are diagnosed at advanced stages. Treatment should focus on tumor eradication as well as limb salvage/preservation. Physical assessment should place emphasis upon a thorough pulse examination and non-invasive vascular studies when indicated. Patients with a history of smoking, diabetes, and peripheral vascular disease (absent or weak pulses), and patients with a history of previous lower extremity

trauma may warrant angiography preoperatively, especially if free-flap reconstruction is considered.

Similar to the trunk, abdomen, and upper extremity, reconstruction of the lower extremity depends on the size of resection, the depth of involvement, and exposure of vital structures. Small surgical defects can be closed primarily or treated with split thickness skin grafts. This is particularly true in the thigh region because of the abundance of muscle onto which skin grafts can be placed. Skin grafting on the anterior lower leg is acceptable as long as the underlying periosteum and/or paratenon remain intact. Local rotation flaps can be used for small surgical defects, including those with denuded bone or tendon.

Larger, more complex surgical defects can be treated with a variety of pedicle flaps or free flaps. Complex upper leg defects can be treated with pedicled rectus abdominis muscle with a vertically oriented skin island.³¹ Traditional reconstruction of complex defects around the knee involve rotational (pedicle) muscle-only flaps or myocutaneous flaps derived from the gastrocnemius muscle. Middle third defects of the lower leg are amenable to coverage with the pedicled soleus flap. Distal third defects of the lower leg typically require free-flap transfer to cover complex wounds. Free flaps commonly used for reconstruction of large distal third defects include the latissimus dorsi, rectus abdominis, and gracilis muscle flaps covered by split thickness skin graft. Defects requiring thin coverage can be managed with anterolateral thigh or radial forearm fasciocutaneous free flaps.³²

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Reconstruction of the hand

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Introduction

The hand is one of the most intricate parts of the human being. It has the multifaceted functional dexterity to allow us to perform all of our tasks from something as simple as a young infant's grasping reflex to a prolific pianist's finger movements. One of the contributing factors enabling the hand to perform its many functions is the skin. There are two types of skin enveloping the intricate structures of hand, and each serves a distinct function. The glabrous skin is found on the palms and soles of the feet. Their rigid texture comes from the microscopic grooves of ridges and sulci arranged in configurations known as dermatoglyphics.¹ Glabrous skin possesses a thick epidermis with clearly defined layers. This dermis possesses encapsulated sense organs to allow these bodily regions with an elevated sensation and a high degree of two-point discrimination.¹ The dermis, however, lacks hair follicles and sebaceous glands. Lack of sebaceous glands implies a dry skin surface. This is functionally useful during certain maneuvers that rely on a degree of friction such as grasping. The second type is hairy skin found on the dorsum of hand. This type has both follicles and sebaceous glands but lacks the density of sense organs. However, it provides the laxity needed to accommodate the smooth gliding of tendons.

Mechanical functions of the skin rely predominantly on the dermis. The elastic properties allow the skin to be stretched reversibly by 10–15%.¹ An initial response to stretch is the reorientation of collagen fibers. Once initial

slack of the skin is taken up, the skin becomes taut and hard to extend. Restored extensibility of the skin comes from the elastic fibers.¹ If the skin is maintained taut for an extended period of time, it will gradually continue to expand. This is analogous to tissue expanding techniques in which irreversible viscous extension occurs. Continued stress to the skin is the mechanical driving force for collagen fibers to slip relative to each other.

The dorsal hand has skin that is functionally useful during stretching maneuvers such as when making a clenched fist. It has a relatively thin dermis replete with elastin, and has loose areolar attachments to the hand's skeleton.² This allows a wide degree of freedom of movement for the hand that is not rigid like the volar side. Limited hand motion is quite noticeable during burn contractures to the dorsal hand.³ In addition, mobility of the dorsal skin allows useful manipulation of local flaps in reconstruction.²

The palmar or volar surface of the hand is used for specific functions. It has a high concentration of sensory nerve endings that provide precise sense of perception.⁴ The volar surface is used for grasping and securing objects in the hand. Thus, the characteristics of the skin here promote rigidity and friction. The volar skin is inelastic and firmly attached to the skeleton by numerous fascial connections. The fibrofatty superficial fascia is between the palmar aponeurosis and the skin.² This provides padding without loss of essential fixation. At the flexion creases of the hand, this tissue is absent. Creases are not directly over corresponding joints, but are slightly

deviated from the axis of rotation. At the flexion creases, skin is anchored most firmly to deep structures. Flexion creases thus serve as a good location for incisions. Increased friction with the palmar skin leads to the development of tough keratin layers called calluses.¹

The pulp of the finger pads have papillary ridges due to linear thickening of the epidermis horny layer.² The palmar skin along the fingers has specific ligaments that attach to the bony skeleton. Cleland's ligament and Grayson's ligament provide useful landmarks for the neurovascular bundles running longitudinally through the digits.⁴ Regarding the blood supply of the volar skin, there are innumerable vertically oriented vessels. This makes flap elevation slightly hazardous on the volar hand. Z-plasties are also limited overall on the palmar surface due to its rigid characteristic and poor orientation of vasculature.²

Hand anatomy, arteries, and nerves

The hand consists of 27 bones arranged in four units: metacarpal, proximal phalange, middle phalange, and distal phalange.⁴ The wrist is in intimate contact with the components of the hand and allows flexion and extension, radial and ulnar deviation, as well as supination and pronation of the hand. The greatest extent of movement comes from the radiocarpal joint of the wrist.² The wrist is made up of two rows of carpal bones. Complex dexterity of fingers comes from the individual function of ligaments and tendons that work together to allow the movements of the digits, hand, and wrist in synchrony.

In addition, power and balance come from the coordinated balance of intrinsic and extrinsic muscles as they insert between the metacarpal region and the phalangeal region of the hand.

Like in all parts of the body, the nerves and arteries of the hand traverse the territories in a similar fashion. The arteries that predominantly supply the hand are the radial and ulnar artery.² The arterial network is located on the volar side of the hand. Both the radial and the ulnar arteries enter the hand from their respective sides in relation to the bones and span the palm while angling medially to join with one another. This joining of the two principle arteries forms the deep palmar arch. This is a second arcade of vessels formed between the radial and ulnar arteries, more distal in the hand than the deep palmar arch, and it is called the superficial palmar arch. This arch gives off digital artery branches that run parallel to and volar to the ligament of Cleland along the digits.² Arteries of the hand lie dorsal to the nerves.

The hands mechanically precise ability comes from its motor and sensory innervation. The hand is innervated by three principle nerves that receive a complex input from the brachial plexus: the median, ulnar, and radial nerves (Figure 24.1). The median nerve provides skin sensibility to the palmar skin of the thumb, index, and middle fingers, as well as the radial aspect of the ring finger.³ The remainder of the palmar surface and receive skin sensibility from the ulnar nerve. In addition, the muscles involved in grasping are innervated primarily by the ulnar nerve. The remaining dorsum receives innervation from the radial nerve.

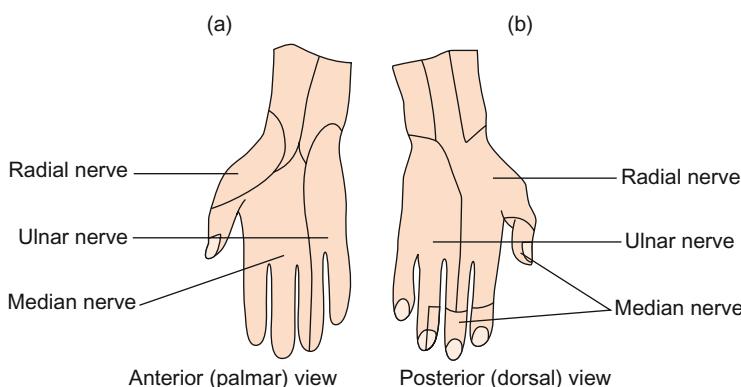


Figure 24.1 Cutaneous innervation of the hand.

Soft-tissue reconstruction of hand

Defects in soft tissues of the hand are created after trauma or surgery.⁶ When contemplating reconstruction, the important aspects to analyze include the defect size, location, etiology of defect (surgical versus trauma), patient demographics, occupation and overall health status of the patient.

Surgical options of hand reconstruction include primary closure, application of dermal regeneration template (Integra)[®], skin grafts, flaps, and free tissue transfer.

Primary closure

Small skin defects can be reconstructed with primary closure.¹³ The tissues are approximated without undue tension and with adequate eversion of wound edges and closure achieved with 4.0 or 5.0 nylon using horizontal mattress sutures. Depending on the overall health status of the patient (presence of comorbid conditions) the sutures are removed within 7–10 days.

Dermal regeneration template

Dermal regeneration template has become the latest addition to the reconstructive ladder. Integra[®] is a bilayer membrane system with the dermal replacement layer made of a porous matrix of fibers of cross-linked bovine tendon collagen and a glycosaminoglycan (chondroitin-6-sulfate) that is manufactured with a controlled porosity and defined degradation rate and the temporary epidermal substitute layer made of synthetic polysiloxane polymer (silicone) which functions to control moisture loss from the wound.⁵ The collagen dermal replacement layer serves as a matrix for the infiltration of fibroblasts, macrophages, lymphocytes, and capillaries derived from the wound bed.⁵ Once adequate vascularization of the dermal layer is achieved, the temporary silicone layer is removed and a thin, meshed layer of epidermal autograft is placed over the “neodermis.” Cells from the epidermal autograft grow and form a confluent stratum corneum, thereby closing the wound reconstituting a functional dermis and epidermis. Formation of the neodermis typically takes 14–21 days.

Application over exposed tendons has resulted in good functional outcome.

Skin grafts

The differences in volar and dorsal skin, as previously discussed, must be taken into account when considering skin grafting. Full thickness skin grafts are used for small defects and offer better sensibility and less contracture than split thickness grafts.⁴ Glabrous skin can be harvested from the hypothenar eminence or the non-weight bearing portion of the foot. Other donor sites for full thickness grafts are volar wrist, antecubital fossa, and the inguinal region.⁴

Split thickness skin grafts are used for large skin defects. Grafts can be harvested at 0.015-inch thickness in adults and thinner in children.

The key criteria for being able to close an open wound with a skin graft is that the recipient wound bed must have adequate blood supply to be able to nourish the graft as it heals. Therefore, in the hand, skin grafts can only be placed over a wound bed composed of viable, vascularized tissue such as healthy subcutaneous tissue, paratenon, perineurium, periosteum or vascular adventitia. Skin grafts in the hand must be used judiciously, however, because the heavy functional loads imposed on the hands during grasping may lead to wound breakdown and dehiscence.

Flaps

Flaps are tissues which are attached to donor site via a vascular or neurovascular pedicle.

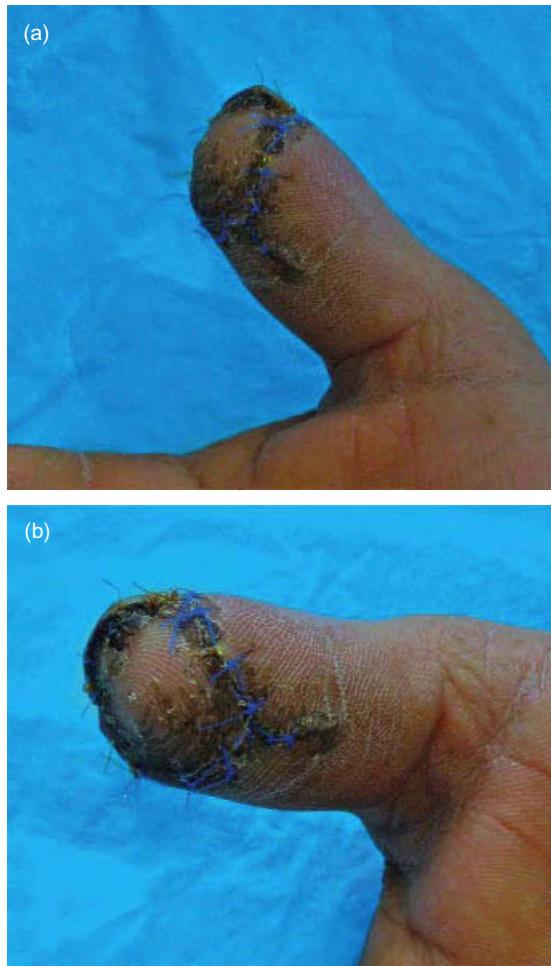
- Indications for flap coverage include
- exposed vital structures (i.e., nerve, joint, tendons)
 - when skin grafting not feasible because of poorly vascularized wound bed, or
 - need for sensation.

Defect reconstruction by anatomic region

Fingertip

Examples of local flaps for fingertip coverage include V-Y advancement flaps such as the Atasoy-Kleinert, and Kutler flaps and volar neurovascular advancement flap (Moberg flap).¹¹

The Atasoy-Kleinert flap is a volar V-Y flap advancement and is ideal for transverse midnail or dorsally directed fingertip injuries, but not for large defects (Figure 24.2).



Figures 24.2 (a,b) Atasoy–Kleinert flap.

The Kutler, a bilateral V-Y advancement flap of triangular lateral skin flaps, is best suited for transverse or slightly volar amputations at the midnail level.¹¹

Disadvantages of V-Y advancement flaps, such as the Atasoy and Kutler flaps, for fingertip coverage include the limited mobility of the flaps and placement of scar on the fingertip. The undermining used to effect advancement may also compromise the viability of the skin flaps.

The Moberg flap is a palmar advancement flap of the thumb and is best suited for transverse thumb tip defects/

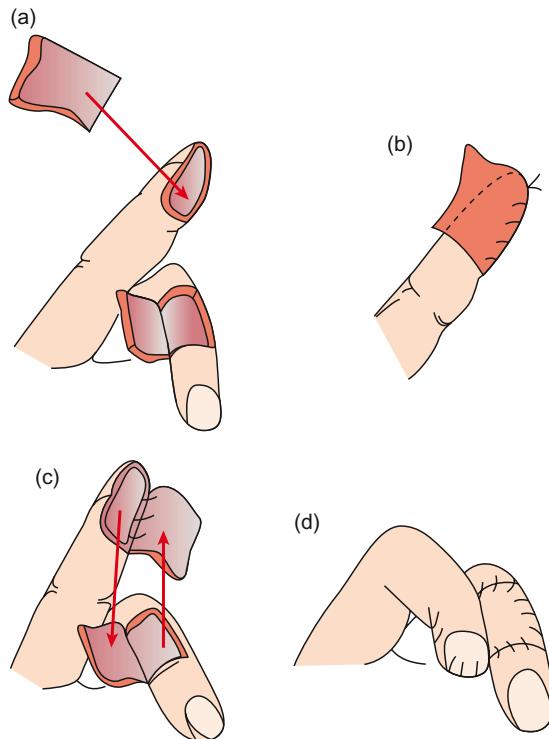


Figure 24.3 Cross finger flap. Full thickness skin graft is sutured to the edge of defect before inserting the flap.

amputation up to about 1–1.5 cm in length. Two parallel incisions dorsal to the neurovascular bundles of the thumb are created with the base at the metacarpophalangeal joint flexion crease and the flap is elevated from the flexor tendon sheath with the neurovascular bundles included and advanced to cover the defect. The Moberg flap preserves good sensibility when used but may cause a flexion contracture if advanced too far.

The cross finger flap is best suited for volar fingertip pulp defects (Figure 24.3).⁵ This flap is elevated from the dorsal surface of the middle phalanx of adjacent digit superficial to the extensor paratenon and inset onto the injured finger's volar surface defect.⁵ The donor site is skin grafted and the digits are immobilized. Pedicle is then divided on the eighth or ninth postoperative day. Complications include donor site defects, skin graft hyperpigmentation, joint stiffness, and cold intolerance.

Reversed cross finger flap is a modification of cross finger flap and can be used for coverage of dorsal digital defects.⁵

Thenar flap is a good technique for distal phalangeal defects because of exact tissue match.⁵ To restore the roundness of the finger the width of the flap must be designed at 1.5 times the diameter of the digit. To obtain good results it is important to flex the metacarpophalangeal joint of the recipient finger to minimize flexion at proximal interphalangeal joint. The thumb should be placed in full palmar abduction or opposition and the flap should be designed with a proximally based pedicle, right on the thenar eminence to have the lateral margin at the metacarpophalangeal skin crease. The donor site can be closed primarily or with a skin graft.⁵ The pedicle of the flap is divided in 10–14 days and active range of motion exercises are initiated to remobilize the hand. The thenar flap is not indicated in older patients as it can cause long term contractures from being held in the flexed posture.

Neurovascular island flap was described by Littler in 1960 for loss of thumb pulp. Vascularized and sensate tissue from ulnar side of ring or long finger is transferred to thumb tip in single stage.¹¹

Defects of dorsum or palm

Radial artery forearm flap can be transferred as a pedicled flap to the dorsum of the hand (Figures 24.4).^{10,12} It is based distally on the radial artery and its accompanying venae comitantes.⁹ Prior to elevating this flap, an Allen's test must verify an intact palmar arch. This will ensure that the ulnar artery will be able to provide vascularity to the entire hand after the radial artery flow is suspended to the hand. This flap can provide up to 8–10 cm of skin and subcutaneous tissue however this results in disfigurement at the skin grafted donor site.⁹

An ulnar artery forearm flap is less desirable since the ulnar artery is the dominant artery to the hand.⁹

Axial pedicled flaps have a specific vascular pedicle. The abdomen is a good donor site and examples include the superficial inferior epigastric artery flap and the superficial circumflex iliac artery flap (groin flap).

Random flaps lack a specific vascular pedicle and can be harvested from abdomen or contralateral arm.

Free flaps commonly used for hand defects include:

- the fasciocutaneous lateral arm flap,
- the temporoparietal fascia free flap,



Figures 24.4 (a-d) Large dorsal hand degloving wound reconstructed with reverse radial forearm flap.

- the fasciocutaneous anterolateral thigh flap,
- the great toe and the first web space of the foot fasciocutaneous free flaps

The lateral arm free flap's vascularity is supplied by the posterior radial collateral artery.⁸ The flap can be sensate by incorporating the lateral cutaneous nerve of the arm. Disadvantages are the limited 6 cm width of the donor site to allow for primary closure, and the possibility of inadvertent injury to the adjacent radial artery.

The temporoparietal fascia free flap is another useful flap for hand reconstruction. It provides thin, fasciocutaneous coverage ideal for tendon gliding with relatively inconspicuous donor site.⁷

Donor tissue can also be harvested from toes. The lateral first-toe flap described by Buncke is a good choice for large soft tissue defects involving the fingers. The flap is harvested on the first dorsal metatarsal artery and anastomosed to the recipient finger palmar digital artery. When the incision is extended to the tip of the toes, the flap can reach a width of 3 cm and length of 6 cm. An advantage of this flap is the ability to achieve good two-point discrimination through neurorrhaphy to the plantar digital nerve.

The fasciocutaneous anterolateral thigh flap is another good option for coverage of large soft tissue defects.⁸ It is located between the rectus femoris and vastus lateralis, measures 12 × 20 cm, and is based on septocutaneous and musculocutaneous perforators of the lateral circumflex femoral branch of the profunda femoris.⁸

Other free flaps for hand reconstruction include scapular flap, groin flap, dorsalis pedis flap, and the omentum.

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Treatment of Dupuytren's contracture by needle fibrotomy

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Introduction

Definitions

Dupuytren's contracture (DC) is a common and disabling autosomal dominant disorder characterized by hypertrophy and contraction of the palmar fascia that results in tethered flexion of the affected digits. DC is also known as palmar fibromatosis. The palmar fascia is also known as the palmar aponeurosis.

Needle fibrotomy (NF) is a procedure in which the DC cords are perforated by percutaneous needling and then ruptured at the perforations by forcible bimanual extension. NF, needle fasciotomy and needle aponeurotomy (NA) are all synonyms.

Guillaume Dupuytren

Baron Dupuytren (1777–1835) was chief surgeon to King Louis XVIII and King Charles X of France. The first DC patients on whom he operated were his own coachman and a wine merchant from Bordeaux. His statue can be found at the Hôpital Hôtel-Dieu in Paris.

Normal anatomy

Skin, subcutaneous tissue, and the palmar aponeurosis cover the tendon sheaths, the tendons, and the bones of the hand. The palmar aponeurosis tethers the bones together, maintains the shape of the palm, and prevents the tendons from bow-stringing across the palm when the hand is cupped. The pretendinous bands are normal

condensations of the aponeurosis and run superficial to the long flexor tendons and their tendon sheaths (Figure 25.1). The digital collateral nerves loop over and around other fascial bands in the palm and fingers.

The anatomy of Dupuytren's contracture

It is these normal pretendinous fibrous bands, and other parts of the normal palmar aponeurosis, that hypertrophy and contract in DC. Thus the normal fibrous bands become the Dupuytren's fibrous cords. The DC cords tether skin and deeper structures. Their shortening restricts movement of the fingers which can be disabling. As the cords thicken and shorten, they often displace the digital collateral nerves, sometimes eventuating in the cord and the nerve forming a spiral, one around the other.

Clinical findings in DC

DC is common and may be disabling. Onset is usually after the age of 50. It has a male predominance and is almost exclusively confined to people of Viking descent (Figure 25.2). It affects 2–6% of the population of the British Isles. It is comparably common in white North Americans.

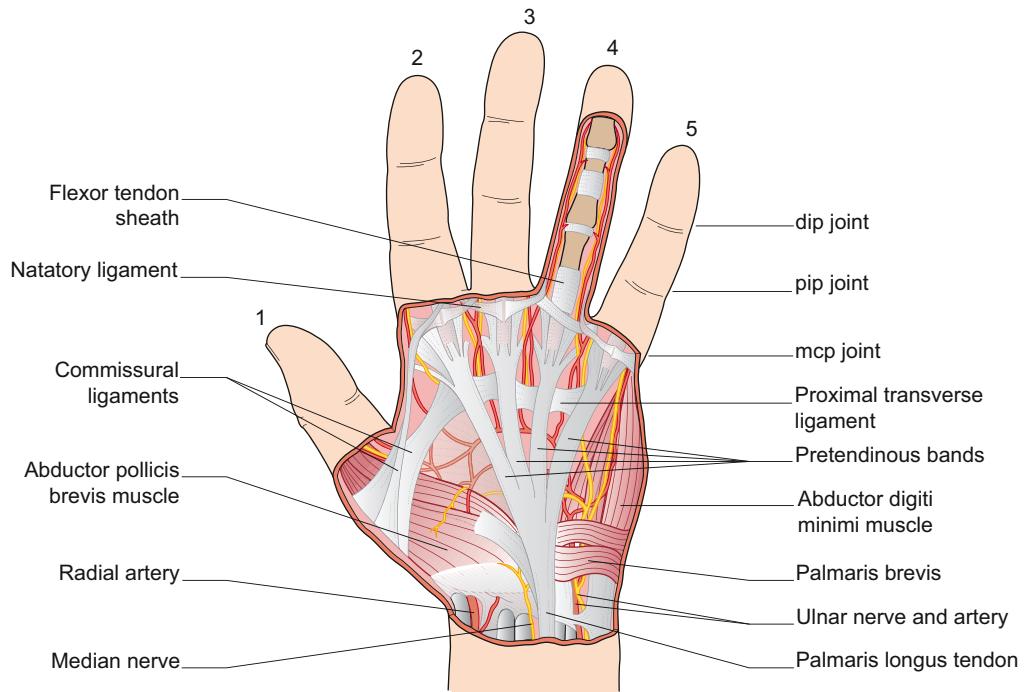


Figure 25.1 Normal hand: the palmar pretendinous bands. In DC they hypertrophy and contract into the cords that characterize Dupuytren's contracture.



Figure 25.2 The Viking diaspora (after Giușcă).

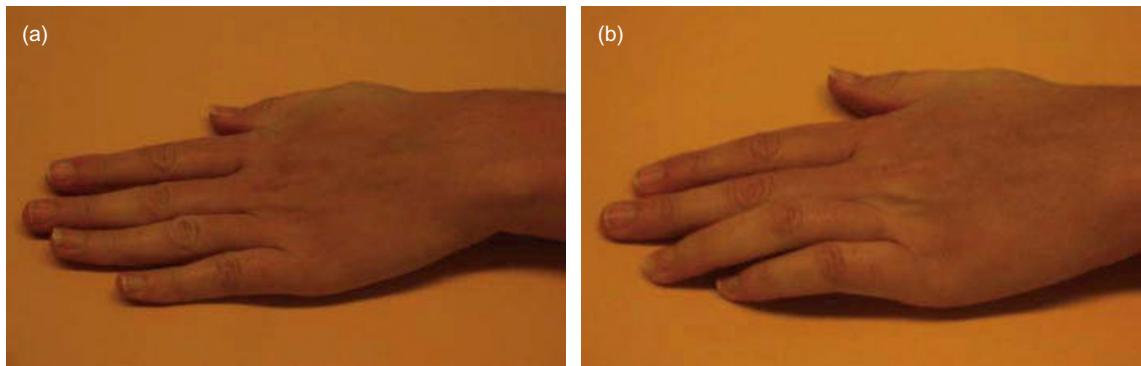


Figure 25.3 Dupuytren's contracture: the table test: (a) negative, (b) positive.

For the patient with DC, manual dexterity is diminished, shaking hands may become impossible, full reach at the piano is reduced or a finger may catch uncomfortably in the nose when washing the face.

All DC cases are manifest first as a pit or a nodule or a progressive fibrous cord, usually in the ulnar side of the hand. Later disabling flexion and tethering affects the digits. The *table test* (an inability to lay the palmar aspect of the hand flat upon a table) can be used to identify patients ready for treatment (Figure 25.3). Another early development is the *prayer sign* (an inability to oppose the palmar aspects of the distal heads of the metacarpal bones of the two hands) (Figure 25.4). DC becomes hazardous when palmar extension is limited to 90° or less, as then there is a risk of dangerous accidental hooking, e.g., in a lift or railway train door. Any flexion at the proximal interphalangeal (pip) or distal interphalangeal (dip) joints is a siren call for treatment because, if left untreated, the flexion often soon becomes complicated by secondary joint contracture. This is because of the arrangements of the periarticular ligaments at the pip and dip joints. By contrast, joint contracture is not a hazard at the metacarpophalangeal (mcp) joints, since the ligamentous anatomy of the mcp joints is different.

DC may be classified according to the angle of contracture. Tubiana¹ identifies stages 0–IV (Figure 25.5).

Of DC patients, 10% also have fibromatosis of the soles (known as Ledderhose's disease), 15% the knuckles (Garrod's knuckle pads) and 5% the penis (Peyronie's disease).

DC patients have an increased mortality.²



Figure 25.4 Dupuytren's contracture: positive prayer sign.

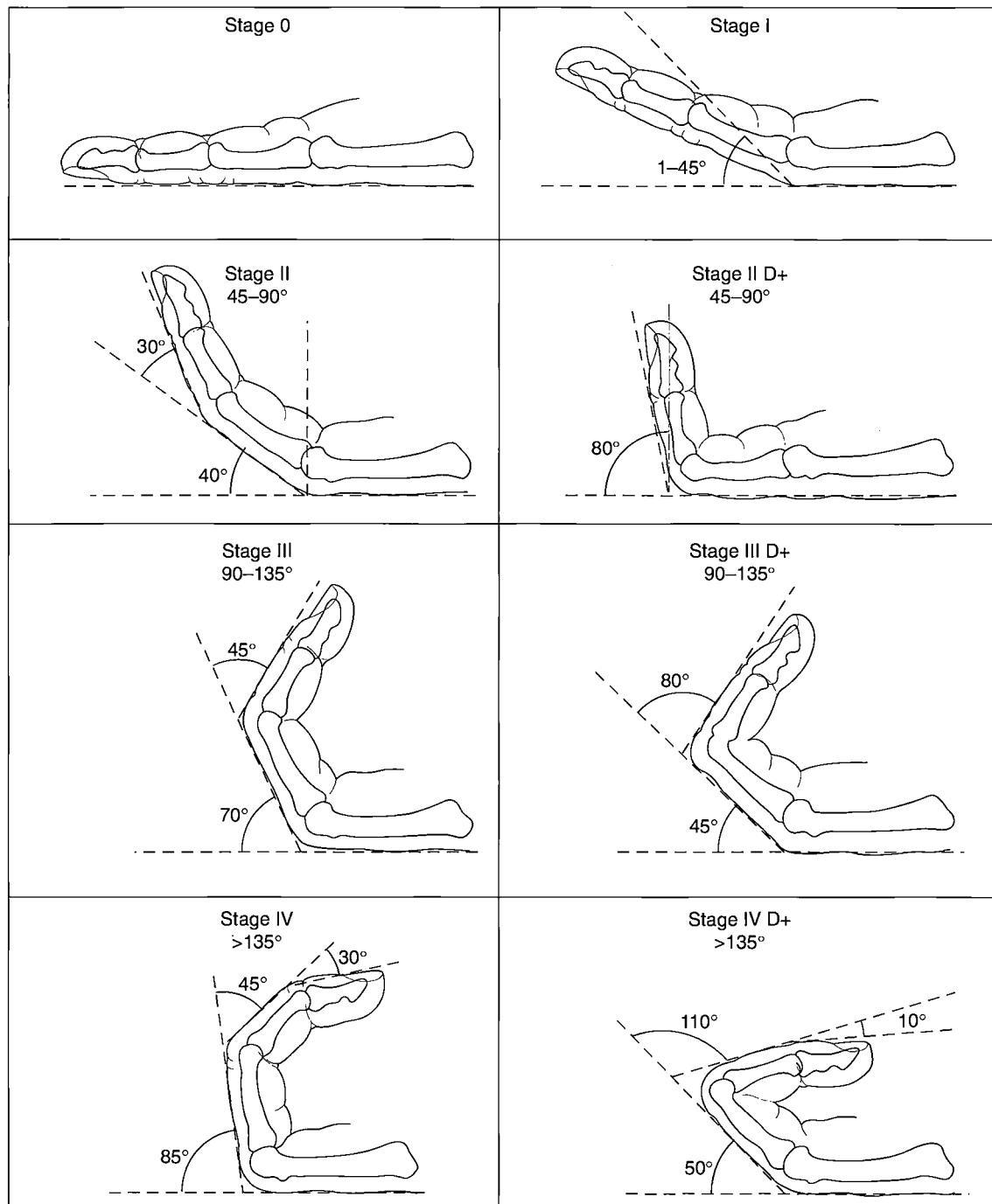


Figure 25.5 Dupuytren's contracture: Tubiana stages 0–IV.¹ Each stage corresponds to a progression of 45° in the overall contracture of a single ray (i.e., the combined total of the angles of extension deficit of metacarpophalangeal, proximal interphalangeal, and distal interphalangeal joints of a single ray). D+ indicates a pip joint contracture with an extension deficit of 70° or more. (Reproduced from Tubiana¹ with permission from Informa.)

DC and malignancy

In DC patients, there is a 25% increase in the overall relative risk of internal cancer, especially of smoking related cancer (such as buccal, oesophageal, gastric, lung, and pancreatic cancers) but also of prostate, renal, and breast cancers.³

Skin malignancy occurs in 30% of DC patients (Rowland Payne, personal series). Total skin examination is therefore sensible in all DC patients. The fairness of Viking skin must be the main factor that predisposes DC patients to sun-induced skin malignancy. (Conceivably perhaps also, Viking descent might be associated with somewhat devil-may-care attitude to life that is not risk free – sun exposure, physical trauma, alcohol and, in the modern world, smoking.)

Pathophysiologically, DC can be regarded as akin to unrestrained wound healing. DC is characterized by a lack of restraint of fibroblast activity. It may be postulated that such a lack of cellular restraint, if shared by cells of other lineages, might also explain why DC patients have a higher risk of cancer.

Associated factors & diseases

Other factors and diseases associated with DC include repeated trauma (manual work, vibrating tools, riding, and golf: the author observes this especially in golfers who use the interlocking grip), alcoholism, maturity-onset diabetes mellitus, thyroid disease, gout, epilepsy or antiepileptic medicines (e.g., phenytoin), HIV, cigarette smoking, chronic lung disease, ulnar nerve damage, and reflex sympathetic dystrophy.

Proposed pathophysiological mechanism: the vasodilatation hypothesis

The author advances a unifying hypothesis to explain the link between DC and these apparently disparate factors and diseases (Box 25.1).

It is proposed that the common denominator may be *increased palmar blood flow*. The associated factors and diseases are, in one way or another, each characterized by increased perfusion of the palms, for example, redness from trauma, or alcohol-induced palmar erythema. Indeed the first two patients on whom Dupuytren

Box 25.1 Dupuytren's contracture: the vasodilatation hypothesis of the pathogenesis of the increased fibroblast activity that characterises DC

CRP hypothesizes that in all cases this increased fibroblast activity is the consequence of a common pathway characterized by palmar vasodilatation. Put another way, increased perfusion will result in an increase in temperature and oxygenation and hence an increase in metabolic activity, proliferation and contraction of the fibroblasts and myofibroblasts of the palmar aponeurosis.

operated were his coachman (palmar erythema from the trauma of holding the reins) and a wine merchant from Bordeaux (palmar erythema from alcohol-induced liver disease perhaps). Increased palmar blood flow also characterises thyroid-related hyperdynamic circulation, weight-related peripheral vasodilatation, phenytoin and carbon dioxide-induced peripheral vasodilatation and peripheral vasodilatation secondary to neurological damage. Increased blood flow means increased local heat and oxygen, two factors which speed any chemical reaction, including fibroblast activity. When stimulated, fibroblasts and myofibroblasts do three things: they proliferate, they produce more fibrous tissue and they contract. In the palm, fibroblasts are most numerous in the fibrous pretendinous bands of the palmar aponeurosis. When these fibroblasts are stimulated, the bands thicken and contract into the cords that characterize the contractures of Dupuytren's disease.

Progression or recurrence

It is more accurate to speak of progression rather than relapse or recurrence.

DC, like venous insufficiency is a progressive disorder. The usual natural history of DC is one of ratchet-like progression rather than steady worsening, i.e. DC often worsens in spurts with periods of relative disease stability between spurts.

The treatments of DC

The traditional treatment is surgical. Collagenase has its adherents. Badois, Lermusiaux and colleagues have been the greatest advocates of NF^{4,5} (which they prefer to term NA).



Figure 25.6 The rationale of needle fibrotomy (NF). Postage stamps are pulled apart at the perforations. In NF, the DC cords are pulled apart at the perforations made by the needling.

Rationale of needle fibrotomy

Postage stamps are pulled apart at the perforations between the individual stamps (Figure 25.6). This is the rationale of NF. In NF, the DC cord is pulled apart at the perforations made by the needling.

Preoperative care

As with any medical or surgical intervention, patient selection and counseling, printed patient information sheets, good documentation, signed consent, pre- and postoperative photographs, and attentive postoperative care each play an important part in achieving the best of outcomes. To minimise bleeding and bruising, wherever possible, patients are asked to avoid aspirin and other non-steroidal anti-inflammatories for 14 days preoperatively. It is prudent to explain the progressive nature of DC to all patients preoperatively. DC sufferers are, by and large, very reasonable people who make very agreeable patients.

Step-by-step surgical technique

Method of NF

NF requires standard aseptic technique, it does not require a formal operating theatre. The doctor's consulting room is the ideal place to perform NF.^{6,7}

After topical anesthesia and skin cleansing, the distalmost part of the DC cord is palpated. A part is selected



Figure 25.7 Dupuytren's contracture treated by needle fibrotomy: needling.

that is not precisely localized to a digital or palmar crease and a very small amount of local anesthetic (e.g., 0.02–0.04 mL 2% lidocaine with epinephrine) is instilled into this part of the distal end of the cord and its overlying skin.

A few seconds later, a needle (21–25 gauge) is introduced percutaneously (Figure 25.7). The needle passes through the skin, moves freely through the subcutaneous tissue, and then enters the scirrrous fibrous Dupuytren's cord, which has the consistency of an unripe pear. Using an in and out movement, without allowing the needle to exit the skin, the bevel of the needle repeatedly perforates the full width and full depth of the cord, over a linear length of 2–3 mm. The needle is then removed and discarded (Video 25.1).



Then the proximal and distal parts of the patient's hand are grasped firmly by each of the operator's hands (Figure 25.8). The patient's hand is steadily and forcibly extended. The controlled forced extension of the hand ruptures the fibrous cord at the perforations. Usually a tearing sound can be heard or even a crack (Video 25.2)! 

The procedure of pinpoint local anesthesia, needling, and forcible bimanual extension is repeated, each time more proximally, at intervals of perhaps 1–3 cm along the full length of each cord. The process is then repeated on any adjacent cords of DC until all the DC cords of one hand have been ruptured. With each tear or crack, there is an incremental improvement in the degree to which the hand can open. Then intralesional corticosteroids are introduced to inhibit inflammation and refibrosis (e.g., 0.05–0.15 mL of triamcinolone acetonide 10 mg/mL into each needling site) (Video 25.3). 



Figure 25.8 Dupuytren's contracture treated by needle fibrotomy: forcible bimanual extension.

Because of the instantly appreciable improvement, when shown the hand immediately postoperatively, patients often gasp with wonder.

If both hands are involved, NF of the other hand is usually best done at a separate visit to avoid risking a period of simultaneous bimanual relative incapacity.

Results of NF treatment

Improvements of 5–180° in the angle of extension can be achieved by NF. Typically a 30–60° improvement can be expected in a single NF treatment. Often a positive prayer sign or positive table test can be rendered negative (Figures 25.9–25.11).

Postoperative care and follow-up

Postoperative care

After the treatment, it is not unusual for the fingers to remain numb for 24 hours or so. Application of a bag of frozen peas to the hand is soothing. Most suitable are two 10-ounce bags of petits pois, one can be kept in the deep freeze while the other is on the hand. Any discomfort after the treatment can be minimized by keeping the hand elevated (e.g., raised upon the arm of an armchair whilst watching television). Acetaminophen (paracetamol) 1 g 6 hourly is seldom needed. Pain greater than this should alert the physician to the possibility of infection.

At the time of operation, all patients are given a prescription for 8 days of antibiotics (usually both penicillin

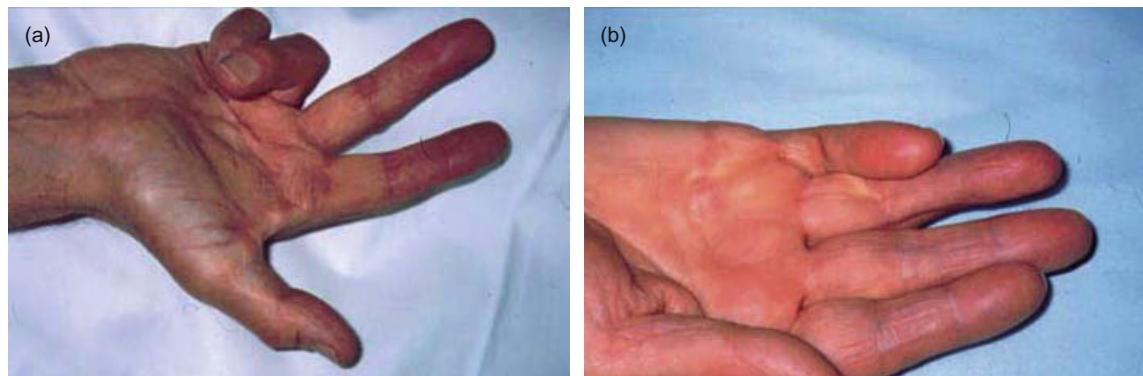


Figure 25.9 Dupuytren's contracture treated by needle fibrotomy: (a) before, (b) after.

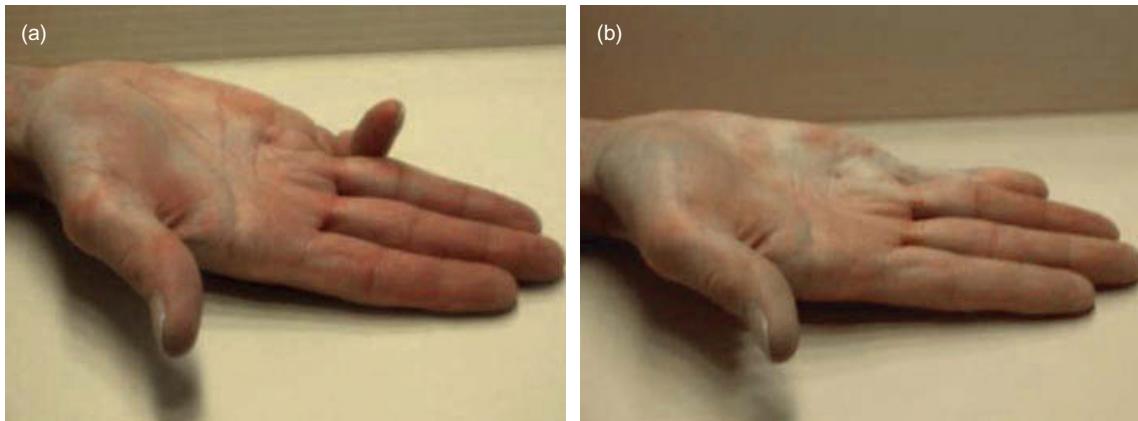


Figure 25.10 Dupuytren's contracture treated by needle fibrotomy: (a) before, (b) after.

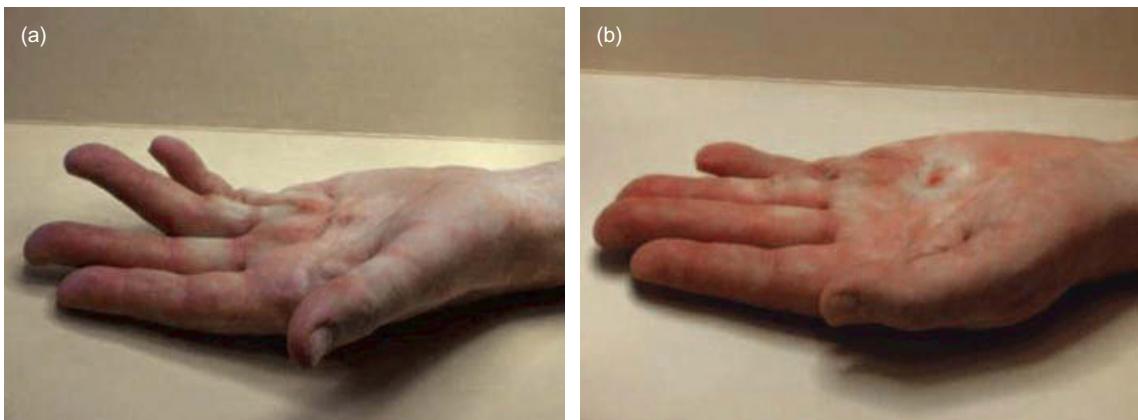


Figure 25.11 Dupuytren's contracture treated by needle fibrotomy: (a) before, (b) after.

V 500 mg qds and flucloxacillin 500 mgs qds or, for those allergic to penicillin, erythromycin 500 mg qds). The patients are asked to get but not to take the antibiotics. They are also given the telephone number of the physician and are exhorted to telephone immediately in the event of any suspicion of any untoward symptoms. Thus, should symptoms suggestive of infection develop, the antibiotics can be started without any delay. Diabetic patients and those with desquamating skin that might harbor organisms, e.g., psoriasis, are given the antibiotics prophylactically.

In the majority of patients with mild DC, NF can be expected to leave no skin wound other than a number of

needle punctures. These are treated for a day or two with antibiotic ointment twice daily (e.g. chloramphenicol eye ointment). A piece of gauze can be applied on top of the ointment to avoid grease stains on the patient's clothing. Patients in this category can return to full activity, including gardening, within a day or two.

Postoperative exercises

Beginning on the day of NF, extension exercises should be performed several times a day for the next 6 weeks or so (Box 25.2). The aim of these exercises is to enable the palm to heal in its longest length, i.e. straightened out. Without exercises, the hand would heal in its shortest

Box 25.2 Dupuytren's contracture: specimen postoperative advice sheet**Postoperative exercises and care for Dupuytren's contracture patients**

The aim of these exercises is to enable the hand to straighten out as much as possible.

Wound healing and Dupuytren's contracture are almost the same process. At all times, and especially postoperatively, there is a tendency for natural wound healing to cause a worsening or recurrence of Dupuytren's. To help overcome this, you may be advised to perform one or more of these exercises:

1. The table exercise. Rest the palm flat on the table. Keep the finger pads and the palm skin (under the knuckles) touching the table. Try to lift the heel of the hand.
2. The prayer exercise. Put your hands together, as if in prayer. Try to ensure that both palms touch each other. It is best if the finger pads all touch one another during this exercise also. The finger pads and the palm skin (under the knuckles) should stay touching as you attempt to separate the heels of the hands.
3. The sitting exercise. Sit with your hands in the prayer position and put your hands between the knees. Those parts of the fingers or palm skin (under the knuckles) that cannot quite reach one another should be pushed together by the knees. Then attempt to separate the heels of the hands.
4. The cat's cradle. Make a cat's cradle with your two hands. Stretch it open.

Each of the above exercises are best performed *four* times in succession in one episode, *five* episodes each day, for *six* weeks.

Following treatment of Dupuytren's contracture, postoperative exercises are essential for best results. Sometimes a splint is also suggested.

After the treatment, it is not unusual for the fingers to remain numb for a good 24 hours. Any discomfort after the treatment can be treated by keeping the hand raised (for example raised upon the arm of an armchair whilst watching television) and also by taking acetaminophen two tablets four times a day. It is very soothing also to apply a bag of frozen peas to the hand. Most suitable are two 10 ounce bags of petits pois, one can be kept in the deep freeze whilst the other is on the hand.

If there are any small breaks in the skin, please treat them with chloramphenicol ointment twice a day.

Six to ten weeks after needle fibrotomy for Dupuytren's contracture, it is important that you attend for a second steroid injection in the hand.

If at any time of the day or night you are worried about your Dupuytren's treatment, please telephone the doctor (24-hour access). He would prefer that you contact him rather than your family practitioner or hospital emergency department about your hand. He is always pleased to hear from you.

Thank you.

length, i.e., more or less flexed. Physiotherapy and/or a splint are seldom required.

course, DC progression usually does occur and then further NF treatment may be performed.

Intralesional corticosteroids

At the time of the NF and at 6 weeks afterwards, the needled areas are treated with intralesional corticosteroids. This is done to inhibit both myofibroblast contraction and fibroblast hypertrophy during the healing phase, in order to reduce the likelihood of early progression of the Dupuytren's contracture.

Prevention of disease progression

Longer term, continuation of some extension exercises is helpful in retarding further progression of the DC. In due

Complications

The principal potential complications of NF (and indeed of open surgery or collagenase treatment) are

- cutaneous ulceration
- infection
- nerve injury
- arterial injury
- tendon rupture
- reflex sympathetic dystrophy
- disease progression
- minor complications
- misunderstandings.

Prevention and management of complications

Not being overambitious at any one visit reduces risks (Box 25.3). If a finger is severely flexed, e.g., Tubiana stage IV D+, it may be prudent to treat the DC by means of more than a single episode of needling. This reduces the likelihood of severe cutaneous ulceration or damage to nerves and tendons as does using finer needles (25 gauge), especially in the digits. The author prefers to exchange telephone numbers with NF patients and he urges them to telephone him personally immediately if they have any queries at all. This is reassuring to patients and facilitates early management of any complication (e.g., speed of commencement of antibiotic therapy which is of paramount importance in the case of wound infection of the palmar space).

Cutaneous ulceration occurs in a large minority of patients, especially in those in whom the DC has resulted in some skin shortening (Figure 25.12). Cutaneous ulceration is treated for up to 10 days with antibiotic ointment

Box 25.3 Dupuytren's contracture: minimizing risks of NF

- Use minimal pinpoint local anesthesia
- Work from distal to proximal
- Use 25-gauge needles in digits
- Be cautious at the sides of the digits
- Be cautious at the volar creases of the digits



Figure 25.12 Dupuytren's contracture treated by NF: skin ulceration after rupture of shortened skin.

and then subsequently with white soft paraffin until the lesions have healed by secondary intention. The greater the severity and duration of the DC, the greater will be the skin shortening. The greater the shortening, the greater will be the likelihood and degree of ulceration. However deep or large, all such ulcers will heal by secondary intention, if allowed to do so. Deeper ones, especially over moving structures such as joints or tendons, take proportionately longer to heal but, in due course, all will heal, even in elderly patients.^{4,5} A 2-mm² tear may close within 3 or 4 days, a 1 cm² tear might take 8–10 weeks to heal. Secondary intention healing is the preferred method of wound healing after NF. Corticosteroid injections slow (but do not arrest) wound contraction and wound healing.⁸ The net result of corticosteroid injections is a more controlled wound healing with a better final result but achieved more slowly. Corticosteroid injections may add two to four weeks to any secondary intention healing time.

Any open wound can be managed by secondary intention healing, regardless of depth or type of tissue exposed, including fat, muscle, cartilage, or bone.⁹ Even open wounds down to bone heal by secondary intention.¹⁰ The management of full thickness lacerations of the hand in particular has been studied in a prospective randomized controlled trial.¹¹ Conservative management (equivalent to secondary intention healing) was compared with suturing. Similar cosmetic and functional outcomes were reported in both groups. The secondary intention group suffered less pain.¹¹ Even when major cutaneous sensory nerve branches are transected, significant return of sensation usually occurs.⁹ Wound infection is not an important risk in open wounds as wound infection is extremely rare in open wounds that are allowed to heal by secondary intention.⁹ Zitelli⁸ even states "... signs of infection are often confused with normal signs of healing" and "colonisation of wounds by resident flora does not interfere with wound healing. Colonisation by *Staphylococcus aureus* does not adversely affect healing ..." The open palm technique of McCash is a surgical treatment for DC that relies on secondary intention healing in the hand.¹² McCash wounds on the palm take up to 8 weeks to heal and on the digits another week longer.

Infection of the palmar space is a complication to be feared. It is possible to inoculate an organism into the palmar space during the needling or afterwards. Strict attention to aseptic technique is the best protection

against this. It is recommended that a new needle is used for each puncture of the skin, whether by the local anesthetic or during the needling itself. If infection occurs, antibiotics must begin without delay. Both NF and surgery have a 2–5% incidence of postoperative infection.

Nerve injury may lead to hypoesthesia, dysesthesia, pain, or weakness. Risk is lessened by using minimal local anesthesia (and also by avoiding nerve blocks at the wrist) so that, if a nerve is touched by the operative needle, the anesthetic is sufficiently light and localized for the patient to feel a small “electric shock” which may radiate distally or proximally. This allows the physician to withdraw the needle from that precise point to avoid damaging the nerve. Work then continues at an adjacent point on that DC band. Also the procedure is begun at the distal end of the cord so that, as the needling progresses proximally, the subsequently treated areas are not already numb (as they would be if the procedure were begun proximally and then progressed distally). In NF, the needling is intended to make perforations, it is not done to try to shatter the cord into dust, neither is it trying to scythe through the cords. If the needle were used as a scythe or scalpel, when breaking the last few strands of a cord the needle tip might move suddenly, which might jeopardize an adjacent nerve. In time, any nerve injury usually largely recovers. NF and surgery have a similar 1–5% incidence of nerve injury.

Arterial damage is rare after NF. Pseudoaneurysm has been recorded. Cold intolerance might occasionally occur.

Tendon rupture by the needle is avoided by working superficially. If the tip of the needle should unintentionally enter the tendon, movement of the finger will move the needle. The needle would then need to be withdrawn a fraction and then the NF work would continue. Shortcomings of corticosteroids (and of collagenase) include a temporary weakening of adjacent fibrous structures, including the tendons. Regular daily controlled stretching exercises are needed after needle fibrotomy but, to minimize the risk of rupture of a tendon, undue or sudden strain on the long tendons in the treated areas should be avoided for 6 weeks after the initial treatment and for a further 6 weeks after the 6 week postoperative corticosteroid injections. Tendon rupture usually requires early surgical repair. Both NF and collagenase carry a 1–2% incidence of tendon injury.

Reflex sympathetic dystrophy (also known as complex regional pain syndrome) is rare, unpredictable, and

of uncertain pathogenesis. Very rarely it may be a consequence of NF or collagenase. After surgery it may occur in as many as 5% of patients. (In occasional patients, it antedates the development of DC.)

Disease progression may occasionally be stimulated by NF or by surgical treatment. In these patients, the treatment acts as a *coup de fouet* to the disorder, whipping the horses of the disease to run faster.

Minor complications can occur. As with any procedure involving the use of needles, there may be some operative pain, vasovagal fainting, postoperative tenderness, hematoma, or a degree of usual non-microbial inflammation that characterizes wound healing.

Misunderstandings are possible. Postoperative care, especially in those cases that have cutaneous tears, is best done exclusively by the doctor who did the NF or by his/her immediate team or by the patient him/herself. Problems of misunderstanding may occur when a patient sees another doctor or nurse or physiotherapist who may be unfamiliar with NF and/or with secondary intention healing. Wounds healing by secondary intention weep a proteinaceous exudate (“natural healing fluid”) which may be somewhat bloodstained. This can be mistaken for bleeding or infection by those unfamiliar with secondary intention healing.

Advantages of NF over surgery

The time honored treatment of DC by surgical fasciotomy has its strong supporters. The operation, which is essentially a nerve dissection, is an elegant treatment calling for great surgical skill.

On the other hand, NF is easier and quicker than surgery, and the postoperative course after NF is easier and quicker than after surgery. Moreover, surgical intervention is not warranted by mild degrees of DC and very severe degrees of DC are sometimes beyond surgical intervention: whereas NF can be performed on DC that is mild, moderate, severe, or very severe. Complication rates and recurrence rates after NF and surgery are similar. Repeat surgery for DC is much more challenging than initial surgery. Repeat NF is not. NF can be performed many times in the same patient and indeed in the same part of the same patient’s hand. NF can be performed before surgery, after surgery and, in most cases, instead of surgery. After surgery, postoperative splints are

often required for up to 8 weeks: after NF, patients often return to work the following day. Surgery almost always leaves scars: NF almost never does.

In a postal survey, NF was preferred by 9 out of 10 patients who had experienced both treatments (Rowland Payne, personal data). NF is far less costly than traditional surgery, as it requires neither admission to hospital, nor a general anesthetic, nor the use of a formal operating theatre.

Nevertheless, surgery retains a number of very important roles. Secondary joint contractures of the pip (and dip) joints are not amenable to NF. Surgical division of the volar plate and the anterior cruciate ligaments (with conservation of the collateral ligaments) remains a very skilled operative challenge. Also, repair of a tendon rupture requires surgery. Maintenance of a close, trusting, and friendly liaison with a hand surgeon is very highly desirable.

Denkler's review of 41 published series of DC patients treated surgically¹³ records major complications in 15.7%: digital nerve injury 3.4%, digital artery injury 2%, infection 2.4%, hematoma 2.1% and complex regional pain syndrome in 5.5%. After surgical treatment for recurrent disease, digital nerve injury occurred in 20% of patients and arterial injury in 20%. Post-surgical patients were also asked to self-report complications: 36% reported numbness and 20% infection. Complication rates after NF are certainly not higher than after surgery and this is particularly true when NF is used to treat recurrent disease.

Conclusions

DC can almost always be improved by NF which is a simple and swift ambulant office procedure. NF is an excellent treatment with wonderful results and very high patient approval. Treating DC patients by NF also provides great satisfaction for the doctor.

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Video list

Video 25.1 Dupuytren's contracture treated by needle fibrotomy: needling

Video 25.2 Dupuytren's contracture treated by needle fibrotomy: forcible bimanual extension and rupture of cord. Listen carefully for the “crack” as the cord ruptures

Video 25.3 Dupuytren's contracture treated by needle fibrotomy: intralesional corticosteroid injections

3

PART 3

Cosmetic Surgery

Treatment of acne scars

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Introduction

Acne is one of the most common problems treated by dermatologists. The psychological impact of acne, resulting not only from active disease but also from post-inflammatory scars, can negatively impact the quality of life. The treatment of these scars represent a great challenge for cosmetic surgery since the desirable result is not always achieved. Many modalities of treatment have been described trying to improve the facial cutaneous contour.

Many attempts to classify the acne scars have been proposed; however, there is no consensus in the literature. The lack of standardization in the classification of the scars makes it difficult to compare treatment results of different authors. Goodman and Baron,¹ based on pathophysiological findings, suggest that acne scars should be divided into superficial macular, deep dermal, perifollicular, and fat atrophy. Koranda² uses the words craters or pits, ice picks, keloidal, and hypertrophic scar. Jacob *et al.*³ classify the scars as ice pick, rolling scar, and boxcar. Bogdana and colleagues suggest an interesting morphological classification of scars and divide them into elevated scars (keloidal, papular, and bridge scar), dystrophic scar, and depressed scar (distensible or non-distensible scar). Based on the literature we have chosen

to classify the different morphological scars according to Figure 26.1.⁴

A detailed examination of each scar should be done before choosing appropriate treatment since each scar has its own characteristics and responds differently to the various therapeutic modalities. Acne scars can be elevated or depressed. Keloidal scars are elevated and are found in patients with a genetic predisposition and their dimension exceeds the initial injury. They are more common on the shoulder area, chest, and mandibular angle, whereas hypertrophic scars can be papular or bridge scars and are more commonly found on the chin and temporal area.

Depressed scars are divided in distensible scars, which disappear when the skin is stretched, and non-distensible scars, which do not disappear when the skin is stretched. In distensible scars, fibrous attachments tether the epidermis and dermis to the subcutis. Ondulated scars are distensible and show good responses to the filler techniques while distensible retraction scars respond better with subcision before filler techniques. Non-distensible scars normally accumulate make-up and sunscreen lotion in the depressed area and are divided into superficial scars, icepick scars, and deep scars (Figure 26.2). Superficial scars are shallow depressions and should be treated with ablative techniques. Icepick scars are small

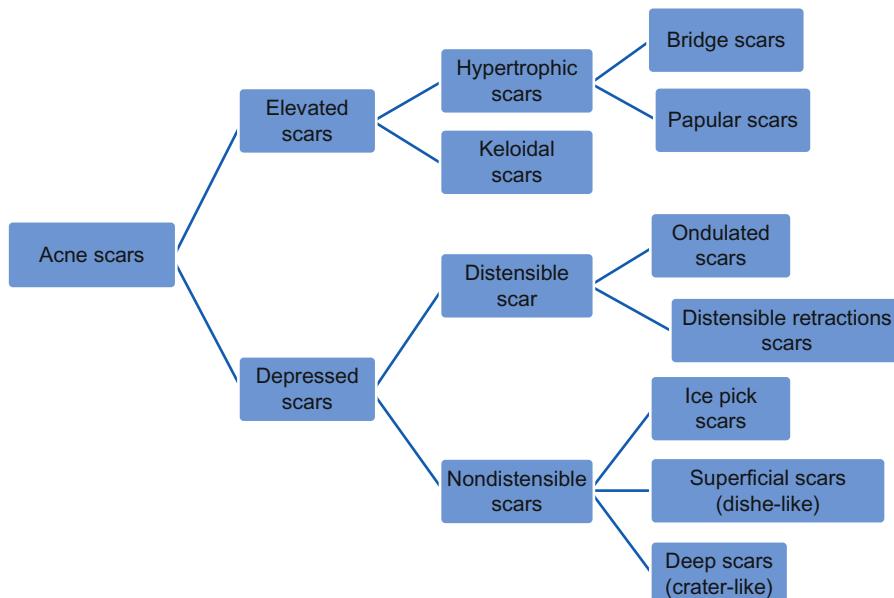


Figure 26.1 Classification of acne scars.

but deep, and normally react well with complementary techniques like CROSS (Chemical Reconstruction Of Skin Scar) peeling, punch elevation, and punch grafting. Deep scars (crater-like) can be treated with block excision and other complementary techniques.

Historically the sequelae of acne have been treated with ablative techniques such as dermabrasion, deep chemical peels, and recently with ablative lasers like the CO₂ laser. Some less invasive complementary techniques have been described for the treatment of acne scars, among them are subcision, punch elevation, CROSS peeling, and filling techniques. Although these techniques may be used separately, most authors suggest combining these modalities and use a three-staged treatment.^{4,5}

- Stage I. Complementary techniques: several techniques can be used in this stage in accordance with the type of scar and several sessions may be necessary (Table 26.1).
- Stage II. Ablative techniques: In this stage, the dermabrasion or ablative lasers like fractional ablative CO₂ laser (10 600 nm) or pulsed erbium YAG (2940 nm) can be

used in non-distensible superficial scars or to supplement the techniques used in stage I.

- Stage III. Filling techniques: Used to complement the techniques in stages I and II, and to correct distensible ondulate scars (waveform scars). Hyaluronic acid injections are recommended to treat superficial (dermal) tissue loss and microlipoinjections⁴ or poly-lactic acid injections to treat subcutaneous tissue.^{6,7}

The purpose of this chapter is to demonstrate the complementary techniques of treatment according to the type of scars. Ablative and filling techniques will be shown in other chapters.

Preoperative care

An explanation including the risks, benefits, and potential complications should be given to all patients. It is important to make sure that the patient has realistic expectations about the treatment. Written informed consent must be obtained before any treatment.



Figure 26.2 (a) Papular scar; (b, c) bridge scars; (d) keloidal scars; (e) ondulate (waveform) scars; (f) distensible retractions scars; (g) superficial scars; (h) icepick scars; (i) deep scars.



Figure 26.2 (Continued)

Table 26.1 Complementary techniques

Complementary technique (stage I)	Type of scar
Tangential excision/scissor excision	Papular scars, bridge scars
Intralesional (steroids,bleomycin,fluorouracil ⁷) injection	Keloidal scar
Block excision	Keloidal scar (with intralesional injections), and deep scars (crater-like) bigger than 3 mm
Subcision	Distensible scars
Dermal grafting	Distensible scars
CROSS peeling	Icepick scars
Punch elevation	Icepick scars, deep scars smaller than 3 mm size
Punch grafting	Icepick scars, pigmented deep scars smaller than 3 mm

All individuals who have used oral isotretinoin in the last 6 months should be excluded from the treatment, and special attention should be given to patients with a history of keloid. Pretreatment prophylaxis with oral antiviral agents is recommended when treating patients with active or recurrent herpes simplex.⁸

The continued use of sunscreen to prevent post-inflammatory hyperpigmentation is recommended. Topical depigmentation agents like tretinoin 0.05% and hydroquinone 4% with hydrocortisone 1% cream can also be indicated before and after treatment. A correct aseptic technique should be performed before all procedures.

Step-by-step surgical technique and postoperative care (Video 26.1)

I. Shave or tangential excision/scissor excision (Figure 26.3)



Figure 26.3 Bridge scar scissor excision.

a. This procedure is indicated for the papular scars and bridge scars

b. Anesthetize with lidocaine 1% with epinephrine 1:100 000

c. Remove the elevated scar with 15 scalpel or Castroviejo scissors parallel to the skin.

d. Apply electrosurgery or aluminum chloride 20% to stop the bleeding.

e. The defects are left to heal by second intention.

f. Cover the surgical wound with Micropore tape dressing and remove it after 48 hours.

g. After 7–10 days the scabs come off and the wound is completely healed.

h. Maintain continuous sunscreen use.

II. Block excision

a. It is a good option for non-distensible acne scars mainly deep scar bigger than 3 mm (Figure 26.4a–c). May also be indicated when treating keloidal scar associated with intralesional injections (Figure 26.4d–f)

b. The incision lines should be marked with skin marking pen before anesthesia infiltration. The infiltration can elevate the skin and hinder the visualization of the scar.

c. After adequate anesthesia, remove the scar with a scalpel blade, no. 11 or 15.

d. Try to orient the suture in the same direction as the Langers lines with 5.0 or 6.0 mononylon.

e. Apply dressing with Vaseline daily.

f. Removal of the threads in 5–7 days.

III. Subcision

a. Technique used in distensible scars. These scars disappear when the skin is stretched. It is a method for subdermal undermining of depressed areas.

b. Mark the area and anesthetize it.

c. Introduce a hypodermic Nokor needle just under the dermis to release fibrous attachments tethering the epidermis and dermis to the subcutis (Figure 26.5).

d. The needle movement from one side to the other, rapid and repetitive advancement and retraction under the scarred area of the needle parallel to the skin results in audible rasping and popping when the underside of the dermis is released from its attachment to the subcutis and from deeper tissues.^{9,10} It stimulates the formation of a new collagen under these areas raising the scars.



Figure 26.4 (a) Deep scar (crater-like); (b) block excision; (c) result 3 weeks after block excision; (d) keloidal scar in mandibular angle; (e) block excision of keloidal scar (70% of the lesion); (f) after keloidal scar block excision.

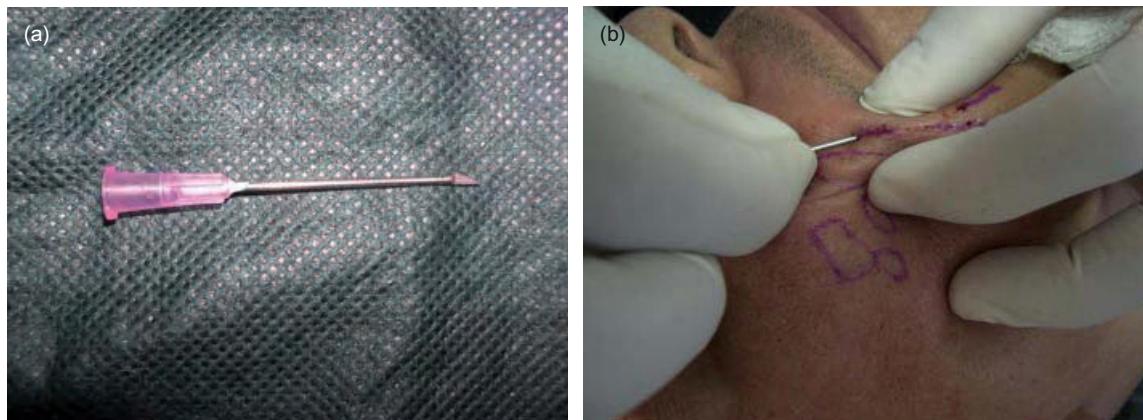


Figure 26.5 (a) Nokor needle; (b) subcision in distensible scar.

- e. Cover the area with Micropore tape dressing for 24 hours.

IV. Dermal graft (Figure 26.6a–d)

- a. This techniques is used to elevate the distensible scars by the insertion of slices of dermis under the depressed area.
- b. Stretch the skin and identify the distensible scars with skin marking pen.
- c. Choose and mark the donor area. The lumbar area is recommended when a dermic collector is used, or the post-auricular area when the removal of the dermis is done with a punch or scalpel. Avoid donor areas containing hair follicles because they can be transferred with the dermis to the receptive area.
- d. Anesthetize the donor and the area to be treated.
- e. When using the dermic collector, an incision with a scalpel blade no. 11 must be made in the donor area and the collector should be introduced into the dermis parallel to the skin. Rotating movements are performed to cut the dermis and to collect it. After collecting the dermal graft, the incision in the donor area should be sutured.
- f. Slice the dermal graft with the scalpel blade into small pieces like discs.
- g. Perform a small incision with blade no. 11 or Nokor needle on the edge of the scar and push and place the grafts under the depressed area.

- h. Micropore tape dressing should be placed on the receptive area and left for 48 hours.

V. CROSS peeling

- a. This is a chemical reconstruction for skin scars and is recommended for icepick scars.
- b. Focal application of higher trichloroacetic acid (TCA) concentration (60–100%) using a sharpened wooden applicator. After application a white frost can be seen in the area (Figure 26.7).
- c. TCA on the skin causes coagulative necrosis of cells in the epidermis and dermis. Re-epithelialization from the adnexal structure will occur in a few days and remodeling of the dermal collagen continues for several months.^{4,7}

VI. Punch elevation (Figure 26.8a–b)

- a. Identify and mark the non-distensible skin color scars smaller than 3 mm.
- b. Anesthetize them.
- c. The base of the scar is surrounded and cut using cylindrical biopsy punches and then elevated with forceps until clot formation, which will keep the scar in the new position.^{4,10}
- d. Micropore tape dressing should be left on the area for 5 days.

VII. Punch graft

- a. Identify and mark pigmented non-distensible scars smaller than 3 mm.

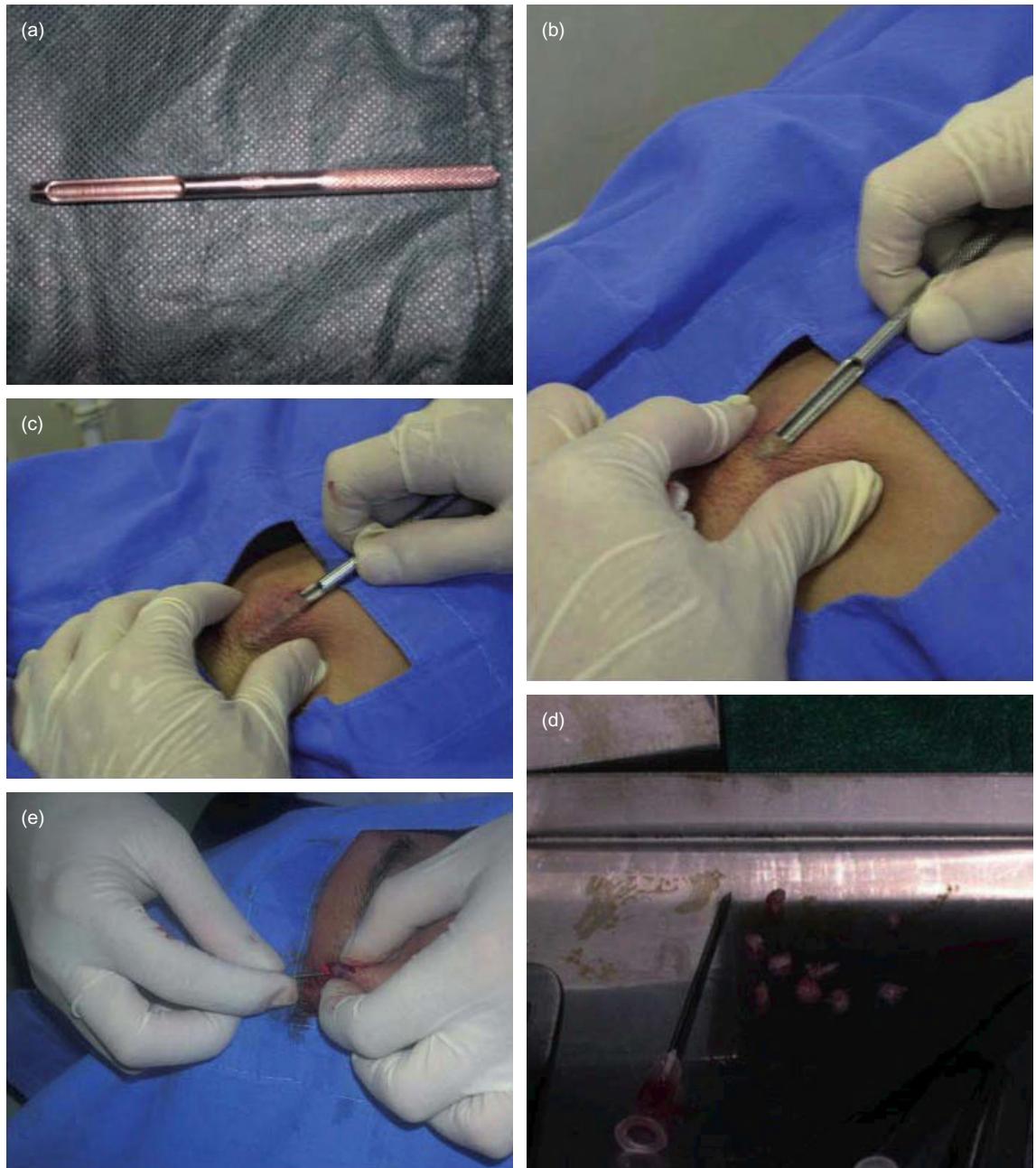


Figure 26.6 (a) Dermal collector; (b) dermal collector under the epidermis; (c) dermal collector under the epidermis; (d) dermal slices; (e) introducing the dermal slices under the depressed area.

- b. Anesthetize the scars and the donor area. Usually the post-auricular area is used as donor area.^{4,10}
- c. Excise the acne scars with cylindrical punches large enough to involve the entire lesion.
- d. Full-thickness grafts from the post-auricular area are removed with punches 25–50% bigger than lesion of the receptive area.

- e. The grafts are placed with forceps on the receptive area and the donor area is sutured with mononylon thread.

- f. There is no need to suture the grafts on the receptive area. A Micropore tape dressing on this area for 5 days will keep the graft in the correct position.

Complications and management of complications

The complementary techniques of acne scar corrections are quite safe. Most of the complications occur when ablative methods have been used.⁹ The most common are ecchymosis and transient dyschromia. All patients must avoid solar exposure to prevent post-inflammatory hyperchromia. Dyschromia is more frequently found in patients with phototype IV–VI; depigmenting agents can be prescribed. Milia formation and herpes simplex flares can also be found. A needle is used for surgical removal of milia and an oral antiviral is recommended for the treatment of herpes simplex.

The treatment of acne scars is difficult and results can be quite inconsistent. Some scars can persist and abrasive techniques and the use of fillings can be used to complement the treatment, although complete disappearance of the scars is infrequent.



Figure 26.7 Frost after CROSS peeling.



Figure 26.8 (a) Punch elevation; (b) icepick scar after elevate with punch.

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Video list

Video 26.1 Various treatments of acne scars (including subcision, micropunch elevator and fractional CO₂ laser)

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Introduction

Dermabrasion is an old surgical technique which peaked in popularity in the 1950s. Recently, dermabrasion has lost some popularity due to significant advances in laser technology, especially the development of ablative lasers and, recently, of fractional laser technology.

Dermabrasion is an ablative resurfacing procedure, as it ablates or abrases tissue to a defined and determinable depth and as such allows planing of the surface. It is ideal to treat defects involving the epidermis and the upper to mid-dermis. Hence, any irregularities of the skin surface, hypertrophic or atrophic, can theoretically be treated with dermabrasion. By ablating the entire epidermis and parts of the papillary and upper reticular dermis, dermabrasion can improve textural and pigmentation irregularities and soften sharp contours and edges. The healing process occurs from unaffected skin on the periphery and from adnexal structures within the reticular dermis. The induced wound leads to a healing process which results in new collagen formation and collagen remodeling with increased collagen bundle sizes and unidirectional orientation parallel to the skin surface. Clinically, this results in a smoother skin surface.

Dermabrasion is a surgical procedure that requires training and is reserved for experienced dermatological or plastic surgeons. In trained hands, dermabrasion is a very effective treatment; however, it is associated with a considerable downtime and potential side effects.

Indications

The classic indications are acne scars and photoaged, wrinkled skin. Other frequent indications include hypertrophic and traumatic scars, rhinophyma, pigmentation abnormalities, and congenital pigmented nevi. Figure 27.1a–c shows a patient with atrophic acne scars who has been successfully treated with dermabrasion. Clearly, the list of indications that can be treated with dermabrasion is much more extensive.¹ With the significant developments in laser technology, especially the introduction of the non-ablative and ablative fractional photothermolysis, dermabrasion is no longer the first-line therapy for most of the above-mentioned indications. Of note, given the various Q-switched lasers, which represent the gold standard for treating tattoos, we do not recommend to treat tattoos with dermabrasion.

Preoperative care

A thorough preoperative assessment is essential for correct patient selection for dermabrasion. Indications have been discussed above. This includes a careful history evaluating indications and potential contraindications. Absolute contraindications to the procedure are unrealistic patient expectations or any psychiatric disorder, such as, for example, body dysmorphic syndrome. Patients taking blood thinning medication should only be treated



Figure 27.1 Atrophic acne scars (a) before and (b) 2.5 months and (c) 3 months after dermabrasion. Note the erythema in (b).

if the medication can be stopped 5–10 days prior to the intervention.

Whether oral retinoid therapy should be regarded as a contraindication as it may prolong or complicate the wound healing process, resulting in atypical scarring, is still a subject of controversy.^{2,3} Our personal opinion is that therapy with oral retinoids within the previous 12 months should be regarded as a contraindication.

Relative contraindications include a family history of hypertrophic or keloidal scarring, a tendency for post-inflammatory hyperpigmentation (PIH), which mostly is associated with darker Fitzpatrick skin types (IV–VI), and previous treatments within the area to be treated. For example, previous undermining procedures should be evaluated with care, as any intervention within the area to be treated might have compromised the underlying vasculature and hence prolong or complicate the healing course.

Preprocedural laboratory evaluation should include a complete blood cell count, serum chemistry, and bleeding time.

Informed consent is essential to ensure realistic patient expectations. The physician should take the time to describe in detail the procedure, the anesthesia, and the time spent at the hospital, including the healing course and the downtime as well as the potential side effects. As

always, alternative therapy options, such as laser resurfacing, should be discussed.

Preprocedural digital photographs from the front and both sides have to be taken to be able to document therapeutic success.

All patients, regardless of personal history for recurrent herpes simplex infections, should obtain a prophylactic antiviral therapy with valaciclovir 500 mg twice daily for a total of 5 days, starting 1 day prior to surgery.

Step-by-step surgical technique

Equipment

Dermabrasion is performed in an operating room.

Dermabrasion devices consist of an electric-powered rotary wheel with 10 000–60 000 rpm and containing an abrasive tip. The abrasive tip can be a diamond fraise or a wire brush. Various sizes, shapes, and textures of tips are available and should be chosen according to the indication.

Anesthesia

Smaller defined areas, such as the nose or one cheek, can be treated by local anesthesia using field block or nerve blocks. If the area to be treated is somewhat larger,

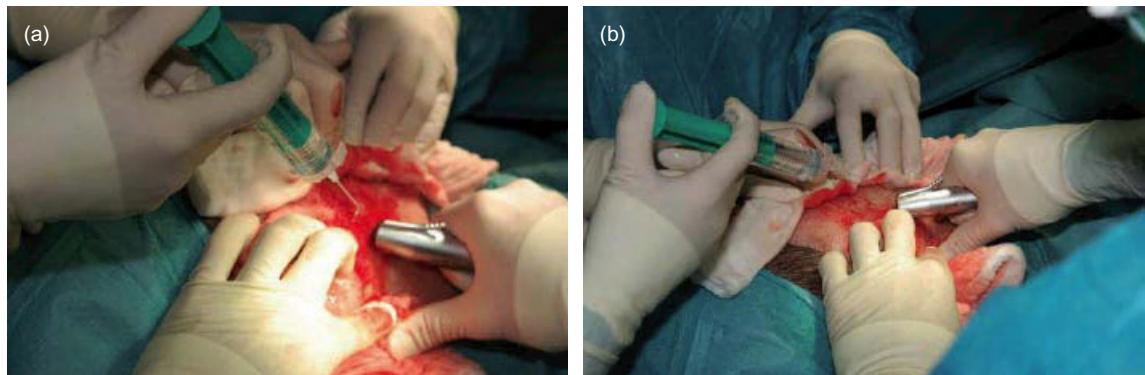


Figure 27.2 Surgeon on the right performing dermabrasion. Note three-point retraction by surgeon and assistant. Surgical nurse wetting the treated area.

tumescent anesthesia can be performed. Care has to be taken to not distort the skin when injecting local anesthesia. Full face procedures are recommended to be performed under general anesthesia.

Surgical technique

There are variations to the technique depending on the surgeon. Ideally two surgeons operate together, one performing the actual dermabrasion while the other one holds the skin taut. A tight skin surface is necessary for proper technique and to prevent gouging the skin. Ideally three-point retraction is performed, with the surgeon retracting with the free hand on one side and the assistant with both hands.⁴ If possible, a third person, usually the surgical nurse, should wet the treated area with sodium chloride in order to prevent overheating and keep the wound hydrated. This is simply performed with a 20 mL syringe with an attached cannula (Figure 27.2a,b).

Everyone should wear face shields as there is considerable aerosolization of blood and skin particles, which might also contain infective particles.

As with any surgical procedure of the face, the anatomical subunits have to be respected. Dermabrasion is hence performed in anatomical subunits. Fragile structures such as the eyelids should be kept at a distance. The direction of the rotating fraise should be oriented toward mobile structures such as the lips, eyes, or nose in order to avoid grabbing the loose skin, which can result in considerable injuries. Regions over bony prominences, such as the malar region have to be treated conservatively



Figure 27.3 Dermabrasion wound directly postoperatively.

avoiding deep injury. In general, the fraise has to be held tightly, as it otherwise will just “rotate away” on the skin surface.

The rotational speed of the machine itself and the pressure applied by the surgeon will determine the depth and clinical outcome. The depth of the injury is evaluated and determined visually. When initially entering the papillary dermis some pinpoint bleeding will be observed, which will become more punctuated and coalesce as the depth increases.

The periphery of the treated area, i.e., adjacent to non-treated skin, should be feathered to ensure a smooth transition and prevent obvious demarcation lines (Figure 27.3).



Figure 27.4 Postoperative occlusive dressings.

Postoperative care and follow-up

From a medication perspective, antiviral therapy is continued for a total of 5 days. As analgesic therapy, most of the time oral paracetamol is sufficient; if not, an opioid, such as metamizole, can be added. Prophylactic antibiotics are not given; however, they should be started if signs of a bacterial infection become evident.

Postoperatively occlusive dressings are used, which should be changed on a daily base (Figure 27.4). We apply Bactigras gauze, which is a mesh-like cotton leno-weave fabric, impregnated with soft paraffin, containing chlorhexidine acetate. The gauze is mixed with an antiseptic fucidic acid-containing cream. Dressings that are dry and crusted can be softened up with saline and then removed painlessly. The wound should be cleaned and debris removed daily using saline.

As soon as the wound is epithelialized, we change topical therapy to a simple wound-healing cream. Patients are usually discharged home on the fifth postoperative day with follow up at 1 week, 2 weeks, 1 month, 3 months, and finally 6 months.

Healing course

Downtime lasts anywhere from 5 to 7 days. Erythema can be expected to persist for up to 3 months.

It cannot be emphasized enough that strict sun avoidance and sun protection with high UVB and UVA protection are essential after this procedure to avoid postoperative hyperpigmentation.

Prevention and management of complications

Among the most common complications are hyper- and hypopigmentation, persistent erythema, telangiectasia, milia formation, keloids, and herpes simplex infection.⁵

Infections

Viral herpes simplex infections are the most common secondary infection, which can be triggered by the procedure. They can easily be prevented with antiviral prophylaxis.

Postoperative bacterial infections with *Staphylococci* or *Pseudomonas* can occur and have to be treated systematically according to therapeutic sensitivities.

For any signs of protracted wound healing or erosions, cultures should be obtained.

Pigmentation changes

Hyper- and hypopigmentation are relatively common but are mostly transient.

The risk for pigmentation problems is increased in dark-skinned patients (skin types IV–VI). With correct patient selection and strict sun avoidance, problems can be prevented. PIH can be treated any topical bleaching and depigmenting agents.

Scarring

Hypertrophic scars or keloids are the most feared and severe complications, and fortunately occur in only a small number of patients. Factors increasing the risk of scarring are personal and/or family history of keloidal scarring, isotretinoin use, too deep dermabrasion, and postoperative infection. Treatment of hypertrophic scars or keloids is performed with a combination of intralesional steroids and cryotherapy.

Other complications

Milia formation is relatively common and can be enhanced by dressings that are too occlusive. If it occurs it can be treated with simple extraction. Acne flare-ups can occasionally occur, also enhanced by occlusive dressings. They respond well to established acne treatments.

Summary

Dermabrasion is a very effective surgical technology to resurface the skin. Most indications can be treated with alternative treatment options, especially laser therapy. However, some indications with severe textural alterations, such as extensive acne scars, might not be treated satisfactorily with other treatment options and hence require dermabrasion. Taken together, the indication should be evaluated carefully and discussed with the patient. Dermabrasion should be performed only by a trained and skilled dermatologic or plastic surgeon. Pre-operative assessment and postoperative care are crucial for a successful intervention.

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Hair transplantation

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Introduction

The procedure of moving individual follicular units from the back of the head, where density is greater, to the front or other areas where hair is thinning or absent, can be rewarding for both patients and physicians alike. The technical aspects of harvesting and separating the hairs require patience and skill, and the placement of hairs in a natural appearing distribution on the scalp also requires careful thought and attention to detail. With the right skills and surgical team, this procedure can be mastered and implemented into nearly any physician's practice. And the psychological effect for both male and female patients can be phenomenal!

Hair loss: who, when, and "why me?"

Male and female pattern hair loss represents an inherited tendency for hair thinning, which can eventually result in dramatic hair loss for either gender. It can develop at any age, and can manifest as rapid shedding or as a slowly evolving phenomenon. There are rarely any laboratory abnormalities present. Over 50% of men and up to 40% of women can be affected. For men who may have seen their fathers or grandfathers lose hair, it can be considered a sign of maturity. But for many women, it can be deeply troubling and greatly affect their self-esteem.

Preoperative care

The consultation

Nearly every patient who arranges for a hair transplant consultation will have some familiarity with the procedure. They may have seen television infomercials, or they may have known someone personally who underwent the procedure. Unfortunately, many people have negative ideas about hair transplantation, based on the unsightly "plugs" of previous years. These were technically successful but unnaturally large in appearance, containing 10–20 hairs per "plug." Hair naturally grows in individual groupings of one to four hairs. Contemporary techniques retain the follicles in their original anatomy, so there is little chance that they will appear unnatural (Figures 28.1 and 28.2).

During the consultation, there are several important questions to ask (Box 28.1). It is helpful to know how long the patient has been losing hair and the treatments tried so far. We encourage nearly all patients to undergo medical therapy such as oral finasteride (for men only) or topical minoxidil (for women and men) for at least 6–12 months in an effort to stabilize their hair loss prior to surgery. One area that should not be transplanted is the vertex, or "bald spot" that occurs in most men. This area of alopecia may continue to expand, leaving an unnatural island of transplanted hairs in the center. Certain exceptions can be made, such as for men in their late 40s or 50s who have a very stable hairline.



Figure 28.1 A 35-year-old male patient prior to hair transplantation.



Figure 28.2 Same patient, 12 months after single surgery with 650 grafts.

Box 28.1 Important questions

- At what age did they start losing their hair?
- What treatments have they already tried?
- Did they help, if so how?
- What would they still like to change about their hair?
- Do they have any major medical problems?
- Are they on any blood thinners?
- Do they smoke?

It is important to understand the patient's medical history. Are they on any blood thinners such as warfarin or Plavix? If so, and these medications cannot be stopped, the surgery may not be feasible. If in doubt, speak with the patient's internist or cardiologist directly before proceeding with the surgery. Patients who smoke should be warned of the risk of tissue necrosis and poor wound healing after surgery. Patients with hypertension or diabetes should be well controlled.

We explain that the patient will have a narrow scar (usually <1 mm wide) in the back of the head where the strip is harvested. If they opt later to shave their heads, the scar may be visible to others. It is not a problem so long as patients keep their hair at least 2–3 cm long at the back. After surgery, we explain that they will have small scabs that form over the transplanted area. These will gently fall off after 1–2 weeks. The short transplanted hairs will stay in place for 1–4 weeks until they enter the telogen phase, and then will be shed as well. For the next 6 months, patients will see nothing in the transplanted area. Then, gradually, individual follicular groupings will appear and grow in as normally programmed to do so. Patients generally can appreciate the full results after 10–12 months.

Candidate selection

Both men and women with male and female pattern hair loss can benefit from hair transplantation. Young male patients present a greater challenge in deciding when and where to proceed with hair surgery because their hairline is subject to more uncertainty. Female hairlines generally stay intact. Patients who have unreasonable expectations may be less optimal candidates for the procedure. It is important to note signs and symptoms of body dysmorphic disorder or other psychiatric conditions, which may compromise patient satisfaction (and your sanity!).

Certain autoimmune or inflammatory conditions should also garner special consideration and only be transplanted in special situations. These include alopecia areata, lichen planopilaris, and frontal fibrosing alopecia. Alopecia areata may flare up or regrow at any time, so it is not widely or commonly transplanted by most hair transplant surgeons. The last two can also be unstable in their tendency to flare, and should be only transplanted in cases which are “burned out” and have no remaining evidence of inflammation.

Day of surgery

It is helpful to provide patients with as much information in advance, in person and through the mail, prior to surgery. They are encouraged to eat a nice breakfast, wear a button down shirt, and arrange for transportation after the procedure. Prophylactic antibiotics may be given but are not necessary. After any additional questions are asked, the consent is signed and patients are given medication to relax them. Blood pressure should be within normal limits. Preoperative photographs are taken and the surgical plan is reviewed. The patient is reminded that he or she is free to get up and use the bathroom, stretch, or have a drink whenever they feel they need to. Also, both authors keep movie viewing screens in their operative suites.

Step-by-step surgical technique

Harvesting the donor area

For most patients, hair is at its greatest density of 80–100 follicular units/cm² in the occiput. This region between the ears and at the level of the occipital protuberance is where most hairs are harvested (Figure 28.3). Patients may lie on their side or in a prone position for this part of the procedure. The area is marked, trimmed with an electric razor, and local anesthesia is used to infiltrate the area prior to harvesting. The authors keep most surgical instruments at the head of the OR table (Figure 28.4a,b).

The most common method used to harvest is the strip technique. This involves removing a strip of hair 0.5–1.5 cm wide by 5–25 cm in length. The size of the strip is determined by the area to be transplanted and the density desired. Strips wider than 1.3 cm can be taken but have a much higher risk of leaving the patient with wide, unacceptable scars, especially over the mastoid processes where tension can be greatest.

Specialized instruments can assist in the creation of a smooth, consistently sized strip (Figure 28.5). While harvesting, the surgeon should constantly check the angle of the blade to avoid transection of hair follicles. The depth of the strip should be at the subcutis, just below the level



Figure 28.3 Donor area located in the occipital scalp.



Figure 28.4 (a) Surgical supplies necessary for graft creation and placement include tongue blades, gauze, cotton-tipped applicators and specialized forceps. (b) Specialized double-blade, suture, skin hooks, scissors, forceps necessary for harvesting donor site.



Figure 28.5 Strip after it has been harvested from the occipital scalp with care not to transect follicles.



Figure 28.6 Technician dividing strip into 'slices' and then individual follicular units.

of the hair follicle. Wide undermining is not necessary. After hemostasis is achieved, this area can be closed with staples or suture. Many physicians like to remove a narrow (1 mm) strip of epidermis from the inferior edge of the defect. This "trichophytic" technique offers improved cosmesis as the hair grows through, and minimizes the appearance of, the scar. Dissolving 4-0 suture is an excellent option for patients who live out of town and cannot return for suture removal.

Another technique used for harvest is called follicular unit extraction (FUE). This can be more time consuming but avoids the creation of a linear scar in the back of the scalp. It is an excellent option for patients who still want to be able to shave their heads after the procedure is done. Individual 1-mm punch biopsies can be used to harvest the hairs. Such instruments are available as motorized or manual extraction devices. Also, a suction-assisted instrument has been developed which many surgeons find increases the speed of harvesting by this technique.

Hairline design and graft site creation

The task of recreating a natural hairline can be more challenging for men than for women, who usually retain their original hairline. The anterior-most hairs should be placed no less than 7–9 cm from the glabella. The natural temporal recessions should be maintained in order to not blunt the hairline, or make it appear too feminine. Markings can be placed by measuring above the eyebrow, at the mid-pupillary line, to ensure symmetry. It is generally wise to stay above their existing hairline, depending on their age and expected rate of thinning. One can always

lower the hairline later but it is impossible to raise it once it has been placed too low.

A number of instruments can be used for graft site creation. Each of these vary in width from 0.8 mm to 1.25 mm, and are selected based on the size of the follicular units being placed. They include 19- to 22-gauge needles (based on the size of the follicular units), sharp-point blades, chisel blades, or custom-made blades. In creating the sites, they should be angled anteriorly at 30–45° from the plane of the scalp. To allow patients maximal styling flexibility, sites should also be oriented slightly toward the midline. The sites should be created in a random pattern and with a density of approximately 30 per cm². Various methods exist to make the sites more visible, such as inking them with gentian violet or methylene blue.

Graft creation and placement

It is essential to have an enthusiastic and well-trained team to assist in the graft dissection process. Most teams use magnification for this process, ranging from high-powered microscopes to simple eyeglass magnifiers. The grafts can be cut with disposable no. 11 or no. 15 blades, Gillette blades, or specialized "Personna" blades, on a hard surface such as disposable tongue blades (Figure 28.6). The strip is first bread-loafed to create thin slices of tissue that each bear 10–25 follicular units. Then, each "slice" is divided into individual follicular units. This process requires trimming the dermal tissue around it and some of the subcuticular fat. Some investing tissue



Figure 28.7 Follicular units must be kept moist throughout the procedure.



Figure 28.8 Specialized forceps are used to place the grafts in the recipient area.

must be left so that the bulbs are protected from trauma and during the placement process. It is essential that the grafts remain moist throughout the procedure (Figure 28.7). If they become desiccated they will not survive the transplantation.

While the team is making the grafts, the surgeon should anesthetize the recipient area where the grafts will be placed. This can be done with any combination of 0.5%, 1%, or 2% lidocaine and a 1:100 000 concentration of epinephrine. The use of BupivAcaine can provide longer term anesthesia, but caution should be taken to limit the amount given the risk of cardiac arrhythmia. Because the placement of grafts can be time consuming, the anesthesia should be reinforced every 30–45 minutes. Also, patients are given acetaminophen by mouth to mitigate any discomfort.

As the sites are created, the placement process begins. This is performed using specialized forceps to gently pick up the grafts just above the bulb, and insert them at the appropriate angle into the sites (Figure 28.8). Care should be taken not to bend the grafts in half or insert them upside down. The visible yellow adipose tissue around the bulb can assist in orienting the bulb properly during placement. Small follicular groupings of one and two hairs are placed along the frontal hairline to ensure a natural appearance. The larger follicular units of three and four hairs can be placed farther back and provide an appearance of greater density.

Postoperative care and follow-up

Patients may resume topical minoxidil 2–3 days after the procedure, and finasteride may be continued the entire time. They are sent home with non-stick bandages over the donor and recipient areas and a bandage wrapped over the entire head. Instructions are given to apply topical antibacterial ointment to the donor site and keep the grafted areas moist and clean, spraying gingerly with saline and hydrogen peroxide. They are also given prescriptions for the anti-inflammatory medication prednisone, which can help reduce swelling due to anesthesia in the forehead area, and a pain medication to relieve any discomfort that first night.

Conclusion

One of the greatest challenges we face as a specialty is overcoming the misconceptions about what can be achieved with hair restoration. It can provide natural appearing results for both men and women, and offers a long-term solution to hair loss when medications such as minoxidil and finasteride cannot. With proper candidate selection, appropriate hairline design, and the expertise of a well-trained team, great aesthetic results can be achieved.

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Introduction

Chemical peeling is a form of skin resurfacing that induces epidermal and/or dermal injury/destruction followed by regeneration of epidermal and dermal tissues.¹ The success of peeling is crucially dependent on the physician's understanding of the chemical and biological processes, as well as of indications, clinical effectiveness, and side effects of the procedure.

Chemical peels can be classified by the depth of penetration into the skin (Table 29.1). *Superficial peels* (epidermis to upper papillary dermis) are the most commonly used peels in all skin phototypes. These agents include tretinoin 1–5%, trichloroacetic acid (TCA) 10–25% or one-coat application of TCA 35%, glycolic acid solution 20–70% or glycolic gel 70%, salicylic acid 20–30% in ethanol, lipo-hydroxy acid (LHA) and Jessner's solution. *Medium and deep peels* (reticular dermis, upper and mid, respectively) are more aggressive and offer a greater risk of inducing scarring, persistent hyperpigmentation, and hypopigmentation. Medium-depth peeling agents include TCA 35–50%, TCA 35% + glycolic acid 70%, Jessner's solution + TCA 35%. Deep peeling agents include phenol chemical peels.²

The main aspect in determining the depth of the wound created by the peeling agent is dependent on several factors: (1) the amount and concentration of the agent used; (2) the amount of pressure applied to the skin during the peel; and (3) the duration that the

peeling agent is in contact with the skin. These factors can be manipulated to yield a heavier peel: (4) skin preparation; (5) the sebaceous quality of the patient's skin; (6) previous use of tretinoin; (7) integrity of epidermal barrier.² To minimize the adverse effects of chemical peeling, the dermatologist should perform staged peels.

Preoperative care

Before performing the peel, patient history should be obtained, with particular attention to a history of delayed wound healing and hypertrophic scar formation, history of postinflammatory hyperpigmentation (PIH), history of herpes simplex virus, recent facial surgery, medications (isotretinoin, minocycline), previous radiation exposure, immunosuppression.² Photographic documentation prior to the peel is mandatory.

The pretreatment phase comprises the use of topical agents, including bleaching agents such as hydroquinone 4% cream associated or not with tretinoin 0.025–0.1% and sunblocks, prescribed 2–6 weeks before the peel. It is helpful to accelerate healing, facilitate uniform penetration of the peel agent, and reduce side effects and complications, including PIH.³ Additionally, tretinoin is known to reduce healing time after resurfacing. A broad-spectrum UVA/UVB sunscreen should accompany any regimen.

Table 29.1 Types of peels by depth

Peel type	Examples
Superficial	Glycolic acid 20–70%; salicylic acid 20–30%; LHA; Jessner's; TCA 10–25% (35% one layer); retinoic acid 1–5%. Combination peels: TCA + salicylic acid; Jessner's + salicylic acid
Medium	TCA 35–50%; Jessner's + TCA 35%; TCA 35% + glycolic acid 70%
Deep	Phenol formulations

TCA, trichloroacetic acid; LHA, lipo-hydroxy acid

The *preparation* phase consists of the steps performed directly before the peel. It includes cleaning with soap and water, and degreasing the skin before the peel (Video 29.1).

- Eye icon: Degreasing is done with alcohol or acetone and allows a deeper and more homogeneous penetration of the exfoliating agent (Figure 29.1).

Step-by-step surgical technique

The equipment used during the procedure include glass cup or beaker in which the required agent is poured; a head band or cap for the patient; gloves; cotton-tipped applicators or swab sticks; cotton or gauze pieces; fan for cooling.

The patient lies down with head elevated to 45° with the eyes closed to avoid accidental spillage of the agent. A syringe filled with water or saline should be kept ready for irrigation of the eyes in case of accidental spillage.

Mild tranquilizers can be used for very anxious patients undergoing medium depth and deep peelings. The label on the bottle must be precisely checked before applying the peel, to avoid any agent mistake. Sensitive areas like the inner cantus of the eyes and nasolabial folds can be protected with Vaseline, if the dermatologist feels it is necessary.

Glycolic acid

Glycolic acid, an α -hydroxy acid (AHA), has become one of the most widely used organic carboxylic acids for skin peeling. Concentrations for peeling range from 20% to 70%, giving a superficial peel.



Figure 29.1 The procedure starts by removing make-up and cleaning the skin.

When the desired depth of wounding has been achieved, AHA peels need to be neutralized to finish their action on the skin. Neutralization is done with an alkaline solution such as 10–15% sodium bicarbonate solution, which causes a lot of fizzing on the face. The depth of the glycolic acid peel correlates with the duration of the agent in contact with the skin, and this can be seen clinically as the skin becomes pink and then red, suggesting intraepidermal wounding. Gray-white coloring and vesication occur with epidermolysis or separation of the epidermis from the dermis and hydration. Frosting signifies dermal injury and can occur in areas of previous skin injury.

Superficial chemical peels do not treat wrinkles or deep pigmentation.⁴ Otherwise, for significant improvement of wrinkling, the peel needs to create epidermal necrosis and dermal inflammation. The physicians

should begin the peeling sessions with low concentrations of the acid (20–30%) and then they can increase its concentration during the subsequent sessions. This peeling regimen includes a monthly peeling session.

Glycolic acid peels have keratolytic, anti-inflammatory, and antioxidant effects.⁵

Salicylic acid

This agent is used in concentrations of 20–30% in ethanol giving a superficial peeling. It is safe to be used on skin types V and VI with lower risk of PIH, especially dark-skinned patients.⁶ Indications for salicylic acid peels include inflammatory and non-inflammatory acne vulgaris, superficial pigmentation disorders, such as epidermal melasma, and mild sun damage.⁷ The peeling regimen includes six peels sessions (one or two monthly peelings). Good results are usually observed after three peels. The peel should be left for 3–10 minutes according to the skin reaction, and then it should be washed off the face. A white precipitate of the salicylic acid appears after 1 minute, and this should not be confused with a real frosting. The salicylic acid peel had sustained effectiveness and fewer side effects.⁸

Lipo-hydroxy acid

This is a recently introduced superficial peeling agent using a lipophilic derivative of salicylic acid, LHA. This β -hydroxyl acid is the newest product in this category. LHA is used in 5% and 10% concentrations.⁹

LHA molecule acts on the corneocyte interface to detach individual corneosomes. LHA also stimulates renewal of epidermal cells and the extracellular matrix, with an effect that is similar to the effect of the retinoic acid.

In a study comparing LHA and glycolic acid, 46% of women showed an improvement in pigmentary disorders on the LHA side versus 34% on the glycolic acid side.⁹

Jessner's solution

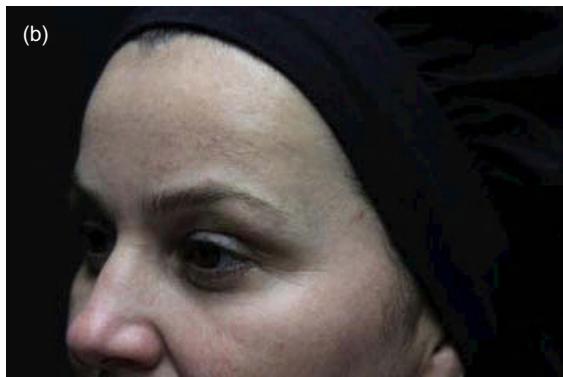
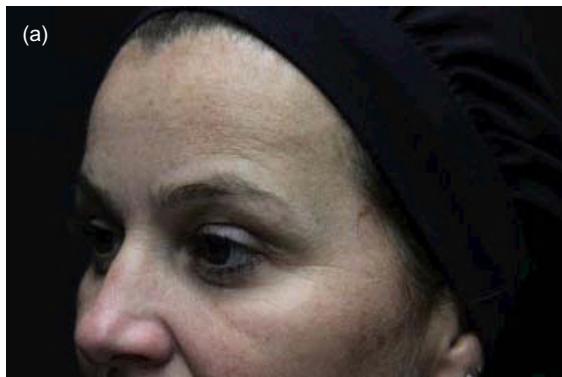
Jessner's solution contains 14% resorcinol, 14% salicylic acid, and 14% lactic acid as well as ethanol 95%. It has been used alone for superficial peelings, or in combination with TCA 35% to reach a medium-depth peel. In general, these peels are well tolerated. The depth of the peel depends on the number of layers of solution applied (Figure 29.2). Jessner's solution peel rarely causes



Figure 29.2 Superficial chemical peeling with Jessner solution and first layers of 20% TCA for improvement of mild photodamage.

“overpeel” phenomenon due to unpredictable deep penetration. Therefore, being a safe and predictable peel agent, the risk of complications is very low.⁴

A very superficial Jessner's peel (one to three coats) results in erythema, with whitening of the skin surface. This is no frosting (coagulation). This is actually due to the solution chemical compounds precipitating on the skin. When applying more coats (4–10 layers) or in patients using daily high concentrations of topical retinoids, there is increased erythema and some pinpoints of true white frosting. Exfoliation follows for 2–4 days, with moderate flaking. Further coats of Jessner's solution create a prominent erythema and increased areas of frosting with a moderate amount of stinging. At this level, exfoliation usually lasts 8–10 days (Video 29.1).



Figures 29.3 (a,b) Patient before and 30 days after a chemical peeling (30% TCA).

Tretinoïn peel

This superficial peel comprises the use of a solution of high-concentration tretinoïn (1–5%) in propylene glycol. The application of the solution is painless and some formulations are tonalized (Video 29.1). It should be kept on the skin for at least 4 hours, and then washed off. Even if left for more than 4 hours, this is still a superficial peeling. Because tretinoïn decomposes on UV light exposure, this peeling should be performed in the late afternoon or evening. It is a very well-tolerated procedure, with minimal side effects. Also, this peel can be indicated for treatment of actinic changes, melasma, and poikiloderma of Civatte. It can be performed twice a month.

Trichloroacetic acid

Superficial or medium peels can be obtained with this agent, which remains one of the most used agents for peelings (Figures 29.3a,b). It is most commonly used for medium-depth peels, especially to treat pigmentary disorders, early facial rhytids, multiple solar keratosis, and textural changes of the skin.

Wrinkles and acne scars can be only slightly improved with TCA peels. Usually, deeper treatment modalities are required to provide more significant improvement in these cases.

A superficial peel is obtained with concentrations of 10–25% of this agent (Figure 29.4) (Video 29.1).

A medium-depth peel is obtained with concentrations of 35% and higher.

Concentrations higher than 35% are not recommended for full face peels because the results are less predictable and it increases the potential for scarring.



Figure 29.4 Mottled frosting in superficial chemical peeling with Jessner solution plus 25% TCA for improvement of mild photodamage. In the lower eyelid, more regular frosting achieved by cotton swab application of same concentration of the agent, indicated slight deep penetration.

TCA precipitates epidermal proteins, causing necrosis of cells. The application of the agent is followed by frosting, which is the whitening due to the coagulation of the protein in the epidermis, indicating that the acid has penetrated down to the papillary dermis (Figure 29.5).

Neutralization of TCA peel is not necessary. The degree of frosting correlates with the depth of solution penetration¹ (Video 29.1). The extent of damage and the risk of post-inflammatory dyschromias and scarring increases with higher concentrations. TCA peels are considered less safe for skin phototypes IV–VI than glycolic acid, Jessner's solution, and salicylic acid peels. The frequency of post-peel hyperpigmentation is significantly higher in dark skin.



Figure 29.5 Different frosting's patterns may be seen in this patient, showing different depth of TCA penetration.

Phenol peels

The main indications for this deep chemical peel include dyschromia, fine and coarse wrinkles, premalignant skin lesions, and acne scars.⁴

Deep peels include modified phenol peels (Baker/Gordon) where the percentage of croton oil directly affects the penetration and thus the cutaneous and cardiac toxicity of the phenol component. Depigmentation is no longer seen with these phenol peels; rather, a pseudo-hypopigmentation develops over the following 1–2 years, which has the cosmetically acceptable skin tone of the patient's non-sun-exposed skin. Risks of phenol peels include cardiac arrhythmias, nephrotoxicity, and hypopigmentation, requiring IV sedation, IV fluids, and cardiac monitoring.²



Figure 29.6 Appearance of the lower face after 5 days of 35% TCA medium depth chemical peeling.

Postoperative care and follow-up

Immediate post-peeling care includes prevention of infection and minimizing inflammation and preventing PIH. Sun avoidance and photoprotection containing both chemical and physical agents such as zinc oxide and titanium dioxide are preferable. Sun exposure must be avoided for at least 8 weeks after the peel to minimize the risks of PIH.

Topical corticosteroids, such as a cream with hydrocortisone 1–2.5%, for 1 or 3 days can be used to relieve symptoms and prevent PIH. Exfoliation is never the same all over the face but generally starts at the perioral area and ends at the forehead (Figure 29.6).

A moisturizing cream should be applied. The physician should advise the patient to avoid peeling, picking, or scratching the skin. For patients presenting personal history of PIH, a single dose of oral corticosteroid (prednisone 20–60 mg) is useful to decrease inflammation immediately after medium depth and deep peels, thus decreasing PIH.^{1,10}

Prevention and management of complications

To avoid complications, photoprotection and bleaching agents pre- and post peel are recommended (Video 29.1). Patients with higher risk of complications are those with a history of keloid formation, PIH, sensitive skin unable to tolerate sunscreen or bleaching agents, and a history of herpes simplex.

- Potential complications of chemical peels include:
- **PIH:** this may develop very soon after the peel or months later. Oral contraceptives and hormonal agents may increase the risk of PIH. There is a major risk in dark-skinned people. PIH can be persistent and very difficult to treat. Early interventions with sunscreens, topical corticosteroids, tretinoin, AHA, kojic acid, azelaic acid, or hydroquinone may ensure good results.
 - **Hypopigmentation:** some areas of permanent hypopigmentation frequently result because of the destruction of melanocytes in the hair follicles with reticular peels. Most patients with this complication need to use cosmetics to camouflage the hypopigmented areas. It can be very persistent and difficult to treat.
 - **Milia:** this can appear in up to 20% of patients after chemical peels, usually 8–16 weeks after the procedure. It can be treated with electrosurgery^{1,4} or a needle and a comedone extractor.
 - **Acneiform eruption:** it usually appears immediately after re-epithelialization. Its etiology is multifactorial and is related to either exacerbation of previously existing acne, comedogenic effects of barrier ointments. It can be treated similarly to acne.
 - **Infections:** the frequency of this complication increases with the depth of peeling, previously existing complications or when chemical peels are combined with invasive techniques, such as cryotherapy, curettage, etc., and is more pronounced when crusting occurs. Infections can be bacterial (more commonly staphylococci and streptococci), viral (herpes simplex), and fungal (candida). They must be treated appropriately with topical and oral antibiotics, antiviral and antifungal agents, respectively.
 - **Scarring:** this adverse effect remains the most feared complication of chemical peels. It is rare in superficial peels. Most scars result from other complications such as infection or premature peeling. Delayed healing and persistent redness are important alarming signs for forthcoming scarring. Hence, a careful monitoring of the patient in the post-peel phase is very important for early detection and treatment of such complications. Hypertrophic scars and keloids can be treated with potent corticosteroids topically or intralesionally. Resistant scars may be treated with dermabrasion or pulsed dye laser followed by compressive silicone sheeting therapy.
 - **Toxicity:** although rare, toxicities can occur with resorcinol, salicylic acid, and phenol peels. The most important potential complication of phenol-based peels

is cardiotoxicity. Adequate patient management reduces this complication.

- **Premature peeling:** premature peeling increases the risks of infection, persistent erythema, PIH, and scarring of the underlying skin. It may occur accidentally or may be the result of picking at the peeling skin. The use of topical antibiotics and hydrocolloid dressings should be included in the care management. Topical steroid cream can be used if epithelialized bright red skin is exposed on premature crusting.
- **Persistent erythema:** persisting erythema lasting for 2 or 3 weeks following a peel is considered normal, especially after a TCA peel. However, patches of erythema persisting for more than 3 weeks are indicative of hypertrophic scars and should be treated with potent topical corticosteroid therapy.

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Video list

Video 29.1 Chemical peels

Liposuction

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Introduction

Liposuction continues to be one of the most desired aesthetic surgery procedures. In fact, since 1997, there has been over a 155% increase in the total number of cosmetic procedures, with liposuction ranking as the second highest surgical procedure with 289 016 cases in 2010.¹ Techniques in liposuction have developed significantly as well, with different modalities available to patients with additional features such as cellulite treatment or body skin tightening. Historically in the mid-1970s, dry liposuction was introduced, with the use of machine-assisted suction of fat using blunt cannulas, a procedure first described by Drs. Giorgio and Fischer.² The Fischer technique evolved into early tumescent liposuction by French practitioners such as Dr. Yves-Gerard Illouz.³ This new tumescent technique involved injecting crystalloid to expand the subcutaneous space, thereby preserving the structure of adipocyte septae and minimizing trauma to neurovascular bundles resulting in less blood loss. In 1987, Dr. Jeffrey Klein⁴ introduced the practice of including lidocaine into the tumescent fluid, heretofore consisting of hypotonic saline. This revolutionized the practice of fat sculpting, since it facilitated the use of local instead of general anesthesia for the procedure. Today tumescent local anesthesia is infiltrated subcutaneously in high volumes not only to anesthetize the area locally but also to prepare the fat tissue for the suction procedure. This

tumescent technique for liposuction has evolved over the last 20 years in terms of extent of treatment area, the type of anesthetics used in the tumescent solution, the time allowed for tissue homogenization after infiltration, and in the type of cannulas used for the liposuction.⁵ Key knowledge of the anatomy of the subcutaneous fat tissue with its different layers in different locations, including the deep fat, and the fat deep and superficial to the Camper fascia, have improved the results of liposuction procedures tremendously. In the hands of an experienced surgeon, liposuction surgery for body contouring with powered vibrating cannulas in high-volume tumescent local anesthesia can yield excellent results.

Additional devices like ultrasound-assisted liposuction or waterjet-assisted liposuction have been developed, but have not shown a major improvement in the results compared with liposuction surgery with vibrating cannulas in tumescent local anesthesia. Only in recent years have the additional devices, like laser lipolysis⁶ and radiofrequency,⁷ augmented the results as an adjunctive procedure to classic liposuction in special indications like skin laxity and cellulite.⁸

Preoperative care

Patient selection is paramount, and a discussion of goals, expectations, and lifestyle should occur between

the patient and physician to accurately assess procedure success and patient satisfaction. The ideal patient is healthy with localized lipodystrophy resistant to intervention through diet and exercise.⁹ In addition, every patient should undergo thorough evaluation through history and physical examination, emphasizing body mass index, areas of lipodystrophy, prior scars or evidence of hernia, evaluation of skin tone, skin quality and laxity, asymmetries, and zones of adherence.¹⁰ Integral patient satisfaction after liposuction surgery is to clarify before the first liposuction that the treated areas in one procedure are limited due to the maximum amount of tumescent local anesthesia (TLA) used in one operation. In many cases at least two liposuction surgeries are needed to contour a whole body optimally. Every patient should undergo informed consent, which should mention, besides the classic risks of a surgery like thrombosis, embolism, and infection, any specific adverse effects associated with adjunctive devices,¹⁰ such as risk of thermal injury when liposuction is accompanied by energy application like laser, radiofrequency, or ultrasound.

Step-by-step surgical technique

Marking

Marking should be performed in front of a mirror in a standing position in agreement with the patient. A usual case of tumescent liposuction surgery addresses a maximum of three or four areas bilaterally. After marking, photographs are taken for preoperative documentation.

Infiltration

IV access should always be obtained before the infiltration, and the patient should be monitored throughout the whole liposuction procedure. Additional sedation is usually not necessary, only in the setting of significant patient anxiety, in which case IV sedation can be performed by an anesthesiologist. However, general anesthesia is not recommended (Figure 30.1).

Multiple miniature local anesthetic skin punctures with 1% lidocaine are given across the liposuction area, before the tumescent local anesthesia is slowly infiltrated through these anesthetized punctures, utilizing multiple sharp spine needles into the subcutaneous fat tissue, always starting deep but remaining above the muscular fascia.⁵ Infiltration cannulas can also be used, although the regular distribution of the fluid is more homogeneous with sharp spine needles when used approximately 9–12 at a time.¹¹ A maximum of 55 mg lidocaine/kg bodyweight is the standard amount which can be given in TLA safely.⁵ Most commonly used is Klein's formula, which consists of the following: normal saline (1000 mL), 1% lidocaine (50 mL), 1:1000 epinephrine (1 mL), 8.4% sodium bicarbonate (10 mL) (Box 30.1).¹²

Box 30.1 Composition of tumescent fluid using lidocaine

- 1 L of normal saline (0.9% NaCl)
- 50 mL of 2% plain lidocaine(1000 mg)
- 1 mL of 1:1000 epinephrine from ampule (1 mg)
- 10 mL of sodium bicarbonate(8.4% sodium bicarbonate solution)



Figure 30.1 (a and b) Tumescent infiltration. Rosenpark Klinik, Germany.

If lidocaine and prilocaine are mixed in equal concentrations, larger TLA volumes are possible in a given liposuction procedure.¹¹ The end point of the infiltration per area is reached when the skin reaches its maximum tension. The more tension in the skin, the better stretched and stabilized the subcutaneous fibers are, such that the risk of rupturing blood vessels is reduced during the liposuction period. Less volume of tumescent local anesthesia in one area results in higher shearing forces during liposuction, followed by greater injury of the subcutaneous fibers. Effective TLA infiltration is mandatory for a good liposuction result.⁵

Homogenizing time

After application of the maximum amount of tumescent fluid, the local anesthetic requires time to take effect. Additionally, the infiltrated fluid should homogenize in the subcutaneous space and soften the fat cells during that time. In these 30–60 minutes the patient rests on the OR table covered by a warming blanket.¹³

Liposuction

For the liposuction procedure the patient is prepared, draped, and disinfected as usual for operations under sterile conditions (Video 30.1). Multiple incisions are made with an no. 11 blade at the access site. Small incisions known as “adits” are placed in well-concealed areas along skin tension lines, not exceeding 3–4 mm. The aspiration of mobilized fat and fluid by liposuction cannula is started. The recommended cannula size is 2.5–4.5 mm in diameter, as larger cannulas may induce more textural irregularities.¹⁴ The cannula is inserted into subcutaneous fat deep to the Camper fascia, and should be moved back and forth always in a sagittal direction; horizontal suction should be avoided. During the suction process the correct positioning of the patient is of great importance for a good result in body sculpturing. This suction maneuver is repeated until the entire treatment site is covered, moving from deep to superficial. The fat lobules superficial to below the skin should never be removed since the result will show skin irregularities after the healing process. The pinch test can be used to estimate sufficient removal. If the patient suffers from extraordinary skin laxity, additional invasive radiofrequency devices can be added to achieve more skin tightening. Finally, after finishing the liposuction procedure, a laser fiber (laser lipolysis) can be used in the

superficial layer, not to extract the fat but to melt the fat lobules to treat cellulite⁹ (Figure 30.2).

Incisions should not be sutured to allow open drainage of the resisting TLA and any hematoma that may have occurred. After the procedure, the treated site should be wrapped in an absorbent dressing covered by a compression garment.⁵

Postoperative care and follow-up

Following the operation, the patient may leave the OR area fully ambulating after approximately 3 hours of observation and after the first change of dressing. During that time the patient should rest but undertake gentle ambulation, which aids drainage of fluid and minimizes the thromboembolic risk.

The extent of bruising, swelling, and pain is variable from one patient to another. Pain medication, oral antibiotics, and a daily single shot of deep vein thrombosis (DVT) prophylaxis should be given to the patient for 1 week to avoid complications.

Leakage of fluid into the dressing will be heavy in the beginning, such that the patient needs to change the dressing every 3–4 hours during the first day. By the second or third postoperative day, only a small volume of fluid still drains; usually by day 3, the incisions close themselves and no additional dressing is needed other than the compression garment. During these first 3 days showers and dressing changes are very important to minimize the risks of an infection.

Follow-up visits are planned 1 week and 2 weeks after liposuction to assess the healing process. To judge the cosmetic result, a mandatory follow-up visit is planned 4–6 months after the liposuction.

If two liposuction sessions are needed for an excellent result, the second procedure in a different body region should not be performed earlier than 2 months after the first liposuction. If correction liposuction in the same area is needed, a period of at least 9 months should intervene between the first and second session.

Complications

Most of the potential complications occur when liposuction is not performed under tumescent local anesthesia,¹⁵

Part 1



Part 2

**Figure 30.2** Before and after liposuction. Gerhard Sattler, Rosenpark Klinik, Germany.

or the tumescent local anesthesia is not infiltrated in the right manner and dosage. Operative risks include lidocaine toxicity, bowel perforation, skin necrosis, volume overload, or shock. Medical risks include DVT, hematoma, seroma, or infections. Cosmetic risks can be divided into early-stage risks and late risks, the latter of which may occur years after liposuction surgery. Excessive or insufficient resection are the major, early cosmetic risks of any liposuction surgery and are influenced by the experience

of the liposuction surgeon and the positioning⁵ of the patient during the liposuction procedure. Proper technique such as avoiding disturbance of the superficial layer of fat above the Camper fascia helps minimize skin irregularities. Increased skin laxity may occur when the fibrous tissue of the subcutaneous fat is ruptured due to insufficient tumescent fluid or overly aggressive surgical technique. The introduction of powered cannulas has reduced this risk tremendously.¹⁶

Later complications that may arise include a disproportional body configuration, which may result from poor preoperative planning and marking, and over-resection in single areas. When liposuction has been performed too superficially, elastosis of the body skin can be seen in the treated areas.

Future directions

Liposuction will continue to be a procedure in high demand. A correct tumescent technique using powered cannulas yields predictable and satisfactory aesthetic results and can avoid complications. Based on this technique, the newer and more successful adjunctive techniques, such as laser-assisted and radiofrequency-assisted liposuction, will also remain desirable. These approaches are especially appealing since they address skin laxity and cellulite. In addition, there will be continued non-cosmetic applications, such as lymphedema, hyperhidrosis, hidradenitis suppurativa, and lipomas.

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Video list

Video 30.1 Liposuction

Upper eyelid blepharoplasty

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Preoperative care

A successful preoperative evaluation should identify underlying causes of eyelid changes, plan the appropriate treatment and manage expectations accordingly.

Most patients presenting for eyelid surgery will complain of “full” or “droopy” upper eyelids. Redundant eyelid skin, or dermatochalasis,¹ typically occurs secondary to loss of collagen and elastin with fat prolapse.² Upper eyelid blepharoplasty is used to restore a youthful look and in many cases improve a patient’s visual field.³

To ensure a result commiserate with the patient’s expectations it is important to identify cases that will not respond to blepharoplasty alone. Patients may have a component of blepharoptosis where the eyelid margin is inferiorly displaced (Figure 31.1). Brow ptosis (Figure 31.2) must also be recognized, as a blepharoplasty may exacerbate the condition by pulling the brows down further.⁴

Investigation for the presence of other conditions must be performed. Dry eyes or inflammation can get worse after eyelid surgery. A patient who has undergone surgery that may have altered the integrity of the cornea (refractive surgery) should wait at least 6 months before having a blepharoplasty. Systemic conditions such as myasthenia gravis, thyroid disease, uncontrolled diabetes, or blood dyscrasias can affect the outcome of the surgery.⁵

Suspicious lesions should be looked for on the skin. If a malignancy is suspected, a biopsy should be per-

formed as excess eyelid skin can be valuable in eyelid reconstructions.

Management of patient expectations is critically important to success. Basics of the surgery, including risks and postoperative expectations should be disclosed to the patient. The patient should stop all blood thinners prior to surgery. Investigation about the condition warranting the medication is necessary to weigh the systemic risks of discontinuation versus the benefits of surgery.

Step-by-step surgical technique

Most blepharoplasties are done under local anesthesia with or without sedation (Video 31.1). Prepare the entire face in sterile fashion. Take care while draping the patient to avoid creating tension on the lids. If a laser is being used for the incisions, corneal protection is necessary.

Make the upper skin marking along the natural lid crease. This marking should extend from the punctum to a lateral laugh line. Using two smooth forceps, gently pinch the excess skin until minimal lid eversion is apparent and mark the upper incision. It is important to leave at least 10–12 mm of skin below the lower edge of the brow hairs to prevent brow ptosis and lagophthalmos. The final skin marking is shown in Figure 31.3.

Infiltrate the lid with 2% lidocaine with epinephrine. The skin incision is made with a no. 15 blade, a monopolar cautery or CO₂ laser. Obtain hemostasis throughout

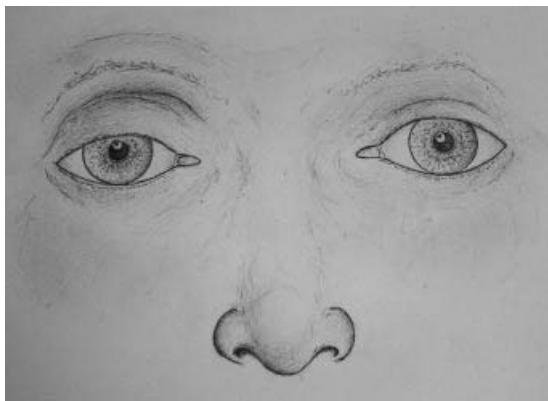


Figure 31.1 Eyelid ptosis secondary to levator dehiscence.



Figure 31.2 Brow ptosis with secondary dermatochalasis.



Figure 31.3 Upper eyelid blepharoplasty marking.

the case with the use of cautery. First remove the skin muscle flap (Figure 31.4). If removing excess fat, incise the septum, place light retrobulbar pressure and gently dissect the fat off of the underlying levator aponeurosis. Clamp the fat with a hemostat, cut and cauterize the stump before release back into the orbit (Figure 31.5). Once hemostasis is ensured, close the wound with several interrupted 7-0 nylon sutures taking bites through the aponeurosis to recreate the lid crease (Figure 31.6), followed by a running suture (Figure 31.7). Alternatively, skin only can be removed.



Figure 31.4 Removal of skin and muscle from a lateral approach.



Figure 31.5 Removal of orbital fat: clamp fat with a curved hemostat while gently pulling the aponeurosis away.



Figure 31.6 Crease-forming sutures: skin edges approximated to aponeurosis.



Figure 31.7 Running suture to close upper eyelid blepharoplasty wound.

Postoperative care and follow-up

Elevate the head and use ice compresses for 2 days. Apply antibiotic ointment to the wounds three times per day for 1 week. Avoid getting water directly into the wound for 2 weeks. Avoid bending, heavy lifting, or straining for 1 week. Patients should not require any pain medication stronger than tylenol.

At the postoperative 1-week visit, any non-absorbable sutures are removed. Medications, such as oral arnica, can help minimize bruising and swelling after surgery. In addition, vitamin K creams can help hasten the

resolution of ecchymosis. At 2 weeks postoperatively, patients can resume all eye creams and make-up.

Prevention and management of complications⁶

Orbital hemorrhage is one of the most feared complications of blepharoplasty, because it can lead to blindness. There are many fragile vessels in the orbital fat, which if avulsed are difficult to control. Discontinuation of blood thinners and meticulous hemostasis with care during dissections will aid in prevention. Most orbital hemorrhages will present within the first 12–24 hours after surgery. The patient may complain of pain and a decrease in vision and present with a swollen, tight, and proptotic orbit. The wound should immediately be opened to create an egress for blood and allow a decrease in the orbital pressure. Exploration and cauterization of bleeding vessels can be performed at this time. If the intraocular pressure is elevated, an ophthalmologist should be consulted and antiglaucoma drops started right away. If drops alone are not effective in lowering the pressure, systemic medications can be used, such as oral acetazolamide or Mannitol.⁷ If the orbital pressure is not relieved with the above measures, a lateral canthotomy with inferior cantholysis should be performed. Occasionally a superior cantholysis will add benefit to the situation. If necessary, an orbital decompression can be performed. It is of utmost importance that the surgeon has a clear understanding of the orbital anatomy before undertaking any of the above-mentioned procedures in order to avoid further damage to the orbital structures.

Asymmetry of the lid creases can be caused by dehiscence of the levator aponeurosis, asymmetry of skin muscle resection, or from making the skin incision at different heights. The best way to avoid asymmetry of the lid creases is to perform careful measurements prior to making the incision. Wait until all postoperative edema has resolved before judging and treating asymmetry. When treating asymmetric lid creases, it is easier to lower the higher lid crease than it is to raise the lower crease. Adequate upper eyelid skin must be present.

Sulcus asymmetry can result from aggressive, asymmetric fat removal.

Gentle pressure on the globe during fat removal can help to prolapse the unwanted fat so that it is more

approachable for removal. Correction of sulcus asymmetry can be addressed in either the deep or shallow side. Excess fat can be removed from the full sulcus or an implant or fat can be used to fill in the deep sulcus.

Insufficient skin removal can result if the drape pulls the forehead superiorly and posteriorly, which can interfere with accurate measurements by masking the amount of skin that needs to be removed. Loosening the drape can prevent unwanted results and the need for reoperation. While pinching up the excess skin, slight eversion of the lid margin will help to correctly estimate a good result. Postoperatively if the patient feels there is excess skin remaining, further skin can be removed if the surgeon agrees or the skin can be tightened with laser resurfacing. It is important to rule out the presence of brow ptosis, lid lag, or lagophthalmos.

Lagophthalmos, or inability to close the eyelids, can result when too much skin has been removed. It can also occur if the septum is incorporated into the closure. Also, if too much skin is removed in the presence of brow ptosis, the brow becomes displaced further inferiorly, potentially resulting in lagophthalmos. Postoperative fibrosis of the levator aponeurosis, aggressive cautery, or inflammation of the septum and levator aponeurosis can also lead to lagophthalmos. Avoidance can be achieved by careful removal of excess tissue, eliminating overaggressive cautery to the aponeurosis or septum, careful closure of the wound, and recognition of brow ptosis. Treatment involves a skin graft if there is anterior lamellar shortening or release of cicatrix. Until treated, copious lubrication of the cornea is necessary in order to prevent epithelial defects, corneal ulcers, and perforations. Antibiotic ointment and/or drops may become necessary if the corneal epithelium has been significantly violated.

Damage to any of the extraocular muscles during blepharoplasty can result in double vision and is very disabling to the patient. The superior oblique muscle can be damaged if dissection is carried too deeply in the superonasal quadrant of the orbit. Avoid aggressive, deep dissection, and fat removal and know the eyelid anatomy. If diplopia persists beyond several months after a blepharoplasty, referral to a strabismus surgeon is advised.

Ptosis can result from damage to the levator aponeurosis or from postoperative inflammation of the eyelid, in which case resolution occurs after the edema subsides. Damage to the levator aponeurosis is best avoided by careful dissection. Ptosis is best repaired intraoperatively

if recognized. If postoperative inflammation is suspected to be the cause, observation for at least 3 months is advised to see if the ptosis resolves on its own. If the ptosis persists, surgery can be performed.

Inclusion cysts can occur if elements of the epithelium get trapped beneath the surface of the skin during wound closure. Avoidance is best achieved with eversion of the wound edges. If they should occur, they can be surgically excised.

Infection is very rare in eyelid surgery. Risks increase with a non-sterile operative environment, poor patient hygiene, poor patient health (i.e., uncontrolled diabetes), and poor patient compliance. In rare instances a patient may develop an atypical mycobacteria infection. The patient may present with nodules forming around the incision. This diagnosis is made by biopsy and culture. If infection of the eyelid tissue is mismanaged, devastating results can occur. Patients can lose tissue to aggressive organisms or the infection can seed to the blood stream and travel to other parts of the body. Proper hygiene and sterilization of the surgical field and instruments is paramount. If infection should occur, the wound should be cultured and cleansed and the patient placed on appropriate antibiotics. If atypical mycobacteria is suspected, a biopsy should be performed and the patient placed on clarithromycin until the infection clears. Suture abscesses are best treated by local excision with removal of the offending suture. Topical or systemic antibiotics can be used on an individual basis.

Surgical fires are a consideration in any procedure where oxygen is being used in combination with cautery. The following are necessary for surgical fires: (1) an oxidizer such as oxygen delivered through a nasal cannula; (2) fuels such as cloth or paper drapes and alcohol-based preparation solutions; and (3) an ignition source such as cautery, lasers, or endoscopes.⁸ Miscommunication and lack of staff education can increase the risk of surgical fires. Surgical fires can lead to serious injuries to both the patient and the hospital staff and even death.

Staff education is key to prevention. In addition, minimization of O₂ concentration underneath patient drapes will help prevent fires. The JCAHO/ECRI established guidelines and recommendations for use of room air or less than 30% FiO₂ for open delivery. During blepharoplasty surgery, the drapes should be placed so that the entire face is open to the surroundings. Not only will this aid in patient comfort and respiration, but it will prevent

concentrated levels of gas to collect underneath a closed space. If a patient should require oxygen, it is important to make the surgeon aware so the gas can be turned down during cauterization.

Treatment of a surgical fire includes putting out the flames then addressing the injured immediately and eliminating the offending agents. Drapes should be removed, oxygen or other gases should be turned off, and cautery use should be stopped.

Summary

Blepharoplasty performed on the upper eyelids can be a very successful surgical procedure functionally and cosmetically. Care must be taken to avoid the numerous potential complications. Sufficient knowledge of the orbital, ocular, and adnexal anatomy is paramount prior to performing blepharoplasty surgery and is the key element in the prevention of complications. Preoperatively, developing a positive rapport with the patient is good practice. This measure alone will quell myriad potential problems between patient and surgeon. Thorough investigation of the patient's chief complaint, goals, and expectations will prove beneficial. In addition, a complete history and ocular examination are the bare necessities. When necessary, postpone surgery until a patient is healthy enough to undergo such an elective procedure. Evaluate patients carefully so as not to miss an underlying diagnosis that may be responsible for your findings. Ensure that a patient has discontinued all blood thinners prior to surgery. When the surgeon is comfortable with the anatomy around the eye and has the proper

education and training to engage in such a procedure, blepharoplasty surgery should be performed with care and respect to the patient. If prevention of complications fails, knowledge and preparation for treatment are a must.

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Video list

Video 31.1 Upper eyelid blepharoplasty

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Indications

Many patients in their forties, fifties, and beyond present with a primary complaint of sagging jowls and neck. Although much can be done in younger faces by addressing volume loss, skin resurfacing, and tightening procedures, the redraping effect of facelifts should not be overlooked. For patients whose primary complaint is “heavy” jowls and sagging neck, and for those who wish to improve the appearance of the lower third of the face, a facelift may be the most efficacious procedure, producing the best possible results (Figure 32.1–32.3)^{1–3, 5–8}.

Preoperative care

Preoperative care begins with the initial consultation, during which the surgeon must carefully listen to the patient’s desires and concerns. Once the patient’s goals are clear, the physician can analyze what may be done. By listening carefully to the patient’s complaints and then educating the patient on the appropriate procedures, discussing the pros and cons of each, the physician can begin to establish a rapport with the patient.

Photographs of typical facelift patients are often helpful in the consultation. In addition, the surgeon may demonstrate to the patient with a mirror how a slight pull of the skin in a vertical vector may simulate facelift results. Various types of facelifts may be discussed with emphasis on the differences in the incisions that are made and the methods of SMAS (superficial muscular aponeurotic system) tightening. This discussion should include

the advantages of minimal incision face lifting, which, with a vertical vector of pull, can produce excellent results for the cheeks and jawline with some neck improvement. Greater neck tightening can be achieved if the incisions are carried back behind the ear in a traditional facelift. Alternative and complimentary procedures, such as volume replacement and laser resurfacing, may also be considered at this time. Finally, the practitioner should discuss the types of anesthesia to be used, whether it be local anesthesia, monitored anesthesia care (MAC, or “twilight” sedation), or general anesthesia.

We suggest a second consultation to ensure that good communication has been established between the surgeon and the patient. At this time, the consent form should be discussed, including a detailed description of the possible complications, including the risks of infection, bleeding, scarring, and nerve damage. It is important for patients to realize that there will be scars, although all efforts are made to minimize those scars. The scars of newer, minimal incision facelifts extend from the temples to the earlobes, and with traditional facelifts, those scars are continued behind the ears and up into the hairline. For patients with short hair, postauricular scars may be noticeable. The position of the earlobes (attached versus unattached) should also be discussed at this time.

Finally, a preoperative work-up should include a standard history and physical examination, which may be carried out in consultation with the patient’s primary care provider. This should include laboratory tests to ensure normal blood counts and coagulation. The patient’s medications should be reviewed, allergies should



Figure 32.1 Before and after photos of a full-facelift patient demonstrating significant improvement in the jowls and neck with a vertical vector of lift, allowing for a natural appearance.

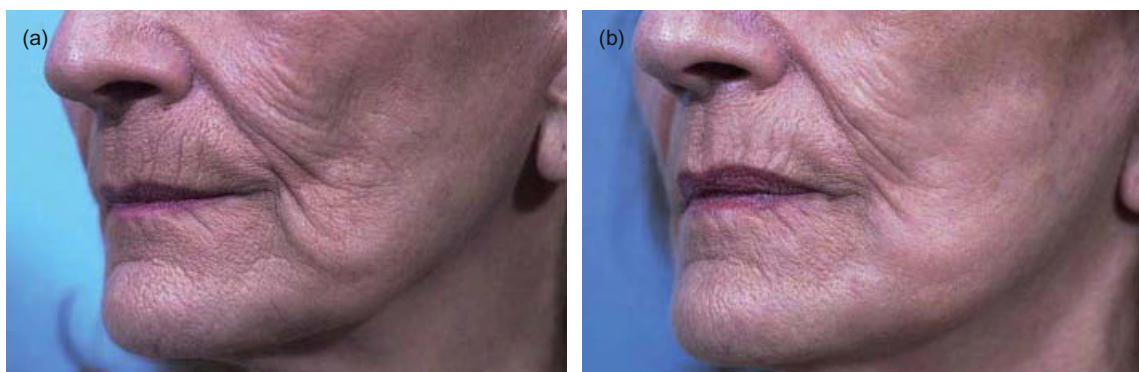


Figure 32.2 Typical minimal-incision facelift results in a 70 year old patient. (a) preoperative. (b) postoperative.

be noted, and the patient should be educated to avoid anticoagulants prior to surgery.

Step-by-step surgical technique

I. Preparation and marking

- a. Patients should be instructed to wash their hair the night before surgery and to wash their faces and necks with antibacterial soap, especially around the ears. Shortly prior to surgery, the entire operative area should be cleaned with chlorhexidine. The planned

incisions are be marked on the patient with a surgical marker, and the patient should look in a mirror to understand exactly where the planned incisions will be (Figure 32.4).

II. Anesthesia

- a. “Twilight” anesthesia may be delivered with oral diazepam, followed by IM or IV fentanyl and hydroxyzine pamoate or other similar combination. The operating room facility must be accredited for conscious sedation and the surgeon should be comfortable with emergency airway procedures if an anesthesiologist is not present. Vital signs must be continuously

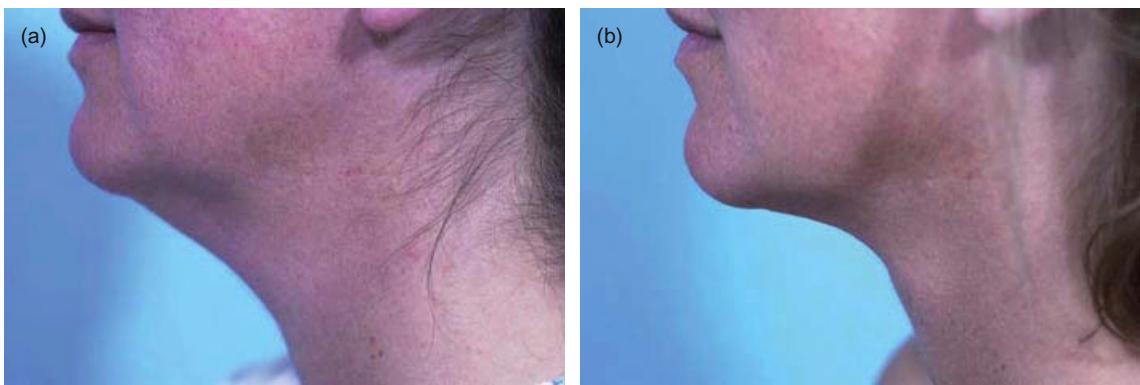


Figure 32.3 Typical minimal-incision facelift results in a 40 year old patient. (a) preoperative. (b) postoperative. Note the marked improvement in the neck with even a minimal incision lift. This is achieved with a vertical direction of pull in the SMAS plication.



Figure 32.4 Preoperative markings should be made and discussed with the patient. This patient's incisions are planned behind the tragus and behind the ear.

monitored when patients are sedated. The patient may elect to have an anesthesiologist handle the sedation or general anesthesia.

b. For facelifts, local anesthetic is most commonly delivered as a tumescent anesthetic solution containing 0.01% lidocaine with epinephrine. We use 50 mL



Figure 32.5 Tumescent anesthesia is used in and around the post-auricular incision to anesthetize the area and to aid with dissection and hemostasis.

of 1% lidocaine with 1:100 000 epinephrine mixed in 500 mL of normal saline or lactated Ringers solution, making it impossible to exceed the maximum lidocaine with epinephrine dose of 50 mg/kg recommended for body liposuction. No recommendations for tumescent anesthesia exist for facial surgery. The tumescent solution is infiltrated in the fat and subdermal plane. It is injected around the planned incision lines and delivered in a fan-like manner to the temples, cheeks, jawline, neck, and post-auricular area (Figure 32.5).



Figure 32.6 Incision (a) pre-auricular; (b) at earlobe; (c) post-auricular.

III. Incision

a. Incisions can be tailored to a patient's needs, but the most common is a beveled temporal incision at least 2 mm behind the hairline. In a minimal incision facelift, the incision extends retrotragal, ending at the earlobe. In a traditional facelift, the incision is further extended behind the ear and into the occipital hairline (Video 32.1).



b. Placement of the temporal incision behind the hairline avoids distortion of the natural hairline, thus preventing the stigmata of obvious cosmetic surgery. This incision also gives a more natural and even vector pull. In the temporal area, the incision should be beveled almost parallel to the hair follicles in order to preserve hair growth at the scar lines and so that any scar line is hidden with hairs. A zigzag incision can help to avoid dog-ear formation in the temple (Figure 32.6a).

c. Without beveling, the incision is then carried inferiorly behind the tragus and down to the earlobe. A retrotragal incision camouflages the scar nicely, but care must be taken not to distort the tragus nor to disrupt the underlying cartilage (Figure 32.6b,c). Thinning of the flap near the tragus and using a tacking suture in front of the tragus can minimize any tragal distortion. In male patients, caution must be taken not to distort the beard line by pulling hair-bearing cheek skin back to the tragus. For that reason, some surgeons prefer to place the incision in the pre-auricular crease rather than behind the tragus for male patients.

d. To remove a dog-ear, it is sometimes necessary to carry the incision behind the ear. This can be avoided by keeping the vector of pull vertical-upward, which maximizes neck improvement and minimizes dog-ear formation.

e. If the incision is extended behind the ear, it should be positioned on the posterior surface of the cartilaginous portion of the ear so that after suturing, the scar will fall into the post-auricular sulcus. The post-auricular incision should be extended well above the level of the auditory canal to minimize the visible portion of the scar across to the hairline. It is then carried into the hairline, where the incision is beveled to respect the hair follicle growth. This posterior portion of the scar allows for a vector of pull that will improve the neck region.

f. Another incision that can improve the neck is a small incision in the submental crease. This incision allows the surgeon to access the platysma to tighten platysmal banding and separation, remove platysmal and subplatysmal fat, and redrape the neck skin anteriorly.

IV. Undermining

a. Undermining is conducted in the deep subcutaneous plane in order to create a flap of sufficient thickness and to minimize bleeding. With the use of tumescent anesthesia, a natural separation occurs in this plane, and bleeding is minimized. This natural separation is extended by using undermining scissors to dissect bluntly in a vertical direction, instead of the more common technique of horizontal separation (Figure 32.7).

b. Countertraction and transillumination with an external, overhead light through the flap may also be used to ensure proper, uniform flap thickness.

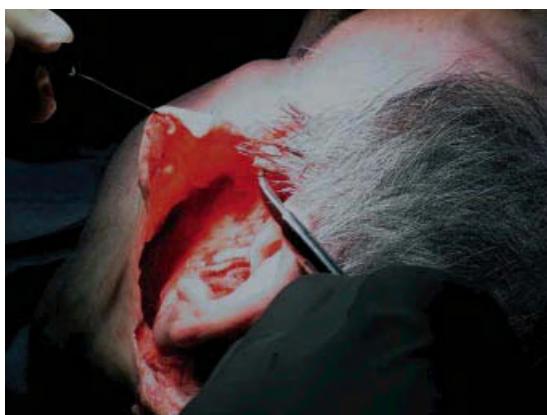


Figure 32.7 Undermining is done with the scissors oriented perpendicular to the undermined plane. Proper flap thickness is demonstrated here via transillumination.

c. Beginning at the tragus, the incised flap is undermined about 4–6 cm away from the incision; this distance must be far enough from the skin edge to allow placement of plication sutures (Video 32.2). Although undermining can be aggressively extended anteriorly to the nasolabial fold, this technique does not offer significant advantages, and it may lessen the effect of SMAS plication by disrupting the connections between the dermis and the fascia. At the temples, undermining must be done minimally and with awareness of facial anatomy to avoid damage to the temporal branch of the facial nerve or to any of the prominent branches of the superficial temporal artery. In the post-auricular area, it can be difficult to separate the skin from the underlying fascia and muscle. Careful sharp dissection with awareness of the correct plane of dissection is necessary.

When undermining is complete, bipolar electrocautery or minimal light cautery should be used for meticulous hemostasis. Care should be taken to avoid damaging any facial nerve branches with cautery. Bleeding should be minimal if tumescent anesthesia was properly administered.

V. SMAS plication

Several methods have been described for tightening the SMAS.

- *Imbrication* involves incising into the flap and suturing to tighten and overlap deeper structures.
- *SMASectomy* is the removal of a 1-inch-wide strip of the lateral portion of the SMAS from the lateral canthus obliquely towards the mandibular angle and then suturing the incised edges together.
- *Suture thread or anchor sutures* may be used to pull up the mid-cheek fat for improvement in the nasolabial folds.
- *Deep-plane facelifting* involves undermining deep to the SMAS, anterosuperior to the parotid. This technique puts the facial nerve at higher risk of damage, and it has not been demonstrated to improve the nasolabial folds more, or to last longer than other techniques.
- *SMAS plication* involves suture tightening of the SMAS without SMAS incision. With superficial bites, multiple large interrupted 2-0 or 3-0 suture loops are used to plicate the SMAS. The plication lifts the loose SMAS in a vertical direction and anchors it to the fixed, stable tissue in front of the ear above the tragus. The vertical pull gives optimal improvement of neck and jowls. This is the simplest and safest method of SMAS tightening (Figure 32.8, Video 32.3).

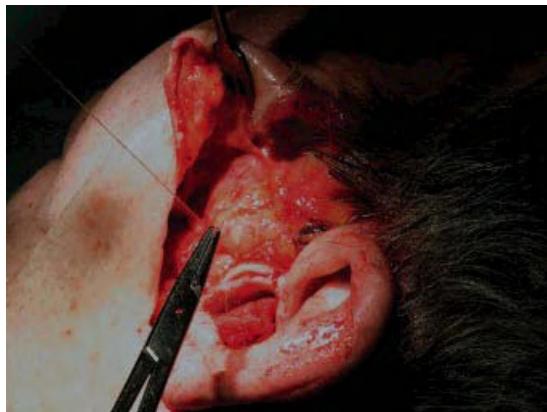


Figure 32.8 SMAS plication sutures are placed with small bites into the fascia and tied securely with a vertical vector of pull.

- *Minimal access cranial suspension (MACS) lift* also provides SMAS plication by utilizing three continuous purse-string sutures. The first suture is anchored to the deep temporal fascia in the pre-auricular area, posterior to the temporal branch of the facial nerve. It is directed inferiorly with small bites through the SMAS and platysma and then carried back superiorly to its origin, providing improvement in platysmal ptosis. The second suture is anchored near the first, and it is used to tighten and plicate the SMAS for improvement of jowls. The third suture is placed from the lateral orbital rim to the mid-cheek area to lift the mid-cheek fat and improve the nasolabial fold.⁴

With any of the SMAS plication techniques, the path of the facial nerve and its temporal branch should be drawn and avoided.

After plication is completed, there may be some dimpling of overlying skin that is easily corrected with more undermining.

VI. Trimming of excess skin

- a. Once the SMAS plication is complete, the skin is redraped, and excess skin is removed. This can be the longest part of the facelift procedure, as careful attention must be paid to skin placement, tension vectors, earlobe placement, and dog-ears.
- b. First, the skin is pulled up in a vertical direction to improve the jowls and neck. The vertical vector of pull is preferred to a lateral-posterior vector because the vertical pull provides superior improvement to the neck and looks more natural.



Figure 32.9 The flap is redraped and trimmed. This first pre-auricular suture takes tension off of the facial flap.

c. A few staples or sutures may be used at points of maximum tension. The skin flap is pulled in a superior direction, and the first staple is placed above the anterior ear (Figure 32.9). It is best to start the wound closure in the temple area and move inferiorly to the back of the ear to minimize any unevenness. If the flap has been extended behind the ear, then a second staple is placed at the apex of the post-auricular flap. The flap must be incised, trimmed, and finessed to minimize tension across the wounds while maximizing jowl-neck improvement (Video 32.4). As most facelifts will relax over the first few months, significant tension may occur at the scars above the ear. Across the tragus and earlobe, tension should be minimized.

d. The incision line is sutured with 4-0 buried sutures, which take tension off of the incision line. The skin edges are then closed with 5-0 gut suture. Suturing should begin from the temporal area and proceed towards the earlobe in order to minimize dog-ear formation. In patients with excessive neck laxity, dog-ears may be unavoidable. In that case, the dog-ear should be removed behind the ear adjacent to the earlobe. At the tragus, the natural contour should be recreated by thinning the fat and dermis over the tragal cartilage. At the earlobe, the natural, unattached earlobe can be created by leaving the earlobe detached from the cheek skin without suturing. The earlobe position (attached or detached) should be observed and discussed with the patient prior to surgery.

e. If the facelift incision has been extended behind the ear to include neck lift, then careful attention should be placed on minimizing tension on the skin flap using

buried sutures, as the post-auricular flap tolerates less tension than the facial flap. This flap tends to be thin with less fat than the facial area.

Ancillary procedures

- I. Neck liposuction may be utilized to improve neck lift results. A submental incision can also be useful to allow for platysmal plication to improve platysmal banding when the facelift alone has not sufficed.
- II. Ablative laser resurfacing may be done at the same time as the facelift, especially around the eyes and the mouth. The entire face may be resurfaced, albeit conservatively toward the edges of the flap.
- III. Lower eyelid pinch excision may be desirable when the facelift flap is pulled in a vertical vector. The pinch excision will improve infraorbital skin laxity.
- IV. Volume replacement may greatly contribute to natural-looking facelift results, as a tighter face does not always look younger. For thin patients, fat or Sculptra injections in the mid-cheek area may help to lift and round the cheeks. Added volume prevents the “wind tunnel appearance” of skin that has been pulled too tight or sideways.

Postoperative care and follow-up

Normal postoperative swelling and bruising can be minimized with a light pressure dressing around the face, although some patients are unpredictably prone to such swelling. Fibrin glue has not been proven to decrease the amount of bruising or hematomas, and drains are not necessary to prevent hematomas. Patients should be seen a few days after the procedure to look for these complications and then followed up regularly for the weeks and months following the procedure.

Prevention and management of complications

Facelift complications are rare. As with any surgical procedure, bleeding, infection, and scarring are surgical risks. Infection is unlikely on the face because of the abundant blood supply. Bleeding and hematoma formation can be largely prevented by ensuring that appropriate preoperative bleeding studies are preformed and that the patient has not been on anticoagulant medications.

Tumescent anesthesia, meticulous, careful hemostasis with minimal cautery (to minimize the chance of nerve damage), and careful dissection all decrease the risk of hematoma. Hematoma formation, if not addressed in a timely manner, can extend inferiorly and even behind the trachea, leading to airway compromise.

Facial nerve injuries are possible but uncommon. To minimize the probability of permanent nerve damage, careful undermining and plication is important. Plication sutures should be taken with small bites to avoid damage to underlying motor nerves. Periosteal sutures should be fixated outside of the projected path of branches of the facial nerve. If a patient does demonstrate unilateral motor nerve weakness, plication sutures may be loosened or released.

Flap skin necrosis can be prevented by creating flaps of adequate thickness and closing with minimal tension. The post-auricular flap of the full facelift is the most likely location for necrosis because it is often thinner and may be subjected to more tension than the facial flap.

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Video list

Video 32.1–32.4 Facelift: incision, undermining and hemostasis, SMAS plication and closure

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Introduction

Varicose veins are enlarged, superficially dilated veins that not only exhibit painful clinical symptoms but are also looked upon as a cosmetic concern. In both instances, they are always the result of increased venous pressure and possibly an underlying source of reflux. Traditionally, treating large varicose veins and complicated venous pathology has been done through surgical means, but now the vast improvement in sclerotherapy methods and progress in minimally invasive techniques has allowed for non-surgical treatment of large diameter vessels.

It is imperative to treat the sources of the high-pressure reflux which can lead to the development of varicosities before attempting treatment of associated feeding varicosities. Options including surgical and endovascular interventions can be considered. Once the source of reflux has been identified and the truncal veins have been addressed, the clinician can proceed to approach the various tributaries involved. To prevent future recurrences and to improve clinical outcomes, tributaries are treated in order of decreasing vessel diameter. Varicosities are corrected first and then the telangiectasias. This chapter will demonstrate the treatment of all vein pathologies with this approach.

Varicose veins

When effectively treating varicose veins, the initial step is to establish and correct the sources of axial reflux. Various treatment options including endovenous laser,

radiofrequency (RF), chemical, or surgical ablation, or duplex-guided sclerotherapy of the reflux site and the incompetent junction can be considered. Any of these options may successfully eradicate most varicose veins. Those remaining varicosities can be further treated with ambulatory phlebectomy or with foam and traditional liquid sclerotherapy.

When choosing between ambulatory phlebectomy versus liquid or foam sclerotherapy for the treatment of varicose veins, several factors should be evaluated. For those patients who experience multiple varicose veins and highly elevated varicosities, ambulatory phlebectomy has shown increased single-treatment efficacy, improved clinical outcomes, and decreased hyperpigmentation risk. Despite its success, this is a surgical procedure and patients who desire a minimally invasive approach or for whom surgery is contraindicated, sclerotherapy is preferred.

Diagnostic approaches

To understand the approach to the treatment of large diameter varicosities, the anatomic variations that may present as large diameter (usually 2–10 mm) veins must be reviewed. Lower extremity varicosities may be divided into four types.

The first type is the most commonly exhibited.

Type I

These varicose veins are only found in the lower leg and receive their reflux from an incompetent saphenofemoral

junction in the groin, which may be demonstrated upon Doppler examination.¹ The great saphenous trunk itself may also be visibly varicose. However, the great saphenous vein looks normal and serves as a passageway for the reflux originating from the saphenofemoral junction.

Type II

These varicose veins are localized to the lower legs arising from an incompetent small saphenous vein (saphenopopliteal incompetence) and its associated tributaries.

Type III

Truncal varicose veins are observed in the thigh or entire lower limb. This varicose tributary also receives its reflux from an incompetent saphenofemoral junction. However, the varicose tributary, which is usually the anterior accessory saphenous vein or another major tributary, drains immediately at the junction without a segment of the great saphenous vein transmitting the reflux.² Upon clinical and Doppler examination, the great saphenous vein is completely normal and there are minimal distal varicose tributaries.

Type IV

This type represents all cases of varicose veins that, on duplex examination, have no relationship with an incompetent saphenofemoral or saphenopopliteal junction. These varicosities can be found anywhere on the lower limb. They usually receive their reflux from incompetent perforators, accessory vein, and the great saphenous veins. Ideal treatment is usually ambulatory phlebectomy or sclerotherapy only.³ These vein perforators are located by physical examination (fascial gaps), Doppler, and/or duplex ultrasound evaluation, and priority treatment is given to these. It is noted in many cases that sclerotherapy or hook avulsion of the varicose vein will often effectively treat associated incompetent perforators.

Preoperative care

When treating these larger diameter veins, thorough and precise attention to detail especially in regards to anatomic and reflux considerations must be given.⁴ This can reduce the risks of post-treatment recurrences and complications, which are of greater concern in dealing with

larger diameter vessels. Tenets to consider in the treatment of large diameter varicose veins are the following.⁵

I. An understanding of the precise anatomy of the varicosity under treatment consideration. Duplex ultrasonography is an important device for visualizing vessel morphology and anatomic regularities, particularly the origin of complex varicose veins, and clarifying the relationship between the target veins and nearby structures.

II. Sclerotherapy injections must commence at the highest point of reflux and follow to the next highest point in a proximal-to-distal direction. In large vein sclerotherapy, it is crucial that injections should be as close as possible to the point of incompetence. Especially effective is injecting several centimeters from the deep venous junctions to avoid complications of a deep vein injury.

III. Duplex ultrasonography is used to determine the diameter of the treatment vein. Typically, it is easier to sclerose a large thin-walled vein than a minimally dilated thick-walled vein.

IV. Venous compressibility should be assessed, as veins which are more compressible may be more prone to panendothelial sclerosis. Veins with extensive wall damage and minimal reflux are easiest to sclerose.

V. Valvular leaflet competency can be assessed with duplex ultrasound to assess valve leaflets, especially in regards to mobility and coaptation capabilities by joining. It can be seen that frozen or immobile valves are commonly the result of post-traumatic or post-phlebitic syndromes.

VI. The degree of reflux in a large vein may be adequately visualized by duplex scanning. Distal compression or valsalva maneuvers may be employed. Vessels with greater degrees of reflux are more difficult to eradicate and are associated with an increased recurrence rate.

Step-by-step surgical techniques

Marking of veins to be sclerosed is carried out with the patient standing in an upright position, whereas injection of the sclerosant is usually carried out in a supine position. Injections in the standing position are not recommended since the veins are maximally dilated and can lead to rapid dilution of the sclerosant below its minimal effective sclerosing concentration. Furthermore,

the injection is applied against the hydrostatic forces associated with gravitational blood flow. This yields an uneven spread of sclerosant, increased non-target vessel inflammation, and in turn increased risk of thrombophlebitis from incompletely treated veins. Standing instillation is also blamed for retrograde flow of sclerosant through perforators, causing indirect damage to the deep venous system. Finally, the risk of vasovagal reaction and subsequent injury is increased when injections are carried out with the patient standing. For these risks, it is recommended that large-vein sclerotherapy is carried out with the patient in the supine position.

Historically, the evolution of sclerotherapy has been rooted to four basic techniques that were applied for the treatment of large varicose veins. Including (1) the Fegan technique; (2) the Fegan variant; (3) the Hobbs technique; and (4) the Sigg technique.

The Fegan technique involves dependent cannulation with the patient standing or sitting at the end of the examination table. The varicose vein is cannulated with a needle or butterfly angiocatheter. The needle is kept in a steady position and for stability tape can be applied. Then the leg is elevated for 1–2 minutes by the physician to secure maximal vessel emptying. Prior to administering the injection, a small amount of blood is drawn to ensure that the needle remains in the correct location.

The Fegan variant is a technique in which the needle is applied with the patient in the recumbent or reverse Trendelenburg position. Here the varicosity is marked with the patient in the standing position similar to the traditional technique, but the needle is applied with the patient lying supine or in a slight reverse Trendelenburg position. This novel variant allows for a quick and effective technique, which allows for less movement of the leg while the needle is being inserted, followed by elevation of the leg and direct compression.

The Hobbs technique is an approach in which multiple puncture sites are drawn at 4–6 cm intervals along the entire treated varicosity. The drawback of this technique is the occurrence of intravascular spasms, which can be reduced by multiple cannulations before the actual injection is conducted. This technique is associated with frequent vascular spasm and lower outcomes of success.

Lastly, the Sigg technique is another technique in which open needle cannulation is administered with the needle attached to the syringe. A needle is inserted into the treated vessel and positioned until blood returns.

Alternatively, blood may be withdrawn until the vessel is emptied. Most physicians apply variations of the above techniques in addition to blood aspiration. A small amount of blood is aspirated into the syringe to ensure that appropriate cannulation of the intact vein has occurred. However, aspiration that is too strong can lead to vein collapse. Here injections usually take place with the leg elevated and in the dependent position with open cannulation using a 27- to 30-gauge needle or angiocatheter.

No matter what technique is administered, the following factors must be considered when treating large varicose veins⁶:

- marking the treated vein in a dependent position
- emptying blood from the vessel before commencing treatment
- confirming location of the injection point prior to injection
- kneading of sclerosant around the injection site immediately post cannulation to ensure even distribution of sclerosant and maximal endothelial sclerosant contact
- the treatment approach should be executed from a proximal-to-distal direction
- treating an entire varicose pathway within one treatment session
- immediate and appropriate post-sclerotherapy compression.

Treatment techniques

Compression sclerotherapy

The standard sclerotherapy set-up is given in Figure 33.1 and Box 33.1. For the treatment of truncal (great and small saphenous) or non-truncal (non-saphenous) varicose veins, the following step-by-step technique is used:

- I. The patient is asked to stand upright for 2–3 minutes in order to allow the veins to refill.
- II. All visible and palpable vein segments in areas to be injected are marked.
- III. The patient is positioned on the treatment table in a comfortable reclined position with the legs flat and the back elevated at 30°.
- IV. The leg to be treated is then elevated to empty any residual blood.



Figure 33.1 Sclerotherapy tray.

Box 33.1 Sclerotherapy tray set-up

- Alcohol preps
- Protective gloves
- 3-mL disposable syringes
- 30-gauge disposable transparent nub needles
- 32-gauge needles or 33-gauge autoclavable disposable angiocaths
- Sclerosant
- 0.9 saline as dilutent
- Clear light source, preferable with a magnifying source
- Transilluminator (to aid in visualization of reticular veins)
- Nitroglycerin paste (for prolonged blanching)
- Hyaluronidase (for suspected extravasation)
- Anatomic region diagrammatic flow sheet (flow sheets with segmented numerical division of the leg are utilized for documenting areas that are treated at each treatment session)

V. Sclerosant is then injected with the patient in the following positions utilizing the multiple-puncture technique:

- anterior veins are injected in the supine position
- lateral and inner veins are injected in a slightly rotated leg on leg position
- posterior veins are injected in a prone position.

A 3-mL syringe is attached to a 27- to 30-gauge needle (or 23-gauge angiograph) for injection. Sotradecol (sodium tetradesylsulfate, STS) and Asclera (polidocanol) are the

primary sclerosants recommended for the treatment of large varicose veins.

Polidocanol is emerging as a leading sclerosant around the world based on safety and efficacy.⁷ Studies have shown it has higher potency and standardization than compounded formulations. Dosing of Sotradecol/Asclera depends on the location of the veins being treated. A maximal volume of 10 mL of sclerosant can be administered for a given treatment session. The cannulation sites for leg injection are distanced 5–7 cm apart along the course of the treated vessel in order to permit adequate distribution of the sclerosant along the length of the treated vein. As mentioned earlier, blood is always aspirated before an injection to confirm the tip of the needle is inside the vein. If the physician is unable to draw blood, then no injection is made. The injection pressure applied is gentle to prevent extravasation or potential neoangiogenic matting.

VI. Post injection, the sclerosant is immediately massaged distally into the surrounding treatment area for a distance of 5–10 cm.

VII. Bulging areas of varicose dilation can be wrapped with either Elastoplast (Beiersdorf, Norwalk, CT) or Medi-Rip (Conco, Rockhill, SC). A graduated compression stocking class II (30–40 mmHg compression) is worn for a period of 20–30 hours day and night, and then for 1 week hence during waking hours.

VIII. It is strongly advised that patients ambulate immediately after treatment. High impact exercise is ill advised for a period of 3 days after each treatment session,⁸ flying is not recommended for 3 days, and lastly dark-skinned patients are told not to spend time in the sun.

IX. Patients attend follow-up visits 1–3 weeks post treatment. The sclerotherapist can note one of five outcomes post treatment, including complete disappearance of the vein; formation of scars effected by successful endosclerosis; partial disappearance of the vein, meaning the injection was effective but further treatment is needed with the same concentration or a slightly stronger one; the vein remains exactly as it was before the injection, therefore requiring a stronger concentration of sclerosant. If there is no response to the initial treatment session, the concentration of sclerosant can be increased by 25% to 50% (i.e., STS 0.05–0.1% or POL 0.5–0.75% increments). The patient is then treated at 2–4 week intervals. The sclerosant is increased by 25–50% at each injection session until the threshold concentration is

Table 33.1 Sclerotherapy flow sheet—see separate table with leg diagrams

achieved to close the treatment vein. As soon as the minimal sclerosant concentration (MSC) has achieved successful sclerotherapeutic response, the concentration usually remains constant for the treatment of similar sized vessels.

Another outcome after treatment is that a firm, cord-like structure can be palpated, which can indicate scarring of the vein. The scar has not yet dissolved, but it will in a few weeks. Lastly, in some treatment sessions, the outcome is tender, lumpy/nodular, and hyperpigmented veins that look worse than before treatment. They are usually the result of an intravascular hematoma (trapped blood), which may be treated with an 18- to 25-gauge needle or an no. 11 Bard-Parker blade (Becton Dickinson, Franklin Lakes, NJ) depending on the size of the vein. The transfer of hemosiderin within the vein to the skin is reduced, and pigmentation following sclerotherapy

resolves at a quicker pace and with greater certainty. Applying this protocol and employing MSCs in the treatment of truncal and branch varicosities will provide successful results that reduce post-sclerotherapy complications. Treatment is recorded in an appropriate treatment flow sheet (Table 33.1).

Duplex ultrasound-guided sclerotherapy

Duplex ultrasound is ideal in the treatment of large non-junctional varicose veins in particular circumstances.

- I. The treatment of obese patients in whom varicose veins are not easily palpable upon physical examination.
 - II. When complex anatomic structures mask the point of proximal reflux during the physical examination and/or Doppler evaluation.

III. Cases in which treatment fails due to unseen sources of reflux which may not be obvious by physical examination, photoplethysmography, or Doppler maneuvers.

IV. In situations where prior varicose vein surgery has been performed as administration of a sclerosant is contraindicated.

V. When assessing treatment responses especially where incomplete endosclerosis presents as partial intravascular thrombosis (multiple echoes) with the vein lumen remaining patent. In successful sclerotherapy the vein wall is fibrosed, non-compressible, and non-echogenic.

Practice of duplex sclerotherapy

Before commencing the sclerotherapy, the extent of venous disease and source of reflux must be isolated, duplex ultrasound (echography) is utilized to guide the physician to the target vein and monitor the injection.⁹ It is also used to confirm correct needle placement.¹⁰

- The vein is quickly punctured with the patient in the supine position. Needle placement is confirmed by duplex ultrasound and then further evaluated by blood aspiration into the hub of the syringe.
- The needle is retracted if bright-red blood appears or if echography does not confirm correct needle positioning.
- When the needle is in the correct position, a small amount of sclerosant is slowly injected.
- Echography will convey that sclerosant is entering the target vein by viewing the shadows produced by micro-bubbles in the sclerosant. If the display shows an arterial flow disturbance or extravasation of fluid into tissues, the needle is immediately withdrawn.
- If the patient expresses pain or severe discomfort, which may be associated with extravascular or intra-arterial injection, the needle is immediately retracted. Notably, STS does not cause pain upon arterial injection and this has often been mixed with a pain-producing sclerosant when performing echography-guided sclerotherapy. In this situation, blood is aspirated to once again confirm correct needle positioning and the rest of the dosage is administered in a rapid infusion.
- If extravasation is suspected and blanching is observed, the area may be flushed with normal saline to decrease the rate of ulceration and dilute the sclerosant. Nitroglycerin paste 1–2% may also be used. If blanching continues then 75 U of hyaluronidase may be used as some studies

have shown that it decreases the rate of ulceration after extravasation.

Tenets to avoid intra-arterial injection are aspiration before injection and examination of duplex to rule out pulsations in B-mode.

Points to consider when treating varicose veins

- Multiple large varicose veins are successfully approached with ambulatory phlebectomy, which may be associated with increased treatment efficacy and reduced complication profiles.
- Sclerotherapy of large varicose veins is always followed by 2–3 weeks of compression and later removal of trapped blood.
- Combination approaches of ambulatory phlebectomy/foam sclerotherapy may be utilized in select settings.

Keys to success when treating varicose veins

- Always treat axial reflux of the great saphenous vein/small saphenous vein prior to treating tributary varicosities.
- Abolishing reflux sources will reduce many varicosities prior to direct treatment of tributaries.
- Post-treatment compression is mandatory to reduce complications and pigmentation changes.
- Advise against platelet aggregation inhibitors for at least 3–5 days prior to treatment.
- Large truncal varicose veins should be treated before progressing to smaller diameter reticular veins and telangiectasias.

Reticular veins

Reticular veins are greenish blue vessels usually 1–4 mm in diameter and adjacent to the skin's surface. They are most visible on the posterolateral aspects of the thigh and the lateral aspects of the calf draining towards the popliteal fossa communicating with telangiectasias appearing in a circular pattern.¹¹

Treatment of reticular veins is justified when there is direct communication with high-pressure reflux from main truncal varicosities, communicating sources of incompetent perforating veins, and associated arborizing foci of telangiectasias.

While treating reticular vessels it is important to be cautious as these vessels are extremely delicate, particularly in the elderly population. A gentle and skillful technique to eradicate these veins is required.

Preoperative care

A detailed examination of the lower extremity to determine all sites of reticular vessels should be performed by direct observation and palpation, looking for associated interconnections with feeding truncal and perforating varicosities and feeding mats of arborizing telangiectasias.¹² It is helpful to mark the reticular veins in the standing position as they are often difficult to see in the supine position.

After a thorough evaluation, a device for transillumination to view the treatment limb is utilized, to identify potential hidden reticular veins that are not visible to the naked eye and may be sources of occult hidden reflux. This can enhance the physician's clinical approach as more sophisticated maneuvers, such as use of transillumination devices or duplex ultrasound, may be necessary in order to identify such occult causes.

Appropriate sclerosant concentrations for treating reticular veins

There is an increased risk of sclerosant extravasation because of the fragility of reticular veins, which can lead to an increased incidence of both hyperpigmentation and ulceration. To prevent these two incidences, it is imperative to proceed with a skillful technique involving gentle injection of small amounts of sclerosant and selection of the lowest concentration of sclerosant that will produce effective endosclerosis with minimal inflammation and vascular spasm.¹³ Suggested choices of sclerosant solutions with concentrations appropriate for the injection of reticular veins are presented in Table 33.2.

Table 33.2 Sclerosant concentrations for treating reticular veins

Sodium tetradecyl sulfate ^a	0.1–0.6%
Hypertonic saline ^{a,b}	23.4%
Polidocanol ^a	0.5–1.5%
Polyiodide iodine	2–3%

^aFDA approved.

^bFDA-approved for non-sclerotherapy indications.

Step-by-step surgical technique

The following step-by-step procedure and techniques are recommended in the treatment of reticular veins.

- I. Treatment proceeds from proximal to distal.
- II. Areas of proximal reflux are addressed and treated initially.
- III. Larger caliber veins are treated prior to smaller caliber veins.
- IV. The entire reticular vein is treated at a given session.
- V. Injections are best begun at the proximal posterior thigh with the patient lying prone.
- VI. Injections proceed distally towards the ankle.
- VII. The patient is then placed in a lateral position, where again injections are carried out in a proximal to distal sequence.

This thorough approach minimizes the chances of producing unwanted "skip zones" in treating desired vessel sites and assures maximal vessel obliteration. As mentioned before, it is always recommended to apply the blood aspiration technique and to administer the puncture – feel technique, where the practitioner is able to feel the vein under the surface of the skin and is able to hear and feel the puncture of the endothelium during injection.¹⁴ It is always helpful to consider the use of infrared illumination devices.

Treatment technique for reticular veins

- I. Before commencing treatment the patient's reticular veins are identified and marked and then the patient is placed in a supine position.
- II. A 3-mL disposable syringe is prepared and filled with appropriate sclerosant and connected to a 27- to 30-gauge needle (Becton-Dickinson, Franklin Lakes, NJ; Air-Tite of Virginia, Inc., Newport News, VA).
- III. The skin is swab cleaned with alcohol.
- IV. The needle can be angled 30° angle with the bevel facing the skin to minimize the possibility of vascular transection. This is done by reducing the vacuum effect which can be created by the bevel and the skin surface.
- V. A three-finger traction technique of the skin of the opposite hand is administered in order to create tautness of the skin.
- VI. A precise and quick injection is administered; fastidious cannulation of the veins thereafter.



Figure 33.2 Reticular veins pre- and post-treatment.

VII. To make sure the vein has been accurately cannulated, a small amount of blood may be aspirated into the hub of the syringe. Avoid a large amount of negative pressure because this can lead to intravascular spasm and subsequent compromise of results.

VIII. Injection is subsequently carried out with a low injection pressure, administering not more than 0.5 mL of sclerosant at a given injection target.

IX. If resistance occurs or vascular spasm (seen as vessel blanching) occurs, the needle is retrieved and cannulation is repeated at a distal site.

X. Injecting at intervals of 3–6 cm along the entire treated reticular varicosity.

XI. Gentle hand kneading or massage evenly distributes the sclerosant along the entire treated vein to ensure and further yield uniform sclerosant endothelial contact.

Soon after treatment of reticular veins the treated vessel spasms, and inflammation may occur. If associated telangiectasias blanch or become erythematous during treatment of reticular veins, it indicates the sclerosant has had a distal effect in these vessels. At this time, no further treatment is required. If these vessels do not disappear in the projected time frame, then they can be reinjected during future visits. Injections administered in already inflamed vessels secondary to filling can lead to an increased incidence of post-sclerotherapy pigment dyschromia and an increased incidence of extravasation and

subsequent ulceration.¹⁵ Optimal results are achieved by applying this technique to reticular veins.

Postoperative care and follow-up

For vessels that are not elevated above the skin, the author at present does not employ spot localized compression maneuvers. In the treatment of larger reticular veins, compression is an essential component of the treatment. Graduated compression stockings of class II 30–40 mmHg are recommended immediately post treatment. These stockings should be put on the patient in the clinic immediately post treatment. Owing to the fragile nature of the reticular vessels, compression is of prime importance in order to minimize post-treatment bruising, pigmentation, and ulceration. Compression may also minimize post-treatment discomfort (Figure 33.2).

Suggested post-reticular vein sclerotherapy compression guidelines are the following.

- No localized spot compressions for non-elevated vessel.
- Class II (30–40 mmHg) compression stockings worn consecutively for at least 3 weeks.
- If a patient is non-compliant to this post-treatment protocol then compression stockings may be removed at night on post-treatment day 2; it is imperative to wear stockings for a period of 3 weeks.

Post-treatment follow-up visits

Follow-up treatment sessions of reticular veins should be staggered at 4- to 6-week intervals for each vessel in order to ensure optimal endosclerosis and to allow the phlebologist to evaluate results from the previous treatment session. One to two retreatment sessions are required if desired treatment results are not seen; occult sources of reflux should be investigated by duplex ultrasound and/or transillumination devices as previously described. Such investigations may reveal occult refluxing perforators and truncal veins, or, less obvious, refluxing reticular vessels.

If the source of occult reflux is localized, the area may be reinjected using a higher concentration of a given sclerosant, using a foam technique, administering a different sclerosant, or ultrasound guided sclerotherapy. In resistant cases, microambulatory phlebectomy utilizing small precise hooks may yield satisfactory results. Furthermore, at this point long pulsed 1064-nm Nd:YAG lasers can be considered in certain cases.

Pearls and pitfalls: reticular veins

- Transillumination can be beneficial in locating occult sources of reflux associated with reticular veins.
- In scenarios where telangiectasias associated with reticular veins appear to be affected by reticular vein injections, the physician must wait 1–6 weeks to notice any resolution of telangiectasias. They should be only retreated if they do not resolve after this observation period.
- In resistant cases or treatment failures, look for occult sources of reflux, consider increased concentrations of sclerosant, a different sclerosant, or the benefits of ultrasound guided sclerotherapy.
- Options of microambulatory phlebectomy or long-pulsed 1064-nm Nd:YAG lasers may be considered in resistant cases.
- It is often difficult to determine the depth of reticular vessels, and misguided injections may lead to inadvertent vessel transection.
- Reticular veins have fragile walls, which can lead to sclerosant or erythrocyte diapedesis, which may be associated with hyperpigmentation, bruising, and extravasation necrosis.

- Considering minimal sclerosant concentration for vessel size and low injection pressure will minimize these undesirable sequelae.

Keys to success: reticular veins

- Remember the extreme fragile nature of reticular veins, particularly in the elderly population.
- Identify and treat reflux sources before treatment of reticular veins.
- Do not treat a given area of reticular vessels repeatedly for at least 4 weeks to assess results of previous treatment sessions.
- Assess patients in both supine and standing positions in order to ensure treatment of all involved vessels.
- Keep patients off platelet inhibitors (i.e., ASA, NSAIDS, Plavix) for at least 7 days prior to treatment in order to minimize bruising associated with increased vascular fragility.
- Utilization of multiple needles, ensuring a constant sharp source may be helpful in minimizing bruising and pigment dyschromia when treating fragile reticular veins.
- Minimize the puncture site and utilize the MSC when treating fragile reticular veins.

Telangiectasias

Telangiectasias are minimally bulging leg veins less than 1 mm in length. Sclerotherapy and the use of lasers and light sources are successful for treating these small vessels. Treatment should only be sought after treating the areas of reflux and the associating larger diameter vessels.¹⁶ Telangiectasias are the last vessels to be considered in the sequence for treating vessels (Box 33.2). As emphasized before, if there are larger diameter vessels present or painful symptoms are noted at the initial consultation, then duplex ultrasound evaluation is warranted to rule out axial reflux.

When establishing a treatment plan for telangiectasias, the option to treat with sclerotherapy or a light source (laser, intense pulsed light, and radiofrequency as an initial approach) must carefully considered. It is generally safe to utilize sclerotherapy when vessels are cannulizable and to employ light sources to treat residual vessels which

Box 33.2 A clinical approach to treatment of venous pathologies

Axial reflux: great and small saphenous veins and associated junctional incompetence

Endovenous laser ablation (EVLT) radiofrequency ablation (surgical ligation/stripping procedures, duplex-guided sclerotherapy)

↓

Truncal varicosities
(foam sclerotherapy, ambulatory phlebectomy)

↓

Perforating veins
(foam sclerotherapy, ambulatory phlebectomy, thermal ablation?)

↓

Reticular veins
(sclerotherapy ± foam, ambulatory phlebectomy)

↓

Telangiectasia
(microsclerotherapy, laser, non-coherent light-source therapy, IPL ± RF)

Table 33.3 Suggested guide for sclerosant concentration utilized in the treatment of telangiectasias

Vessel diameter	Sclerosant concentration
Less than 1 mm	Hypertonic saline 11.7% Sodium tetradecyl sulfate 0.1% Polidocanol 0.25% Scleremo 100% Polyiodide iodine 1% Sclerodex Ethanolamine oleate 2% Chromated glycerin 72% Sodium morrhuate 2% ^a
1–3 mm	Hypertonic saline Sodium tetradecyl sulfate 0.25% Polidocanol 0.75% Polyiodide iodine 1% Ethanolamine oleate 5% Sodium morrhuate 2.5%

Choosing the appropriate sclerosant concentration for treating telangiectasias

Similar to other veins, the MSC should be used to treat telangiectasias.¹⁸ It is especially important when treating small-diameter vessels, since the risk of extravasation necrosis, hyperpigmentation, and telangiectatic matting is greater.¹⁹ A suggested guide to choosing the initial concentrations of sclerosing agents for treating telangiectasias is given in Table 33.3.

Step-by-step surgical technique: sclerotherapy for telangiectasias

were untreatable with sclerotherapy because of their small diameter, or in scleroresistant vessels in areas of new angiogenesis manifested by telangiectatic matting or flushing.¹⁷

Preoperative care

Before commencing the treatment, the following points must be discussed with the patient about the treatment of telangiectasias:

- I. The patient is advised to shave the areas for treatment on the day of the procedure.
- II. The patient is asked to dress in loose fitting clothing and comfortable shoes in order to accommodate post-sclerotherapy compression garments.
- III. The patient must be prepared to ambulate following the sclerotherapy procedure.
- IV. Arnica or topical vitamin K cream may be used pre- and post treatment if there is a history of easy bruising.

- I. The patient is positioned in the supine position on the treatment table. The physician is usually positioned at or below the level of the patient's knee. Vessels that cannot be injected on the lateral posterior thigh may be treated with the patient in the prone position.
- II. Appropriate visualization of the treatment site utilizing bright, shadow-free lighting; aided by the use of a lighted, high-intensity magnifying head lamp, magnifying glass loupes (2–5× magnification) or a transillumination device. The skin is cleansed with either an alcohol swab or 1:1 compound of 70% alcohol with 1%

acetic acid solution. Improved visualization of superficial telangiectasias can be achieved by the addition of acetic acid, which can create a more transparent skin by changes in the coefficient.

III. A 27- to 30-gauge 0.5 inch (1.3 cm) disposable needle (Becton-Dickinson and Co., Franklin Lakes, NJ, and AirTite, Newport News, VA) is used to administer the injections. Smaller needles (31, 32, and 33 gauge) are available for microtelangiectasias injection but it should be noted these needles can easily clog upon repeated usage and lose their sharpness upon repeated cutaneous puncture. The needle is inserted at a 30–45° angle with the bevel side up. Injection with the bevel of the needle facing the skin surface will minimize the possibility of vascular transection by decreasing the vacuum produced by the bevel and the skin surface. Proper hand placement is crucial. Most often, the three-point tension technique is employed in which the non-dominant hand stretches the skin adjacent to the treated vessels in a linear direction while the fifth finger of the dominant hand exerts counteraction in a forward direction as the sclerosant is being instilled with the rest of the dominant hand. It is advisable that entire vessels should be treated at a given treatment session.

IV. The sclerosants utilized for treating telangiectasias are sodium tetradecyl sulfate (Sotradecol) 0.1–0.25% and polidocanol (Asclera) 0.5% for vessels 1–4 mm in diameter and glycerin for microtelangiectasias (1 mm in diameter). Hypertonic saline is a weak sclerosant with minimally successful results and is associated with a great deal of pain and discomfort, and is therefore rarely employed. A 3-ml syringe allows for slow, low-pressure injection of the sclerosant. When injecting, pressures should be gentle utilizing low volumes (less than 0.5 mL per injection site), as large amounts of sclerosant may lead to localized placement of sclerosant in deeper vessels. This can yield deep vein thrombosis and pulmonary emboli as well as an increased chance for post-inflammatory hyperpigmentation and telangiectatic matting.

V. Smaller 1-mL tuberculin or insulin syringes is commonly associated with leakage of sclerosant, and high injection pressures, which may compromise results as well.

VI. Persistent tension is applied for rapid cannulation with low injection pressure, so immediate blanching

is seen in both the treatment vessel and the adjacent tributaries. If the needle is not within the vessel, extravasation will occur and either a superficial tissue wheal will appear or the sclerosant will leak onto the skin surface. To prevent this, immediate administration of nitroglycerin paste or injection of hyaluronidase (150–175 U/mL; Hopewell Pharmacy, Hopewell, NJ) may decrease the extent of the adverse necrotic ulcerative reactions associated with extravascular cannulation.

VII. The quantity of solution injected should produce an effect extending 1–2 cm around the site of injection. No more than 0.5 mL of sclerosant per injection site is injected in order to avoid large amounts of inflammation in the venous system, which could result in an increased incidence of neoangiogenesis (telangiectatic matting/superficial thrombophlebitis) and post-sclerotherapy hyperpigmentation.²⁰ For treating non-cannulizable vessels less than 1 mm in diameter, with the above instrumentation, or in cases of microvessels associated with telangiectatic matting, a 31-gauge 1-mL insulin or tuberculin syringe or a small 33-gauge angiocath (STD, Herford, UK) may be used. These smaller diameter systems are not practical for treatment vessels with large surface areas. Yet, there are circumstances where microvessels cannot be appropriately cannulated using conventional 30-gauge needles attached to 3-mL syringes; furthermore, if a laser source is not available, there are other treatment options.

VIII. There are four basic principles which should be adhered to in the treatment of lower extremity telangiectasias.

- a. Treat an entire vessel pattern at a given treatment session. Treatment of an entire vessel at a given treatment session will minimize incomplete vessel disappearance and the potential for recanalization as well as neoangiogenesis and telangiectatic matting.
- b. Identify and inject the most proximal “arborizing feeder” vessel associated with a telangiectatic cluster. Treatment of feeding arborizing foci, which feed clusters of telangiectasias, can reduce the number of punctures necessary to achieve desired results. By noting this treatment pearl, fewer complications occur.
- c. Empty the vein prior to injection. Emptying of vessels under treatment consideration prior to sclerosant solution instillation increases sclerosant endothelial contact and thus likely improves endosclerosis and

may help to diminish recanalization of vessels secondary to the development of intramural thrombosis.

d. Knead the sclerosant immediately post instillation into the surrounding injection vessel area. Local kneading or distribution of sclerosant should theoretically lead to diminished pooling of sclerosant and this produces uniform results. It should also minimize the potential for sclerosant “sludging,” which could lead to an increased incidence of superficial thrombophlebitis and post-sclerotherapy hyperpigmentation.

Postoperative care and follow-up

Post-treatment complications of burning and swelling associated with urticaria and vein refilling may occur. Cramping is commonly associated with the injection of hypertonic saline while often scotomata can occur after instillation of Sotradecol or Polidocanol. Although immediate post-sclerotherapy onset of urtication does not signify sclerosant allergy, it is actually a local immunogenic effect mediated by the release of histamine and other inflammatory cytokines. Administration of a corticosteroid cream such as hydrocortisone probutate cream (Pandel 0.1%, Pandel, CollaGenex, Newtown, PA) may be advised immediately after treatment to decrease this response.

The treated patients are advised to remain in the treatment room for 10–15 minutes after the first treatment session. This is particularly important if any sclerosing agent with hypersensitivity potential (all agents other than saline) is utilized, so that any potential type I anaphylaxis is observed, although this complication is rare. Studies have shown that post-telangiectasia treatment hose worn for at least 3 weeks may minimize post-sclerotherapy hyperpigmentation and improve clinical results. Compression should improve clinical results by causing effective vascular lumen occlusion, diminished recanalization, and reduced risk of vascular thrombosis. For compression, options include either fashion hose 18–20 mmHg or class I 20–30 mmHg graduated support hose worn for up to 3 weeks after treatment. Most companies including Sigvaris, (Branford, CT) Jobst, (Charlotte, NC), and Medi USA (Arlington Heights, IL) manufacture such hose. Graduated support hose should be applied immediately after therapy before the patient

has left the office. It is important to administer localized spot compression using compression pads and gauze for treatment of non-elevated telangiectasias. Lastly, it is recommended to not treat a given area for 4–6 weeks in order to evaluate the response to the previous treatment session.

Treating approaches to resistant telangiectasia

Several approaches can be taken when successful results are not achieved after two to four treatment sessions in a given anatomic area utilizing an appropriate MSC for a given vessel diameter. These include:

- Searching for areas of larger feeding vessels such as reticular veins or perforators that may have been overlooked on physical examination. Treating these feeder sources under duplex guidance may be helpful in this clinical setting.
- Administer a stronger concentration of the same sclerosing agent.
- Consider an alternative sclerosing agent.
- Consider an alternative mode of therapy such as lasers or intense pulsed light sources.

Conclusion

Patients present to the phlebologists office not only for clinical symptoms of vein pathologies but for cosmetic reasons as well. Sclerotherapy and ambulation are the gold standard for the treatment of vein pathologies. Advancements in non-invasive technique and extensive use of ultrasound have increased the demand for procedures. The establishment of a treatment and management plan for varicose veins is the same for both reticular veins and telangiectasias. Approaching the feeding sources of reflux and considering the delicate nature of these vessels, particularly in more vulnerable patients (i.e., elderly people), are keys to success in the management of patients. For optimal results, abiding by the basic principles stated in this chapter allows the physician to achieve successful results in treating tributaries of the lower extremities. The correct choice of sclerosant, using the MSC, considering the variations in anatomy from

patient to patient, remembering the principles of reflux, practicing fastidious technique, and using appropriate compression promotes the most successful of results.

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Introduction

Since its initial approval by the US Food and Drug Administration (FDA) 20 years ago for the treatment of strabismus, hemifacial spasm and blefarospasm in adults, botulinum toxin type A (BoNT-A) has become the leading procedure^{1,2} in facial rejuvenation because of its safety and efficacy for hyperfunctional facial lines, which has been demonstrated in numerous clinical trials, including multicenter controlled studies.³

Different preparations of BoNT-A are currently available for clinical use worldwide, including abobotulinumtoxinA (Dysport 300 and 500 U/Azzalure 125 U per vial, Ipsen, UK; commercially available as Dysport), onabotulinumtoxinA (Botox 100 and Vistabel 50 U per vial, Allergan Inc, USA, commercially available as Botox), Prosigne 100 U per vial (Lanzhou Institute of Biological Products, China), and Xeomin 100 U and Bocouture 50 U per vial (Merz, Germany).

Preoperative care

Patient education and counseling are integral parts of the BoNT-A treatment. It is essential for patients to have a realistic expectation of the treatment outcome, as their expectations will directly determine the level of satisfaction after treatment.⁴

First, physicians have to analyze the facial anatomy, observing patients at rest and during movement, in order to propose a coherent treatment plan, based on the patient's request, facial anatomy, and the status of skin ageing. Then, physicians should explain about BoNT-A mode of action, onset and duration of effect, expected results, and potential adverse events.⁴ Anticoagulants may worsen ecchymosis, thus the risk–benefit ratio of discontinuation of such drugs 7–10 days before the injections should be discussed.²

Patients should read and sign an informed consent form before treatment. Photograph documentation should also be obtained before the procedure, documenting the facial dynamics in repose and contracted.

Step-by-step surgical technique

Reconstitution

BoNT-A is commercially available typically in a lyophilized form, and should be reconstituted in preservative-free 0.9% sodium chloride solution prior to its use.⁴ During reconstitution, it is best to avoid the formation of bubbles.² The volume of reconstitution is a physician decision, based on his/her experience and type of product being used. It can be also adapted according to the quantity of product in units (U) in the vial, physician's preference, and patient's needs.⁴ Low volumes and high



Figure 34.1 Injection technique for glabellar lines. Two-fingered palpation of corrugator muscles is recommended.



Figure 34.2 Injection technique for glabellar lines. A single injection is made at the procerus m. to treat the horizontal lines at the root of the nose.

concentrated solutions are preferable, since they allow precise injections with less risk of side effects.^{2,5}

Syringe

A 30-gauge, 13-mm needle is standard,⁴ but shorter needles and small syringes, such as BD Ultra Fine II, are appropriate for the injections of BoNT-A.

Setting

BoNT-A applications are performed in an outpatient setting. Topical anesthetic may be used before the injection in those patients more sensitive to pain. A cooler device may also be used to decrease the pain of the injections (Video 34.1). Make-up must be removed and antisepsis is carried out using 70% isopropylalcohol or iodine.² A special pen is used to mark specific points over the area to be injected.⁵

Injection point, dose, and technique

Applications should be symmetric regarding both location and dosage, following some rules to increase the precision of the injections, which will be mentioned below.

Glabellar lines

For the treatment of glabellar lines, BoNT-A is injected slowly into one to two points in each corrugator muscle (m.), keeping the needle tip at a distance of approximately 1 cm above the orbital rim (Figure 34.1). The needle must be placed perpendicularly and pushed slowly upwards towards the hair implant line.² Injection should

be perpendicular, intramuscular, and deep.⁴ Two-fingered palpation of these muscles is recommended, since this minimizes the occurrence of side effects, especially eyelid ptosis² (Video 34.1).

BoNT-A can be applied in one or two points of the procerus m. to treat the horizontal lines at the root of the nose. A single injection made along the midline at a point below the line joining the brows and above the crossing point of the "X" formed by joining the medial eyebrow to the contralateral inner canthus is usually sufficient (Figure 34.2) (Video 34.1). In patients with a long procerus m., the dose can be injected in two points of this muscle.

Regarding dosage and injection points, the usual recommended dose for the treatment of the glabella is 20 U of Botox and 50 U of Dysport/Azzalure.^{6,7} Three central injection sites are essential for the treatment of glabellar wrinkles as the two additional injection sites originally described for the glabellar area, targeting the frontalis m., were reported to not significantly improve efficacy.⁸ The final dosage for each individual depends on the muscle being treated, the wrinkle severity, and physician's and patient's decision for just relaxing or paralyzing a specific muscle, giving a more natural or static look. The dose should also be adjusted based on muscle mass, as bigger muscles require higher doses to achieve a similar effect.²

Periorbital wrinkles

For the treatment of periorbital wrinkles, the target is the orbicularis oculi m. The injections should be made in the



Figure 34.3 Injection technique for periorbital wrinkles. Injection should be made in the area of the wrinkles, at least 1 cm lateral to the lateral orbital rim.

area of the wrinkles, at least 1 cm lateral to the lateral orbital rim (Figure 34.3). This technique is effective in reducing hyperkinetic wrinkles, but it is not suitable for treating the static wrinkles caused by photoaging or sleeping habits.⁴

The doses for treating periorbicular wrinkles vary according to different studies; generally, 10–30 U of Botox is recommended on each side.⁹ Doses are usually distributed in two to three points, sometimes four or five points, on each side according to the patient's needs. Injection should be lateral (20–30° angle to the skin) and superficial⁴ (Video 34.1).

To treat muscular hypertrophy and thin wrinkles in the lower eyelid, intradermal injections of 2 U of Botox or 5 U of Dysport/Azzalure can be injected in the mid-pupillary line, 3 mm from the lower ciliary border. Caution should be taken to avoid increasing skin laxity and eye-bulging.²

Horizontal forehead lines

For the treatment of horizontal forehead lines, a total of 5–10 points are recommended in the forehead below the hairline.² The points should form a slightly curved V shape in women, and straight in men.⁴

To date no dose-finding study have been performed on this indication, but the consensus papers recommend the range of 10–30 U for Botox and from 25 to 60 U for Dysport/Azzalure.² Injection should be superficial, intra-muscular, and perpendicular to the skin (Video 34.1). It is recommended to start with a small dose to avoid a “frozen look.”⁴



Figure 34.4 Injection technique for perioral wrinkles. Injection should be applied at the vermillion border or up to 5 mm from the border of the lip.

Mid- and lower face

Low doses should be used in the mid- and lower face. In order to treat nasal wrinkles, injection must be applied in the high lateral nasal wall below the angular vein¹⁰ (Video 34.1). For the treatment of gingival smile, injections of BoNT-A should be applied on each side of the levator labii superioris alaeque nasi m., in each nasofacial groove.¹⁰

In order to treat perioral wrinkles, injections of BoNT-A can be applied at the vermillion border or up to 5 mm from the border² (Figure 34.4, Video 34.1). For the treatment of marionette lines, BoNT-A is applied directly above the mandibular angle, along its rim and 1 cm lateral to the oral commissure, bilaterally,¹⁰ in an imaginary line that follows the direction of the nasolabial furrow. The dimpled or “cellulitic” chin may be treated with two points of BoNT-A injections, at the most distal point of the orbicularis oris m. at the proeminence of the chin² (Figure 34.5, Video 34.1). A facelift may be achieved by injecting 1–2 U of Botox or 2–5 U of Dysport/Azzalure at two to four points along the lateral mandibular border (Figure 34.6).

Postoperative care and follow-up

There is no consensus among specialists about the role of limiting physical activity or avoiding bedding after BoNT-A procedure. However, patients are usually guided not to lay down, manipulate the treated area, or practice physical activity up to 4 hours after the injections.²



Figure 34.5 Injection technique for treatment of dimpled or "cellulitic" chin. Injection should be applied at the most distal point of the orbicularis oris m., at the proeminence of the chin.



Figure 34.7 Injection technique for the treatment of horizontal forehead lines. Injections should be mostly in the upper part of the frontalis m., to reduce the risk of brow ptosis and facial mask.



Figure 34.6 Injection technique for face lift. Injections should be applied at two to four points along the lateral mandibular border.

The muscular effects of BoNT-A usually appear 24–72 hours after application, reach maximum level at around 2 weeks, and last from 4 to 6 months.² Touch-up can be done after 15–30 days to treat residual lines or correct minor side effects. To prevent antibody formation, it seems to be important to avoid frequent or repeated touch-ups.

Prevention and management of complications

- To prevent eyelid ptosis, injections at the glabellar region must be 1 cm above the orbital rim and local

massage must be avoided. Two-fingered palpation of each corrugator m. is also recommended.

- When treating the periocular region, injections should be applied 1 cm from the orbital rim, with the needle oriented in the opposite direction to the ocular globe. Caution should be taken to avoid increasing skin laxity and eye-bulging when treating muscular hypertrophy and the thin wrinkles in the lower eyelid.
- Avoid frontal total paralysis to prevent facial expressiveness. Consider injecting mostly the upper part of the frontalis m. (Figure 34.7) to reduce the risk of brow ptosis and facial mask.
- To prevent the appearance or aggravation of nasal wrinkles when the patient smiles or attempts to frown, the nasalis m. should be treated (Video 34.1). When treating this muscle, avoid injections near the nasofacial groove in order to prevent relaxation of the levator labii superioris m., which may lead to ptosis of the upper lip.¹⁰
- Low doses are preferred in the treatment of the perioral area in order to prevent mouth incompetence. Avoid injections at the corners of the mouth.
- Apply BoNT-A symmetrically, in order to prevent asymmetry of facial structures.

Complications

Complications can be divided in three types:

- Common adverse effects of limited duration that are related to the injection itself:



Figure 34.8 Edema and erythema around injection sites in the glabella.

- a. mild stinging, burning, or pain with injection
 - b. edema and erythema around the injection site (Figure 34.8)
 - c. mild headache.
- II.** Very rare adverse effects that can be serious and are not technique dependent:
- a. immediate hypersensitivity reactions: urticaria, dyspnea, anaphylaxis.
- III.** Uncommon adverse effects that are technique dependent:
- a. ecchymosis and bruising
 - b. ptosis of the upper eyelid
 - c. brow ptosis
 - d. lip ptosis and possible oral incompetence
 - e. ectropion, keratitis
 - f. diplopia
 - g. pseudoherniation of the infraorbital fat pad (in patients who have festooning).

Transitory upper eyelid ptosis is the most feared complication. It may occur when the injection volume is too large, when the injection sites are too close to the orbital rim, or by manipulation of the injected areas, with a consequent displacement of the product and paralysis of the upper eyelid elevator m. Instillation of α -adrenergic apraclonidine 0.5% eyedrops (Iopidine, Alcon Laboratories, Inc., Fort Worth, TX) will stimulate Mueller's muscle to contract, raising the upper eyelid about 1–3 mm.

Brow ptosis may occur following treatment of forehead wrinkles, when high doses of BoNT-A are used, or when the forehead musculature is completely paralyzed, leading to a significant reduction of facial expression,

known as "masked face." This symptom is temporary and usually does not require additional treatment.

In the mid- and lower face, high doses of BoNT-A may cause unwanted paralysis of the muscles related to the perioral area, causing difficulty in articulating words and incompetent mouth functions.

The application of BoNT-A in the lower eyelids may cause subsequent ectropium, entropium, and damage to the ciliary ganglion caused by Adie's pupil as well as more evident skin laxity and bulging eyes. Secondary complications of prolonged corneal exposure can lead to dry eye and corneal damage.

Diplopia may occur when injections are close to the ocular globe or when there is accidental migration of the toxin into the orbit, with consequent paralysis of the lateral rectus m. If this complication occurs immediate consultation with an ophthalmologist is mandatory.

In patients who have festooning, complications that occur when injecting the lower eyelid include pseudoherniation of the infraorbital fat pad. This may be due to muscular weakness or lymphatic drainage impairment.

Final considerations

BoNT-A is a simple, safe and highly effective, widely used therapeutic modality, which continues revolutionizing the cosmetic treatment of the aging face. It has become one of the most common and safe procedures for facial rejuvenation and it is considered the best alternative treatment for dynamic wrinkles. Moreover, BoNT-A can be safely combined with other cosmetic procedures, including fillers, lasers, and different surgical treatments.

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Video list

Video 34.1 Botulinum toxin injections: step by step

Temporary fillers

Autologous fat transfer – Kavita Mariwalla¹ and Rhoda S. Narins¹

Collagens – Luitgard G. Wiest²

Poly-L-lactic acid – Katiein França³, Yasser Alqubaisy³, and Janelle Vega³

*An overview of the dermal filler calcium hydroxylapatite
(Radiesse) – Mariano Busso⁴*

*Hyaluronic acid fillers – Fredric S. Brandt⁵, Joely Kaufman⁵,
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Autologous fat transfer

Kavita Mariwalla and Rhoda S. Narins

Introduction

Autologous fat transfer, otherwise known as microlipoinjection, represents an ideal filler to replace the volume

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loss associated with the aging face. The procedure can be done in an outpatient setting, the results in many areas are long lasting, and since the material is derived from the patient's own body, there is no risk of allergic reaction. The results of grafted fat, like those of any filler procedure, are technique dependent and rely on the methodology of the physician rather than the reliability of the material itself. However, if placed correctly, autologous fat is pliable, easily extracted, and has the ability to age with the patient, producing a natural looking appearance.

Preoperative care

Before undertaking autologous fat transfer, the physician must ensure that the office is equipped with the materials needed to successfully transplant fat. This includes the following pieces of equipment: a tumescent lidocaine infiltration system that can be as simple as a syringe filled with tumescent anesthetic and a spinal needle or an infusion pump attached to a small cannula, marking pen, 10-mL and 1-mL syringes, 18-gauge needle, fat transfer and harvesting cannulas, female-to-female syringe adaptors, camera, centrifuge, test tube stand, syringe covers, gauze pads, and temperature-monitored and alarmed freezers on back-up generators.

Patient selection is paramount to successful microlipoinjection. It is important to express to patients that fat transfer imparts a soft contour to the face to give it a fuller look as opposed to the taut posterior tension that results from traditional face lifts. For this reason, patients are encouraged to bring old photographs of themselves to the initial consultation. These will allow the physician to construct a game plan of tissue augmentation and to allow the patient to see how a fuller face will look. Preoperative photography is essential, as are sequential photographs in the frontal, lateral, and inferior oblique positions to monitor progress.

When evaluating the patient for microlipoinjection, it is important to take a careful patient history. Contraindications for fat transfer include abnormal liver function, bleeding disorder, dependence on anticoagulant drugs, debilitating illness, autoimmune disease, pregnancy, and sensitivity or true allergy to lidocaine. Patients with HIV/AIDS are less likely to be successful candidates for autologous fat transfer because of the effect of protease inhibitors on the viability of the harvested fat and are thus recommended to consider other fillers.

Prior to the procedure, laboratory tests, including prothrombin time, partial thromboplastin time, basic chemistry panel, and complete blood count are important to check. On the day of the procedure, a urine pregnancy test should be checked on all women of child-bearing potential, and antibiotic prophylaxis to cover normal skin pathogens should commence the night before the procedure and continued for 5–7 days after the procedure.

Step-by-step surgical technique

Autologous fat transfer requires three essential steps. The first step involves the careful harvesting of adipocytes from the patient. The second step involves isolation of adipocytes and the third step involves injection of fat cells into targeted facial areas.

Adipocyte harvesting

The ideal place to harvest fat is from a reservoir of dense adipocyte accumulation which also benefits the patient esthetically. With the patient in the standing position, assess the hips, posterior waist, outer thighs in women and flanks in men, keeping in mind that the total amount harvested is not significant enough to produce asymmetry. These sites are preferable to the lower abdomen which contains less dense fat.

After obtaining informed consent and preoperative vitals, the donor site is prepped and draped in a sterile manner and anesthetized with Klein's tumescent solution. This keeps the lidocaine dilute, which is less harmful to adipocytes.¹ After approximately 20 minutes, when the typical vasoconstrictive blanch after tumescent anesthesia occurs, harvesting can begin. An incision site is created with a 2-mm punch biopsy tool or a 16-gauge NoKor needle. Attach a blunt cannula with an open tip to a 10-mm syringe. Examples of such cannulas are the Donofrio 18-gauge infiltrator, Coleman 17-gauge infiltrator or Coleman extractor.² Insert the cannula into the incision site and begin manual extraction by holding negative pressure (2–3 mL) on the syringe plunger and passing the cannula back and forth within the fat. A low vacuum pressure allows atraumatic removal, and the ideal depth of removal is at least 1 cm below the skin surface. If fat will be frozen and used at a later time, consider harvesting up to 80 mL in one session. After harvesting, standing syringes in a test tube rack makes them easier to handle.

Isolation of adipocytes

Once the fat has been collected, at issue is survival of the adipocytes. Unfortunately, few controlled studies exist regarding a single approach. The basic guidelines however are the same. The fat must be separated from the infranate, containing blood and tumescent fluid and the fractionate

of liquid triglycerides. One way to do this is to cap the syringe and centrifuge it at 3400 rpm for a maximum of 20 seconds.² Another way is to stand the syringe upright for a period of at least 15 minutes to separate the layers. Some then rinse the fat with Ringer's lactate to remove enzymes that may interfere with fat survival or add human albumin to enhance adipocyte survival while others inject the fat without any additional manipulations.³ In all scenarios, the fat is then transferred to 1-mL syringes using a female–female Luer device. If fat is to be frozen for future use, the infranate should be discarded and the fat stored in 10-mL syringes with the triglyceride layer. Labeling must be precise to include patient identifiers and date of the procedure. These syringes should be stored at –20°C to –30°C in freezers that are alarmed and are attached to back-up generators. If these are to be used at a future date, an individual syringe can be removed and thawed using the patient's own body heat by placing the syringe in an examination glove and asking the patient to place the syringe under their axilla. Studies have shown that frozen fat can remain viable and stored using proper aseptic technique without growing bacteria for up to 24 months.⁴ The method of storage for frozen fat has come under increased scrutiny and although some studies do not show adipocyte viability once frozen, practitioners who use frozen fat attest to its tenacity and long-term effect.^{5–7}

Injection of fat

The key to injection of fat is to keep in mind that the technique aims to lift and redrape the skin rather than to simply fill in the lines. To minimize damage to vital structures, all infiltration should be with a blunt-tipped 17- or 18-gauge cannula through an incision site made with an 18-gauge NoKor needle. Facial nerve blocks and/or regional anesthesia are recommended prior to filling and a low-dose oral anxiolytic such as diazepam may be given to the patient. The most common plane for placement of fat is within the subcutis. Transfer should occur in small volumes using 1-mL syringes delivering the filler in a retrograde threading technique. An aliquot or droplet approach is preferable to a large bolus of fat. Overcorrection should be kept at a minimum with this technique. Blunt-tipped cannulas reduce the risk of vessel injury and the rare complication of intravascular injection. Specific placement planes by region are listed

Table 35.1 Sample planes of infiltration for autologous fat transfer by facial region²

Location	Plane for autologous fat transfer
Forehead	Subcutaneous and intramuscular
Supraorbital/brow	Deep to the superior border of the orbicularis oculi muscle
Suborbital area	Deep to the orbicularis oculi muscle, anterior to the orbital septum
Buccal fat pad and lateral cheek	Deep subcutaneous tissue
Nasolabial crease	Deep subcutaneous tissue
Mandible	Dermal subcutaneous junction
Perioral area	Between the orbicularis muscle just anterior to the oral mucosa

in Table 35.1. It is important to keep in mind that fat is a volumizing agent that lifts tissue, so the injection technique should avoid simply “filling the lines.” Best results are often seen with cross-hatching to make the infiltration very even.

Postoperative care and follow-up

Autologous fat transfer results in substantial edema in the first few days following the procedure; IM Celestone will often prevent this from occurring. Ecchymosis is also common, which is why patients are encouraged to avoid vitamin E, aspirin, non-steroidal inflammatory drugs, and garlic for 1 week postoperatively. Antibiotics should be continued for their full course. Ice packs should be applied for 10–20 minutes of every hour for the first and second postoperative days, and patients should sleep with their head elevated on two pillows. Swimming should be avoided for 1 week. Donor sites should be dressed in compression garments and absorbable material that can wick off the tumescent drainage. These dressings may need to be changed with some degree of frequency in the first 36 hours. Wound sites should be kept moist with petrolatum as they heal. After the first session, follow-up should be at 1 week and then at 1- to 3-month intervals to assess for additional augmentation needs. It should be noted that many studies show that retention rates for

autologous fat are site specific with higher retention rates around the eyes and cheek and lowest in the lips and perioral area. Most practitioners avoid the lips as fat can volumize this area too much. Photographs should be taken at each visit.

Prevention and management of complications

Microlipoinjection results in severe edema, which can be managed with postoperative steroids (intramuscular or by mouth). If fat is placed around the eyes, protrusions of fat can persist which may require additional blending on follow-up examination with a cannula. That is why this area is usually treated from two directions; from the bottom through the mid-face area and from the upper nasolabial fold. It is never carried out horizontally from the lateral commissure to the eye. Contour irregularities are rare if the fat is placed in the correct position, but can occur in inexperienced hands. If so, the fat must be

extracted manually from these areas for correction. Other complications include eruption of herpes simplex virus, which can be avoided with antiviral medications and a careful patient history, bacterial infection, cannula track marks, submandibular lymph node enlargement, scarring at the donor site from cannula insertion sites, and hyperpigmentation due to inflammation or hemosiderin deposition. The senior author has never seen any of these complications. The literature reports additional complications such as middle cerebral artery infarction and blindness.⁸ Therefore, the glabella area should never be injected with fat. Additionally, when injecting around the eye it is always important for the non-injecting hand to be protecting vital structures at all times to prevent accidental piercing of the globe if the patient were to move. Occasionally prolonged pain may be encountered if a nerve is grazed during the structural augmentation procedure. As with all fillers, poor retention is always a possibility. Overall, however, autologous fat is a safe and efficacious filler when the procedure is performed by an experienced physician.

Collagens

Luitgard G. Wiest

Introduction

Collagen has always been considered an important source for soft-tissue injectable implants, as it gives support and structural integrity to the skin and associated soft tissue. Collagen products were the first biodegradable injectable implants and remained for many years the mainstay for dermal fillings. The first animal model injections of collagens were performed in 1974; in 1978 patients were treated with bovine collagen for the first time. Since then, over 2.5 million patients have received injectable collagen treatments.⁹

Bovine collagen

Zyderm I was approved by the FDA in 1981 and is the dermal filler that has been in use longest.¹⁰ It was followed

by two additional formulations of bovine collagen, Zyderm II (1983) and Zyplast. Zyderm I and Zyderm II differ only in the concentration of the suspended collagen (Zyderm I: 35 mg/mL, Zyderm II: 65 mg/mL). Zyplast contains bovine collagen cross-linked with 3.5% glutar-aldehyde enhancing the product's stability and longevity. Bovine collagen (Zyderm I, Zyderm II, Zyplast) became the most frequently used filler because it was relatively inexpensive, easy to inject, and versatile.

Zyderm should be placed superficially in the upper dermis, whereas Zyderm II and Zyplast have to be injected into the mid-dermal plane.¹¹

Significant drawbacks of bovine collagens include the potential for allergic reactions that necessitated two separate skin tests (see Preoperative care). Furthermore, its short-term persistence limited cosmetic satisfaction. These specific bovine collagen products are no longer being manufactured.

Human collagen

Cosmoderm and Cosmoplast were approved by the FDA in 2003. They contain dermal fibroblasts that are harvested from bioengineered human skin.¹² As this tissue is of human origin, skin tests before treatment are not necessary. Cosmoderm and Cosmoplast contain type I and III triple-helix collagen that is capable of binding with hyaluronic acid and other molecules of the extracellular matrix, thus improving skin structure. Cosmoderm and Cosmoplast collagen is dispersed in a phosphate-buffered saline solution with lidocaine. During administration of Cosmoderm, overcorrection of 1.5–2 times the initial defect was recommended. Cosmoderm was placed in the superficial papillary dermis, Cosmoplast in the deeper dermis.⁹ The disadvantages of these products were the relatively short duration of action of 3–6 months. These human products are no longer produced.

Porcine collagen

A porcine derived collagen product (Evolence and Evolence Breeze) attained FDA approval in June 2008, and was marketed until 2009. Evolence Breeze had a somewhat lower viscosity due to modification of the production process.

Porcine collagen is less allergenic than bovine collagen. It has been used in heart valves, skin grafts, and dental membranes with only a few reported hypersensitivity reactions;¹³ therefore, this product does not require skin testing. In contrast to some other collagen fillers, overcorrection is not necessary. Evolence should be placed in the mid- to deep dermis, Evolence Breeze in the mid- to upper dermis.⁹

A clinical trial with Evolence demonstrated no evidence of adverse immunologic effects. Regarding longevity Evolence is superior to all other collagen products because of a unique cross-linking with D-ribose using Glymatrix technology. Its effects lasted for 6–9 months.¹⁴ This was shown in a double-blind, within-subject bilateral facial comparison of Evolence and Restylane for the correction of nasolabial folds. Subjects were followed for 6 months initially and then for 1 year for efficacy and safety. The results from immunoglobulin titers and skin tests indicated no potential for allergic reactions, and the

FDA released the product without the need for prior skin testing. Regarding of efficacy, there was no meaningful significant difference between the treatment effect of Evolence and Restylane at any point. Patient evaluation indicated a 90% improvement over baseline at 6 months on both sides. Evolence Breeze is particularly recommended for augmentation of the tear trough.¹⁵

One drawback of this product is nodule formation when injected into the lips, and it is therefore not recommended.¹⁶

At present there is not a single pure collagen preparation on the market, but collagen is a major component of two non-resorbable aesthetic injectable fillers, Artefill and Artecoll. Artefill consists of polymethylmethacrylate microspheres (20% of implant volume) and purified bovine collagen (80% of implant volume, containing 0.3% lidocaine) and requires skin testing.¹⁷ Artecoll consists of homogeneous polymethylmethacrylate (PMMA) microspheres, evenly suspended in a solution of partly denatured 3.5% collagen of bovine origin. According to the manufacturer, a novel production method has contributed to a known allergy rate of only 0.08%. Allergy testing is optional before use.¹⁸ Artefill was approved by the FDA in December 2006 to treat nasolabial folds with the added condition that a 5-year follow-up study of patients using Artefill must be carried out.

Patient selection

A proper evaluation regarding selection of patients is essential when performing aesthetic procedures. With regard to collagen-based fillers, they should only be used in patients without allergic disposition.

Preoperative care

Bovine collagen warranted two separate skin tests before use because of its potential for allergic reactions. Today testing is mandatory before the use of Artefill and optional before use of Artecoll.

The skin test is performed by placing an intradermal injection of 0.1 mL of the product into the antecubital area. Thirty days later a second injection in a separate area (such as the scalp line) has to be performed. Approximately 3.5% of patients have a positive first reaction

(local wheal and flare reactions), with 70% of these reactions manifesting in the first 48–72 hours. A negative second test lowers the risk of a subsequent collagen-hypersensitive reaction to less than 0.5%.¹⁹

Injection techniques

As collagen implants were the first used to correct skin scars, wrinkles, and folds, most of the basic injection techniques were developed using these products. With the exception of Zyplast and Cosmoplast bovine and human collagen-based fillers required overcorrection. This was not necessary with Evolence. The injection technique depends on the area and the particular collagen filler (see above). Different injection techniques can be used, such as serial puncture technique, linear threading, fanning or crosshatching, or a combination of these techniques. Enhancement of deepened glabellar lines and nasolabial folds is done primarily with linear threading or serial puncture technique. Management of the tear trough is usually also performed with linear threading or serial puncture technique. Treatment of the adjacent malar region is often performed in combination with tear trough augmentation. Radial fanning is the preferred technique in this area because of the broader region being enhanced.²⁰

Zyderm I/CosmodermI can be layered over Zyplast/Cosmoplast to give complete correction. The combination of ZydermI/Cosmoderm I and Zyplast/Cosmoplast is also helpful for lip augmentation, which requires both volume filling with the cross-linked implant and superficial correction of rhagades and the vermillion line, which is accomplished with Zyderm I/Cosmoderm I. The results are gratifying for correction of the aging atrophic lip in which collagen will give the filling, support, and superficial correction that is more natural early on than that obtained with hyaluronic acid products. Volume is usually addressed first by injection of the cross-linked collagen along the vermillion and the junction of vermillion and mucosa giving both volume filling and elevation. This is best performed via retrograde tunneling or threading technique. The vermillion line is then addressed by injection laterally within that potential space and “flowing” small amounts of collagen along it maintaining even application and avoiding nodules and overcorrection.⁹

Volume enhancement of the marionette lines is usually done with linear threading or serial puncture technique. When there is a deep line extending from the commissure and a loss of volume in the surrounding area, a cross-hatching technique can be used to add more volume. Distribution of the filler often ends up following the shape of an inverted triangle with the lateral margin based on the deepest marionette line.²⁰

Indications

Wrinkles and scars amenable for treatment are distensible, static as opposed to dynamic wrinkles, and are not caused by gravitation pull alone. A primary indication for collagen replacement is nasolabial wrinkles and folds, lip wrinkles and lip volume filling, and perioral marionette lines. To a large degree, the hyaluronic acid fillers have replaced collagen as volume fillers for lips, deeper folds, and for volumizing. The need for injectable collagen products still exists for wrinkles and for finer surface lines on the lips and other areas as the combined use of Zyplast/Zyderm enables the most natural lip and perioral correction.⁹ Collagen is better suited for superficial dermal placement with less likelihood of overcorrection.²⁰ Collagen products can also be used in dynamic wrinkles already treated with botulinum toxin in which full muscle immobilization is obtained, yet a static wrinkle persists.

Postoperative care and follow-up

Light massage of the area can be done following injection. This should be performed immediately after injection if a visible contour irregularity is noted. A cold compress is helpful during the first 48 hours after treatment to minimize swelling and ecchymosis. Some authors recommend a follow-up appointment 2–4 weeks later so that any touch-up treatments can be administered if necessary.²⁰

Tolerability and contraindications

Bovine collagens had an incidence of acute hypersensitivity of 3.5% and delayed hypersensitivity rates ranging



Figure 35.1 Wrinkles of the periorbital region before treatment.



Figure 35.2 Excellent flow properties of Zyderm I. Patient immediately after treatment.

from 3% to 10%.^{19,21} Additionally, granulomatous foreign-body reactions against animal-derived bovine collagens are well documented, with an incidence reaching as high as 1.3% in some series.²² Human-derived collagen products carried a very low risk of reactivity. A study published in 2007 showed that porcine derived collagen (Evolence) also carries a very low risk of hypersensitivity of only 0.58%. The hypersensitivity after injecting Evolence was even lower than what was observed with non-animal hyaluronic acid, which had a calculated risk of 0.74%.¹⁴

Some trials suggested a causal relationship between collagen dermal implants and autoimmune disease, in particular polymyositis.²³ Although epidemiologic review of the literature refuted this link, collagen-containing products are contraindicated in patients with a known history of reactive autoimmune disorders such as systemic lupus erythematosus and scleroderma.

Closing remarks

Today collagen fillers are no longer in use although some authors still consider them as ideal fillers for treatment, particularly of superficial fine lines and wrinkles in the perioral and periorbital region, especially Zyderm I with its excellent flow properties (Figures 35.1 and 35.2). They lost their significance primarily because of the development of longer lasting, more versatile, and easy-to-use fillers based on hyaluronic acid. Recent dermatological literature lacks scientific articles on the use of collagen preparations for wrinkle treatment except for validation purposes using collagen implants as gold standard.²⁴ Two clinical trials showed the superiority of dermal fillers based on hyaluronic acid in the treatment of the hand and nasolabial folds.^{25,26} Furthermore, the need of pre-testing bovine collagen products and the brevity of the effect (with the exception of Evolence) were major limitations of these products and contributed to their decline.

Poly-L-lactic acid

Katlein França, Yasser Alqubaisy, and Janelle Vega

Introduction

Dermal fillers are an alternative to invasive surgical procedures for facial cosmetic enhancement. Subcutaneous fat loss in the aging patient can create cosmetically

unappealing changes, which can be restored with fillers that replace volume loss and fillers that stimulate neocollagenesis.^{27,28}

Poly-L-lactic acid (PLLA) is a member of the α -hydroxyl acid family. It is a synthetic and biodegradable

polymer that stimulates an inflammatory response in the tissue to which it is injected.^{29,30,31} Considered an immunologically inert substance of non-animal origin, PLLA is available under the trade name of Sculptra and is indicated for correction of the signs of facial lipoatrophy in people with HIV. Sculptra Aesthetic is available for use in people with healthy immune systems. It is injected into the subcutaneous plane and gradually causes volumetric expansion and dermal thickness, stimulating fibroblasts and endogenous production of collagen.^{27,32,33,30}

Composition and mechanism of action

PLLA is part of the α -hydroxyl acid family and has multiple medical applications and can be used for suture, mesh, plates, and screws. In its currently commercially available dermatologic formulation, the microparticles are suspended in carboxymethylcellulose and non-pyrogenic mannitol in 40- to 63- μm spheres. The size of the particles allows for injection with a 26-gauge needle; however, the particles are large enough to prevent phagocytosis by dermal macrophages or exit through the capillary walls. Fortunately, allergy testing is not required given that it is a synthetic product and not of animal origin.³⁴

The exact mechanism of PLLA is not fully understood, although it is thought to stimulate the production of fibroblasts and stimulate endogenous production of collagen.²⁷ Animal models in preclinical studies show that in response to the implant, a connective tissue capsule forms, and within 6 months, newly formed collagen type I replaces PLLA as it is degraded via normal body metabolism.³⁴ The new collagen formation is thought to be the reason for the gradual volumetric expansion in the areas that are treated. It is the only filler on the market approved by the FDA to last up to 25 months.³⁵

PLLA reconstitution

PLLA is packaged as a powder in a sterile glass vial and must be hydrated prior to use. Improper reconstitution methods can result in nodules and papules forming after the procedure.^{32,36} After reconstitution, the vial must stand for at least 2 hours to complete the hydration, and

during this period cannot be shaken.²⁹ It is best to allow the reconstituted PLLA to hydrate overnight for best results. The complete process should be performed at room temperature up to 30°C or 86°F. Prior to its use, the product must be gently agitated, obtaining a uniform translucent suspension or “slurry.”³⁷ It is usable up to 72 hours after reconstitution.

The volume used for reconstitution depends on the patient, the area being injected and the preference of the injector. Most commonly, a dilution of 8–9 mL is achieved with a combination of sterile water for injection (SWFI) or bacteriostatic saline and lidocaine with or without epinephrine. A bolus of 5 mL or greater of SWFI is added for the 2- to 12-hour hydration period, and prior to injection *a small amount of lidocaine without epinephrine can be added to the product to provide local anesthesia* and to complete the dilution.^{32–34} We recommend the use of lidocaine without epinephrine to prevent blanching which can be a sign of vessel occlusion.

A more concentrated suspension of 3 mL of SWFI^{36,38} can be used in severe cases of facial lipoatrophy.³³ It is important to remember, however, that with this dilution, there is a higher incidence of granuloma formation.³⁹ PLLA can also be prepared in a more dilute suspension for chest wall rejuvenation. Dr. Goldman has described a “double dilution” technique where 1.5 mL of reconstituted PLLA is diluted to 3 mL with bacteriostatic saline or SWFI for broader areas such as the chest wall with no complications of nodule formation.³⁷

Injection techniques

The correct injection technique of PLLA must consider some important aspects, including the severity and extent of the volume deficiency, and the target area for treatment. Usually, a 26-gauge needle is used and injections are placed 0.5–1.0 cm apart.³⁸ The needle should be inserted at a 45° angle into the subcutaneous plane, just below the dermis and 0.1–0.2 mL should be used per pass of the needle.^{27,28,40}

The mid-face

This is the first place where volume loss becomes visible as the facial fat pads atrophy over time.⁴¹ The criss-cross-type and tunneling injections should be used to perform these corrections. Usually, considerable amounts of

material are necessary to correct this large area, but it is important to avoid overcorrection.

Correcting the cheek

A 5-mL dilution of PLLA is better for correcting a mild-to-moderate volume deficiency in the region of the mid-to lower face. The threading or tunneling technique can be used. In this technique, the needle is inserted into the deep dermis or at the junction with the subcutaneous layer and the syringe is plunger depressed as the needle is withdrawn. A cross-hatching-type pattern can be used to deliver the injections in order to create a “blanketing” of the area.³⁵ The physician needs to massage the area every three or four injections.^{27,38}

The upper face

The PLLA injections into the upper face should be deep, either next to the bone or intramuscular. To avoid intravascular injections and blood vessel occlusion, it is important to use a reflux maneuver. Once the correct position is achieved, and no reflux of blood is seen, a microdeposit of the substance is injected as the needle is withdrawn. Correcting areas around the eyes using very small quantities of the product can provide a rejuvenating effect, but is mandatory to avoid injecting into the orbicularis oculi muscle as with repetitive contractions of the muscle there will be a tendency for clumping of the product. The needle should be carefully inserted beneath to this muscle and all the way to the bone.^{27,38}

The temple

The hollowing of the temples can give a cadaveric appearance and replacing this volume loss can provide a rejuvenating effect. One can use a cross-hatching technique in this area, but a simple yet effective treatment can be achieved using larger depot injections under the temporalis fascia with subsequent vigorous massaging.^{27,35,38}

The lower face

A combination of bony remodeling and loss of the fat pads in the cheeks can cause ptosis of the face creating what is commonly called “jowls.” Correction of the loss in these fat pads can improve the contour of the lower face, but a patient may require supraperiosteal injections lateral to the mentalis to correct the ptosis. A small bolus may also be placed underneath the mentalis muscle to help with recession of the chin due to bone loss.^{27,35,38}

Indications

- Facial volume restoration
- HIV lipoatrophy

Complications

- Adverse events can be related to the injection technique or can be related to errors during reconstitution of the product.
- The injection can cause local reactions, such as pain, bruising, tenderness, redness, bleeding, ecchymosis, and, sometimes, local inflammation. These events usually resolve spontaneously. It is important to inform all patients about the possibility of swelling related to the injection volume which is usually short term in duration and resolves over 1–3 days.³³
- Rarely, local infections such as subcutaneous abscesses, cellulitis, and folliculitis can develop.
- The most feared side effects with the product are the formation of nodules and papules, which are a result of poor product placement such as periorbitally or peri-orally, which can cause the product to clump, and incomplete reconstitution of the product. These lesions usually resolve over a period of months and do not readily respond to intralesional steroids.^{35,42} Some of these nodules are to be expected as the product can generate a foreign body reaction which may be more clinically apparent in some patients.
- Granuloma formation, although rare, is an unpredictable side effect and can occur with most commercially available fillers.⁴³ These granulomas may be apparent after months or years, and usually respond to intralesional, oral or intramuscular steroids.^{32,44}
- Sculptra and Sculptra Aesthetic contains no animal proteins, so allergies are uncommon.²⁷

Contraindications

- Patients with history of keloid formation, hypertrophic scarring or hypersensitivity to the components should not use the product. The safety and efficacy have not been evaluated in subjects who are pregnant, lactating, breast feeding, or under 18 years of age. The presence of local skin infection or inflammation is also a contraindication to use.

Postoperative care and follow-up

Immediately after the procedure, a local massage with deep and circular motions should be performed for at least 5 minutes.³² To prevent edema, pain, and bruising after the injection, an ice pack is applied to the area.^{27,40} Patients should be instructed to perform a local massage for 5 minutes, five times a day for five consecutive days (“5–5–5 rule”). A hand-held massager can be useful in this process. This will help the stimulation of the physiological response and neocollagenesis.²⁹

Conclusion

Dermal fillers are an alternative to surgical procedures for facial cosmetic enhancement. PLLA is a biostimulatory

molecule which induces neocollagenesis, and was first introduced as treatment for facial lipoatrophy in HIV patients and in the last few years has increasingly gained popularity for use in facial volume restoration and contouring. Depth of placement is important in achieving the desired effect and superficial placement of the product should be avoided. Patients need to be educated that treatment with Sculptra and Sculptra Aesthetic will achieve a desired response in a gradual manner, and the treatment regimen may require multiple treatments 4 weeks apart (anywhere from two to four sessions). The injector must avoid overcorrection as collagen synthesis may continue to occur over the next 24 months. Side effects are usually related to improper product placement and reconstitution and true granulomatous lesions are rare.

An overview of the dermal filler calcium hydroxylapatite (Radiesse)

Mariano Busso

Introduction

The aging process is most obviously perceptible in the face, where subcutaneous atrophy, bone resorption, and diminished dermal elasticity result in wrinkles, folds, sagging, and thinning skin.^{45,46} In the last few years we have witnessed the evolving versatility and efficacy of semi-permanent dermal fillers like calcium hydroxylapatite (CaHA; Radiesse, Merz Aesthetics, San Mateo, CA (formerly Bioform Medical)), a durable material for injectable, non-surgical cosmetic treatments. Approved by the FDA in 2006 for the treatment of facial lines and nasolabial folds and for dermal augmentation due to HIV-related facial lipoatrophy, CaHA mixed with lidocaine received FDA approval in 2009 as viable, safe, and nearly painless.^{45,47,48} CaHA has also been approved in the United States for radiographic tissue marking, treatment of urinary tract incontinence, and correction of oral/maxillofacial defects and vocal cord insufficiency.

Biocompatible, highly viscous, and non-allergenic, CaHA has been effectively employed in a variety of

documented off-label uses, including marionette line and oral commissure correction,⁴⁵ mid-face volume restoration,⁴⁹ pre-jowl sulcus and perimental hollow correction,⁵⁰ chin and mandibular contouring,⁵¹ acne scar filler,⁵² and nasal sculpting.⁵³ Physicians have successfully begun employing off-label application of CaHA into the dorsa of the hands, which are equally vulnerable to volume depletion.⁵⁴ While CaHA has demonstrated its efficacy and durability for treating individual areas of the face, practitioners are increasingly evaluating its application to the mid- to lower face for non-surgical correction of the “triangle of beauty” to add volume, eliminate lost elasticity, and achieve structural contouring.^{55,56}

Composition and mechanism of action

A synthetic, injectable dermal filler, CaHA consists of 30% of CaHA microspheres (25–45 µm) suspended in a 70% aqueous carrier gel of purified water, glycerin, and

sodium carboxymethylcellulose. CaHA, a mineral constituent found in bone and teeth, renders the filler biocompatible and non-allergenic, eliminating the need for skin pretesting. CaHA microspheres are considered bioceramics, not polymers such as poly-L-lactic acid (Sculptra) or polymethylmethacrylate (Artefill).

CaHA microspheres are metabolized by dissolution. Once engulfed in a macrophage, the CaHA microspheres are broken down into their constituent components: calcium and phosphate ions. These ions are subsequently excreted through the urinary system.⁵⁷

CaHA is available in 1.5-, 0.8-, and 0.3-mL single-use syringes requiring no refrigeration or special handling, and can be injected through a 0.5- to 1.5-inch 27-gauge needle or 28-gauge needle with a 27-gauge bore, depending upon the area to be treated. The high viscosity of the gel and CaHA microspheres enable practitioners to administer the material subdermally, deep dermally, subcutaneously, or supraperiosteally (Figure 35.3).⁵⁰

Upon injection, the gel carrier is phagocytosed by macrophages; meanwhile, the CaHA microspheres provide a scaffold for soft-tissue ingrowth and collagen deposition.⁸ The microspheres are anchored at the injection site preventing translocation of CaHA and ensuring a long-lasting cosmetic correction of 6–14 months.⁵⁸ CAHA is easily molded and shaped immediately following injection. Well-tolerated by patients, CaHA has in some cases produced such short-term, mild post-treatment effects as

erythema, itching, and ecchymosis, which are resolvable without treatment.⁵⁹

A pilot histologic study showed that when CaHA is injected into the nasolabial folds, both standard light and electron microscopy revealed CaHA microspherules with minimal to no cellular inflammation or fibrosis.⁵⁸ Given the approved use of CaHA as a radiographic tissue marker, researchers investigated the radio-opacity of CaHA to determine its potential for X-ray or computer tomography (CT) scan distortion. Following 58 patients treated with CaHA for HIV-associated lipoatrophy or nasolabial fold remediation, and imaged from 1–427 days after injection, researchers concluded that CaHA was not consistently visible on radiographs but was clearly distinguishable from bones and adjacent structures on CT scans.⁶⁰

CaHA in clinical literature

Since its use as a dermal filler in 2002, CaHA has received considerable attention in the literature. Studies following FDA guidelines have compared CaHA with collagen in treatment of nasolabial folds,⁶¹ assessed its efficacy in treatment of patients with HIV-associated facial lipoatrophy,⁶² explored its use in persons of color,⁶³ and described its use in treatment of the aging hand.^{64,65}

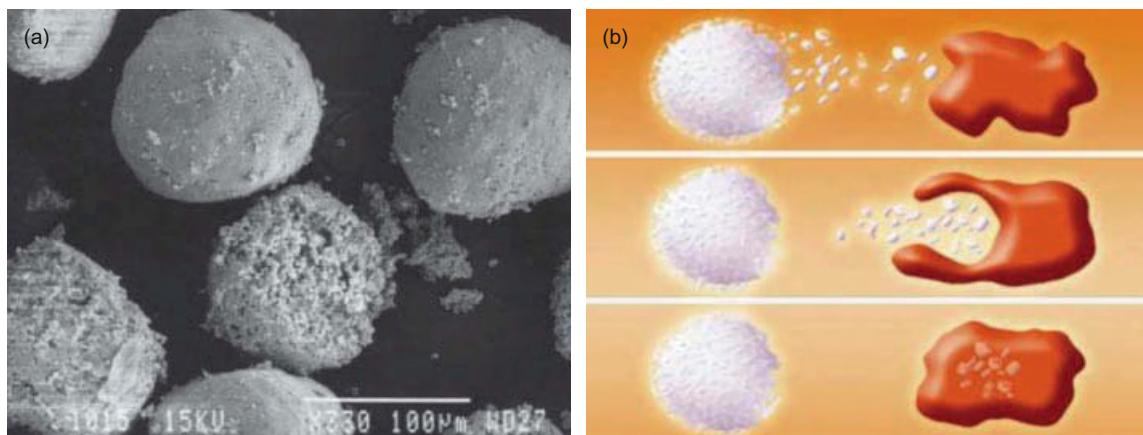


Figure 35.3 (a) Gel and (b) calcium hydroxylapatite particle post implantation, followed by calcium hydroxylapatite slowly metabolizing into calcium and phosphate ions. Courtesy of Merz Aesthetics (formerly BioForm Medical), San Mateo, CA.

CaHA and collagen

To assess the long-term effectiveness and safety of Radiesse dermal filler, researchers injected Radiesse and the human collagen (HC) filler Cosmoplast (Inamed, Santa Barbara, CA) into 117 randomly selected patients with moderate to severe nasolabial folds during a pivotal, multicentered, prospective split-face 6-month study. Subjects were initially injected with a total mean volume of 1.2 mL of Radiesse per nasolabial fold and 2.4 mL of HC and received periodic touch-ups to ensure optimal correction. Thereafter, subjects were seen at 1, 3, 6, and 12 months from the last injection.

Radiesse outperformed Cosmoplast on both the Lemberle Rating Scale (LRS) and the Global Aesthetic Improvement Scale (GAIS). Folds injected with Radiesse were rated superior on the LRS (84.6% at 3 months, 78.6% at 6 months) to those injected with HC (12.8% at 3 months, 16.2% at 6 months).⁶⁶ Nearly 95% (94.6%) of folds treated with Radiesse achieved an “improved grade” compared with 2.7% of the HC-treated folds. Neither filler yielded delayed adverse events. Forty percent of all CaHA folds were graded at least “improved” a minimum of 30 months from last injection.^{61,67}

CaHA and hyaluronic acids

In two separate randomized trials developed to assess the efficacy, durability, and aesthetic performance of Radiesse injected into nasolabial folds compared with non-animal stabilized hyaluronic acid (NASHA, Restylane; Medicis, Scottsdale, AZ) and with Juvederm 24 (Allergan, Irvine, CA), Juvederm 24HV, and Perlane (Medicis), each filler was deemed equally safe with no notable adverse events reported for any of the fillers.⁶⁸ However, CaHA outperformed the hyaluronic acids in patient and evaluator satisfaction, GAIS ratings (Significantly more CaHA gel-treated nasolabial folds were improved on the GAIS than any HA-treated folds at 4 and 8 months ($p < 0.0001$)), durability, and patient willingness to explore future treatment. The volumes of CaHA gel and three HA materials injected over 4 months were 2.2 mL (CaHA), 2.9 mL for Juvederm 24HV and Perlane, and 4.8 mL for Juvederm 24 ($p = 0.005$). In another study, CaHA was shown to be more effective than the hyaluronic acid Restylane (HA-R).⁶⁹ On the GAIS, 79% of the CaHA-treated folds were still improved or better than 44% of the HA-R-treated folds ($p < 0.0001$). In addition, 0.88 mL total volume for

CaHA and 1.26 mL total volume for HA-R are required for “optimal correction.”^{68,69}

CaHA and Fitzpatrick skin types IV–VI

In an open-label, non-randomized, prospective trial designed to evaluate the efficacy of subdermally administered CaHA among 100 patients identified as African-American, Hispanic, Asian, and “other,” evaluators noted that the filler was safely tolerated by people with dark skin. Injection of CaHA into nasolabial folds did not stimulate keloid formation, scarring, or skin discoloration.⁶³

CaHA and the aging hand

In a large-scale, multicenter study in Europe, 101 patients either received CaHA or received no treatment (control) for 3 months, then treatment in both hands for all patients. At 3 and 6 months, 66% and 56% of CaHA-treated hands respectively were improved at least one point on a validated hand scale and 89% and 75% respectively improved on a revised GAIS.⁶⁴ Another European study of 62 patients for treatment of the aging hand with CaHA also reported favorable results.⁶⁵

FDA-approved indications

Indicated and FDA-approved for subdermal injection to correct moderate to severe facial wrinkles and folds, including nasolabial folds, and to augment volume loss due to HIV-related facial lipoatrophy. Additionally, CaHA with lidocaine has been approved as an admixture to significantly reduce pre-injection pain levels in nasolabial folds.⁷¹

Patient counseling and evaluation

While CaHA requires no pretesting for allergies, physicians should obtain a candidate’s case history to evaluate any pre-existing conditions, potential hypersensitivity, or likelihood for bruising. Physicians should discuss anticipated outcomes and expectations of any procedure and consider the potential adverse reactions among those with a history of bleeding disorders, hypertrophic scarring, collagen disease, keloidal formation, or acute or chronic infection. Other factors to consider include

history of anaphylaxis; pregnancy, lactation; taking systemic or anabolic steroids; facial augmentation other than CaHA; application of over-the-counter or prescription anti-wrinkle products.⁴⁸

Some practitioners advise patients to seek permission from their prescribing physicians to refrain for 5–10 days from taking blood thinners (e.g., warfarin, Plavix, aspirin), anti-inflammatories, vitamin E, or other herbal supplements that may prevent clotting or delay the healing process. A history of facial herpes simplex I may indicate pretreatment administration of antiviral prophylaxis.

Physicians should receive informed consent for all procedures and discuss the potential outcomes of approved and off-label applications. As with any treatment, patients should be apprised of the pros and cons of correction options available to them for specific aesthetic intervention, including the choice of pretreatment anesthesia.

Lastly, patients should be given an assessment of the safety of the procedure, anticipated discomfort, if any, and instructions and expectations for post-treatment care, downtime, and filler durability. Baseline and post-treatment photographs of the area to be treated should be taken on the day of treatment and at regular intervals thereafter. Depending upon the area of treatment, physicians recommend post-treatment evaluations at 1, 3, 6, 9, and 12 months.

Preoperative care

Historically, pretreatment for administering anesthesia has included a number of protocols aimed at reducing the pain of filler injection as the needle is introduced at the junction of the deep dermis and subdermal tissue.⁷² Post injection, patients have responded positively to the application of ice, vibration, topical anesthetic, local, or regional anesthesia, such as infraorbital and mini-nerve blocks.

A 2007 study in which an admixture of CaHA and lidocaine was administered into the dorsa of the hand proved significantly less painful to the patient and resulted in less swelling, bruising, and reduced post-treatment patient recovery.⁵⁵ In 2009 the FDA approved this protocol for application to nasolabial folds (Video 35.1). The lidocaine/CaHA filler mixture entails the connection of one 1.3-mL or 1.5-mL syringe of CaHA to a



Figure 35.4 Creating an admixture of calcium hydroxylapatite and lidocaine—approximately 10 passes back and forth have been shown to create sufficient homogeneity. Courtesy of Merz Aesthetics (formerly BioForm Medical), San Mateo, CA.

3.0-mL syringe containing <0.5 mL of lidocaine via a Rapid Fill Luer-Lok to Luer Lok adaptor (Baxa; Englewood, CO). Introducing the filler into the syringe filled with anesthetic, the practitioner pushes the material back and forth 10 times to yield a uniform mixture that maintains the inherent properties of the filler while lowering the viscosity, hence the extrusion force, of the combined materials (Figure 35.4).⁷³

Step-by-step injection technique

CaHA is typically injected slowly in small amounts (0.05 mL per pass) with a 1.25-inch (3.2 cm), 27-gauge needle in a retrograde fashion, employing a tunneling technique, into the deep dermis and subdermal plane.⁵⁷ Depending upon the area being treated, linear threading, fanning and/or cross-hatching may also be appropriate to bolster surface depression. For areas requiring less volume, a 0.5-inch (1.3 cm) needle is recommended. Using a non-dominant index finger to guide the needle, the physician massages and molds the product. Care should be taken especially when injecting material into the subdermal plane of the superior nasolabial fold to prevent occlusion of the blood vessels (Figure 35.5).⁴⁵

For treating hands, the physician is advised to tent the dorsum with thumb and forefinger of the non-dominant hand to avoid injecting blood vessels or tendons. Admixture of filler and lidocaine is injected as a bolus (0.5–1.4 mL) in the areolar plane between the subcutaneous and superficial areas. Immediately after injection, the site



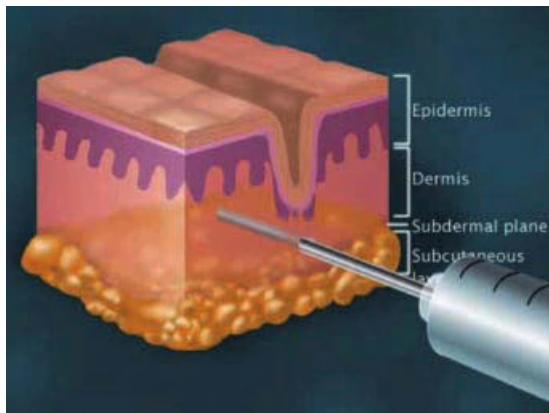


Figure 35.5 Proper placement of CaHA into skin is at the juncture of the dermis and the subdermal plane. Courtesy of Merz Aesthetics (formerly BioForm Medical), San Mateo, CA.

should be massaged and molded.⁷⁴ Filler should be injected to achieve a 1:1 correction. Subsequent touch-ups may be performed, if necessary.

Common applications of CaHA

Some of the more popular applications of CaHA are described below. Note that with the admixture of CaHA and lidocaine, anesthetic pre-administration (topical, nerve block, or tissue infiltration) is less commonly used in our clinical practice. The anesthetic information is included in the interest of a comprehensive discussion on the use of CaHA.

- *Nasolabial folds:* characterized by the descent of fat from the malar and medial cheek pads, nasolabial folds respond well to CaHA as a structural, durable underpinning to the folded skin. A 1.25 or 0.5 27-gauge needle is inserted at a 45° angle into the subdermal space at the lip commissure until resistance is encountered in the deep dermis/subdermal plane.^{45,48} The physician should slowly inject fine threads of CaHA filler while withdrawing the needle with a retrograde technique and proceed to inject parallel threads medial to the original CaHA thread. As the needle is advanced and withdrawn, 0.05- to 0.1-mL aliquots are injected and deposited, stopping before the needle is completely withdrawn.⁷² If injecting a prominent crease, CaHA should be placed in a deeper plane to support the fold. Physicians are advised to use a fanning motion at the perilar depression to bolster at the dermal/

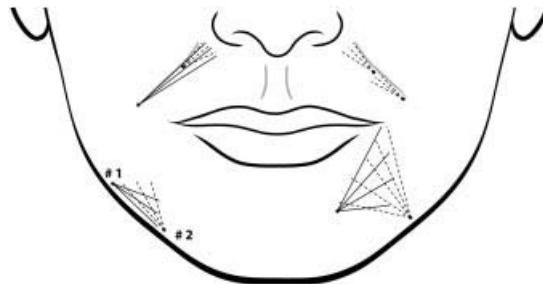


Figure 35.6 Placement of calcium hydroxylapatite into nasolabial folds, marionette lines, and pre- and post-jowl sulci. Courtesy of Merz Aesthetics (formerly BioForm Medical), San Mateo, CA.

subdermal junction, then minimally massage and mold with thumb and forefinger as needed in order to avoid erythema.⁴⁵

- *Marionette lines, oral commissures:* CaHA is injected slowly to avoid bruising with a 0.5-inch (1.3 cm) to 1.25-inch (3.2 cm) needle into the dermal and subdermal planes, from the most inferior portion of the fold down to the oral commissures. A fanning and cross-hatching technique will lift the corner of the mouth.
- *Prejowl sulcus:* resulting from bone loss, tissue atrophy and the descent of soft tissue around such areas as the nasolabial folds and marionette lines, pre-jowl sulcus can be corrected and the jaw recontoured with deep dermal or subdermally placed CaHA. CaHA is then injected into the deep dermal and/or subdermal plane to both amplify and recreate the inferior border of the mandibular area. To avoid the facial vein and prevent ecchymosis, CaHA may be injected slowly and simultaneously massaged laterally or medially along the periosteum. Whether a physician chooses to place a suprperiosteal, intraoral bolus of CaHA to avoid minimal bruising or introduce 1.0–3.0 mL of filler with deep, gradual threading, the objective is to strengthen and shape the area and avoid injuring the mental nerve (Figure 35.6).^{45,70}

- *Mid- to lower facial contouring:* three-dimensional vectoring entails the application of CaHA premixed with lidocaine to recontour the entire mid- to lower facial area to correct both skin surplus and bring into relief the structure of the face.⁴⁹

Terino's work on the four mobility zones of the face has allowed physicians to approach the face from the

lateral to the medial by bilaterally treating the regions from temporal to zygomatic to malar:

- central zone (mouth, nose areas): relative immobility
- paramedial zone (nasolabial folds and malar fat compartments): most mobility
- lateral zone (pre-auricular fossa): minimal mobility
- ear concha: anchoring point.⁷⁵

Temporal augmentation is accomplished by injecting with a 27-gauge, 1.25-inch needle deep boluses of 0.7–3.0 mL of CaHA with lidocaine (0.5 mL of lidocaine per 1.5-mL syringe) per fossa directly above the zygomatic rim, and into the area between fascia and subcutaneous tissue, carefully avoiding vascular structures. The zygomatic region requires 0.7–1.4 mL of supraperiosteal filler injected at a 90° angle at the thinnest entry point, lateral to the lateral canthus. The needle should be re-oriented as it contacts the bone and gradually advanced below the soft tissue. To recontour cheeks, a bolus of CaHA mixed with lidocaine is injected intraorally at the canine eminence through the gingival and lateral to the maxilla, carefully avoiding the area above the orbital rim. Some providers continue to use a transcutaneous route of administration for injection of CaHA (Figure 35.7).

To recontour the lower face and chin (the chin, pre-, and post-jowl sulci), three injection sites may be warranted. For chin projection, filler is deposited over the central mentum; the lower third of the face can be lengthened through submandibular augmentation; and pre-jowl sulcus reduction can be achieved by depositing CaHA with lidocaine over the supraperiosteum directly below the sulcus.⁵⁶

Figures 35.8 and 35.9 are before and after figures of patients with CaHA in the mid- and lower face (Figures 35.8 and 35.9).

- **Hands:** the aging hand can be treated with an admixture of CaHA and 1–2% lidocaine (0.2–1.0 mL, depending how much filler spreadability is desired). The practitioner may choose to inject boluses into one to five sites over the tented dorsum of the hand, then vigorously massaging the product (Videos 35.2 and 35.3). Volumes and sites vary according to the practitioner. A bolus technique can be used to inject 0.3–1.0 mL at three to five sites, for example.⁷⁶ For single-site injection, the physician may employ a retrograde introduction of 0.5–1.3 mL of lidocaine–CaHA mixture into the areolar

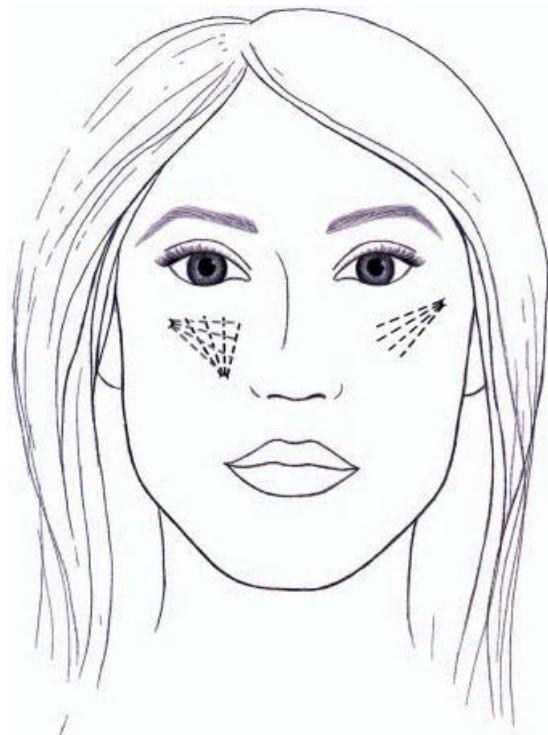


Figure 35.7 Mid-face contouring can include the temporal region (not shown), the zygomatic region, and the malar/submalar regions. Courtesy of Merz Aesthetics (formerly BioForm Medical), San Mateo, CA.

plane between the subcutaneous layer and superficial fascia.⁷⁷

Once injected, the patient makes a fist as the dorsum is massaged and contoured by the practitioner. Treatment with ice pack, NSAIDs, or antibiotics may mitigate bruising and pain. Touch-ups may be required to enhance volume (Figure 35.10).

Complications

Because of the inherent biocompatibility of the CaHA microspheres, Radiesse causes a minimal cellular inflammatory reaction, with no evidence of granuloma formation, migration, or foreign-body reactions.^{58,78} In a study of 113 patients, two non-granulomatous submucosal nodules of the lip were reported, both of which resolved

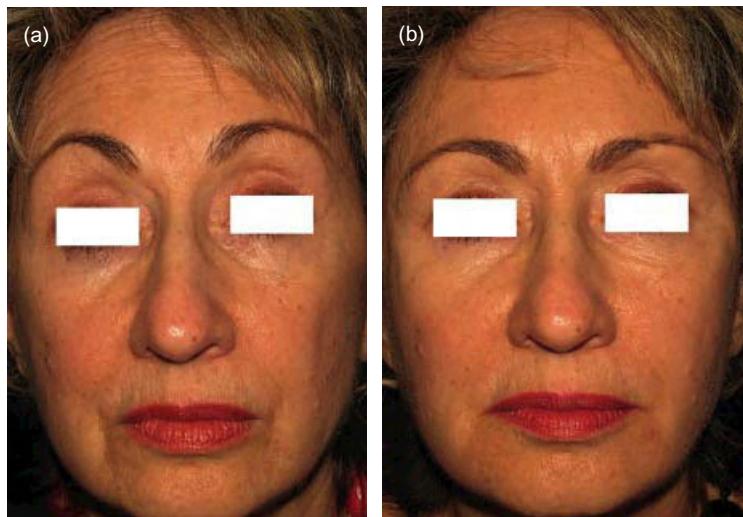


Figure 35.8 (a,b) Before and after photographs of a 66-year-old woman treated with 10.8mL of CaHA for full-face contouring.⁵ This patient also received 1.0mL of hyaluronic acid Restylane in her suborbital area. Reproduced from Busso *et al.*⁵⁶ with permission from Quadrant HealthCom Inc.

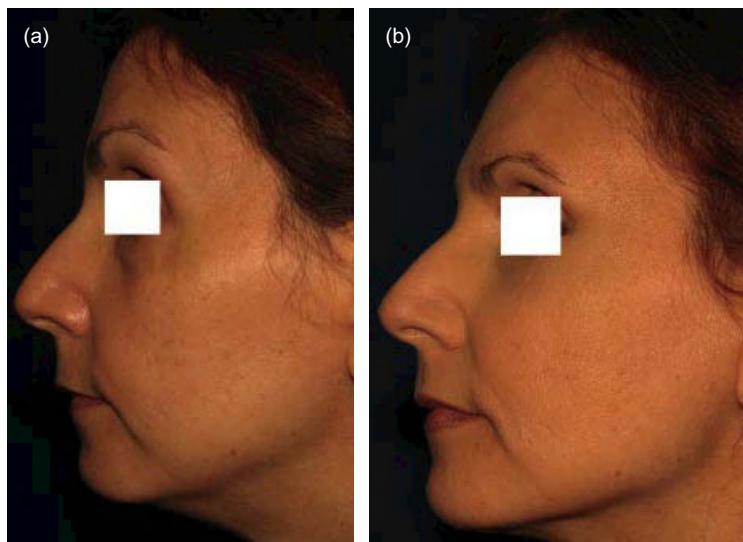


Figure 35.9 Before (a) and after (b) photographs of a 44-year-old woman treated with 22.1mL of calcium hydroxylapatite for full-face contouring.⁴⁹ This patient also received 3.0mL of hyaluronic acid Restylane in her suborbital area. Reproduced from Busso *et al.*⁵⁶ with permission from Quadrant HealthCom Inc.

without difficulty after treatment with triamcinolone.⁵⁰ Lip nodules may be treatment experience related.^{50,51} Regardless, the product is not recommended for use either for lip outline or lip body augmentation. As shown in HIV lipoatrophy studies in which amounts >3mL per cheek were used, the radio-opacity of CaHA did not interfere with the reading of routine radiographic

images. It is clearly seen in CT imaging but easily differentiated from other structures.⁶⁰ In one split-face study of 118 folds, treated with CaHA on one side and hyaluronic acid on the other, one non-granulomatous nodule was noted in a CaHA-treated nasolabial fold. The nodule was treated with triamcinolone and resolved without complication within 14 days.⁶⁸ In a pivotal

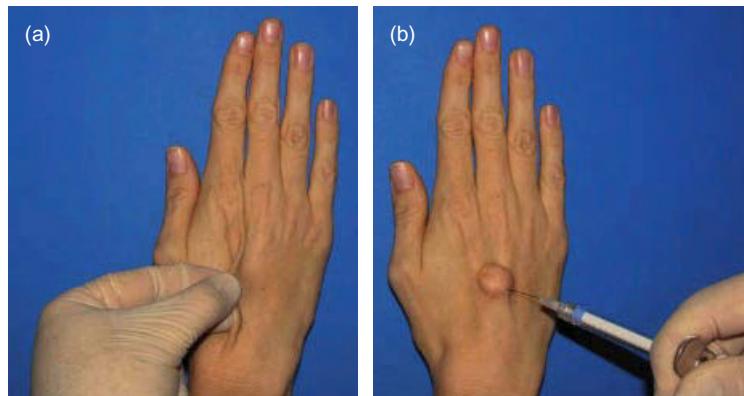


Figure 35.10 (a,b) When injecting the hand, the skin is first tented; calcium hydroxylapatite is injected into the tented space to create a bolus of product, which is then massaged to smoothness. Courtesy of Mariano Busso, MD.

split-face study of 113 patients who were treated with CaHA in one nasolabial fold and human collagen in another, no necrosis, granuloma, hematoma, infection, embolization, extrusion, or erosion was reported. One nodule was observed on an CaHA-treated fold and three nodules on human collagen-treated folds.⁶¹

As with other fillers, vascular occlusion with the subsequent reduction of tissue perfusion and even necrosis remains a possibility. Practitioners should be knowledgeable of facial vasculature as well as the danger zones for tissue necrosis such as glabella and the intersection between nasolabial fold and nasal crease. To date, there has not been a case report that associates injection of CaHA and the development of biofilm. A reliable source nevertheless recommends an oral antibiotic followed in 30 minutes by either 1000 mg of Keflex or 500 mg of Biaxin (in individuals who are allergic to penicillin).³⁴ No allergic reactions have been reported, although one instance of activation of herpes zoster has appeared in the literature.⁷⁹

As this publication goes to press, more than 2 million syringes of CaHA have been sold, with no severe adverse events reported in the clinical literature. However, not unlike other dermal fillers, injection of CaHA can be associated with local, short-term, minor adverse events at the injection site.⁸⁰ In particular, patients may notice some ecchymosis and edema, especially if a larger gauge needle is used. If present at all, these symptoms ordinarily

resolve within the first few days and most decidedly within 2 weeks.

Conclusion

The popularity of permanent and semi-permanent fillers has created a burgeoning market for a non-invasive, safe, affordable and virtually painless way to achieve a rejuvenated appearance. Radiesse is a relatively novel product in the dermal filler armamentarium, with CaHA as its primary component, rather than a type of collagen or a hyaluronic acid. The durability, safety, efficacy, and inherent biocompatibility of CaHA have earned it high marks among a population eager to retain its youthful outlook and restore its youthful appearance. The addition of lidocaine to CaHA immediately prior to injection has obviated much of the need for pre-anesthetic protocol and helped dampen the hesitations often expressed by patients about avoiding pain.

Acknowledgements

The author expresses appreciation to Sally Sherwood (New York City) and David J Howell, PhD (San Francisco) for their editorial contributions on behalf of this chapter.

Hyaluronic acid fillers

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and Alex Cazzaniga**

Introduction

Hyaluronic acid

Hyaluronic acid was discovered in 1934 by Karl Meyer and John Palmer, scientists at Columbia University. They isolated the substance from bovine vitreous humor and named it hyalos, the Greek word for glass.⁸¹ This name reflects the clear physical appearance of purified hyaluronic acid. Endre Balazs first patented hyaluronic acid for commercial use in 1942,⁸² and technological advancements of the subsequent decades led to its 2003 approval by the FDA for temporary treatment of wrinkles.

Hyaluronic acid is a non-sulfated glycosaminoglycan, a polysaccharide consisting of repeating D-N-acetylglucosamine and D-glucuronic acid disaccharide units. It exhibits no tissue or species specificity, consequently the structure of animal and bacterial derived hyaluronic acid is identical, although animal hyaluronic acid exhibits a considerably longer polysaccharide chain. Hyaluronic acid is the most abundant glycosaminoglycan found in the human dermis. It is found in the extracellular matrix of the skin, the vitreous body of the eye, and the articular cartilage. It is an extremely hygroscopic molecule, binding up to 1000 times its weight in water. This property allows it to contribute to the hydration and volume of tissues, as well as providing structural support. Naturally occurring hyaluronic acid is a viscous liquid in its non cross-linked or free form, and thus is completely metabolized a few days after injection into the skin. It is broken down by hyaluronidase and eliminated through lymphatics.⁸³

Hyaluronic acid has been FDA cleared for use as a dermal filler for over a decade. The current FDA-approved products available to the practitioner are bacterial derived via fermentation of equine *Streptococcus* and cross-linked to provide longevity (Table 35.2). Despite their similar origins, there are important structural differences among the available hyaluronic acid fillers, including hyaluronic acid particle size, degree and methods of cross-linkage, and product concentration. These factors are important

in determining gel hardness and longevity, which in turn can influence which filler the physician chooses for a particular indication or patient (Table 35.3). One of the great advantages of hyaluronic acid fillers is that they can easily be removed by injecting commercially available hyaluronidase.

Aging face

Facial aging is the result of decreased thickness and elasticity of skin, absorption of fat, and resorption of the craniofacial skeleton, all these elements lead to volume loss. Also, decreased adherence between the skin and subcutaneous tissue, sagging of the soft tissues, and muscle alterations are present in facial aging.^{84,85}

The paradigm of muscular involvement in the aging face has shifted. It was thought that muscle weakness and laxity caused downward displacement of soft tissue. Le Louarn *et al.*⁸⁶ studied the facial mimetic muscles through the use of magnetic resonance imaging. Their study showed that repetitive muscle contractions combined with increased resting tone exerts constant pressure on the underlying bone, favoring its erosion and posterior remodeling, thereby projecting underlying fat anteriorly.

Table 35.2 FDA-approved hyaluronic acid dermal fillers

Without lidocaine	Company	With 0.3% lidocaine	Company
Restylane	Medicis	Restylane-L	Medicis
Perlane	Medicis	Perlane-L	Medicis
Juvéderm Ultra	Allergan	Juvederm Ultra XC	Allergan
Juvéderm Ultra Plus	Allergan	Juvederm Ultra Plus XC Prevelle Silk	Allergan Mentor
		Hydrelle	Coapt Systems Inc.

Table 35.3 Characteristics of most commonly used FDA-approved hyaluronic acid dermal fillers

	Restylane	Perlane*	Juvéderm Ultra	Juvéderm Ultra Plus
HA concentration	20 mg/mL	20 mg/mL	24 mg/mL	24 mg/mL
Form	Particle 125 µm, 100 000/mL	Particle 325 µm 10 000/mL	Homogeneous	Homogeneous
Cross-linker	BDE	BDE	BDE (6%)	BDE (8%)
Gel hardness	513 Pa [†]	541 Pa [†]	28 Pa [†]	75 Pa [†]
Degree correction	100%	100%	100%	100%
FDA approval	2003	2007	2006	2006
Syringe volume	0.4/1 mL	1 mL	0.4/0.8 mL	0.4/0.8 mL
Needle size	30 gauge	27 gauge	30 gauge	27 gauge
Manufacturer	Medicis	Medicis	Allergan	Allergan

*Perlane is a highly cross-linked version of Restylane.

[†]Sundaram *et al.* *Dermatol Surg* 2010.⁹¹

This facial aging concept is important when approaching anti-aging procedures.

Rohrich and Pessa⁸⁷ studied the face's subcutaneous fat by dissecting cadavers. They demonstrated that the subcutaneous facial fat is highly compartmentalized, and that not only a change in volume but also a change in position of these compartments can be present in the aging face. Replacing lost or misplaced fat pads with filler is another approach to restructuring the aging face.

The aim of hyaluronic acid fillers is to restore volume loss, whereas botulinum toxins are employed to treat muscle hyperactivity. Both agents act therapeutically, but in addition, may also be preventative by lowering the resting tone of musculature, thereby preventing recurvature/remodeling of the face. Therefore, to optimize outcomes it is necessary to utilize a combination of available therapies.

Differences between aging face proportions

A “frozen” corrugator or procerus muscle affects facial expression, but does not present any functional problems. In contrast, a “frozen” orbicularis oris or mentalis muscles affects important functions such as oration, expression, and mastication. The same way a “frozen” orbicularis oculi affect the eye closure. Therefore, botox injections are riskier in the mid- and lower face. Moreover, volume loss is often more prominent in mid- and lower face aging. These considerations explain

Box 35.1 Contraindications to treatment with hyaluronic acid dermal fillers

Contraindications

- Pregnancy
- History of severe allergies manifested by history of anaphylaxis or history of multiple severe allergies
- History of allergy to gram positive bacterial proteins (trace amounts present)
- Bleeding disorder
- Previous hypersensitivity to local anesthetics of the amide type, such as lidocaine*

* Contraindication for products containing lidocaine only.

the extensive use of fillers to mid- and lower face rejuvenation.

Preoperative care

The FDA approved hyaluronic acid “injection to mid to deep dermis for correction of moderate to severe facial wrinkles and folds (NLF).” In October 2011 the FDA approved Restylane for submucosal implantation for lip augmentation. All other indications are off label: marionette lines, perioral rhytides, ear lobes, zygomatic arch, scars, dorsum hands, glabella, and tear trough.

Contraindications are listed in Box 35.1.

Step-by-step injection technique

Patient evaluation

Patients are encouraged to verbalize their concerns about their face and their expectations of any interventions. A hand-held mirror is indispensable for this purpose. The patient's skin should be thoroughly cleansed with make-up remover or soap to ensure removal of all cosmetic products.

For upper face rejuvenation, botox remains the cornerstone of treatment⁸⁸ Wrinkles that cannot be eliminated by chemodenervation can be treated concomitantly with hyaluronic acid fillers. In contrast, fillers are usually the first options for mid- and lower face rejuvenation.

Preoperative photos are important for many reasons, one of which being the failure of patients to recognize their natural asymmetries until after they invest in cosmetic procedures.

Product choice

G prime is the technical "hardness" of the gel, or how much force it takes to displace two plates with gel in between the plates.⁸⁹ The higher G prime products (Table 35.3) are better at lifting and are frequently used off label for lifting of the cheeks and oral commissures. The lower G prime products are softer and diffuse into the skin more evenly and are commonly used for more superficial rhytides or for diffuse filling.⁹⁰ The G prime of the product does not determine the longevity of the product. Longevity is based on stabilization of the hyaluronic acid itself, which is determined by the type and amount of cross-linking. Free (uncross-linked) hyaluronic acid injected lasts only a few hours in the skin. Its presence in the syringe is to assist in flow of the product from the syringe.⁹¹

The more robust/dense the filler material, the more profound in the skin it will be deposited. Therefore, dense fillers (with bigger particle size, higher cross-linked, higher G prime, and more concentrated (more particles/mL)) are beneficial for filling deeper wrinkles and softer gels for more superficial use (Table 35.3). It is also important to evaluate the skin thickness.⁸⁸ The thinner the skin, higher probability of the product became visible, so a softer product is preferable.

Needle choice

Most products come with a recommended needle for injection (Table 35.3). These needles are convenient and

inexpensive to use and good results can be obtained using a needle approach. Bruising can be an issue due to the multiple insertion points required with a needle use. More recently, cannulas have become available in the United States. Microcannulas allow the injection of hyaluronic acid dermal filler with minimal to no bruising and without multiple needle sticks. Since microcannulas do not have a sharp tip, they slide under skin, causing minimal to no damage. In the authors' experience this allows for greater patient comfort during the procedure and generally less post-injection pain, bruising, and swelling. In addition, the cannulas are flexible, so manipulation from a single insertion site to fill an entire area is possible. Larger areas such as the cheek, a 27-gauge, 37-mm cannula is used. For smaller areas such as the chin a 30-gauge, 27-mm cannula is preferred. For fine lines (e.g., perioral rhytides), the serial micropuncture technique is preferred using a 32-gauge × 0.5-inch and dilute hyaluronic acid. Every cannula has a slightly different feel and selection is based on personal preference. There is a learning curve with using a cannula, and more comfort is obtained with increased experience.

Injection technique

Some patients elect for anesthesia with topical anesthetics such as 4% lidocaine or 7% lidocaine with 7% tetracaine for at least 30 minutes. Others prefer nerve blocks, especially with lip augmentation. In a more experienced cosmetic patient it is not unusual for the patient to forgo anesthesia.

There are several techniques for hyaluronic acid filler implantation: linear threading, serial puncture, fanning, and cross-hatching, or a combination of all four (Figure 35.11). Injection techniques vary and in any given area there may be different ways to achieve correction. It is important to inject these products into the correct plane in the skin. Although the package inserts for these products instruct the user to inject in the mid- to low dermis, most experts agree that this plane is seldom used. The hyaluronic acid product flows most liberally in the superficial subcutaneous plane and not in the dermis. Superficial injections into the dermis are used for superficial lines with a soft product. Injection of hyaluronic acid too superficially results in visible filler or "tyndall effect." For facial sculpting and replacement of lost or misplaced fat pads, injections are very deep, many times at the periosteum.

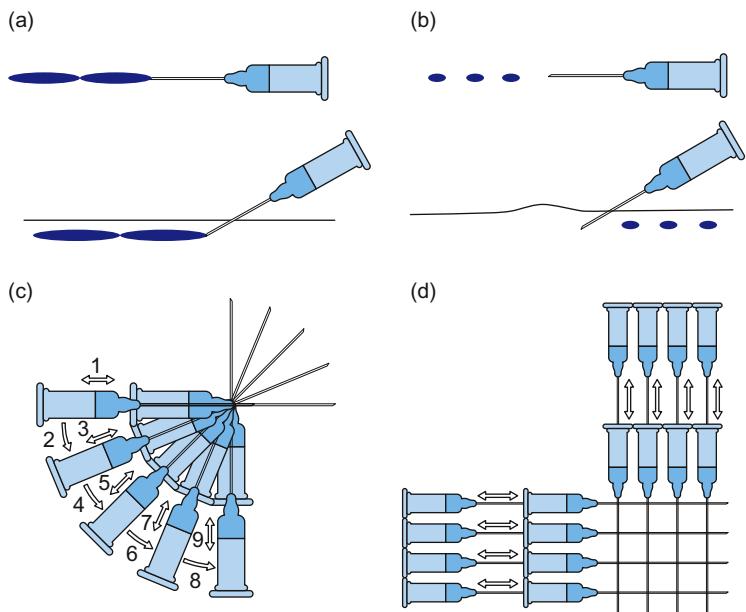


Figure 35.11 Hyaluronic acid dermal fillers implantation techniques: (a) Linear threading; (b) serial puncture; (c) fanning; (d) cross-hatching.

After the hyaluronic acid filler injection, the practitioner should perform gentle massage to the implantation area to smooth irregularities. An ice pack can be applied to the treated area to reduce swelling and discomfort.

Upper face

For upper face rejuvenation, botox remains the cornerstone of treatment.⁸⁸ Wrinkles that cannot be totally eliminated by chemodenervation therapy can be treated with hyaluronic acid fillers.

Glabellar lines

Tissue fillers can be used for the treatment of deep glabellar furrows, and hyaluronic acids are the treatment of choice. The authors recommend hyaluronic acid of small particle size (Restylane) or the less cross-linked homogeneous hyaluronic acid (Juvederm Ultra).

The filler is implanted in this area by serial puncture or linear threading technique without overcorrection. Care must be taken when injecting this area. hyaluronic acid filler should be applied superficially to minimize the risk of cutaneous necrosis caused by occlusion of the supratrochlear arteries.

Forehead lines

Repeated motion of the frontalis muscle produces horizontal rhytides. Botulinum toxin injections are an effective treatment modality. Non-dynamic wrinkles are the result of underlying tissue loss, and a filler replenishes this lost tissue volume.

Forehead lines that qualify for filler correction are superficial. Small particle size or the less cross-linked homogeneous hyaluronic acid (Juvederm Ultra) are recommended, and at times the authors dilute these to produce a less robust filler. Injections are performed via a 32-gauge needle. The horizontal lines are injected by the serial puncture technique.

Brow ptosis

An aesthetic brow position is above the superior orbital rim in females and along the orbital rim in males. Palpation of the orbital rim helps to differentiate between eyebrow ptosis and excess skin in the upper lid. A brow lift can be achieved with botox injection. Patients that still presenting brow ptosis after chemodenervation therapy can benefit from hyaluronic acid fillers injected just below the body and tail of the eyebrow using a fanning technique. In general, injections are made parallel to the

brow. Avoid injection below the inferior margin of the superior orbital rim, and in areas between 1.5 cm and 2.7 cm lateral to midline of the glabella (supratrochlear and supraorbital arteries territory). Lambros reported results lasting two years or more with hyaluronic acid injected in to the brow.⁹²

Mid-face

Periorcular area

The periorcular rhytides that extend inferiorly into the upper cheek are the most favorable place for hyaluronic acid injections.⁹³ These wrinkles are difficult to treat with botox because ptosis of the oral commissure can be a major side effect if the toxin diffuses into the levator labii superioris/zygomaticus muscles. Fines lines should be injected using the serial puncture technique, with small particle or less cross-linked hyaluronic acid.

Tear trough/nasojugal groove

This is an area that should be addressed with caution and only by physicians with advanced experience. As the skin is thin and high vascularity is present in this area bruising and swelling can be an issue.

Among the causes of infraorbital dark circles is volume loss in the underlying fat pads and a visible prominence of the subcutaneous vascular plexus.⁹⁴ Therefore hyaluronic acid fillers injected into the tear troughs may correct them. Patients with pre-existing inferior eyelid edema are not good candidates.

Deposits of hyaluronic acid should be deep into the cutaneous tissues to avoid a Tyndall effect. An anterograde serial deposit injection technique is the most advisable. It is imperative not to overfill this area as the result will be cosmetically unacceptable and appear edematous or lumpy. Some injectors prefer to deposit the material directly on the periosteum of the zygomatic and infraorbital bones.

Nasolabial folds

The nasolabial folds are the lines from the nasal ala to the oral commissures. With age they become deeper and longer, especially as atrophy of the fat pads in the cheeks progresses. Two points should be considered prior to injection.

I. A slight nasolabial fold is present even in young faces. Some nasolabial folds do not require correction, and overcorrection can result in a “simian” appearance.

II. Evaluate the patient’s cheek area, because the origin of the nasolabial fold may be pseudoptosis of the cheeks, whereby the loss of volume in one area leads to the development of folds in a neighboring area.⁹⁵

Injection techniques for the nasolabial folds include a retrograde fanning technique, linear retrograde threading technique and serial anterograde deposition. Depth of injection varies based on depth of the folds.

Cheeks

Tissue loss in the cheeks can be result from normal aging, weight loss, and/or medications such as those used to treat HIV. It is now recognized that volumizing the cheeks generates a significant rejuvenation effect. The absorption and descending movement of the fat pads leaves a cheek depression. By adding volume to the sunken mid-face (Figure 35.12), a great lifting effect can be achieved, which reduces the severity of the nasolabial fold, and lifts the corners of the mouth.⁹⁵

The more robust filler formulations such as Perlane and Juvederm Ultra Plus are employed via serial puncture or linear threading techniques in the lower dermis/subcutaneous tissues.

Lower face

Lip augmentation

With age, the lips undergo a decrease in vermillion border definition, a decrease in fullness, inversion of the vermillion, and a lengthening of the cutaneous portion of the upper lip. Hyaluronic acid fillers are ideal for correction of these undesirable features.

To redefine the vermillion border producing a natural contour of the lip, the serial puncture anterograde technique is used (Figure 35.13). For replenishing mucosal lip atrophy, a robust hyaluronic acid filler can be utilized using a serial puncture depot technique at the wet/dry border of the body of the lip (Figure 35.14). The most robust formulations provide for longer lasting results.⁹³

Marionette lines

The marionette lines are a consequence of facial aging and form as curvilinear wrinkles extending downward from the oral commissures to the jawline. The downward

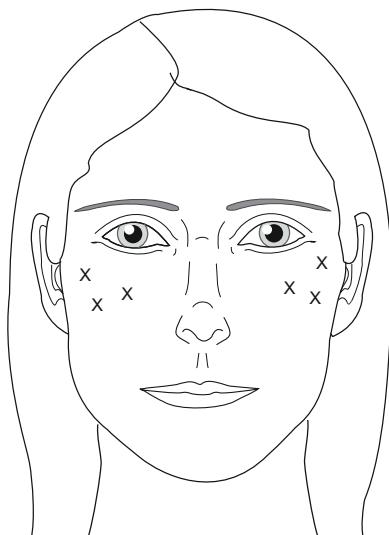


Figure 35.12 Points of injection to volumizing the cheeks. Deep depot injection technique.



Figure 35.14 Illustration of the areas of fullness designed to create a "triangle of fullness" in the body of the upper and lower lips. These are the areas that fillers should be injected for lip augmentation.



Figure 35.13 Technique suggested to redefining the vermillion border.

turn of the oral commissures is also present. The etiology of marionette lines is unclear, but they are probably related to depressor anguli oris muscle hyperactivity, the effects of gravity, bone resorption, and fat absorption.

Hyaluronic acid fillers can be injected by serial puncture and/or cross-hatching techniques while elevating the

affected area with the non-injecting hand before implantation of the material. This helps visualization of the treatment area.

Radial perioral rhytides

The repetitive muscular actions of the orbicularis oris and volume loss contribute to the radial perioral rhytides (so-called smokers' lines or lipstick lines).

Restylane or Juvederm Ultra diluted with 0.4 mL of 0.9% sodium chloride solution is the preferred method of correction, and is injected with a 32-gauge × 0.5 inch using the thorough micropuncture technique.

Complications

In general, hyaluronic acid fillers are well tolerated by patients. Adverse events are commonly mild, transient, and limited to the site of injection including bruising, redness, edema, and pain. Persistent swelling, nodule formation, migration of product, skin discoloration, allergic reactions, and granulomatous reactions are uncommon. Injection necrosis is a rare complication.^{96–99} It can be attributed to an interruption of vascular supply due to external compression or frank obstruction of vessels by direct injection of the material into a vessel.⁹⁸

Prevention and management of complications

To mitigate the risk of complications, proper patient and material selection for specific indications is crucial. Also, remember the fill with caution in the following anatomic sites:

- I. supratrochlear artery: approximately 2.7 cm lateral to midline of the glabella
- II. supraorbital artery: approximately 1.7 cm lateral to midline of the glabella
- III. angular artery: where nasolabial fold meets nasal ala
- IV. superior and inferior labial arteries.

It is recommended to aspirate before injecting, especially in these areas.

Hyaluronic acid fillers can easily be removed whenever the practitioner and patient consider necessary by injecting commercially available hyaluronidase (Vitrase; ISTA Pharmaceuticals, CA).^{97,100,101} Hyaluronidase is a soluble protein enzyme that acts at the site of local injection to break down and hydrolyze hyaluronic acid.

Mariano Busso expresses appreciation to Sally Sherwood (New York City) and David J Howell, PhD (San Francisco) for their editorial contributions on behalf of this chapter.

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Video list

Video 35.1 Calcium hydroxylapatite mixing with lidocaine

Video 35.2 Hand augmentation with a bolus of calcium hydroxylapatite

Video 35.3 Blending massage after bolus of calcium hydroxylapatite

Permanent fillers: liquid silicone and polymethylmethacrylate

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Liquid silicone

Liquid silicone (LIS), an inert and biocompatible synthetic polymer, was first used as an injectable filler in the 1950s. Before collagen-type injectable fillers became available in the early 1980s, LIS was the injectable filler of choice. However, there was no standardized FDA-approved LIS, and different products of varying purity were often injected in large bolus form, which led to frequent product migration. Many products were intended for industrial rather than *in vivo* use, and impurities led to frequent foreign-body reactions. Subsequently, in the early 1990s, all forms of silicone for cosmetic implantation were banned by the FDA, citing possible toxicity and systemic reactions related to LIS and silicone breast implants.¹

After a lengthy review, the FDA resolved safety issues regarding implantable silicon and LIS, and in the 1990s, two new forms of highly purified LIS were approved (Silikon-1000 in 1997 and Adatosil-5000 in 1994) for use as an injectable intraocular implant to treat retinal detachment. Although this is the only FDA-approved indication for LIS, the FDA Modernization Act of 1997 makes off-label uses legal, provided that the physician or drug manufacturer does not advertise for such use. Therefore LIS may now legally be used off label for soft-tissue augmentation. Compared with Adatosil, Silikon-1000 has a lower viscosity and is the most suitable for injectable soft-tissue augmentation, as it is easier to inject through smaller gauge needles.¹

Mechanism of action

After LIS is injected, a capsule of new collagen develops to encircle each microdroplet of silicone. This process continues for about 3 months, during which time the collagen capsule adds volume around the LIS microdroplet. The collagen also holds the droplets in place to prevent migration.¹

Indications

Although LIS is used off-label for many indications, it is the author's opinion that LIS should not be routinely employed for the average cosmetic patient until longer term studies with current products resolve some of the controversy regarding longer term safety and efficacy. However, for the unique and disfiguring defects associated with HIV facial lipoatrophy and serious acne scarring, LIS often produces cosmetically superior and more durable results than currently available less permanent options.

Efficacy and safety

LIS has been demonstrated to be an excellent choice for HIV-associated facial lipoatrophy (Figures 36.1 and 36.2). In one trial, highly purified 1000-cSt silicone oil was studied among 77 patients with HIV facial

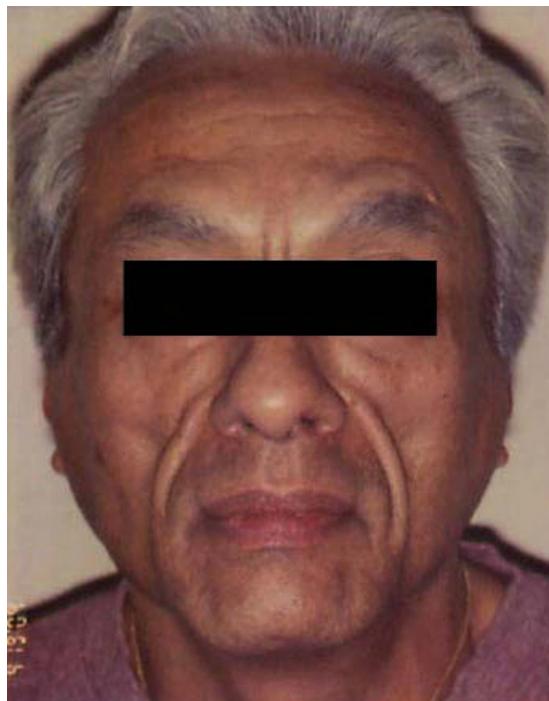


Figure 36.1 Pretreatment HIV, stage 3 HIV-related facial lipoatrophy.

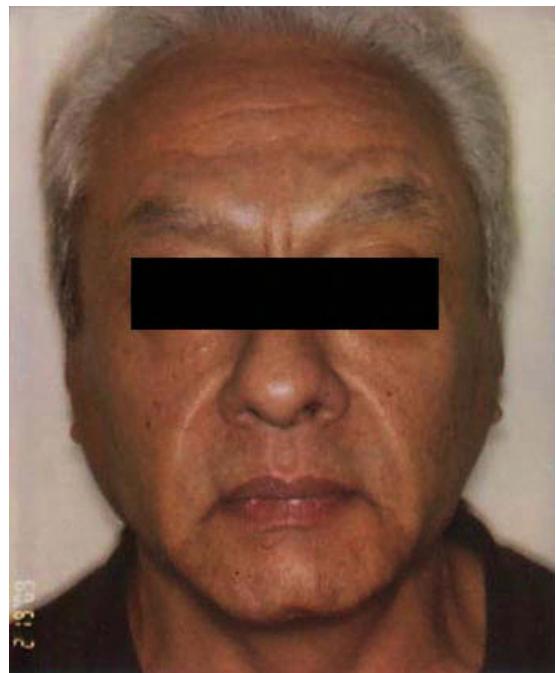


Figure 36.2 After treatment with greater than 30 mL of liquid injectable silicone (Silikon-1000) utilizing microdroplet technique with serial monthly treatments with 2 mL per treatment.

lipoatrophy who received 2 mL of Silikon 1000 at monthly intervals using the microdroplet technique until optimal correction was achieved. The researchers reported that the number of treatments, amount of silicone, and time required to reach optimal correction were directly related to the initial severity of lipoatrophy and that highly purified 1000-cSt silicon oil is a safe and effective treatment option for HIV-associated lipoatrophy² (Figure 36.1). Five-year data are now available on this cohort and no serious or untreatable adverse events have been found (D. Jones, data on file).

Using the microdroplet, multiple-injection technique, Barnett and Barnett³ also have had success with injections of LIS for acne scars lasting over a 10-, 15-, and 30-year follow-up period (Figure 36.3a,b).

🕒 Technique (Video 36.1)

The most appropriate LIS for off-label soft-tissue augmentation is Silikon-1000 (Alcon, Fort Worth, TX)

(Figure 36.4); 5000-cS Adatosil (Bausch & Lomb, Rochester, NY) may also be used off label, but proves to be rather viscous as a soft-tissue filler. Immediately prior to treatment, 0.5 mL of LIS is drawn through a 16-gauge Nokor needle into a 1 mL Becton Dickinson (BD) Luer-Lok syringe using sterile technique (Figure 36.5). LIS is most easily injected through a 27-gauge 0.5-inch (1.27 cm) Kendall Monoject aluminum hub needle. Plastic hub needles tend to pop off with the higher injection pressures needed for injection through smaller gauge needles. To increase injector comfort, 0.5 inch (1.27 cm) inner diameter rubber electrical bushings purchased from a hardware store may be sterilized and placed over the barrel of the syringe to cushion the physician's second and third finger during injection (Figure 36.6).

As with all fillers, patients should avoid aspirin, non-steroidal anti-inflammatory drugs (NSAIDs), and anticoagulants for 7–10 days prior to injection. Perhaps more than with any other minimally invasive procedure, a thorough discussion regarding the risks, benefits, and alternative treatments to LIS should occur and be



Figure 36.3 Long-term correction of facial acne scarring with liquid injectable silicone. (a) Pretreatment (courtesy of Jay G. Barnett, MD. and Channing R. Barnett, MD); (b) 30-year follow-up (courtesy of Jay G. Barnett, MD. and Channing R. Barnett, MD).



Figure 36.4 Silikon-1000.



Figure 36.5 Instrumentation.



Figure 36.6 Assembled instrumentation.



Figure 36.7 Pretreatment markings.

documented prior to injecting LIS. Patients must understand that LIS is a permanent filler and must understand that it is being used off-label. Written informed consent must be obtained.

High quality pretreatment photographs should be taken. Make-up is removed, and the skin is washed with an antibacterial cleanser and prepped with a povidone-iodine antiseptic or other surgical preparatory solution. Areas to be injected are outlined under good lighting with the patient in a sitting position, using a fine-tip marking pen (Figure 36.7). Target areas for volume restoration should be marked in both the smiling and resting position, as these often change remarkably with facial activity. When treating HIV facial lipoatrophy, mid-malar depressions often become slightly elevated on smiling, and overcorrection of this area may result in a “chipmunk” appearance when the patient smiles. A topical anesthetic such as lidocaine or other topical amide mixture is then placed on the treatment area and wiped off after 30 minutes with clean gauze.

LIS should only be injected by the microdroplet serial puncture technique. Other injection techniques risk undesirable consequences, including pooling or beading of silicone macromolecules in the injection tract and possible migration via escape from the anchoring fibroblas-



Figure 36.8 Dermal erythema and ridging secondary to intradermal injection.

tic capsules. A microdroplet is defined as 0.005–0.01 mL of product, an amount that possesses a very large surface area compared with volume. A larger surface area to volume ratio effectively allows the microdroplet to be anchored into place by the ensuing fibroplasia that occurs around it. With larger macromolecules, defined as >0.01 mL, encapsulation may not be sufficient to prevent product migration.

Injections are made into the immediate subdermal plane or deeper. Often, as the needle enters the subdermal plane, there is a slight give in the tissue resistance to the needle. Except for certain cases of dermal scars, intradermal injection should be avoided, as it may result in dermal erythema and ridging (Figure 36.8). Care should be taken to make sure that the needle is in the subdermal plane prior to depressing the plunger. Furthermore, the injector's thumb should be removed from the plunger prior to removing the needle. Injections should be placed at 2- to 5-mm intervals along the skin surface at the optimal angle for penetration and deposition into the subdermal plane. As a rule, multiple passes over the same treatment area in a single session should be avoided, although experienced injectors may sometimes make a second pass at a different subcutaneous level. Per-session treatment volumes should be limited to 0.5 mL for smaller surface areas such as the nasolabial fold, and no more than 2.0 mL for larger surface areas such as facial lipoatrophy.

Moreover, injection sessions should be spaced at least 1 month apart, or longer, to allow for a limited fibrous

tissue reaction to occur around each silicone microdroplet. As with all fillers working mainly by fibroplasia, intentional overcorrection immediately following injection should be avoided. As optimal correction approaches, treatment intervals should be extended to allow complete deposition of fibrous tissue prior to the next injection.

Prevention and management of complications

When injected with the appropriate technique, LIS is remarkably similar in texture and sensation to natural soft tissue. However, when larger cumulative volumes are employed, such as in HIV facial lipoatrophy, the treated area may occasionally feel slightly rubbery and firmer than natural soft tissue. Migration of LIS is an often-mentioned and undesired side effect of LIS. Using small volumes over multiple treatment sessions with the microdroplet technique avoids this problem, as microdroplets of silicone are anchored to the surrounding soft tissue by fibroplasia. However, LIS may track along tissue planes in the path of least resistance when injected in large boluses all at once.¹

Skin dyschromia is a rare side effect of LIS, occurring most often when LIS is inadvertently injected into the dermis. When the inflammatory response to LIS extends into the dermis, postinflammatory erythema, postinflammatory hyperpigmentation, and telangiectasias may occur. Often, dermal ridging occurs in conjunction with the dyschromia. Erythema and telangiectasia may be treated with a pulsed dye laser or intense pulsed light device. Hyperpigmentation may be treated with hydroquinone and sun protection. Dermal ridging may improve with intralesional steroid injection, but the response is often incomplete and the problem persistent.¹

A more concerning potential adverse event to LIS is granuloma formation, presenting as edematous, inflamed, indurated nodules or plaques in the subcutis or dermis. Such reactions have been described with LIS and a variety of other permanent or longer lasting fillers such as polymethylmethacrylate and polylactic acid. These reactions are thought to be immune mediated, yet the basis of the immune mechanism remains unclear. It has been postulated that granulomatous reactions may be a result of infection at a distant site, as granulomatous reactions

to LIS have been noted to appear with acute bacterial dental abscesses or sinusitis and to resolve upon treatment of the infection. Another leading and perhaps complementary theory is that bacterial biofilm formation around the LIS microdroplet may serve as a nidus for a chronic infection and resultant inflammatory host response. Biofilms may occur if bacterial organisms are introduced upon filler injection or seed the filler later during bacteremic episodes, and once present may remain dormant for months or years on foreign body surfaces such as implanted LIS. Biofilms may serve as a target of a delayed immune response by the patient when organisms convert back to a planktonic state, explaining the potential for granuloma formation years after LIS injection. It is estimated that some fraction of 1% of patients correctly treated with injectable grade LIS may eventually develop such granulomatous reactions.⁵ Should granulomatous reactions develop, they may be treated with high concentrations of intralesional triamcinolone (20–40 mg/mL) at 2- to 4-week intervals. However, based on the biofilm hypothesis, institution of a full dose, broad-spectrum antibiotic such as minocycline once or twice daily should also occur. Isotretinoin, intralesional injection of 5-fluorouracil, etanercept, and topical imiquimod have also been used successfully to treat LIS granulomas. Ultimately, however, granulomas that fail to resolve may require surgical removal.¹

Polymethylmethacrylate

Injectable polymethylmethacrylate (PMMA, ArteFill, Artes Medical, San Diego, CA) is a suspension of 20% PMMA smooth microspheres and 80% bovine collagen. ArteFill is the product of third-generation PMMA microsphere technology. Previous generations include Arteplast (used in Germany from 1989 to 1994) and Artecoll (used worldwide, except in the United States and Japan, from 1994 to 2006). Artefill represents a third-generation product containing fewer nanoparticles (less than 20 µm), which were thought to be associated with granulomatous reactions observed with previous generations. ArteFill was approved by the FDA in 2006 for the correction of nasolabial folds. Artes filed for Chapter 7 bankruptcy in December 2008, and was subsequently acquired by Suneva, Inc (San Diego, CA), who now distributes the product in the United States.



Figure 36.9 Artefill correction of the nasolabial fold.

Mechanism of action

After PMMA is injected, the collagen vehicle is absorbed within 1–3 months. Afterward, foreign body neocollagenesis ensues which engulfs and encapsulates the remaining estimated 6 million PMMA particles in 1 mL of ArteFill. This process of fibroplasia also contributes to tissue augmentation. Although the collagen is absorbed, the PMMA is permanent and not reabsorbed.

Indications

Injectable PMMA is indicated for nasolabial folds. It is also been used off-label for glabellar frown lines, radial lip lines, and mouth corners.

Injectable PMMA is contraindicated for use in patients with a positive result to the required ArteFill skin test, patients with severe allergies (as indicated by a history of anaphylaxis or multiple severe allergies), patients with known lidocaine hypersensitivity, patients with a history of allergies to bovine collagen products, and patients with known susceptibility to keloid or hypertrophic scarring.

The product should not be used for lip augmentation or in thin-skinned areas such as tear troughs.

Efficacy and safety

The US pivotal clinical trial for ArteFill was a controlled, randomized, prospective, double-masked trial of 251 patients at eight centers across the United States. Patients received either ArteFill or bovine collagen dermal filler (control). Efficacy was rated by masked observers using a photographic Facial Fold Assessment Scale. The study

demonstrated a significant improvement with ArteFill compared with the control group at 6 months ($p < 0.001$) in nasolabial folds. A subset of patients was observed at 12 months and all showed persistent wrinkle correction.⁴

A subgroup of 69 patients returned for follow-up 4–5 years later. Investigator Facial Fold Assessment ratings at 4 or 5 years were improved from baseline by 1.67 points ($p < 0.001$) (Figure 36.8). Nearly all subjects (95.5%) reported that they were at least somewhat satisfied and 81.8% reported that they were either satisfied or very satisfied.⁶ (Figure 36.8).

Five patients reported six late adverse events that occurred from 2 to 5 years after the initial injection. Of these, four were mild cases of lumpiness, and two were severe. The total number of late, adverse events was six of 272 (2.2%) of wrinkles injected.⁶

Granulomatous reactions (manifested by inflamed red nodules), which were more common with previous generations of Artefill, may be treated with intralesional cortisone combined with antibiotic therapy.

Technique

Injectable PMMA is placed into the dermal–subcutaneous junction using the tunneling or linear threading technique with a 26-gauge, 5/8-inch needle. Overcorrection is not recommended. It is preferable to inject more deeply as superficial injection can cause permanent skin surface texture or color impairment.

Patients should be evaluated 4–6 weeks after the injection to assess the need for further treatments. Optimal correction usually requires two or three treatments, and

touch-up implantations should be at intervals of at least 2 weeks or longer depending upon the amount of implant used, the site of placement, and the dynamics of the corrected sites.

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Video list

Video 36.1 Silikon-1000 for HIV facial lipoatrophy

Cosmetic dermatologic surgery in ethnic skin

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Introduction

Cosmetic dermatologic surgery remains much the same for both ethnic and Caucasian skins. We have chosen to describe surgical procedures that we routinely perform with cosmetically satisfactory outcomes.

However, the ethnic skin has special considerations as it is more prone to postinflammatory hyperpigmentation (PIH) and scars. Ethnic skin includes a range of skin types that characterize individuals with darkly pigmented skin, including persons of African, Asian, Latino, Native American, and Middle Eastern descent. They constitute the majority of the world's population.¹

People with skin of color are found in increasing numbers even in countries and places with a predominant Caucasian population. In the United States alone, it is estimated that 50% of the population will be made up of persons of color by 2050.² Hence, dermatologists need to recognize clinical differences and learn to manage procedures in ethnic skins.

Evaluation of the ethnic patient

- I. History of atopy, diabetes, thyroid, etc.
- II. Current medications:
 - a. anticoagulants: coumadin, heparin, aspirin, clopidogrel, ticlopidine, dipyridamole

b. supplements: vitamin E, tocopherols, garlic, ginseng, ginger, gingko, St John's Wort

c. isotretinoin

III. Allergies: contact or systemic; especially local anesthetics

IV. Herpes simplex virus (HSV)

V. Bleeding/keloid tendency

VI. Lifestyle: alcohol, tobacco, sun/dust exposure, etc.

VII. Family history: pigmentation, scarring

VIII. Routine cosmetics

IX. Written consent

Preoperative care

- I. Avoid harsh cosmetics
- II. Use sunscreen with adequate UVA and UVB protection
- III. Use of skin lightening agents like hydroquinone, kojic acid, arbutin, etc., for at least 2 weeks prior
- IV. Oral antibiotics as required

Postoperative care and follow-up

- I. Topical antibiotics
- II. Ice packs
- III. Appropriate dressing

- IV. Regular follow-up
- V. Silicon and skin lightening topicals as soon as wound heals
- VI. Avoid sun exposure
- VII. Sunscreens

Complications

- I. Bleeding
- II. Infection
- III. Activation of HSV I
- IV. Hyperpigmentation
- V. Hypertrophic scars/keloids

Dimpleplasty

- I. Day procedure under local anaesthesia
- II. Plan the location of the dimple along with the patient
- IV. The point of intersection of a line dropped vertically down from the lateral canthus to the mandible and the line drawn from the angle of the mouth to the tragus is the optimum point, i.e., there are fewer chances of injury to underlying structures like nerves
- V. Inject lignocaine 2% with adrenaline at and around the marked spot
- VI. Pass a needle through this spot as a marker
- VII. Through the mouth excise a small cuff 4–6 mm of mucosa with underlying muscle
- VIII. A double stitch of 2-0 vicryl is passed through the muscle to the dermis at the marked spot to tether the muscle to the skin
- IX. Close the buccal mucosa with 2-0 vicryl

Postoperative care and follow-up

- I. Advise excess movement to help resolve edema
- II. The dimple appears at rest and in animation for 6–8 weeks. Later it shows up only on animation and as a part of natural facial expression.³

Complications

- I. Persistent swelling
- II. Asymmetry
- III. Knot dissolves too early and dimple disappears: can be redone
- IV. Rarely facial nerve damage

Sebaceous cyst

Narrow hole excision technique (NHET)⁴

Advantages

- I. No linear scar, barely a tiny dot
- II. Simple, safe, and time saving

Techniques

- I. Identify the punctum
- II. Infiltrate 2% lignocaine with adrenaline around the punctum area
- III. Using an Ellman radiosurgery equipment, set at 3 with the needle attachment, stab the punctum, and slightly widen the aperture. Applying gentle pressure around the cyst, squeeze out the sebum.
- IV. Pass a thin curette into the aperture and scrape around the cyst wall to express more sebum and the cyst wall, which pops out with this manoeuvre
- V. Hold the cyst wall firmly with a forceps while applying pressure around the periphery and extract the entire wall. Should there be adhesions gently cauterize them to release the wall *in toto*. This is an almost bloodless procedure
- VI. Apply antibiotic cream to the area and give a pressure dressing for 48 hours

Postoperative care

- I. Change dressing after 48 hours, and after 5 days (Figure 37.1a,b)

Xanthelasma

Step-by-step surgical technique (upper and lower eyelids)⁵

It is a modified blepharoplasty technique where only the required lesion is excised.

- I. Gently pinch the xanthelasma with non-toothed forceps, making sure there is enough skin, to resuture after excision to avoid lagophthalmos
- II. Mark the lesion
- III. Infiltrate 2% lignocaine with adrenaline all around the lesion
- IV. Using an Ellman RF needle in cutting mode, cut along the marked area elliptically

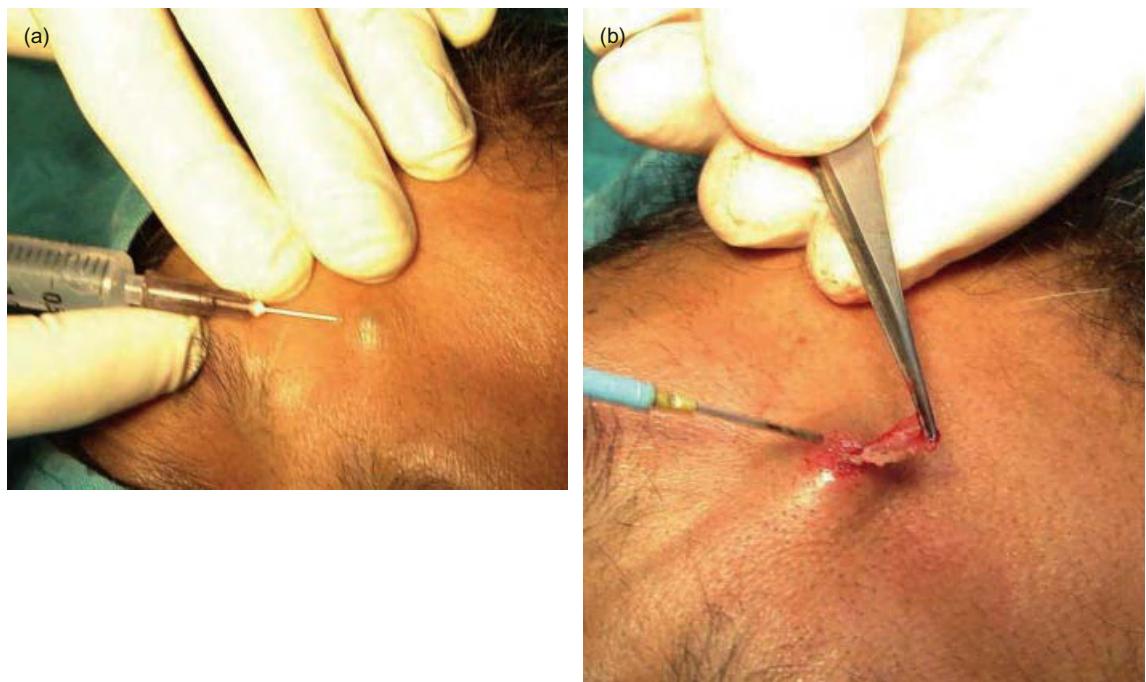


Figure 37.1 (a) Sebaceous cyst before removal; (b) sebaceous cyst being removed.

V. Lift one end off the ellipse and cauterize the xanthelasma (distinctly yellow) while separating from the underlying tissue

VI. Maintain hemostasis

VII. Suture back the elliptical incision with a running stitch using 6-0 Prolene suture material

VIII. Apply antibiotic cream and a small dressing

II. Fractional laser can be used for multiple lesions at settings not exceeding 1000 mJ/cm^2 and not more than two or three passes (Figure 37.3a,b)

Syringomas

For ethnic skin, two to four sittings of fractional laser works best. The dose and procedure should be followed as for freckles. Eye shields are necessary.

Postoperative care

I. Change dressing after 48 hours

II. Suture removal after a week

Complications

I. Gaping of wound

II. Lagophthalmos if too much skin is excised (Figure 37.2a,b)

Ephelides/lentigenes

Step-by-step surgical technique

I. Electrocautery: For ethnic skin, very low voltage is required

Acrochordons

I. Apply EMLA 1 hour prior

II. Smaller sessile lesions: electrodessication

III. Smaller and larger pedunculated lesions: electrodessication followed by snipping

IV. Antibiotic ointment two to three times a day until crusts fall off



Figure 37.2 (a) Xanthomas before surgery; (b) xanthomas after surgery.



Figure 37.3 (a) Ephelids before treatment; (b) ephelids after fractional laser treatment.

Vitiligo

Vitiligo can be devastating socially in Asian and caucasian skin.

Indications

- I. Failure of medical treatment, in lesions stable for 2 years
- II. The basic principle of the surgery is to transplant autologous melanocytes from pigmented to non-pigmented vitiliginous skin. The techniques used are listed:

Grafts

- I. Tissue grafts: minipunch, suction blister, thin split thickness

- II. Cellular grafts: non-cultured cell suspensions/ cultured melanocytes

Non-grafting techniques

- III. Lasers, micropigmentation and dermabrasion
This chapter deals with commonly used techniques:⁶⁻⁸

- punch grafting
- split thickness grafting
- blister grafting.

The following are the same for all three techniques:

- Donor site: the gluteal region, the anterolateral aspect of thigh or medial aspect of upper arm
- The donor and the recipient sites are shaved and surgically prepared with cetavlon, spirit and povidone iodine

- After healing, all recipient areas are exposed to sunlight directly or treated with PUVA/PUVASOL. Complete repigmentation may take 2–3 months

Punch grafting

Donor site

- I. Anesthetize the donor area by raising a wheal of approximately 2- to 3-inch (5–7.5 cm) square with 1% lignocaine with adrenaline. A wider area may be used if the recipient site is larger.
- II. Rotate the 2.5-mm biopsy punch over the anesthetized area until the upper dermis is reached. Take as many punches, 1–2 mm apart, in parallel rows, as your recipient site may need and about 10 more in case of loss. In a 2- to 3-inch (5–7.5 cm) square area you may get about 20 grafts. Lift the epidermis gently and cut through the upper dermis to free the grafts. Place them in a sterile steel bowl over a saline soaked gauze.
- III. Hemostasis is achieved by pressure. Antibiotic cream and a firm tulle gauze elastocrepe dressing should follow.

Recipient site

- I. Anesthetize area with 1% lignocaine with adrenaline.
- II. Rotate the 2-mm punch in this area, cutting up to mid-dermis, 5–10 mm apart, depending on size and shape of lesion to be grafted. Discard this tissue leaving little “wells” behind.
- III. Fill these wells with the donor grafts already taken, the dermal side down.
- IV. Firm pressure, antibiotic tulle gauze and elastocrepe dressing completes the procedure.
- V. Should the dressing get soaked, it may be changed after 48 hours. At this time, if any grafts have shifted they can be put in place again. Any leftover donor grafts should be saved refrigerated in sterile condition. They remain viable for 48 hours. If some grafts are lost, then these areas could now be filled with the saved tissue. The next dressing is after 8–10 days. Oral antibiotics and anti-inflammatory drugs must be given.

Complications

- *Donor site:* Scarring and rarely small area of depigmentation.
- *Recipient site:* Failure to “take” in some grafts. There may be an unacceptable “cobblestone” look.

- Advantages: it is simple, even for post-burn leucodermic areas with satisfactory outcomes.

Split-thickness grafting

- *Donor site:* Select and anesthetize the donor area. Apply KY jelly over the site, to lubricate and reduce drag. Stretch the donor area with one hand. Cut through the skin with a Humby's knife or Davols dermatome. Take thin tangential slices up to upper papillary dermis depth, with a to-and-fro motion as required. Keep these sheets on sterile saline soaked gauze. Dress with an antibiotic tulle gauze and elastocrepe.
- *Recipient site:* Infiltrate 1% lignocaine with adrenaline in the four quadrants up to deep dermis and subcutis level, of the vitiliginous skin.
- Dermabrade the area with a diamond fraize electrical instrument, or a manual dermabrader until you find freely bleeding pinpoint bleeders. Feather into the surrounding skin. Cover the raw area with saline soaked gauze .
- Spread the slices of skin taken over the denuded skin with dermal side down. Dress with tulle gauze and pressure with elastocrepe to keep the graft in place. Immobilize the area. Grafts take in 10 days. Even if the grafts peel off, the melanocytes do get transferred onto the abraded skin. PUVA/PUVASOL initiates further pigment recovery.

Suction blister technique

Applying suction to the donor site for 2–3 hours produces a blister at the dermo-epidermal junction. The blisters are then cut and transferred to the dermabraded or laser ablated vitiliginous recipient site.

Donor site

- I. Infiltrate 1% lignocaine with adrenaline
- II. A suction cup/syringe is inverted and connected to a three-way connector
- III. Suction is then applied with a 50-mL syringe and is monitored on the vacuum gauge to maintain a negative pressure of 250–350 mmHg for 1–2 hours till the blisters are formed. Disconnect cups/syringes
- IV. Multiple suction cups/syringes can be used for larger areas
- V. The blister is cut all along its border with the curved iris scissors and its roof is everted over a glass slide smeared with an antibiotic cream



Figure 37.4 Suction blister cup.



Figure 37.5 Suction machine.

VI. Spread the graft over a glass slide with the help of jeweler's forceps

Recipient site

- I. Prepared as for the split thickness graft
- II. Invert the glass slide with the graft on the dermabraded area with the dermal surface of the graft in contact with recipient site
- III. Spread the graft with overlapping borders and secure with cyanoacrylate adhesive
- IV. Both donor and recipient sites are dressed with tulle gauze. Immobilize for 7 days
- V. For the lip area a surgical glue and then antibiotic ointment are applied without dressing. Liquid diet is advised (Figures 37.4 and 37.5)

Complications

- I. Scarring at both donor and recipient sites
- II. Failure to recover pigment uniformly
- III. Perigraft halo of depigmentation
- IV. Donor site vitiligo
- V. Graft rejection

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4

PART 4

Lasers

Laser for treatment of vascular lesions

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Preoperative care

- Assess the patient with a clinical examination. Special attention should be made to a history of hypertrophic or keloid scars, HIV other infectious diseases, bleeding diatheses, or any medication that could cause prolonged bleeding.
- The composition, structure, and nature (congenital/acquired) of the lesion(s) should be evaluated prior to treatment.
- In some instances, the mixed nature of some lesions will require changes to the laser parameters or the use of multiple lasers.
- Realistic expectations have to be discussed with the patient or patient guardians, including the number of treatments, the potential adverse events, and the possibility of incomplete clearance.
- It is important to capture pretreatment digital photographs at baseline to demonstrate progress.

Anesthesia

- Many of the patients will not require anesthesia.
- If indicated for certain patients, apply a thick layer of topical anesthetic under occlusion for 60 minutes.
- Consider local infiltration and nerve blocks in patients with low pain thresholds. Epinephrine should be avoided, if possible, so that the blood vessels that are targeted by the laser do not become constricted.

- Premedication with a mild sedative or analgesic can be helpful for anxious patients.
- General anesthesia or conscious sedation is controversial; however, it may be a good option in pediatric patients with congenital vascular lesions because multiple passes may be required. In these instances, an anesthesiologist may provide anesthesia using mask inhalation. If a mask is used, be cautious of any gas escaping to avoid ignition by laser radiation. The mask and its apparatus should not have any reflective material on it to prevent the laser beam from being reflected towards unwanted targets.

Laser safety

- Appropriate wavelength-specific safety goggles must be worn by all personnel in the treatment room.
- Corneal shields inserted with the aid of ocular anesthetic drops are essential when treating periorbital areas. Make-up should be removed prior to treatment to avoid flash fires. If any alcohol is used prior to the laser treatment, it should be allowed to dry completely.

General considerations

- Set realistic expectations with the patient. Lesions that are dermatomal or centrofacial are slower to respond to laser treatment. Additionally, lesions on the distal extremities respond slower than those on the trunk.
- In general smaller vascular lesions respond better, with a 67% decrease in post-treatment size for those

under 20 cm² compared with a 20–25% decrease in those over 40 cm².

Patients on oral isotretinoin therapy should wait at least 6 months following discontinuation before pulsed dye laser (PDL) treatments are undertaken in order to avoid the risk of scar formation.

Step-by-step procedure for port wine stains

I. Put the patient in the Trendelenburg position to increase the blood vessel diameter. The dilatation is thought to increase the chromophore target.

II. Adjust the setting of the PDL appropriately according to the size of the vessels that will be treated:¹

a. Fluence: 5–8 J/cm²(depending on skin type) for initial treatments

b. Pulse duration: 0.5–3 ms

c. Spot size 7–10 mm

d. Cryogen spray cooling is in the range of 30–50 ms (reduce the spray duration to 20 ms when treating darker tones to avoid the risk of dyspigmentation and blister formation)

III. Hold the handpiece perpendicular to the skin, with the attached spacer resting on the skin.

IV. Delineate the borders of the lesion with a marking pen prior to treatment to avoid skipping any portion of the lesion.

V. Treat the edges of the port wine stain (PWS) first to avoid the development of an erythematous flare that could obscure the view of the full lesion.

VI. During the treatment, overlap pulses by approximately 10–20% to avoid skip areas.

VII. Direct overlapping or pulse stacking at vessel-rupturing doses should be avoided during the first pulse to prevent non-specific collateral damage derived from extravasated hemoglobin.

VIII. The immediate clinical end point of treatment is a transient intravascular purpura, also known as coagulum. Whitening or grey coloration of the treatment area should be avoided, which indicates impending blistering that may potentially result in scarring.

IX. PWSs that are resistant to the 585 nm PDL may respond to longer PDL wavelengths.

X. Increasing the wavelength to 595 nm or 600 nm moves away from the hemoglobin absorption peak at 577 nm.

Higher fluences can be used with longer wavelengths. The longer pulse duration targets larger blood vessels because the thermal relaxation time in seconds is proportional to the square of the target's diameter in millimeters.

Step-by-step procedure for telangiectasias and spider angiomas (Videos 38.1 and 38.2)

I. Test spots are not necessary.

II. Assessment of the patient is carried out on a similar basis as mentioned in preoperative considerations steps 1 and 2.

III. An elliptical spot may be useful for treatment of linear telangiectasias, while a conventional circular spot may be useful for non-linear lesions.

IV. The 585 nm PDL with a pulse duration of 0.45 ms and the 595 nm PDL with a pulse duration of 1.5 ms are more commonly used for treatment of telangiectasias.

V. A larger spot size means a smaller fluence can be used, and vice versa.

VI. The immediate endpoint is similar to that in the treatment of a PWS, namely vessel coagulation with blanching, followed by purpura.

VII. Whitening or blistering are signs of epidermal damage and should be avoided.

VIII. Subpurpuric doses can be achieved by setting the pulse duration at 10–20 ms and lowering the fluence while utilizing pulse stacking or multiple passes.

IX. Treat the feeding arteriole first (central papule).¹ A good technique is to isolate the blood flow within the central papule by compressing a glass slide against the skin (diascopy).¹

X. Follow the radiant veins and treat them even if they appear to blanch after the treatment of the central papule.

Step-by-step procedure for hemangiomas

I. Assessment of the patient is carried out on a similar basis as mentioned in steps 1 and 2 of preoperative considerations.

II. Test spots can be considered, but are unnecessary.

- III. Best results are obtained using larger spot sizes.
- IV. Multiple treatments are necessary and treatments are normally repeated every 2–8 weeks, with shorter intervals for proliferating lesions.

- IV. Advise the patient to use a sunscreen with a sufficient SPF² and a hydroquinone containing agent to avoid post inflammatory hyperpigmentation.

Postoperative care

- I. Digital photographs of the patient should be taken to compare to pretreatment appearance.
- II. Ice packs should be applied immediately following treatment to prevent local swelling and purpura. Cool hydrogel dressing can be used to decrease discomfort.
- III. Patients should apply ice packs and elevate the treated area for the first day after treatment to diminish swelling. Cooling soaks, mild analgesics, and emollients can also be used.

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Video list

Video 38.1 Treatment of facial telangiectasias

Video 38.2 Treatment of poikiloderma

Laser treatment for pigmented lesions

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Introduction

Pigmented skin lesions are diverse, affect all skin types, and may be congenital or acquired. Some examples of these ubiquitous lesions include lentigines, café au lait macules, Becker's nevus, nevus spilus, and nevus of Ota. Lentigines are hyperpigmented macules, most often secondary to sun exposure. Café au lait macules are well-circumscribed homogeneous light-brown lesions that can be associated with syndromes such as Noonan syndrome or neurofibromatosis, and when these café au lait spots have dark macules or papules *within* the lesion itself, it is referred to as nevus spilus.¹ Becker's nevus typically manifests in males as an irregular brown patch, associated with coarse dark hair.² Finally, nevi of Ota appear unilaterally as mottled, blue-grey macules often in the distribution of the trigeminal nerve.¹

Although lasers have been used to treat these lesions for many decades, early approaches utilized ablative, continuous-wave laser technology, such as argon and carbon dioxide lasers.¹ The approach has shifted towards a selective photothermolysis technique, in which specific chromophores are targeted within the lesion to eradicate it, while minimizing trauma to surrounding tissue. In addition, the development of Q-switched lasers, which deliver very short pulses of laser irradiation corresponding to the target's thermal relaxation time, has facilitated safe and effective laser treatment of pigmented lesions.²

Preoperative considerations

- Assess the patient with a thorough clinical examination. Special attention should be made to a history of hypertrophic or keloid scars, HIV or other infectious diseases, bleeding diatheses, or any medication that could cause prolonged bleeding.
- The composition, structure, and nature (congenital/acquired) of the lesion(s) should be ascertained prior to the treatment. A pretreatment biopsy should be performed if there is any question of atypia.
- In some instances, the mixed nature of some lesions will require changes to the laser parameters or the use of multiple lasers.
- Patients taking oral retinoids should wait for 6–10 months following discontinuation of the treatment before beginning laser therapy.
- Patients with sun-tanned skin should have their treatment postponed until the skin returns to its normal color to avoid post-treatment laser pigmentary changes.
- For patients with a tendency for hyperpigmentation, prescribe a topical hydroquinone cream to be used twice daily at least 1 week before each treatment session.
- Realistic expectations have to be discussed with the patient, including the number of treatments, the potential for adverse events, and the possibility of incomplete clearance. It is important that the patient understand that multiple treatments may be necessary.

- Pretreatment digital photographs are important so that a baseline can be established to compare with future improvement.³

Anesthesia

- I. Anesthesia is not generally required for the treatment of epidermal pigmented lesions.
- II. If indicated in certain patients, apply a thick layer of topical anesthetic under occlusion for 40–60 minutes.
- III. Consider local infiltration and nerve blocks for certain patients. Premedication with a sedative or analgesic can be helpful for anxious patients.
- IV. The use of general anesthesia is controversial. If an anesthesiologist provides anesthesia via a laryngeal mask airway or mask inhalation, be cautious of any gas escape to avoid ignition by laser radiation.
- V. The mask should not contain any reflective material that could reflect the laser beam.

Laser safety

- I. Appropriate wavelength-specific safety goggles must be worn by all personnel in the treatment room.
 - a. Retinal injury is the primary hazard of laser treatment for pigmented lesions.
- II. Corneal shields inserted with the aid of ocular anesthetic drops are essential when treating periorbital areas.
- III. For all procedures with lasers, the adequate size and correct placement of eyewear is crucial.
- IV. Make-up should be removed prior to any treatment to avoid any flash fires.
- V. If any alcohol is used prior to the laser treatment, it should be allowed to dry completely.
- VI. Non-flammable, water-based lubricants may be used to protect eyebrows and other hair bearing areas from singeing.
- Hydrogel dressings can be applied to the lesions during the treatment to act as a heat sink.

Step-by-step procedure for epidermal pigmented lesions

- I. Calibrate the Q-switched laser.
- II. Hold the handpiece perpendicular to the skin with the attached plastic cone or guide resting on the skin to ensure that the laser beam is focused on the area to be treated.

III. Set the parameters depending on the skin type and lesion (Table 39.1).

IV. Deliver one or two test pulses.

a. An ash-white color without epidermal disruption should be observed where the laser beam has interacted with the tissue. If this is not observed, then an adequate fluence has not been used.

V. Deliver pulses with a 10% overlap until the entire lesion is treated.

VI. When the fluence is too high, epidermal sloughing and bleeding can result.

VII. The fluence should be lowered for patients with darker skin (types IV and V)

VIII. Avoid treating patients with recent tans to minimize risk of spotty hypopigmentation.

IX. The optimal end point is uniform but faint, immediate whitening without epidermal disruption. There may also be pinpoint bleeding.

X. With IPL, pulse durations in the millisecond range may be used.

XI. Further treatments may be required to clear the lesion as defined in Table 39.1.

Step-by-step procedure for dermal pigmented lesions

- I. Use anesthesia for larger lesions in the form of topical (LMX-5 cream) or local infiltration of lidocaine or regional nerve blocks.
- II. For deeper lesions such as nevi of Ota and Ito, nerve blocks and supplemental infiltration of anesthesia can be used.
- III. Larger spot sizes (4–6.5 mm), higher fluences, and longer wavelengths are required than for epidermal lesions to achieve deeper penetration.
- IV. Further treatments may be required to clear the lesion as defined in Table 39.1.

Postoperative care for pigmented lesion patients

- I. Take digital photographs of the treated lesions.³
- II. Ice packs should be applied immediately following treatment to prevent local swelling and purpura. Hydroocclusive dressings may be used to decrease discomfort.

Lesion	Laser	Spot size	Fluence	Treatment interval (weeks)
Lentigines	QS ruby	6.5	2.0–4.0	4–8
	QS Nd:YAG	3	0.7–1.0	4–8
	QS Alexandrite	4	3.5–5.5	4–8
Café au lait macules	QS ruby	6.5	3.0–4.0	4–8
	QS Nd:YAG KTP	3	1.0–1.5	4–8
	QS Alexandrite	4	2.5–4.5	4–8
Becker's nevus	QS ruby	6.5	3.0–5.0	4–8
	QS Nd:YAG KTP	3	1.5–2.0	4–8
	QS Nd:YAG	3	4.0–5.0	4–8
	QS Alexandrite	4	3.0–5.0	4–8
Nevus spilus	QS ruby	6.5	3.0–5.0	4–8
	QS Nd:YAG KTP	3	1.5–2.0	4–8
	QS Nd:YAG	3	4.0–4.5	4–8
	QS Alexandrite	4	5.0	4–8
Nevus of Ota	QS ruby	6.5	5.0–6.0	6–15
	QS Nd:YAG	3	4.0–6.0	6–15
	QS Alexandrite	3	5.0–6.0	6–15

Table 39.1 Pigmented lesions and the laser settings used for treatment¹

III. Patients should be advised to apply ice packs and elevate the treated area for the first day after the treatment to diminish swelling.

IV. Cooling soaks, mild analgesics, and emollients (petroleum ointment) may help with pain relief.

V. Patients should avoid excessive sun exposure and wear a broad-spectrum sunscreen for several months after treatment.³

Major side effects: post-inflammatory hyperpigmentation, especially when using subthreshold fluences.¹

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Laser treatment of tattoos

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Introduction

A tattoo is a mark created by the insertion of ink into the layers of skin for decorative or other purposes. Tattoos have been a form of expression for ages. Nearly 6% of individuals with a tattoo wish to have his or her tattoo removed due to psychosocial and cultural reasons.¹ Although methods such as dermabrasion,² excision,^{3,4} salabrasion,^{5,6} cauterization, infrared coagulation,^{7,8} etc. have been employed to achieve tattoo removal, laser removal of tattoos is the currently most popular modality, simply because it is more convenient, less painful, and results in minimal or no scarring.

Classification of tattoos is based on the following characteristics:

I. Color

- a. Single color, usually black
- b. Multicolored, red, green, blue, brown, gray, etc.

II. Style

- a. Professional: tattoos made by expert artists who place the appropriate composition of ink deep in the dermis, making the tattoos last for years.² These tattoos may contain iron oxide, which is very difficult to successfully treat with a laser.
- b. Amateur: tattoos made by non-experts, generally teenagers, gang groups, etc. These tattoos may be made by tattoo guns using guitar strings and a battery, or using a needle by hand. The inks commonly used are pen ink, charcoal, soot, mercury, cadmium, etc. These

tattoos may be easier to remove in many instances, as the ink is placed superficially, but, if the ink is placed deeper, it may be beyond the range of lasers.² Although these tattoos usually have a heterogeneous ink composition, generally their color scheme is homogeneous.

c. Medical: tattoos made by medical professionals mainly for marking body parts for radiation therapy, or nipple reconstruction after mastectomy.²

d. Cosmetic: tattoos placed as part of permanent make-up. These tattoos can be placed by professional artists or even physicians. Compared with non-permanent make-up, these tattoos are waterproof, time-saving, and hassle-free, and are becoming quite popular.²

e. Traumatic: undesirable tattoos caused by foreign bodies (gunpowder, sand, and similar materials). These tattoos can affect the face, hands, and eyes and may respond dangerously to lasers if composed of explosive material.²

Currently, lasers used for tattoo removal work via the principle of selective photothermolysis, with tattoo ink being the targeted chromophore. Present-day technology involves the use of Q-switched (quality-switched) lasers. Q-switching is a technique that produces nanosecond laser pulses by suddenly releasing all of the excited state energy from a laser medium. A whitening reaction occurs upon exposure to this laser due to rapid local heating of the pigment or tattoo ink, leading to gas formation and subsequent dermal and epidermal vacuolization. The

Table 40.1 Types of Q-switched lasers and the tattoo ink targeted

Laser	Fleunce (J)	Spot size (mm)	Colors targeted	Treatment interval (weeks)
Q-switched Ruby (694 nm)	8–10	5–8	Blue, black, does not work well with red	6–8
Q-switched Alexandrite (755 nm)	3–4	3	Blue, black, green	6–8
Q-switched Nd:YAG (1064 nm)	2.5–3.0	6–8	Black, blue	6–8
Q-switched Nd:YAG-KTP (532 nm)	3–4	3	Red, orange	6–8

exact mechanism of action of the laser is unknown but the irradiation likely leads to instant alteration of tattoo pigments via photochemical and photoacoustic effects.²

Choosing the appropriate laser

- For multicolored tattoos, multiple lasers of different wavelengths may be needed to remove the tattoo (Table 40.1).
- Sometimes a laser removes only some of the pigment and only alters the remaining ink. The altered pigment is no longer affected by the same laser resulting in a refractory tattoo.
- Longer wavelengths penetrate deeper into the skin and exhibit less beam scatter.
- Larger spot sizes have the least scatter at the edge, and maximum delivery to the target.
- Larger spot sizes can deliver more energy and can be used for treating refractory tattoos.
- For black tattoos, any of the lasers are effective, because black absorbs all wavelengths of light.
- A laser that emits light in the wavelength corresponding to the color of the tattoo cannot be used for the removal of the same colored tattoo.
- Table 40.1 shows the commonly used lasers and their role in treating tattoos of different colors.

Preoperative care

- Assess the patient by a physical and clinical examination. Special attention should be made to any history of hypertrophic or keloid scars, HIV or other infectious diseases, bleeding diatheses, or any medication that could cause prolonged bleeding.

II. The composition, structure, and nature (congenital/acquired) of the lesion(s) need to be ascertained prior to treatment.

III. In some instances, the different colors of some tattoos will require changes in the laser parameters or the use of multiple laser wavelengths.

IV. Realistic expectations have to be discussed with the patient, including the number of treatments that may be required, the potential adverse events, as well as the possibility of incomplete clearance.

V. Emphasize that not all tattoos can be completely removed, and successful treatment may require a number of treatments.

a. Black ink is relatively easier to remove than other colors of tattoo ink.

b. Amateur tattoos can usually be removed more easily than professional ones.

Digital photographs before the treatment are important to capture so that future treatments can be compared with a baseline.

Anesthesia

I. For many of the patients, anesthesia is not generally required.

II. For sensitive patients, apply a thick layer of topical anesthetic under occlusion for 40–60 minutes.

III. Consider local infiltration and nerve blocks for sensitive patients. Premedication with a sedative can be helpful for anxious patients.

Laser safety

- Appropriate wavelength-specific safety goggles must be worn by all personnel in the treatment room.

- II. Corneal shields inserted with the aid of ocular anesthetic drops are essential when treating periorbital areas.
- III. Make-up should be removed prior to any treatment to avoid any flash fires. If alcohol is used prior to laser treatment, it should be allowed to dry completely.
- IV. Non-flammable, water-based lubricants (Surgilube or KY jelly) may be used to protect eyebrows and other hair-bearing areas from singeing.
- V. Hydrogel dressings can be applied on the lesions during the treatment to act as a heat sink.

Step by step procedure for tattoo removal (Video 40.1)

- I. Use anesthesia for larger lesions in the form of topical (LMX-5 cream) or local infiltration with lidocaine containing 1% epinephrine.
- II. A clear Tegaderm patch can be placed over the tattoo ink to be treated so that tissue splatter onto the surgical field is minimized. It should be noted that although tissue splatter is minimized with the Tegaderm, the laser can be reflected off the Tegaderm towards unwanted targets in the operative room.
- III. Each color of the tattoo in a multicolored tattoo should be treated with a specific wavelength (Table 40.1). In addition, each color of the tattoo should be treated with a single laser pulse with approximately 10% overlap.
- IV. When treating tattoos with colors that may darken (these are usually inks that contain iron oxide or titanium dioxide and may include colors such as red, white, green, blue, or flesh tone), deliver a single pulse and watch for any darkening to occur. If darkening occurs, following the first pulse, retreat again.
- V. A white, macular-papular lesion that outlines the boundaries of where the tattoo ink has been placed should be observed immediately following the laser pass. This is a result of dermal vacuolization.

Postoperative care and follow-up

- I. Digital photographs of the patient should be taken and compared with pretreatment photographs.
- II. Ice packs should be applied immediately to prevent the local swelling and purpura. Hydro-occlusive dressings (e.g., Vigilon) can also be used to protect the post-operative area.

- III. Patients are advised to apply ice packs and elevate the treated area for the first day after treatment to diminish swelling. Cooling soaks and mild analgesics and emollients (aloe vera or aquaphor healing ointment, Beirsdorf inc., Norwalk, CT) can be used to decrease patient discomfort.
- IV. Patients should avoid excessive sun exposure and wear a broad-spectrum sunscreen for 6 months after treatment.

Other considerations

I. Freedom-2 tattoo ink

- a. This ink consists of microspheres which contain bioresorbable particles. The microspheres can easily be ruptured with a single laser treatment. The ruptured ink is then reabsorbed leaving behind no traces of its prior existence.

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Video list

Video 40.1 Laser treatment of a tattoo

Lasers for hair removal

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Introduction

The first reports regarding a laser's ability to damage hair follicles appeared approximately 50 years ago.^{1,2} Since that time, laser photoepilation has advanced a long way scientifically and in popularity with patients. Now, photoepilation is the fastest growing cosmetic procedure.³ The scientific advancement was greatly aided by Anderson and Parrish's⁴ concept of selective photothermolysis, and later, an extended theory of selective photothermolysis.⁵ The melanin of the hair shaft is known to be the chromophore that absorbs a majority of the laser energy; however, it is probably the follicular stem cells in the dermal papillae and bulge region, which are responsible for a decrease in hair growth as a result of laser treatment.⁶ The melanin in the hair shaft and the follicular stem cells are separated by space; therefore, to achieve destruction of the follicular stem cells a longer pulse duration must be used.

Preoperative care

- Assess the patient by a physical and clinical examination. Special attention should be made to any history of hypertrophic or keloid scars, HIV, or other infectious diseases, bleeding diatheses, or any medication that could cause prolonged bleeding.

- Rule out endocrine disorders in patients presenting with hirsutism in the context of other signs and symptoms.
- Realistic expectations have to be discussed with the patient, including the number of treatments, the potential adverse events, and the possibility of incomplete clearance.
- Patients should be aware that the average number of hair removal treatments to achieve a significant reduction of hair is between five and seven performed at 1- to 3-month intervals.
- It is important to capture digital photographs before the treatment so that future progress can be compared with the baseline.
- The individual's skin type, hair color, and hair coarseness should be noted as these factors will determine which device is most suitable (Table 41.1).

Anesthesia

- I. Anesthesia is not required for many patients.
- II. For sensitive patients, apply a thick layer of topical anesthetic under occlusion for 60 minutes.
- III. Local infiltration of lidocaine or regional nerve blocks may be used, but these techniques are rarely necessary.
- IV. Premedication with a sedative or analgesic may be helpful for anxious patients.

Table 41.1 Light Sources commonly used for hair reduction

Laser source	Skin type	Hair color	Hair thickness
Normal mode ruby	I–III	Dark to light brown	Fine and coarse
Normal mode alexandrite	I–IV	Dark to light brown	Fine and coarse
Pulsed diode	I–IV	Dark to light brown	Coarse
Normal mode Nd:YAG	I–VI	Dark to light brown	Coarse
Q switched Nd:YAG	I–VI	Dark to light brown	Fine
IPL	I–VI	Dark to light brown	Coarse

Laser safety

- I. Corneal shields inserted with the aid of ocular anesthetic drops must be worn by the patient when treating periorbital areas.
- II. Appropriate wavelength-specific safety goggles must be worn by all personnel in the treatment room.
- III. Make-up should be removed prior to any treatment to avoid any flash fires. If any alcohol is used prior to the laser treatment, it should be allowed to dry completely.
- IV. Hair vaporization following contact with laser radiation results in a noxious plume and odor. It is recommended that patients shave their hairs 1–2 days prior to treatment to minimize this odor.
- V. Smoke evacuators and adequate ventilation are essential.

General consideration before treatment

- I. Patients with any active cutaneous inflammation, infection, sunburns, or tans should wait until resolution. Patients who have psoriasis or vitiligo should not have treatments in the affected areas to avoid koebnerization.
- II. Advise patients to refrain from plucking or waxing for a period of 6 weeks before laser therapy. Laser treatment is believed to be more effective when the pigmented hair shaft is present within the follicle.
- III. Patients who have a history of herpes labialis should be prescribed the appropriate antiviral prophylaxis, which can be taken immediately prior to the laser treatment.
- IV. It is recommended to use broad-spectrum sunscreen following the treatment for at least 6 months.

Step-by-step procedure surgical technique (Video 41.1)



- I. The laser should be calibrated before treatment.
- II. Ideal treatment parameters must be individualized for each patient. The largest spot size and the highest tolerable fluence based on both pain and epidermal injury should be used.
- III. Hold the hand-piece perpendicular to the skin, with the attached spacer resting on the skin. The skin should be stretched taught.
- IV. Delineate the borders of the area to be treated by a marker pen prior to treatment to avoid skipping any portion of the area.
- V. Visualization can be improved using magnifying headlamps.
- VI. During the treatment, overlap pulses by around 10–20% to avoid skip areas.
- VII. The immediate clinical end point of treatment is transient, perifollicular erythema and edema, which usually develops within several minutes of treatment.
- VIII. The intensity and duration depends on the hair color and hair density. Marked or confluent erythema, whitening, blistering, or purpura indicates acute epidermal injury from overly aggressive treatment.
- IX. If there is a sign of epidermal damage, the fluence should be reduced by 20–30%.
- X. Ruby and alexandrite lasers achieve their best results with a spot size of 7 mm and a fluence of at least 30 J/cm^2 .
- XI. Higher fluences should be used with devices emitting longer wavelengths to compensate for the reduced melanin absorption.
- XII. Appropriate cooling approaches must be used. If the device is not equipped with a cooling device, a thick

layer of cooled gel is applied before delivery of the laser pulses.

Postoperative care and follow-up

- I. Digital photographs of the patient should be taken and compared to pretreatment photographs.
- II. Ice packs should be applied immediately to prevent the local swelling and purpura. Cool hydrogel dressing can be used to decrease discomfort.
- III. Patients are advised to apply ice packs and elevate the treated area for the first day after treatment to diminish swelling.
- IV. Cooling soaks, mild analgesics, and emollients (aloe vera or aquaphor healing ointment, Beirsdorf Inc., Norwalk, CT) may help with pain relief.
- V. Vesiculation or crusting is abnormal and could be a sign of infection. It requires an antibiotic ointment and non-stick dressing that should be changed twice daily until resolution.
- VI. Advise the patient to use a sunscreen with a sufficient SPF and a hydroquinone-containing agent to avoid post-inflammatory hyperpigmentation.

Complications

- I. Erythema, edema, pain, hyper- and hypopigmentation, crusting, erosions, blistering, purpura, and folliculitis.

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Video list

- Video 41.1 Laser for hair removal

Laser and light treatment for hair transplantation and growth induction

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Introduction

Hair frames our face. It is one of the few physical attributes that we have control over in how we present ourselves to the world and how we perceive ourselves. Whether through the color, length, or style of our hair, hair is a reflection of our personality. The *involuntary* loss of hair that can happen gradually over years takes away our ability to express ourselves through our hairstyle. The loss of hair in men and women not only changes how we perceive ourselves but also changes our physical appearance to the world. The natural frame of hair around our face is gradually lost. The “see through” appearance of the frontal hairline creates great psychological and emotional stress for men and women. Over centuries patients have sought effective treatment for their hair loss. Most have been disappointed. Over the past few decades effective medical and surgical therapy has been developed for men and women with hair loss. Most recently, low-level light therapy (LLLT) has purported to be a safe effective treatment for pattern hair loss.

Medical therapy for hair loss

All patients with hair loss should have a consultation with a dermatologist to establish a diagnosis before

considering any therapy. Too often patients with hair loss assume they have genetic pattern hair loss when in fact they may have another reason for hair loss which can be successfully treated.

There are currently two effective FDA-approved medications to treat male pattern hair loss: finasteride and minoxidil. The only currently effective FDA-approved medication for female pattern hair loss is minoxidil. Both are effective in maintaining or regrowing hair at earlier stages of loss. Both need to be continued long term for continued maintenance. The key to success is compliance with the medication. Both require 8–12 months to judge their effect on patients. The vast majority of patients who consistently take the medication during this period of time see a clear benefit from it.^{1–3}

Hair transplantation

Hair transplantation consistently restores natural appearing hair for men and women. Over the last 15 years, the use of natural one- to four-hair follicular groupings has eliminated “pluggy,” unnatural appearing transplants. All patients should expect natural appearing transplanted hair (Figures 42.1–42.4). The procedure has a high patient and physician satisfaction. It is performed as an outpatient under local anesthesia. The donor hair

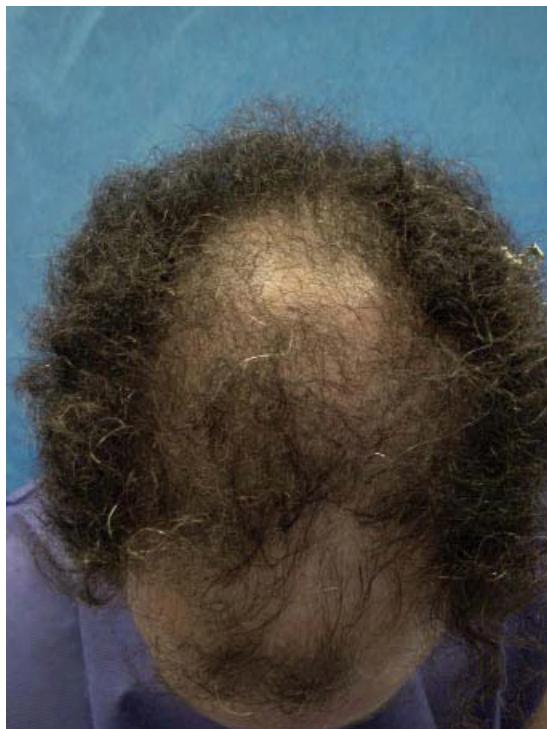


Figure 42.1 Norwood IV.



Figure 42.2 After 1000 one- to three-hair grafts.

is obtained from the posterior scalp where hair follicles largely remain unaffected by male and female pattern hair loss. The donor hair is harvested either through a surgical ellipse or by removing individual follicular groupings using a 1-mm punch, known as follicular unit extraction (FUE). From an ellipse the follicular groupings are carefully dissected by trained surgical assistants while the recipient sites are made by the physician using 19- to 21-gauge needles. The sites are created to mimic the natural angle and distribution of hair on the scalp.



Figure 42.3 Ludwig II.

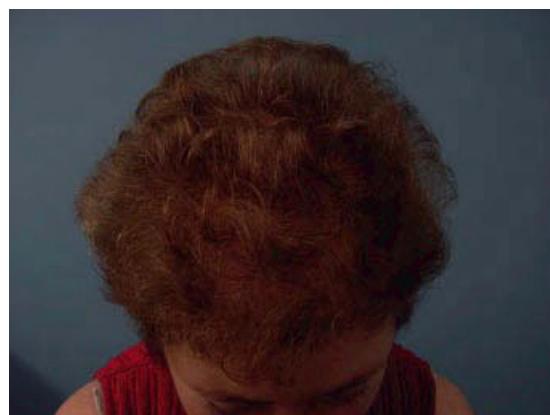


Figure 42.4 After 700 one- to three-hair grafts.

The follicular groupings are carefully placed into hundreds and up to thousands of recipient sites. The procedure takes a trained surgical team 2–5 hours to complete. Patients should expect their result 8–12 months after their procedure.⁴

Laser-assisted hair transplantation

With the introduction of pulsed carbon dioxide lasers in the mid-1990s to treat sun damage and acne scarring, the role of lasers in hair transplantation was explored as well. The potential advantage of carbon dioxide lasers was their ability to create recipient sites on the scalp with minimal to no bleeding. Clinical trials led to FDA approval for carbon dioxide laser-assisted hair

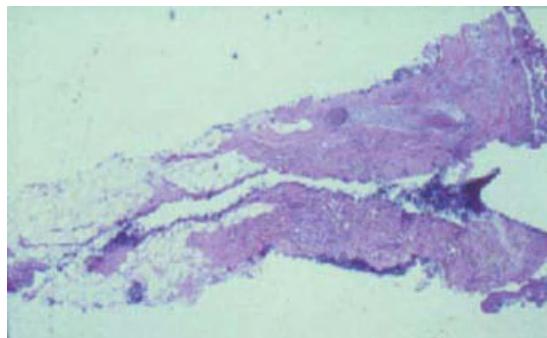


Figure 42.5 Cutaneous laser recipient site with necrosis at site.

transplantation. Despite their FDA approval and clinical success, lasers are currently not being used in hair transplantation. The chief obstacle in laser-assisted transplantation remains the amount of tissue necrosis throughout the dermis (Figure 42.5). The necrosis is necessary to establish hemostasis but requires recipient sites to be created further apart from each other than traditional needles leading to less density.⁵

Currently the use of 19- to 21-gauge needles is standard for creating recipient sites. Using small needles, physicians can create 15–30 sites per cm² for maximum density. The incisions are so small with 19- to 21-gauge needles that hemostasis is rarely a problem, further negating any role for carbon dioxide assisted lasers.

Low-level light therapy and hair loss

While we have effective medical and surgical treatments for male and female pattern hair loss, there are currently limited choices. Low-level light laser therapy (LLLT) has been used to treat a variety of medical conditions ranging from musculoskeletal disorders to cutaneous ulcers.⁶ Over the past several years LLLT has been proposed as a safe and effective treatment option for male and female pattern hair loss. The biochemical mechanism of action of LLLT remains unclear.⁷

Light can affect hair follicles in the skin. High-energy lasers have been used to permanently remove unwanted pigmented terminal hair by targeting the melanin in follicles. In addition, paradoxical hair stimulation has been reported as a side effect in a small percentage of patients undergoing laser hair removal.⁸ Ultraviolet light has been reported to stimulate hair follicles for alopecia areata.



Figure 42.6 Patient using the Hairmax lasercomb.

LLLT has been investigated to stimulate hair growth over the past several years. In 2007, the FDA granted 510(k) approval for a continuous visible light wavelength of 655 nm (HairMax LaserComb, Lexington International, Boca Raton, FL) device. Although the FDA approval was based on a predicate device it did create a widespread interest among physicians and patients as a new possible treatment for male and female pattern hair loss.

Clinical application of the devices

LLLT devices are Class 3R hand-held devices which can be sold directly to the consumer by the manufacturer. They also exist as large stand-up devices which can be administered in physician and non-physician clinics. There are no studies demonstrating any advantage of clinic-based devices over direct to consumer devices. Home-based manufacturers recommend “combing” the device through the scalp for 10–15 minutes three times a week. Clinic treatments range from 10 to 60 minutes two or three times weekly. Manufacturers and physicians who are treating patients claim that patients should see a clinical affect within 3 and 12 months of starting their therapy (Figure 42.6).

Peer-reviewed evidence

There are very few peer-reviewed published clinical trials on LLLT and hair growth. Avram and Rogers⁴ published a pilot trial that did demonstrate an increase in pigmented terminal hair and its diameter but not in a statistically significant manner (Figures 42.7 and 42.8). They



Figure 42.7 Before treatment with Lasercomb; photo taken using Bodelin Proscope 30x magnification.

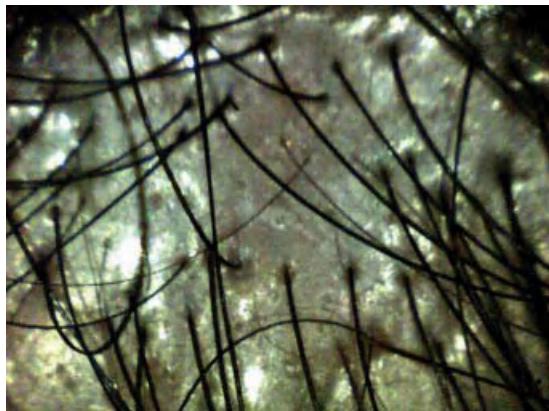


Figure 42.8 Microscopic evaluation after using Lasecomb for 6 months; photo taken using Bodelin Proscope 30x magnification.

concluded that larger, longer term studies were needed to define the efficacy of LLLT in treating hair loss.⁹ Leavitt *et al.*¹⁰ published a larger double-blind controlled trial that did demonstrate a clear benefit in the treatment of male pattern hair loss. They reported the device was well tolerated with no side effects. No studies have been done to examine the effects of altering dose frequency or wavelength. Larger clinical trials and studies are necessary to determine the precise role of LLLT in the treatment of male and female pattern hair loss.

Current role of LLLT in treating male and female pattern hair loss

Currently finasteride and minoxidil for men and minoxidil for women remain the medical treatments of choice for male and female pattern hair loss. In appropriate candidates, hair transplantation remains a consistently effective treatment option with high physician and patient satisfaction. LLLT remains a secondary choice in the treatment of hair loss because of the lack of long-term, well-designed, peer-reviewed clinical trials demonstrating efficacy and long-term safety.

Future challenges

Many challenges remain in defining the role of LLLT as a treatment for hair loss. Reproducible large independent studies need to be published. The optimal wavelength and energy need to be defined. Perhaps pulsed light has an advantage over continuous light. In addition, the frequency and length of treatment need to be defined. Researchers also need to explore any other hair or cutaneous applications for LLLT. Initial clinical experience and trials suggest LLLT does have a biologic effect on hair follicles. What precise role this effect has on the treatment of hair loss remains to be further defined in the future.

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Laser treatment for keloid, hypertrophic, and surgical scars

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Introduction

Hypertrophic scars generally occur within weeks of the injury. They stay within the boundaries of the original wound and can regress with time. The collagen fibers are arranged in a wavy pattern,¹ with nodular structures comprising fibroblasts, collagen, and α -smooth muscle actin-staining myofibroblasts. It has been hypothesized that perhaps the contraction observed with hypertrophic scars can be attributed to the α -smooth muscle.¹

Keloid scars tend to occur months to years following an injury. In contradistinction to hypertrophic scars, keloid scars extend beyond the boundaries of the original wound, and tend to enlarge with time. The collagen fibers in keloid scars are disorganized and bundle organization is non-existent.¹

Some patients are prone to developing hypertrophic scars and keloid scars. In particular, patients with a family history of hypertrophic scars or keloid scars, dark skin, or wounds in high-risk areas such as the trunk, extremities, earlobes, mandible, and neck are at an increased risk of developing hypertrophic scars and keloid scars.² In addition, patients who have had a wound closure with tension, infection, hematoma, or dehiscence are also at increased risk of keloid or hypertrophic scar formation.²

Castro *et al.*³ were the first to suggest that lasers may be beneficial when treating hypertrophic scars after

noting that a 1060-nm neodymium:yttrium-aluminum-garnet (Nd:YAG) laser decreased the *in vitro* production of collagen in fibroblasts. Approximately 1 year following this initial study, CO₂ and argon lasers were also investigated^{4,5} and shown to have high rates of recurrence. The pulsed dye laser (PDL) was tried next and was found to be more effective at improving scar texture, redness, and pliability.^{6,7} An additional benefit of the PDL is the prevention of hypertrophic scars, which has been shown in animal models.^{8–10} Remarkably, the PDL can be used as early as the day of suture removal to improve scar quality.¹¹

A number of different lasers have been examined for use in keloids. The first reports were made by Apfelberg *et al.*¹² using argon and CO₂ lasers. Only one patient out of 13 demonstrated any improvement. Next, the Nd:YAG laser was explored and the results were variable. Following that, the PDL laser was investigated and demonstrated some promise.

I. PDL for hypertrophic and keloid scars¹³ (Video 43.1)

- a. Topical anesthetics or makeup must be washed from the cutaneous surface. Anything left on the cutaneous surface can interfere with light absorption.
- b. The lesion must be assessed; specifically, note its size, color, height, and pliability. Ask the patient if he or she has any symptoms associated with the lesion. In addition, the scar characteristics can be assessed if a

particular scale is used; such as the Vancouver Scar Scale.

c. Pretreatment photographs with a high-resolution camera are encouraged before every laser treatment session takes place. Pay careful attention to the lighting, distance, and angle of the camera from the lesion so that the photographs are standardized and intricate details are noted.

d. The patient and all personnel in the room should be wearing appropriate protective eyewear.

e. The laser should be calibrated, and the correct parameters should be used for each particular laser. If using the 585-nm PDL laser, use a pulse duration of 450 µs, spot size of 10 mm, and fluences of 3–4 J/cm². If a smaller spot size is chosen, then a higher energy should be used. In addition, if the patient has darker skin, a lower fluence should be used. As a guiding principle, the early treatments should begin with lower fluences and then move to higher fluences according to the lesion response.

f. It is important to inform the patient when the procedure is about to occur and that the laser beam feels similar to a snapped rubber band on the skin surface.

g. A continuous pattern over the entire scar should be used with 10% overlap similar to the Olympic Games symbol.

h. The patient should be instructed to strictly avoid the sun so that the risk of pigmentary changes is minimized. Soap and water for cleansing are appropriate to use in the days following treatment. Care should be taken not to traumatize the treated area.

i. The patient may feel a burning or pruritic sensation for up to 2 days after the treatment.

j. If desired and indicated, another treatment session can occur in 4–6 weeks.

II. Side effects of the PDL

a. Purpura over the treated area can last up to 10 days.

b. Hyperpigmentation may also result; consider treating with a bleaching cream or postpone the next laser treatment.

c. More rare complications can include oozing, crusting, or vesicles. Keep the affected area moist and covered with a dressing. Future laser treatments should use a lower energy setting.

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Video list

Video 43.1 Laser treatment of a surgical scar

Laser for treatment of leg veins

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Introduction

There has been an increasing demand for the treatment of leg veins for medical purposes and for aesthetic concerns. Lasers and light treatments are steadily increasing in popularity as there is a desire for non-invasive options offering minimal downtime and pain. The American College of Phlebology has estimated that more than 80 million people in the United States experience leg vein pathologies. These vascular pathologies can be categorized into superficial spider veins or telangiectasias, deeper reticular veins, and protuberant varicosities. Heredity factors, hormones, prolonged standing, obesity, pregnancy, and aging are all examples of the causes of venous pathologies. Many patients may endure symptoms of fatigue, aching, swelling, throbbing, and pain. Despite experiencing these symptoms, patients mainly seek treatment for aesthetic reasons.

Anatomy of venous system

The vascular system of the lower extremity is an intricate system of the highly interconnected deep and superficial plexus. The superficial veins that can be seen are just below the skin's surface and the deep veins are located deep within the muscles of the leg (Figure 44.1). Pressure in the deeper reticular or varicose veins can be created by the patterns of flow between the superficial and deep networks producing superficial spider veins (Figure 44.2).

Factors such as size, depth, flow pattern, and vessel thickness can create more difficulty in the treatment of leg veins than the treatment of smaller veins such as facial veins. The smaller telangiectasias of the face are found at a consistent depth with usually thinner and uniform walls that have lower hydrostatic pressure than leg veins. In the venous system of the legs, vessels are deeply situated with less homogeneous depth, thick walls, and increased hydrostatic pressure. The fine, superficial telangiectatic vessels of the legs are not very close to the surface of the skin but in fact are located several millimeters below the skin. The most common cause of complaints in patients are the smaller telangiectasias (0.2–1.0 mm) which lie approximately 300 µm below the surface of the skin. Owing to the varying approaches to leg vein treatments, lasers are used in addition to sclerotherapy, ambulatory phlebectomy, or endovenous ablation (Box 44.1).

Highly effective results have been seen in the laser treatment of small spider veins or telangiectasias (<0.5 mm) and also in the treatment of telangiectatic matting that occurs with other types of treatments. Lasers can be utilized in the treatment of both large spider veins and small reticular veins. Despite sclerotherapy being considered the gold standard treatment for larger leg veins, several studies have suggested that the outcomes of laser therapy and sclerotherapy are equally effective in treating spider and small reticular veins. In a study by Coles *et al.*,¹ a comparison of laser therapy with a long pulsed Nd:YAG laser with foam sclerotherapy with 0.6% sodium tetradecyl sulfate was investigated in a group of

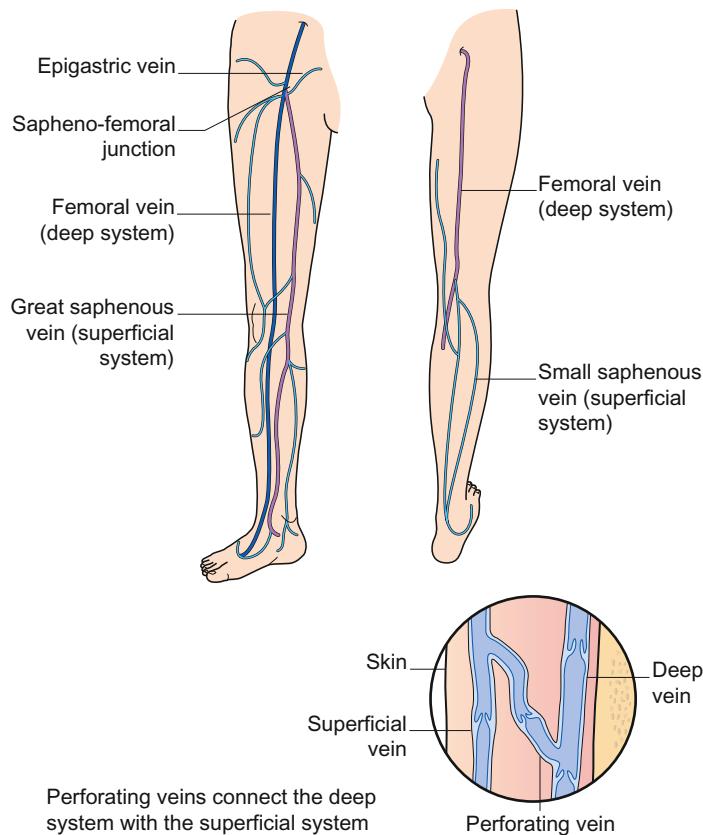


Figure 44.1 Venous system.

20 patients. Vessels in these patients ranged from 0.25 to 3.0 mm. End results showed that there was more of an improvement in clearance scores by laser therapy, and interestingly only 35% of the patients preferentially chose laser treatment over sclerotherapy. In another study conducted by Levy² comparing liquid sclerotherapy with 0.5% polidocanol to the long pulsed Nd:YAG laser for vessels ranging from 0.5 to 2 mm, there was no statistical difference found between the two treatment methods. Phlebectomy, ligation, or endovenous ablation are the methods of choice in the treatment of larger varicose veins.

Patient selection

Marked results with laser light are seen in the treatment of telangiectasias, specifically in the small superficial red

or blue veins which are difficult to cannulate. Indications include those patients who are more inclined to telangiectatic matting, are scleresistant, or have needle phobia (Box 44.2). Pregnancy, tanned skin, iron supplements or anticoagulant therapy, history of photosensitivity disorders, or hypertrophic/keloidal scarring are relative contraindications to laser treatment.

It is imperative to note that sclerotherapy is the gold standard for vein treatment and lasers or an intense pulsed light source (IPL) are not substitutes for sclerotherapy. Laser and light treatment will not treat issues of hydrostatic pressure. Furthermore, it is very difficult to deliver light energy safely and effectively through deeply situated leg extremity vessels. These are large vessels and have increased basal laminas compared with other vessels of the body such as facial telangiectasias. Injections into a specific vessel are more efficient and effective at an intrinsic level.

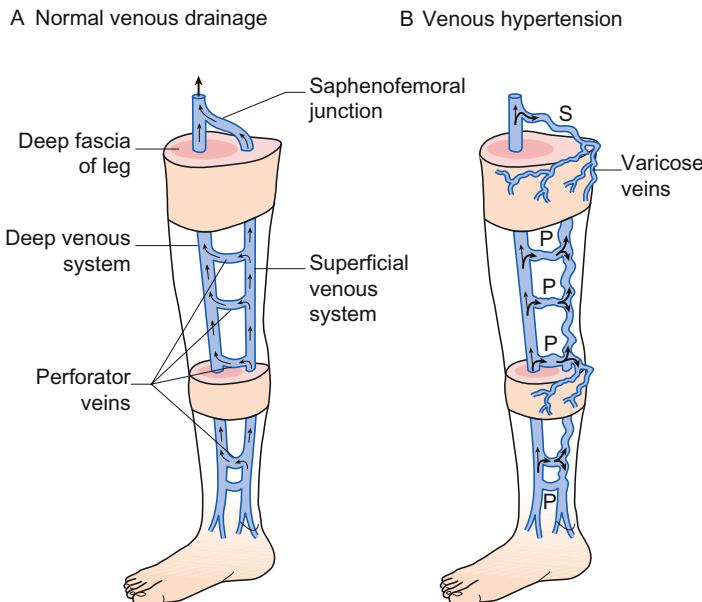


Figure 44.2 (a) Anatomic view of patterns of blood flow between the superficial and deep vein networks (b) occurrence of superficial spider veins due to the disruption of flow in the superficial and deep vein networks. P, perforator vein incompetence; S, saphenofemoral incompetence.

Box 44.1 Treatments approaches for the various types of leg veins

- Varicose veins: endovenous laser ablation, ambulatory phlebectomy, or ligation
- Larger spider veins, reticular veins: sclerotherapy
- Telangiectatic matting: laser or sclerotherapy
- Small telangiectasias: laser or sclerotherapy

Clinical outcomes of laser and light treatment

Technological expansions in laser therapy have yielded highly effective options to treat leg veins. Results have been high in small telangiectasias, which have disappeared on treatment providing immediate satisfaction. However, the larger telangiectasias and reticular veins do not vanish immediately but slowly over several months after treatment. Hyperpigmentation after treatment can occur because of the coagulation of blood in the vessels. In a study by Sadick,³ in the treatment reticular veins and spider telangiectasias of the lower limbs using a mono-modal approach with the 1064 nm Nd:Yag laser and variable spot size and pulse width parameters, it was found that approximately 20% of treated vessels had a 50–75% improvement after three treatments spaced 1 month apart. Improvements were noted over time, with 80% of vessels clearing by 75% at the 6-month follow up. Of all the patients treated, 90% were highly satisfied with the treatment.

Box 44.2 Indications for lasers in the treatment of telangiectasias

- Refractory non-cannulizable vessels
- Telangiectatic matting “neovascularization”
- Angiogenic flushing
- Scleroresistance
- Needle-phobic patients

Eremia *et al.*⁴ conducted a comparative study of the 1064-nm Nd:YAG, 810-nm diode, and 755-nm Alexandrite lasers for the treatment of leg veins (0.3–0.33 mm); it was seen that the Nd:YAG laser showed the greatest percent improvement at the 3-month follow-up. In the 22 patients treated, the results with the long pulsed dye diode were insignificant, and complications of purpura and telangiectatic matting were observed with the Alexandrite laser. No studies have been conducted regarding the long-term efficacy of laser treatments on legs.

Lupton *et al.*⁵ compared the clinical efficacy of leg telangiectasia treatment with sodium tetradecyl sulfate sclerotherapy to long pulsed 1064-nm Nd:YAG laser irradiation in 20 patients with size-matched superficial telangiectasias of the lower extremities. Each patient was randomly assigned to receive two consecutive monthly treatments with injectable sodium tetradecyl sulfate on one leg and long pulsed 1064-nm Nd:YAG laser irradiation on the other. Patients were evaluated by two masked assessors at each treatment visit and at 1 and 3 months after treatment to assess clinical improvement within matched sites. The telangiectasias responded best to sclerotherapy in fewer treatment sessions than to long pulsed 1064-nm Nd:YAG laser irradiation. Adverse events were minimal and equivocal in both treatment groups. Lupton noted that laser leg vein treatment appears to be most beneficial in patients with telangiectatic matting, needle phobia, or sclerosant allergy.

Considerations for treatment strategy

Treatment approach

A physician must complete a comprehensive physical examination which should be performed on all patients prior to treatment of leg veins, including an evaluation of the type and size of venous pathology and to establish the presence of reflux or incompetent valves. A physician can see that the large veins are most prone to reflux and must be treated first to prevent the unsuccessful treatment of smaller telangiectasias and also avoid the possibility of adverse events such as pigmentation and telangiectatic matting.

For optimal results, a thorough and systematic approach to the treatment of leg veins should be applied to seek successful results (Figure 44.3).⁶ Before

proceeding to the smaller veins, the physician must treat varicosities and large feeder vessels. Surgical options including ligation, stripping, or ambulatory phlebotomy can be used to remove the larger veins as well as use of endovenous ablation. It is important to note that sclerotherapy must always be performed first in treating the larger and then the small vessels. This will clear about 80–90% of vessels in a single treatment.⁷ Any unaffected vessels or vessels too small to be treated by sclerotherapy with a 30- to 32-gauge needle can then be treated by laser and light therapy.

Key determinants

When utilizing lasers for treatment of leg veins it is wise to adhere to the properties of selective photothermolysis, thereby increasing the likelihood of effective results and minimal adverse events. There are several major parameters to consider in selective photothermolysis when treating individual vessels, including wavelength, pulse duration, spot size, and fluence (Box 44.3). The laser must have a wavelength that is preferentially absorbed by hemoglobin in the target tissue, the pulse duration should be shorter than the time needed to cool the target to one-half of its peak temperature after being treated, and the fluence should be adequate enough to cause thermal injury to the target area. Lastly, the penetration of the laser should be relayed over an exposure time to the full depth of the target vessel, and sufficient amount of energy must be delivered to damage the vessels but not the adjacent skin.

When treating vascular lesions, oxyhemoglobin is the target chromophore and has major absorption peaks at 410, 540, and 577 nm with smaller peaks at 920–940 nm in its absorption spectrum. It was noted that blue veins react effectively to wavelengths targeting the deoxyhemoglobin spectrum and red veins respond better to wavelengths targeting the oxyhemoglobin spectrum⁸ (Figure 44.4). For vessels >0.5 mm in diameter and at least 0.5 mm below the skin surface, it is imperative to have absorption of hemoglobin in the long visible to near infrared range.

These principles have paved the way to the development of the bimodal dual wavelength approach for the treatment of red and blue lower extremity veins.⁹ Application of this approach specifically with short wavelengths (500–600 nm) was found to be effective in the treatment of small, reddish telangiectasias which contain

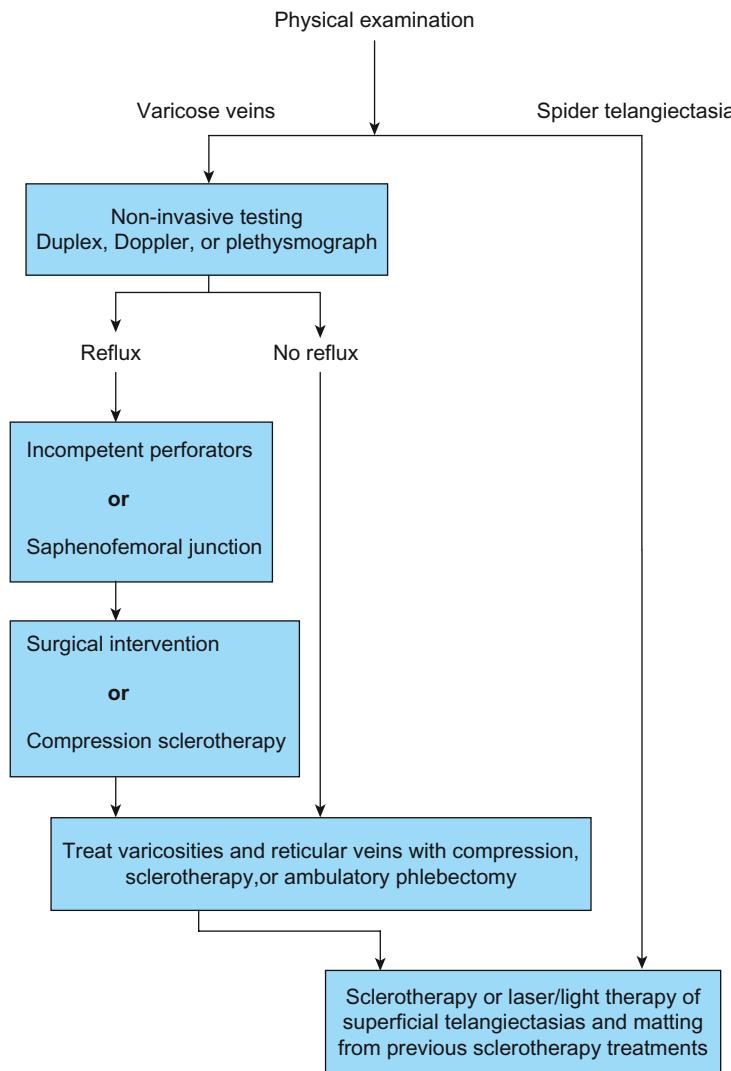


Figure 44.3 Systematic approach to the treatment of leg veins. Reproduced from Dover *et al.*¹ with permission from Blackwell Publishing.

Box 44.3 Optimal laser parameters for the treatment of leg veins

- Wavelength: 530–1064 nm
- Pulse duration: 2–100 ms
- Fluence: 30–150 J/cm²
- Spot Size: 1.5–10 mm

high levels of oxyhemoglobin. Longer wavelengths (800–1000 nm) yielded clinical benefits in the treatment of deeper blue telangiectasias and reticular veins. Despite these benefits, this approach does have its disadvantages, since multiple laser technologies must be employed to obtain the greatest results. This can be highly unpractical for most physicians.

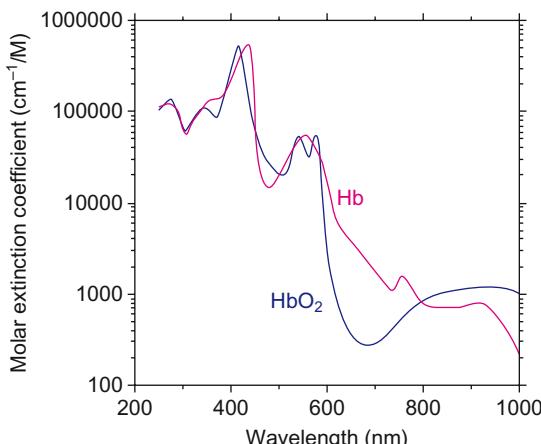


Figure 44.4 Absorption spectrum of hemoglobin/deoxyhemoglobin. Reproduced from Ross and Domankevitz²³ with permission from John Wiley & Sons.

A modified monomodal approach has been developed to discuss the differences in vessels size and depth with a single 1064-nm Nd:YAG laser.³ Larger blue vessels, which are usually 1–4 mm in diameter, located deeper in the extremity and have a lower oxygenated hemoglobin component, are successfully treated with larger spot sizes (2–8 mm), moderate fluences (100–370 J/cm³), and longer pulse duration (30–60 ms). For those superficial fine red vessels that are <1 mm in diameter and have a high oxyhemoglobin saturation, effective treatments with small spot sizes (<2 mm), high fluences (350–600 J/cm²), and shorter pulse durations (15–30 ms) are appropriate.

In the armamentarium of lasers available for leg vein treatment, the KTP laser, pulsed dye laser, Alexandrite laser, and diode lasers have all been utilized successfully, but the higher wavelength technologies are rapidly becoming the leaders in treatment of telangiectasias. Further novel approaches include combination of diode laser plus radiofrequency technology for treating lower extremity telangiectasias. When combined, the radiofrequency energy heats the outer vein thereby destroying it while the laser targets the endoluminal hemoglobin. Histopathological findings indicate that no matter which laser is utilized in treatment of lower extremity telangiectasias, some degree of intravascular thrombosis associated with vessel fragmentation will be seen (Figure 44.5).¹⁰

Patient interviews

A thorough medical history is necessary to establish a diagnosis and careful treatment plan for a patient experiencing veins pathologies. A discussion including details of potentials risk factors or sources of pathologic leg veins, such as heredity, hormones, prolonged standing, obesity, pregnancy, or aging, is imperative. The physical examination should be carried out while the patient is standing. Careful observations on pre-existing epidermal pigmentation and the size and type of abnormal veins on both legs should be evaluated. The use of a hand-held Doppler ultrasound device is advisable to map the leg veins and determine the direction of blood flow. A duplex ultrasound machine is suggested in patients with reflux or backflow. It is imperative not only to thoroughly evaluate the patient during the initial visit but also to appropriately advise the patient regarding optimal treatment approaches, including discussing all options such as surgery, sclerotherapy, lasers, or combined treatments.

Treatment techniques

Patient selection

Candidates for laser treatment of leg veins are ideally patients who have previously undergone surgery or sclerotherapy for the treatment of varicosities, incompetent perforators, and reticular veins to treat the majority of superficial vessels. However, there are unique circumstances in which laser therapy of leg veins can be considered prior to sclerotherapy in patients. These ideal special circumstances are for patients who (1) are needle phobic; (2) do not tolerate sclerotherapy; (3) have legs veins unresponsive to sclerotherapy; (4) or are prone to telangiectatic matting; (5) have small vessels less than the diameter of a 30-gauge needle.

Available laser technologies

Many different types of lasers are available for treatment of leg veins (Box 44.4). Each innovative laser is different with unique wavelengths (Table 44.1). One of the first to be developed in the 1980s was the 585-nm pulsed dye laser. The results showed that the device was able to sufficiently target fine, superficial telangiectasias but the pulse duration was too short to effectively damage larger

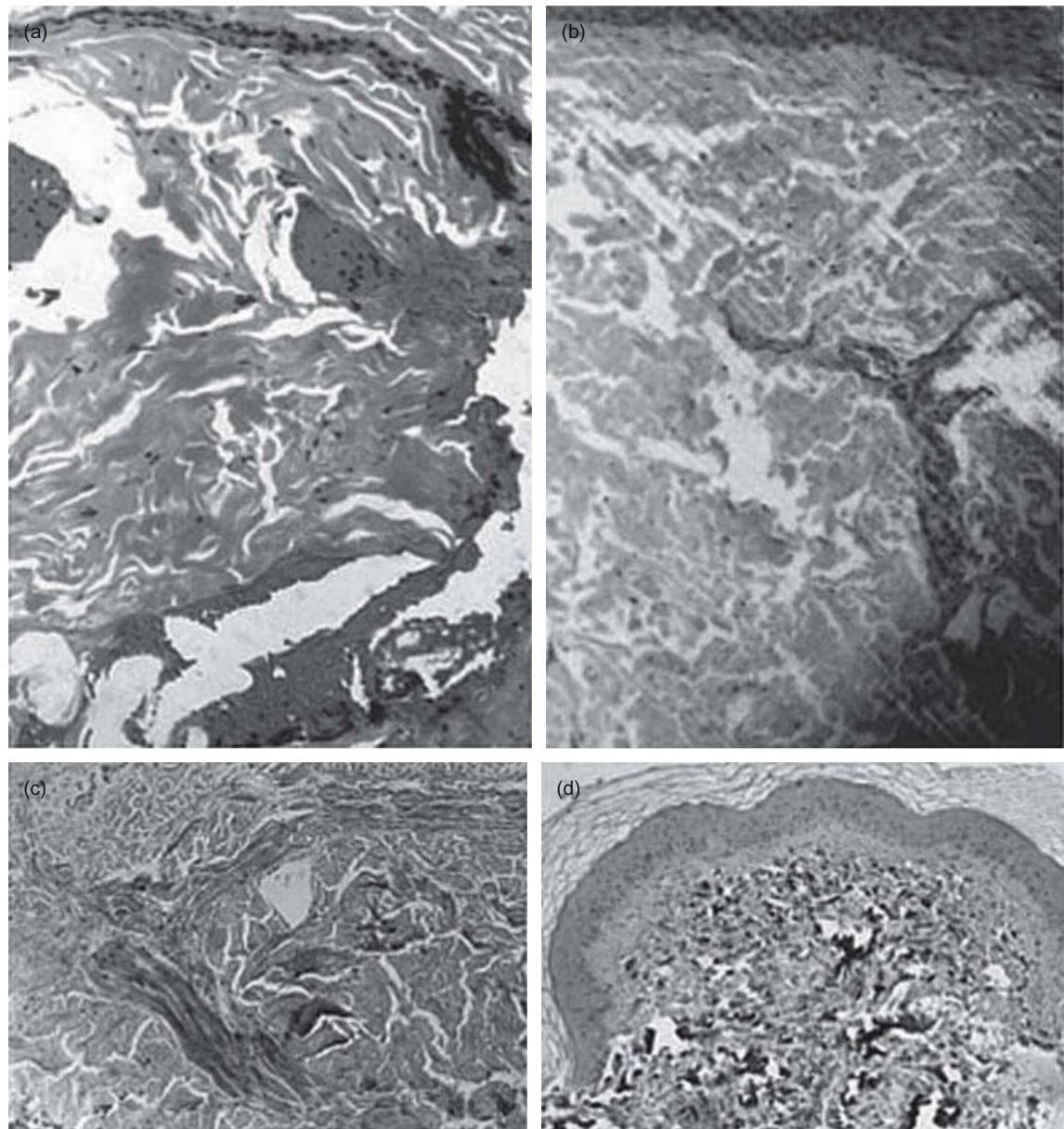


Figure 44.5 Representative histological and immunohistochemical findings: (a) pretreatment findings showing large vessels in a lax dermis (skin H&E, original magnification 125), (b) immediately after treatment, the vessels are closed and coagulated, with some coagulation also seen in the adjacent dermal collagen (skin H&E, original magnification 125), (c) Masson's trichrome staining shows

a clearly coapted and convoluted vessel, with some coagulation of the surrounding dermis, (d) CD34 positively stained cells (dense black) immediately after treatment show the presence of severely damaged, disrupted, and coapted vessel endothelial walls.
Reproduced from Sadick and Trelles [20] with permission from John Wiley & Sons.

vessels.¹¹ Adverse effects included bruising and post-treatment hyperpigmentation.

Since then, developments in longer wavelengths, longer pulse duration lasers, and light sources have vastly improved treatment outcomes and minimized

Box 44.4 Advances in external light technology for treatment of leg telangiectasias have improved clinical results because of:

- Cooling technologies
- Laser wavelengths
- External pulse duration
- Variable spot sizes
- Accurate matching of fluence with blood vessel size and color

Table 44.1 Lasers and light sources for the treatment of leg veins

Laser	Wavelength (nm)
Pulsed dye	585–605
KTP	532
Alexandrite	755
Diode	810
Nd:YAG	1064
Intense pulse light	515–1200

some adverse events by incorporating technologies of cooling to protect the skin at higher fluences. A number of long pulsed dye lasers are available with variable pulse durations that are capable of deeper penetration into the skin and are able to treat the larger superficial telangiectasias. Pulse durations of 40–60 ms are found to be more suitable for thermolysis of leg telangiectasias.¹² An elongated 3 × 10 mm spot has also been developed to converge the laser on a small linear vessel while attenuating energy delivery to adjacent tissue. Patients may experience adverse events such as purpura, which can last up to several weeks, and post-treatment hyperpigmentation, which could take up to several months to resolve.

Potassium titanyl phosphate (KTP) lasers have shown successful results for the treatment of small telangiectatic leg veins in fair-skinned phenotypes.¹³ However, it is important to note that these lasers do not have the ability to penetrate as deeply as the pulsed dye laser or the Nd:YAG lasers. Significant results have been achieved by using 3- to 5-mm spot sizes, 10- to 15-ms pulse durations, and fluences of 12–10 J/cm² (Figure 44.6).¹⁴

Adverse events are temporary erythema and superficial crusting; however, purpura are rare.¹⁵ Darker skinned patients are limited to lower fluences because melanin preferentially absorbs green light more effectively, creating difficulties in achieving optimal vessel coagulation.

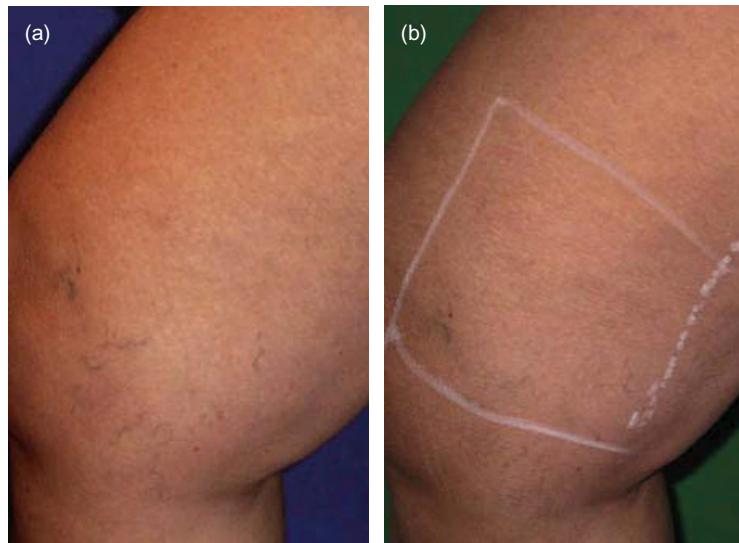


Figure 44.6 KTP laser. (a) pre-treatment, (b) post treatment.



Figure 44.7 Alexandrite laser. Before (a) and 3 months after (b) treatment with a 755-nm laser with a 3-ms pulse duration, 8-mm spot, and a fluence of 60 J/cm^2 . Reproduced from Kauvar and Khrom¹⁶ with permission from Elsevier.

It is necessary to avoid multiple passes at relatively high fluences when utilizing this laser to treat facial telangiectasias. No immediate or visual tissue changes are noticed, and such repeated pulses can therefore yield excessive thermal damage producing irregularities or depressions of the overlying skin.

The long pulse Alexandrite diode lasers are effective lasers with longer wavelengths, deeper penetration, and equal absorption by hemoglobin, which make them appropriately useful for larger telangiectatic and deep reticular veins. These longer wavelengths have been found to be successful in treating all skin phenotypes including the darker skin types as there is less interaction with epidermal melanin, allowing for safe treatment.⁴ Favorable parameters for this laser include 20 J/cm^2 double pulsed at a repetition rate of 1 Hz¹⁶ (Figure 44.7). These lasers are most suited to treat medium-sized vessels, as those larger than 1 mm or smaller than 0.3 mm respond poorly because of ineffective heat activation in larger vessels and infrared wavelengths inherently missing the smaller vessels within their target scope. Adverse events have been noted in and include purpura, matting, and long-term hyperpigmentation due to melanin absorption.

The Nd:YAG laser is considered the most popular laser of choice among long-pulse lasers for the treatment of leg veins. This technology has the ability to treat small telangiectasias and large reticular veins by making the appropriate adjustments in spot sizes, energy, and pulse durations. This all-in-one device can also treat veins up to 3 mm in diameter, thereby approaching concerns of

hydrostatic pressure of feeder and reticular veins, although extreme pain can be an issue in this application (Video 44.1). Optimal specifications of small spot sizes ($<2\text{ mm}$), short pulse durations (15–30 ms), and high fluences ($350\text{--}600\text{ J/cm}^2$) are the choice for superficial veins less than 1 mm in diameter. Reticular veins 1–4 mm in diameter can be successfully treated with larger spot sizes (2–8 mm), longer pulse durations (30–60 ms), and moderate fluences ($100\text{--}370\text{ J/cm}^2$)³ (Figure 44.8).

Intense pulsed light (IPL) technology is also useful in the treatment of leg veins, but results are found to be variable with this device. Unparallel light and wavelengths between 500 and 1200 nm are emitted in single, double, or triple pulses with this device. The longer wavelengths can penetrate deep in the skin to target the deeper veins. The 550- and 570-nm filters are adequate to deliver primarily yellow and red wavelengths along with some infrared component (Figure 44.9). Even though there is the advantage of a large spot size in this device, an alarming rate of adverse events have been reported with IPL, including blistering, crusting, discoloration, especially in darker skin types.

A combination approach utilizing both bipolar radiofrequency plus optical energy using either the diode laser or the intense pulsed-light source has been attempted in the destruction of leg veins. These two energy forms synergistically achieve a greater target effect. The laser constituent selectively heats the vessel therefore enabling preferential absorption of the radiofrequency energy due to the increased temperature and high electrical conductivity of blood. Studies by

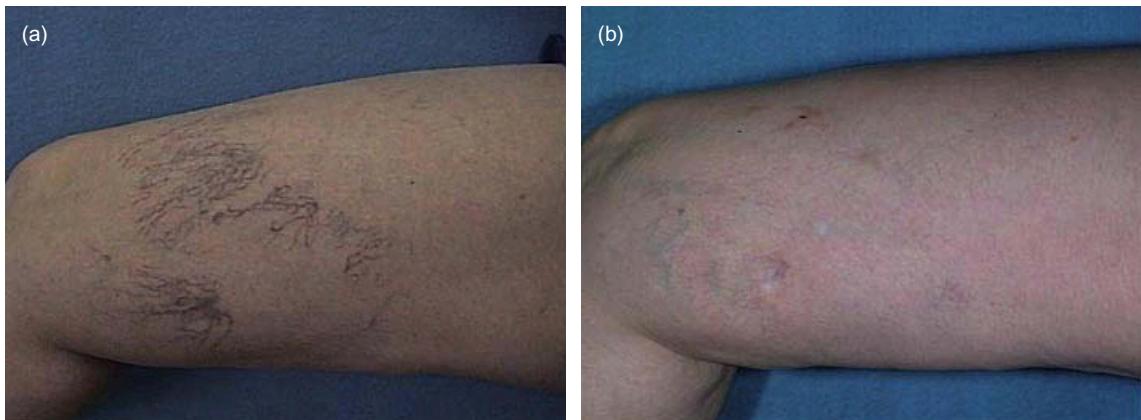


Figure 44.8 Nd:YAG laser (a) pre-treatment, (b) post-treatment.



Figure 44.9 Before and after results for treatment of leg veins utilizing intense pulsed light (500–550 nm).

Sadick¹⁰ using a 915-nm diode laser with radiofrequency energy show 30% of patients achieving greater than 75% clearance and 78% of patients achieving greater than 50% clearance of their leg veins in one to three treatments.

Treatment algorithm

Application of lasers for the treatment of leg veins is usually well tolerated by most patients with minimal complaints. Before commencing the procedure, the treatment area is cleansed with alcohol, and the patient, physician, and any assistance should wear appropriate eye protection. For those patients who do feel heightened sensitivity or if larger telangiectasias or reticular veins are involved, a topical anesthetic cream should be applied on the treatment area and covered with a plastic wrap an hour before treatment. The treatment of reticular veins can produce significant discomfort and in some cases it is so deep and extensive that even topical anesthesia is unable to mask it. The physician must advise patients of this possible occurrence; however, it is rare to provide supplementary anesthesia.

When treating a patient with the 532-nm KTP laser for smaller telangiectasias, fluencies of 12–20 J/cm² delivered with a spot size of 3–5 mm and pulse duration of 10–15 ms produce successful results. Cooling the skin should be essential before, during, and after treatment to prevent any thermal damage to the surrounding tissues and of course to alleviate discomfort during the treatment. Cooling provides the skin with protection while a target area is being treated. Cooling methods include contact cooling with cryogen cooling, convection air cooling, a sapphire plate or copper plate, or application of cold gels¹⁶ (Figure 44.10). Any of these applications will draw heat from the epidermis yet maintaining heat in the vessels for appropriate damage. Each laser pulse is separated by at least 1–2 mm and should be followed along

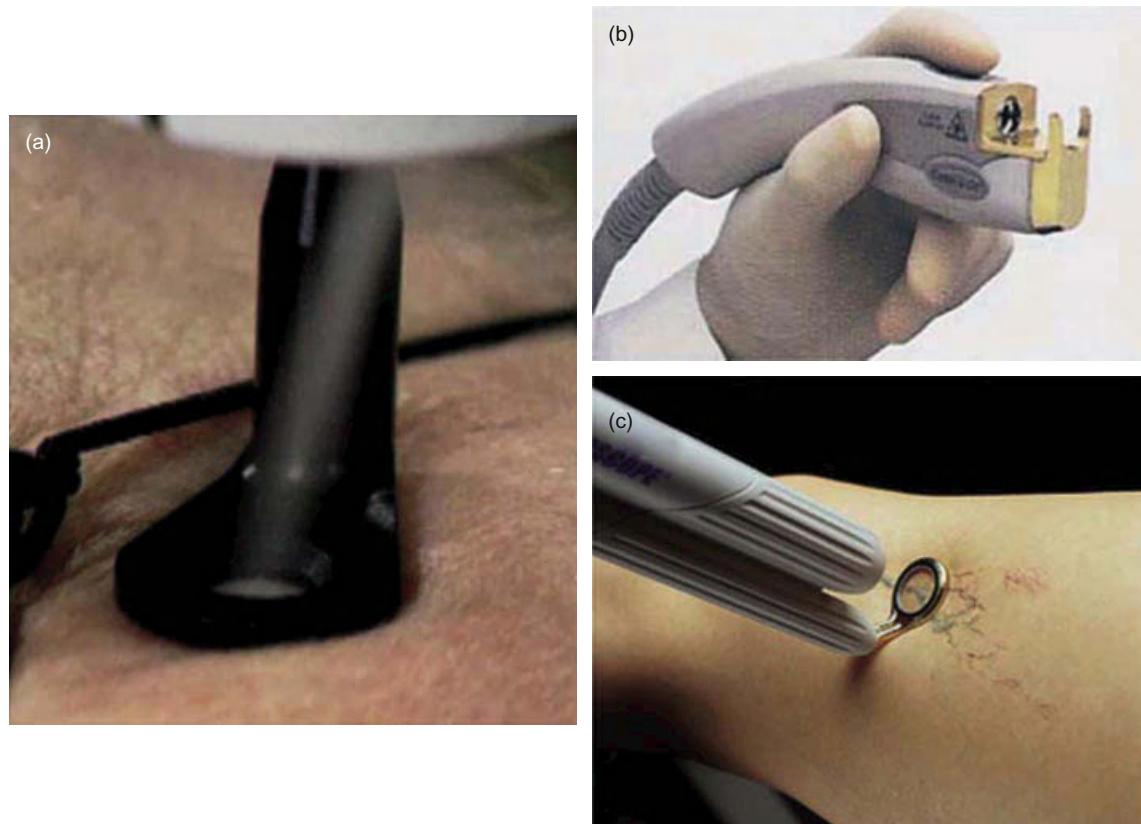


Figure 44.10 Various skin cooling devices, including (a) cryogen cooling, (b) contact cooling with a copper cooled plate, and (c) contact cooling with a water- cooled sapphire laser tip. Reproduced from Kauvar and Khrom¹⁶ with permission from Elsevier.

the length of the vein carefully avoiding overlap or double pulse of the treatment area.

When treating with the handpiece, minimal pressure is applied to avoid any physical compression of the target vein. The goals of laser treatment should include achieving either vessel spasm with immediate clearance or thrombosis followed by darkening of the vessel. Transient bluing showing cyanosis and microcoagula has been noted in studies when treated at lower radiant exposures.¹⁷ Moments after treatment the vein will appear to be normal again, usually because of reperfusion, or an interruption in the blood flow by potential microcoagula that may adhere to the vessel wall. As treatment continues there is increased constriction that occurs in the smaller vessels and fixed coagula block a return of flow. Total or complete stenosis is only observed in small vessels

as the larger vessels show more transient bluing or no immediate clinical results at all. It is crucial to understand this concept to avoid increasing laser fluencies to seek immediate results. These increases in fluences can potentially cause full thickness necrosis in these larger vessels because of extreme light exposure. Usually only one treatment session is required to achieve appropriate vessel damage and resolution of these vein pathologies; however, it is usually essential to perform two or three treatments at least 1 month apart for optimum improvement.

Reticular veins or telangiectasias >1 mm have shown to be successfully treated by the long pulsed Nd:YAG laser.¹⁸ Several 1064-nm lasers have the advantage of variable spot sizes and pulse width parameters to treat a large scope of leg veins including small telangiectasias. For

superficial vessels <1 mm in diameter, a 1.5-mm spot, 15- to 30-ms pulse duration, and 350–600 J/cm² is optimal. For reticular veins 1–4 mm in diameter, a 2- to 8-mm spot, 30- to 60-ms pulse duration, and 100–370 J/cm² is optimal. Lower fluences tend to yield more effective results for larger vessels and higher fluences are required to treat vessels smaller than 0.5 mm. It is seen that longer pulses are effective in appropriately heating treated vessels and providing a greater ratio of contraction to thrombosis.

In many cases, patients experience discomfort and epidermal damage, particularly caused by the use of higher fluences; to avoid these issues, it is essential to cool the skin before, during, and after the pulse. It can be beneficial to apply mild pressure with the handpiece, similar to the KTP, when treating reticular veins to minimize the diameter and the amount of hemoglobin in the lumen of the vessels. In this method, there is greater vessel penetration utilizing less overall heat and there is significantly less thermal damage to the surrounding skin. Here immediate clinical results are seen in the small vessels; however, larger telangiectasias and reticular veins may require more time to clear, improving over weeks to months.

During post treatment, it is common to see swelling, urtication, or erythema around treatment areas. Application of ice packs or topical steroids will increase healing time and reduce the risk of post-inflammatory hyperpigmentation. Patients are advised to wear compression stockings for at least 1 week after treatment to avoid vessels refilling in larger telangiectasias and reticular veins.

Complications

When utilizing laser and light technologies to banish telangiectasias, it is advisable to avoid retreatment for 8–12 weeks to allow for extensive cytokine release. Excessive inflammation and postinflammatory hyperpigmentation may develop if vessel treatments are too close together. As mentioned before, it is imperative to not retreat or double pulse stack vessels if one does not see an immediate effect, as it may take a few minutes after treatment for appropriate thermocoagulation to ensue.

Avoid retreating a target area until the tissue has appropriately cooled down to avoid skin burns from the

Box 44.5 Side effects

- Transient hyperpigmentation
- Purpura
- Telangiectatic matting
- Thrombosis
- Incomplete clearance of vessel
- Pain and severe discomfort
- Damage to the epidermal layer

excessive heat. It is beneficial to wait 10–15 minutes and then return to the area while another segment of vessels is treated. Lower fluences are recommended to effectively treat a given vessel. The pulses should be separated by 1–2 mm as lateral spread of thermal energy can thermocoagulate surrounding adjacent vessels without actually interacting with the treatment handpiece. Finally, in the darker skin phenotypes V–VI, individual spot sessions may be employed to be sure that there is no risk of post-inflammatory hyperpigmentation.

Adverse events of epidermal damage, thrombosis, hyperpigmentation, and telangiectatic matting are commonly seen when utilizing lasers for treating leg veins (Box 44.5). Telangiectatic matting may be combated utilizing retreatment with lower fluences, and if matting is seen with flushing an intense pulsed light source is recommended. Events of localized thrombus may be treated with a no. 9 Bard-Parker blade or 18-gauge needle. Hyperpigmentation is usually transient and resolves without treatment; however, in cases of persistent hyperpigmentation 3–4% hydroquinone compounds can be applied. Epidermal crusting secondary to overheating is another side effect that can be addressed by immediate wound care involving petrolatum-based ointments and topical steroids.

Conclusion

Laser surgery is one of the most dynamic and rapidly growing areas of aesthetic medicine. Many technologies have been developed to combat the issues of vein pathologies and will continue to evolve to achieve immediate satisfactory results with minimal adverse events. The principles of evaluation and management for

treatment of varicose veins are similar for both reticular veins and telangiectasias. Successful results can be seen by considering laser therapy as an adjunct to first-line treatment, which is sclerotherapy. By considering the basic tenets discussed in this chapter, the physician may achieve rewarding results in treating leg veins. Considerations of anatomic variation, reflux principles, the practice of fastidious technique, a varied pulse width monomodal wavelength laser approach, and adequate compression are the foundation of success. As lasers evolve, highly efficacious lasers are being developed with minimal downtime and a high safety profile. Progression towards longer wavelengths, longer pulse duration, and effective cooling devices and techniques are improving treatment of leg veins.

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Video list

Video 44.1 Laser for treatment of leg veins

Laser treatment for acne

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Introduction

Acne vulgaris is the most common cutaneous disorder known to man, affecting between 80% and 95% of people.^{1–4} Approximately 40 million adolescents are affected by acne in the United States.^{5,6} It can cause severe psychological problems, especially depression and poor self-image.^{7,8} Adolescents with acne are at least twice as likely to contemplate suicide.⁹

Various etiologies of acne vulgaris have been suggested.

- An interleukin (IL)-1-mediated inflammatory response with subsequent sebaceous follicle obstruction along with concomitant hyperkeratosis.^{10,11}
- A deficiency of linoleic acid.¹²
- Follicular occlusion by outside forces.¹³
- Dihydrotestosterone-mediated sebaceous gland hypertrophy.¹³
- Bacteria such as *Propionibacterium acnes* colonizing the upper and midportion of the hair follicle, converting lipids within sebum to proinflammatory free fatty acids, and triglycerides.^{14,15}
- A genotype of XYY.^{16,17}
- An immune response involving cytotoxic and chemoattractant factors along with follicular inflammation^{11,18,19}

The most commonly used topical therapies for acne are keratolytic agents, anti-inflammatory, retinoids and antimicrobials.^{3,20–22} Systemic treatment includes oral antibiotics, hormones, steroids and isotretinoin.

Isotretinoin is a retinoid, made from a synthetic form of vitamin A. It is considered one of the most effective treatments for patients with severe cystic acne, although important side effects can occur, such as dry skin, lips and eyes, photosensitivity, thinning hair, fatigue, and headache.

Surgical treatments such as lesion removal, incision and drainage, intralesional corticosteroid, chemical peel, and microdermabrasion can be considered depending upon the need of the patients.

In addition to the above modalities, phototherapy has also been investigated because medical therapies have certain drawbacks, such as irritation from topical therapy, bacterial resistance, pain from the procedure, and often involve a prolonged course of treatment.²³

Laser/light-based therapies are known to cause self-destruction of *P. acnes* via absorption of the laser energy in the range 400–700 nm by protoporphyrin.²⁴ In addition to the effect on *P. acnes*, lasers are also known to cause direct photothermal damage to the sebaceous glands.²⁴ A number of lasers have been investigated for treating acne, including the pulse dye laser (PDL), potassium titanyl phosphate (KTP) laser, 1450-nm diode laser, 1320 neodinium:yttrium aluminum garnet laser (Nd:YAG), and the 1540 erbium:glass laser.

The 532-nm KTP laser primarily targets *P. acnes* porphyrins.²⁵ Bowes and colleagues demonstrated a 36% decrease in mild and moderate acne using 7–9 J/cm², with a 20-ms pulse duration and a 4-mm spot size.²⁶

The 585 and 595 PDLs have also been explored as treatments in acne. Seaton *et al.*²⁷ have shown a 49% reduction in acne versus a 10% reduction in a control group using the 585-nm PDL with 1.5–3.0 J/cm², a 350-ms pulse duration, and a 5-mm spot size. Orringer *et al.*²⁸ demonstrated that the PDL was not effective for treating acne vulgaris. Despite these findings, Alam *et al.*²⁹ showed statistically significant clearance using the 595-nm PDL with 8–9 J/cm², a 6-ms pulse duration, and a 7-mm spot size in 25 patients compared with the 1450-nm diode laser for treating facial acne.

The 1320-nm ND:YAG has been hypothesized to affect the sebaceous gland and has been directly shown to improve comedonal acne.³⁰ Chernoff³¹ used the 1320 Nd:YAG laser on 50 moderate to severe cases of acne vulgaris and found that 80% of the subjects thought they had 75–100% improvement; 72% of the subjects believed that their improvement did not last longer than 3 months.

Paithankar *et al.*³² explored the use of the 1450-nm diode laser for acne vulgaris and showed that at an average fluence of 18 J/cm², 14 out of 15 patients had reduced acne lesion counts after four treatments with intervals of 3 weeks. Mazer³³ used the 1450-nm diode laser to treat 61 patients at 14 J/cm², and 26 patients demonstrated at least 65% improvement. Friedman *et al.*³⁴ reported an 83% reduction in acne lesions of the face in patients taking oral/topical acne treatments.

The 1540 erbium:glass laser has been used to target the sebaceous glands. Angel and colleagues³⁵ used it at 10 J/cm², a 3-ms pulse duration, with a 5–6 pulse train at 2 Hz, and observed a 78% decrease in lesions on the back and face.

A number of light-based treatments are currently under investigation, including visible light, specific narrow-band light, intense pulsed light (IPL), and photodynamic therapy (PDT). Aminolevulinic acid (ALA) applied 15–60 minutes prior to red, blue, or IPL light has also been demonstrated to be effective.²⁵

Endogenous porphyrins produced from *P. acne* have a spectrum of maximal absorption in range of 405 to 420 nm with a peak at 415. Blue light therapy for acne provides the excitation of these porphyrins by a high-intensity violet/blue light source and decreases the bacteria count. Noborio *et al.*³⁶ performed a study in 10 patients. This light was used during bi-weekly sessions with 48 J/cm² and 15–20 minutes per session; 80% of patients received around a 60% improvement of

palponodular acne lesions after eight treatments. The study showed that this light has little effect on the number of non-inflammatory comedones.

Red light has been shown to be effective in acne treatment by activating porphyrins in the Q bands (509, 544, 584, 635 nm). It can also decreases inflammation by controlling cytokine release from macrophages and stimulating fibroblast proliferation, release of growth factors, collagen deposition, and neovascularization.

A combination of blue and red light has also been used. Goldberg and Russel³⁷ used a combination of blue and red light-emitting diode therapy to treat acne in 24 subjects. The study showed that this combination appears to have excellent potential in the treatment of mild to severe acne; it is side-effect free and with no pain.

Photopneumatic devices have become popular for treating acne vulgaris. These devices use a negative pressure vacuum and intense pulsed light ranging from 400 nm (broadband blue) to 1200 nm (infrared). The negative pressure raises the sebaceous gland closer to the surface to be targeted by the light, and, at the same time, the contents of the sebaceous glands are mechanically removed. The broadband blue light is believed to cause bacterial destruction via absorption of light energy by the protoporphyrin. The infrared light is thought to have anti-inflammatory effects.²³ Different filter tips are available: the 580-nm tips are safer for darker skin types.

Suggested procedure for use of the photopneumatic device²³ (Video 45.1)



- I. A filter tip of 400 nm is used for patients with Fitzpatrick skin types I–III, and 580 nm for patients with Fitzpatrick skin type IV.
- II. The face is washed with a mild cleansing soap so that make-up and/or debris is removed prior to treatment.
- III. The photopneumatic device is applied to the skin and a negative pressure of 3 psi is applied to the skin.
- IV. Fluences ranging from 3.6 to 4.2 J/cm² are used.
- V. A single pass is used with approximately 10% overlap.
- VI. A second pass with the same or similar settings can be used on individual acneiform lesions as judged by clinical experience.
- VII. The patients are advised to avoid sun exposure for at least 48 hours after the treatment.

VIII. Care should be taken to ensure a complete seal so that the light and vacuum enacts a uniform effect on the skin.

Side effects of the photopneumatic device

I. Acne may transiently worsen in the first 5–7 days

II. Transient erythema

III. Purpura (rarely)

Another modality which has been explored for acne vulgaris is photodynamic therapy. Photodynamic therapy targets the pilosebaceous unit for destruction.¹³ The complete procedure is described in Chapter 54.

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Video list

Video 45.1 Laser treatment for acne

Laser treatment of psoriasis, vitiligo, and alopecia areata

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Introduction

The xenon-chloride gas excimer laser is a light source which delivers high doses of monochromatic, 308-nm, long-wave, UVB light. Compared with narrow-band UVB, it emits short pulses of high-intensity coherent light that is delivered through a flexible handpiece so that adjacent normal skin is left untouched. The mechanism of action proposed is that it affects keratinocyte proliferation and induces T-cell apoptosis, thus improving inflammatory skin conditions mediated by T cells. The excimer laser is FDA approved for psoriasis and vitiligo, and is commonly used for other conditions, such as alopecia areata.

Psoriasis

Psoriasis is a common, chronic, and recurrent inflammatory disease of the skin that affects approximately 1–2% of the population. Laser treatment of psoriasis was first reported in 1986.¹ Early treatments focused on ablation of psoriatic plaques using the carbon dioxide (CO₂) or erbium yttrium-aluminum-garnet (Er:YAG) laser.^{2,3} The theory behind the use of these lasers was based on the “reverse Koebner phenomenon” that is observed after

the removal of both the epidermis and papillary dermis, which results in clearing and prolonged remission of psoriasis. Additional theories of using lasers to treat psoriasis involved targeting the hypervascularity of psoriasis lesions using a pulsed dye laser (PDL) at a wavelength of 585 nm or 595 nm.⁴

The most recent advance in laser treatment of psoriasis is the excimer laser, which uses high-intensity UVB light. Compared with narrow-band UVB (NB-UVB) the excimer laser can achieve similar improvements in fewer treatment sessions, with remissions of up to 2 years being reported.⁵ It is especially useful for recalcitrant plaque psoriasis in combination with other therapies.

Vitiligo

Vitiligo is a skin disease characterized by loss of epidermal melanocytes, resulting in patches of depigmentation on the skin. One proposed mechanism involves the action of CD8+ T cells in the pathogenesis of this condition, and treatments are often aimed at decreasing inflammation. One common method of treatment is NB-UVB, with a wavelength of 311–312 nm, which is proposed as the first-line treatment modality for generalized vitiligo in adults and second-line for children.⁶ In 2001,

the 308-nm excimer laser appeared in the literature as a potential treatment modality for vitiligo.⁷ It offers some advantages over NB-UVB such as more selective treatment areas and avoidance of tanning non-affected skin. Additionally, it appears to be more effective in inducing T-cell apoptosis than NB-UVB.⁸ Drawbacks include the higher expense of the treatment, and the time-consuming nature of the treatment if a large body surface area is involved.⁶ Treatments are administered two or three times weekly, with lesions on the face, neck, and trunk responding better than those on the extremities. Clearing of lesions may be enhanced by a combination therapy of excimer laser and topical immunomodulators.⁶ Side effects are generally minimal, and include erythema most commonly, with only occasional pruritus or blistering, similar to a sunburn.⁶

Alopecia areata

Several small studies show efficacy in patchy alopecia areata. A recent study in children showed a 63% improvement in treated patches of alopecia on the scalp, previously unresponsive to conventional therapies.⁹ However, patients with alopecia totalis or universalis did not respond to laser treatment, nor did patients with a history of atopy.⁹ In patients with patchy scalp alopecia areata failing conventional therapies such as intralesion corticosteroids and topical steroids, and no history of atopy, the excimer laser may be a safe and effective treatment. However, it is common for recurrence within 6 months following treatment.

Preoperative care

Patient selection checklist

- I. How long have you had psoriasis/vitiligo/alopecia?
- II. What treatments are you currently using?
- III. What past treatments have you used?
- IV. Have you had a biopsy to confirm the diagnosis?
- V. Do you have joint pain or swelling (for psoriasis)?
- VI. Is there a family history of this condition?
- VII. What are your current medications, including any medications that may be photosensitizing (ask specifically about use of isotretinoin in the last 6 months?)
- VIII. Have you had any prior surgeries?

- IX. Have you had any complications from bleeding or wound healing?
- X. Are you able to come to regular treatment session two or three times per week for excimer laser?
- XI. Do you have a personal or family history of skin cancer?
- XII. Do you have any photosensitizing conditions such as lupus or porphyria?
- XIII. Do you have any history of herpes infection at or near the site of treatment?

Favorable patient characteristics

- I. Psoriasis: has stable plaque or inverse psoriasis; vitiligo: does not have generalized involvement, and has areas of body which respond well to excimer (face, neck, trunk); alopecia areata: has patchy hair loss and no history of atopy
- II. Understands treatment protocol and associated risks
- III. Realistic expectations
- IV. Willing to comply with postoperative care

Unfavorable patient characteristics

- I. Psoriasis: widespread or unstable plaque psoriasis, guttate psoriasis, or erythrodermic psoriasis; vitiligo: generalized involvement or involvement of hands or feet only; Alopecia areata: Alopecia totalis or universalis, or a history of atopy
- II. Unable to understand treatment protocol or associated risks
- III. Unrealistic expectations
- IV. Long travel distance to appointments or inability to make follow-up appointments

Supplies needed

- I. Appropriate eye protection for operating personnel
- II. Protective eye shields for patient
- III. Mineral oil to enhance penetration (for psoriasis)
- IV. Procedure tray with gauze to wipe off mineral oil (for psoriasis)

Step-by-step surgical technique

Note that these are guidelines only. Individual patient responses and the practitioner's experience should dictate the proper and safe treatment of each patient. There are several excimer laser machines available for purchase.

Table 46.1 Suggested MED range for test spots (mJ/cm^2) for excimer laser

MED test spot	Skin types I-II	Skin types III-IV	Skin types V-VI
1	100	150	200
2	130	190	250
3	160	230	300
4	190	270	350
5	220	310	400
6	260	350	450

Adapted from Goldberg¹⁰ with permission from Elsevier.

The dosing recommendations for each individual laser should be thoroughly studied prior to treating patients, as each machine will differ slightly in its use.

Preprocedure checklist

- I. Patient should be informed of risks and benefits of the procedure
- II. Patient should sign written consent
- III. Written postoperative instructions should be provided to patient
- IV. Take baseline photographs of patient
- V. If patient has hyperkeratotic plaques can use keratolytics for 1–2 weeks prior to treatment to improve laser penetration (for psoriasis)
- VI. Skin type of patient should be determined and minimal erythema dose (MED) testing should be performed on non-sun-exposed area of skin such as volar forearm or buttocks at least 1 day prior to treatment (Table 46.1)
- VII. Patient should return 24–48 hours after MED test to identify the minimal erythema dose intensity

Low- or medium-dose UVB treatment advised for some psoriasis, and all vitiligo and alopecia areata (AA) patients (adapted from the Clinical Reference Guide for the Xtrac excimer laser)

- I. In general, weekly or bi-weekly treatments are required. Treatments are quick, however, and take less than 2–3 minutes for a 10 cm^2 lesion.
- II. Combination treatments in which topical or oral therapies are combined with excimer laser are likely to yield even better clinical outcomes.

- III. Make sure patient is in a comfortable position
- IV. Ensure appropriate protective eyewear for the patient and the provider
- V. Apply mineral oil to intended treatment areas to enhance UV penetration (for psoriasis)
- VI. Treat the affected areas with the laser (Video 46.1) 
- VII. Initiate treatment at 2–3× MED for psoriasis; start with 50 mJ/cm^2 less than MED for vitiligo or AA
- VIII. Deliver treatment pulses in non-overlapping pulses over target lesions
- IX. Observe the skin for erythema, burning, or blistering
- X. Notate the treatment settings and any side effects in the patient's chart
- XI. The goal is to produce moderate erythema for psoriasis, and minimal erythema and clinical response for vitiligo and AA
- XII. If there is no erythema or response then increase dose by 25% for psoriasis, or 50 mJ/cm^2 for vitiligo and AA and re-evaluate patient at next visit
- XIII. If minimal erythema is produced then increase dose by 10–15% each subsequent visit as treatment continues for psoriasis; maintain this dose for vitiligo or AA
- XIV. For moderate erythema in treating psoriasis, maintain this dose; for vitiligo or AA, decrease dose by 50 mJ
- XV. If severe erythema, burning, blistering or pigment alteration occurs then skip one treatment session and decrease dose by 15–25% for the next scheduled visit for psoriasis; for vitiligo or AA, decrease by 100 mJ/cm^2

High-dose excimer laser treatment (8–16× MED): psoriasis only

- I. Can be used for only one or two recalcitrant plaques if the patient understands the risk of blistering versus the benefit of needing a single or very few treatments
- II. Higher fluences may produce faster and longer remission but have a greater risk of phototoxic reactions.

Postoperative care and follow-up

- I. Typically the patient does not require any post-treatment care

- II.** After treatment mild erythema is typically present
- III.** For treatment with low- or medium-dose excimer laser the patient will return for follow-up on a weekly or bi-weekly basis

Complications

- I.** After treatment mild erythema is typically present
- II.** Tanning is most common side effect in patients with skin types that are capable of tanning
- III.** Blistering or pruritus may occur in patients treated with higher fluences
- IV.** Hyperpigmentation may occur at treated sites

Prevention and management of complications

- I.** To prevent severe erythema or burning of the skin, MED testing is extremely important.
- II.** Patients should be advised to use sun protection and sunscreen when going outside following treatment.
- III.** If blistering occurs, the area should be covered with antibiotic ointment or hydrophilic petrolatum until healed.
- IV.** Pruritus may be treated with a low-potency topical steroid twice daily until resolved.
- V.** Hyperpigmentation may occur at treated sites.
- VI.** Higher fluences of the excimer laser produce faster and longer remissions but are associated with a higher risk of phototoxic reactions and blistering.

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Video list

Video 46.1 Laser treatment of vitiligo

Lasers for skin resurfacing

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Introduction

Laser skin resurfacing has evolved to include a variety of procedures, most of which involve laser and light sources. A synopsis of these is included in Table 47.1.

Ablative resurfacing

The 10 600-nm CO₂ laser precisely ablates skin by emitting either a high-energy pulse of 1 ms or less (pulsed CO₂) or by rapidly scanning a continuous-wave laser beam so that the dwell time on any individual spot is less than 1 ms (scanned CO₂). The light penetrates 20–30 µm and the exposure is less than the thermal relaxation time of the cutaneous tissue that absorbs this wavelength, thus limiting thermal damage to surrounding structures. These devices yield impressive improvements in scars and rhytids not only because of controlled tissue vaporization, but because of the presence of residual thermal damage (RTD) that extends approximately 100–150 µm into the dermis and stimulates collagen contracture, remodeling, and skin tightening (Figure 47.1).^{1–3} The multiple-pass technique has a longer associated recovery and higher risk of complications than single-pass CO₂ or multiple-pass 2940 nm Er:YAG laser.⁴ The Er:YAG has an absorption coefficient that is 16 times that of the CO₂ laser, a shorter pulse duration, narrower depth of vaporization, and smaller zone of RTD. Although Er:YAG resurfacing is associated with shorter recovery times, it is less efficacious than treatment with a CO₂ laser.^{1–4} Various

combination procedures utilizing these wavelengths have been reported in an effort to maximize efficacy and minimize recovery. More recently, the erbium:yttrium-scandium-gallium-garnet (Er:YSGG) 2790-nm laser was introduced as a unique system with hybrid characteristics including an absorption coefficient roughly five times that of the CO₂ laser, better coagulation than Er:YAG, and reportedly shorter recovery times.⁵

Non-ablative resurfacing

Most non-ablative systems used for resurfacing were developed to protect the epidermis and deliver heat to the dermis in an effort to stimulate neocollagenesis, collagen remodeling, and skin tightening.^{2,3,6} Some modalities that were originally developed for other clinical applications have also been observed to have some ability to remodel collagen and smooth the texture of photodamaged skin. Examples include vascular lasers (pulsed dye, potassium titanyl phosphate), intense pulsed light sources, and photodynamic therapy. Longer wavelength infrared lasers (1000–1500 nm) have been successfully used for non-ablative laser resurfacing. The Q-switched 1064-nm Nd:YAG laser, alone or in combination with carbon solution, induces some dermal remodeling, but its use for this purpose was replaced by longer wavelength infrared devices which penetrate deeper into the dermis yielding more consistent improvement.⁶ Both the 1320 nm Nd:YAG and 1450 nm diode lasers employ cooling systems for epidermal protection and are able to effect

Ablative		Non-ablative	
Laser	Wavelength (nm)	Laser	Wavelength (nm)
CO ₂	10 600	PDL	585–595
Erbium:YAG	2940	KTP	532
Erbium:YSGG	2790	Nd:YAG (Q-switched, long-pulsed)	1064
		Nd:YAG (long-pulsed)	1320
		Diode (long-pulsed)	1450
		Erbium:glass	1540
		Non-laser	515–1200
		Intense pulsed light (IPL)	Activation with blue or red light, IPL, PDL
		Photodynamic therapy with 5-ALA or MAL	

CO₂, carbon dioxide; YAG, yttrium-aluminum-garnet; YSGG, yttrium-scandium-gallium-garnet; PDL, pulsed dye laser; KTP, potassium-titanyl-phosphate; Nd, neodymium; Q-switched, quality-switched; 5-ALA, 5-aminolevulinic acid; MAL, methyl aminolevulinate

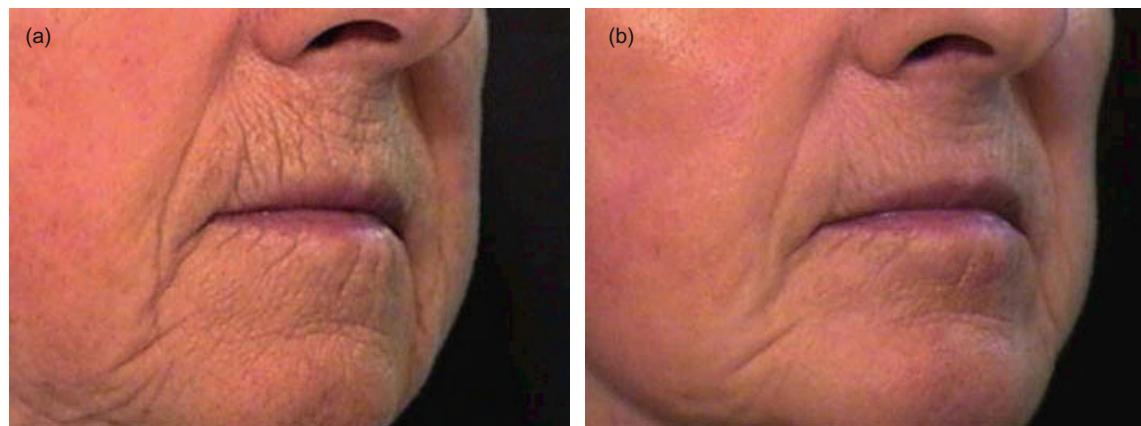


Figure 47.1 Photoaging with severe perioral rhytids (a) before and (b) 6 months after ablative carbon dioxide laser resurfacing.

mild improvement in photoaged skin and scars with virtually no postoperative recovery (Figure 47.2).^{2,3} The 1540-nm erbium:glass laser has the least amount of melanin absorption and is useful for non-ablative resurfacing in darker skin types, with only transient, mild erythema and edema during recovery.⁶

Fractional laser technology has revolutionized the field of laser skin resurfacing and has essentially replaced traditional ablative and non-ablative lasers because of its ability to be applied to facial and non-facial regions, its faster recovery and lower complication rates, and clinical

efficacy similar to ablative techniques, particularly when repeat treatments are applied.^{7,8} Fractional resurfacing is discussed in detail in another chapter.

Preoperative care

Prior to treatment, the patient should be carefully screened as to their understanding of the procedure, recovery, expected results, and potential risks. Patients seeking dramatic improvement in photoaged skin,

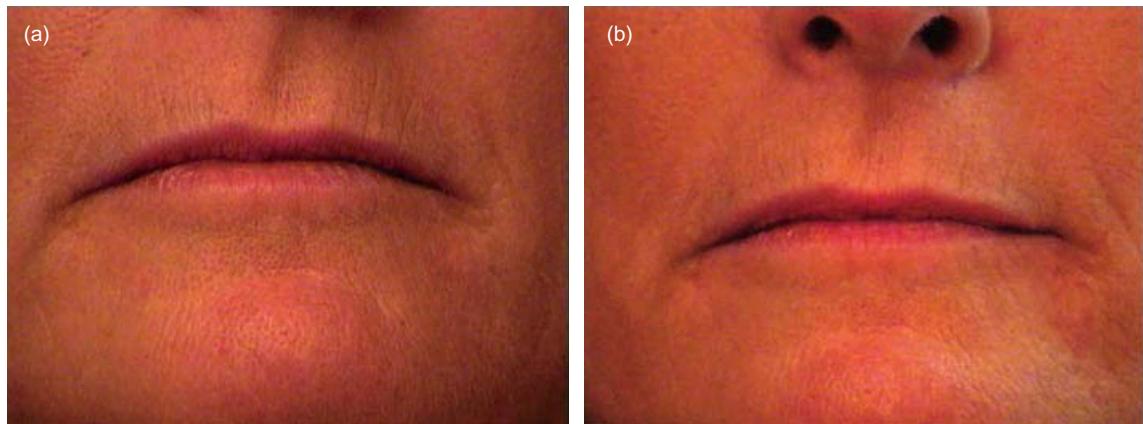


Figure 47.2 Mild improvement in perioral rhytids (a) before and (b) 6 months after three monthly 1450-nm long-pulsed diode laser treatments.

rhytids, or acne scarring are more appropriate for ablative (fractional or traditional) modalities. It is essential that they are agreeable to treatment and able to strictly adhere to pre- and postoperative instructions. Those who cannot tolerate a significant recovery are better suited to non-ablative approaches, but they must understand and accept the potential for modest efficacy and the requirement for a series of treatments in exchange for reduced risk. Table 47.2 summarizes the components of the preoperative evaluation and their management.

The best candidates for ablative resurfacing have Fitzpatrick skin phototypes I and II and are in good general health. Fractional ablative resurfacing can generally be performed on those with Fitzpatrick skin phototypes III and IV, but they should be informed of their higher risk of postinflammatory hyperpigmentation. Pretreatment regimens with hydroquinone, glycolic acid, or topical tretinoin have been shown to have no effect on the incidence of postinflammatory hyperpigmentation following laser resurfacing.⁹ If general anesthesia is planned for the procedure, an age-appropriate preoperative medical evaluation is required. Reliable home transportation of the patient after treatment should be arranged. It is essential that the patient is prepared with adequate postoperative assistance and wound care supplies. Preoperative baseline photographs with consistent lighting and head positioning (frontal view, lateral side profiles, oblique views) should be obtained. Patients should have reviewed and signed the relevant consent forms, have had all

questions answered, prescriptions verified, and medications reviewed prior to the procedure.

Step-by-step surgical technique

Anesthesia

Non-ablative resurfacing is associated with only mild to moderate discomfort that can generally be controlled with topical anesthetic cream (e.g., 4% or 5% lidocaine) for 1 hour before treatment. Compounded higher concentrations are safe when limited to a small area. Ablative resurfacing generally produces significantly more discomfort. Systemic anxiolytics, pain medication, sensory nerve blockade, and additional local infiltration of the lateral face, mandible, and eyelids are helpful, but intravenous anesthesia is the method of choice for full-face ablative (CO_2 or erbium) resurfacing. The latter requires the presence of an anesthesiologist or nurse anesthetist, intravenous access, monitors, and emergency equipment.

Safety

The treatment room should have the appropriate eye protection for all persons present. External eye shields are sufficient for patient protection during most non-ablative procedures, but internal metal shields are essential for any laser or light procedure that involves treatment of skin within the orbital rim. The necessary supplies for

Table 47.2 Preoperative considerations and management

Preoperative consideration	Management
Darker skin phototype	Proper wavelength selection, caution regarding postinflammatory pigmentation risk, consider test area
History of HSV	Antiviral prophylaxis*
Anticoagulant use	Discontinue two weeks prior to treatment for pulsed dye and ablative resurfacing
Acne prone	Empiric systemic therapy if recent history of inflammatory lesions
Smoking	Avoid or reduce smoking following ablative resurfacing
Dermatographism	Consider pretreatment with antihistamines
Rosacea	Consider vascular laser in combination, anticipate flare
Atopic history	Anticipate and control dermatitis
Psoriasis or vitiligo	Consider potential for Koebner phenomenon
Pregnancy/nursing	Delay procedure
Isotretinoin use	Delay treatment 6 months
Concurrent infection	Avoid laser treatment to affected area
Ectropion	Avoid ablative infraorbital treatment, caution in patients with lower blepharoplasty
Previous dermabrasion or phenol peel	Greater risk for poor healing and postoperative hypopigmentation, consider non-ablative therapies
Seizures or migraine headache	Possible laser-induced trigger, avoid treatment with visible light wavelengths
Keloids or abnormal scarring	Greater scar risk, avoid ablative resurfacing (exceptions possible)
History of radiation or scleroderma	Greater risk for poor healing, avoid ablative resurfacing (exceptions possible)

*All patients (regardless of HSV history) receive oral antiviral prophylaxis with perioral or full face ablative laser resurfacing.

ablative resurfacing are listed in Table 47.3. No flammable solutions or materials should be present in the laser field.

Intraoperative considerations

Any/all topical anesthetic cream should be removed and the skin thoroughly dried prior to laser irradiation. Non-ablative resurfacing techniques vary, but generally involve a series of full-facial treatment with non-overlapping pulses delivered at 4- to 6-week intervals.

For ablative procedures, the patient is positioned with appropriate drapes over the chest and a headband to secure the hair before prepping the skin to ensure a clean, dry surface. Intravenous or local anesthesia is administered as appropriate, and gel lubricant (Surgilube) is

applied to protect the eyebrows and hairline. Test laser pulses should be initially fired on a tongue depressor to ensure proper equipment functioning. Papular lesions and scar edges can be first sculpted using a spot handpiece until the areas are level with surrounding skin. The scanning handpiece can then be used to deliver laser scans over the cutaneous surface in a non-overlapping manner. Deeper rhytids are stretched to ensure that the cutaneous base is treated evenly. Periorbital skin is treated with decreased fluence and fewer passes, while using the Jaeger bone plate to protect the lashes and brows. The perioral area is vaporized to include the vermillion border of the lip while covering the teeth with moist gauze to protect from laser-induced etching of dental enamel. The transition of the mandible to the neck

Table 47.3 Ablative laser resurfacing supplies and equipment

Mayo stand tray	Equipment and other supplies
Sand-blasted metal eye shields w/rubbery plunger	Appropriate laser, handpiece, foot pedal
Proparacaine 0.05% ophthalmic drops	Protective eyewear (for OR personnel)
Lacrilube	Headband (for patient)
Alcohol prep pads	Extra towels
Surgilube or bland ointment for hairline and eyebrows	Smoke evacuator
Small metal bowl with sterile water and 4 × 4 inch gauze	Forced air cooling device
Dry gauze and cotton tip swabs	Laser masks with 0.1 micron filtration efficiency
Wooden tongue depressor	Emergency resuscitation cart
Jaeger bone plate	
Non-sterile gloves	

should be feathered with lower fluence and/or fewer passes to prevent a sharp demarcation line between treated and untreated skin.

The first pass with CO₂ laser is sufficient to ablate the epidermis. If additional passes are performed, any partially desiccated tissue present is removed with saline-soaked gauze and dried prior to placement of additional passes. The second pass ablates into the dermis and a third or fourth pass is only employed in areas of fibrotic acne scars or deep rhytids. The Er:YAG laser vaporizes less tissue per pass and may require as many as four passes, depending on the energy, to achieve epidermal ablation. Erbium laser resurfacing is performed with moderately overlapping pulses to the clinical end point of rhytid/scar effacement. After the final pass, the partially desiccated tissue is left intact to serve as a biologic wound dressing. The patient is comforted with cool, moist gauze and forced air cooling or ice packs. Finally, petrolatum-based ointment (or short-term occlusive dressing) is applied and vital signs are documented at the end of treatment.

Postoperative care and follow-up

Non-ablative resurfacing methods require minimal post-operative care. Patients can expect variable amounts of erythema and edema, depending on the device, but the effects generally resolve within the first few days. Ice packs reduce post-treatment edema and aggressive sun protection of the treated area is necessary. Light-emitting diode irradiation has been shown to reduce postoperative erythema following non-ablative procedures and can be a useful adjunct.¹⁰

Recovery following ablative resurfacing is more involved both physically and emotionally. The patient should be discharged to a caretaker with written post-treatment instructions. Postoperative pain diminishes rapidly within the first few postoperative hours and only minimal discomfort is experienced thereafter. Oral analgesics, anxiolytics, and antihistamines can be prescribed as needed for pain, insomnia, and pruritis. No consensus regarding the use of bio-occlusive dressings to speed re-epithelialization within the first 24–72 hours has been reached, but examination of the patient during the initial postoperative period is necessary to assess for signs of infection. Water, saline, or 0.25% acetic acid-soaked compresses to the treated skin for 15–20 minutes assists in the removal of serous discharge and reduces crusting. The patient should repeat the process every 2–4 hours and follow with a generous application of bland ointment. Icing regularly and sleeping on elevated pillows helps to minimize edema, but in the case of severe edema, particularly when periorbital swelling is significant enough to impair vision, a 3- to 5-day course of systemic corticosteroids should be prescribed.

In general, patients should maintain a regular diet with good nutrition, ingest copious fluids, and engage in only light activity such as walking. Treatment areas should be completely protected from the sun until epithelialization is complete, followed by aggressive sun avoidance and sunscreen use during the period of postoperative erythema to minimize the risk of postinflammatory hyperpigmentation. Botulinum toxin injections should also be considered in order to diminish the recurrence of movement-associated dynamic rhytids (e.g., brow, lateral canthi) following laser resurfacing.¹¹ Depending on the procedure performed and individual patient needs, one or more follow-up visits during the first postoperative week and regular (e.g., monthly) follow-up visits

Mild/Transient	Moderate	Severe/Prolonged
Prolonged erythema	Localized infection	True hypopigmentation
Postinflammatory hyperpigmentation	Topical anesthesia toxicity	Disseminated infection
Relative hypopigmentation	Eruptive keratoacanthomas	Scarring
Milia and acne exacerbation		
Dermatitis		

Table 47.4 Complications of ablative laser resurfacing

thereafter should be anticipated until the skin has completely healed.

Complications

Non-ablative modalities are rarely associated with transient post-treatment erythema, pigmentation, herpes simplex outbreak, or acne flare. Patients enjoy a much lower risk of undesirable side effects and, depending on their goals, many people will be willing to accept modest efficacy if their social and work schedules remain uninterrupted. Side effects following ablative resurfacing are predictable and well documented, but patients must be emotionally prepared and anticipate a more involved recovery. All patients experience varying degrees of post-operative discomfort, erythema, edema, serosanguinous discharge, and pruritis. These should be expected and managed. True complications range from mild acne flares and prolonged erythema to devastating infection and hypertrophic scarring. Reported complications of ablative laser resurfacing are listed in Table 47.4.⁹

While the same complications are of primary concern following fractional treatments at similar wavelengths, the incidence is far lower than traditional ablative methods.⁸ Fractional laser skin resurfacing has become popular because of the shorter recovery and lower risk profile.

Prevention and management of complications

The duration of *postoperative erythema* depends on the procedure and re-epithelialization time. Multiple-pass

CO₂ resurfacing takes approximately 7–10 days to re-epithelialize, and postoperative erythema can last 6 months or longer. The recovery following single-pass CO₂ laser resurfacing is similar to multiple-pass Er:YAG, with approximately 5 days to re-epithelialize and an average of 4.5 weeks versus 3.6 weeks of postoperative erythema, respectively.⁴ Underlying rosacea or dermatitis may predispose to more significant erythema. Management involves aggressive sun protection during resolution and cosmetic camouflage with green-tinted facial make-up.

Postinflammatory hyperpigmentation can be seen in more than 30–40% of patients treated with CO₂ or erbium laser resurfacing and is even more typical in those with darker skin phototypes (Fitzpatrick III–VI).^{2–4,12} The dyschromia typically appears in the first few weeks after treatment and resolves spontaneously over several months. Topical hydroquinone, retinoic, azaleic, ascorbic, and glycolic acid as well as biweekly mild chemical peels can be used to hasten its resolution. *Hypopigmentation* most commonly represents the relative color difference between lighter, treated skin and the adjacent photodamaged skin with actinic bronzing (particularly on the mandible and lateral neck). True hypopigmentation is rare, appears after 6–12 months, and is most common after multiple-pass CO₂ laser resurfacing. Treating within cosmetic units and feathering of the mandible with lower energy and/or fewer passes to blend the skin minimizes this undesirable effect. Alternative treatments such as fractional laser skin resurfacing, intense pulsed light, and chemical peeling can improve the appearance of the adjacent photoaged skin on the neck and chest.

Patients that are acne-prone or those with recent inflammatory lesions should have their acne well



Figure 47.3 *Staphylococcus aureus* infection following carbon dioxide laser resurfacing presenting with increased erythema and excessive crusting. Patients should be cultured and treated with empiric oral broad-spectrum antibiotics and topical wound care until a firm diagnosis is established.

controlled prior to resurfacing. Flares of *acne* and *milia* are thought to be related to the use of occlusive ointments and/or aberrant follicular epithelialization during the healing process.¹² Although mild lesions resolve spontaneously without treatment, those with significant involvement should be treated with systemic antibiotics to prevent scarring. Milia also resolve spontaneously, but can be manually extracted to improve clinical appearance.

Dermatitis can occur in laser resurfacing patients because the impaired epidermal barrier makes the skin more sensitive to allergens or irritants. For this reason, topical antibiotics, herbal/natural home remedies, and fragrance-containing solutions are avoided and only bland petrolatum-based ointment is applied to the skin during re-epithelialization.¹² Most episodes of dermatitis resolve with discontinuance of the offending agents, but potent topical corticosteroids should be prescribed to speed recovery and prevent excoriations to newly resurfaced skin.

Viral, bacterial, and fungal infections can have an atypical presentation following ablative resurfacing.¹² Signs of infection include focal erosions, localized pain, increased erythema, and excessive crusting (Figure 47.3). Suspicion should remain high, and all patients should be immediately cultured and treated empirically until a firm



Figure 47.4 Disfiguring hypertrophic scars following carbon dioxide laser resurfacing.

diagnosis is established. Frequent follow-up appointments in the early postoperative period ensure early initiation of empiric, broad-spectrum therapy in case of suspected infection. Oral antiviral medication is prescribed for all patients, starting on the day of or prior to resurfacing and continuing for 7–10 days, or until re-epithelialization is complete. Despite this, 2–7% of patients will still develop herpes simplex infection.¹² Dissemination of the herpes virus should be treated aggressively with intravenous acyclovir in order to reduce the risk of infection-associated atrophic scarring. Although the use of prophylactic antibiotics is controversial and not supported by evidence in the medical literature, bacterial infection in the setting of newly resurfaced skin can have devastating consequences and most laser surgeons routinely prescribe cephalexin or azithromycin for 7–10 days.

Hypertrophic scarring and textural changes are rare (Figure 47.4). Failure to uncover important details pre-operatively such as those outlined in Table 47.2 represents a serious pitfall. Overlapping pulses and/or use of high-energy densities can lead to excessive thermal damage, as can aggressive treatment of periorbital skin, particularly in patients with histories of lower blepharoplasty. Postoperative infections, severe acne flares and pruritis with excoriation can also lead to scarring. Focal areas of tenderness in high-risk locations should raise suspicion of impending scar formation. Early treatment with potent topical corticosteroids and pulsed dye laser

can improve the appearance and symptoms of laser-induced scars.¹²

Other rare but reported side effects of laser resurfacing include eruptive keratoacanthomas, anesthesia toxicity and recall phenomenon.

Conclusions

As new technology becomes available, laser surgeons will have the ability to choose and combine techniques and parameters to enhance efficacy and minimize postoperative morbidity. Technical advances have expanded the clinical applications of laser resurfacing and have improved its safety profile. Many complications can be prevented or reduced by proper patient selection, careful pre- and postoperative care, and early intervention.

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Fractional resurfacing lasers: ablative and non-ablative

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Introduction

Over the past 5 years, fractional laser resurfacing has nearly replaced older pulsed and scanned resurfacing technology as the gold standard for the repair and rejuvenation of photoaged skin, scarring, and other cutaneous textural abnormalities. The concept of fractional photothermolysis was first described by Manstein *et al.* 2004.¹ The fractionated laser energy is limited to regularly spaced microthermal zones (MTZs), or photocoagulated columns of skin, with intervening areas of untreated skin providing a reservoir of healthy keratinocytes for rapid wound healing (Figure 48.1). Fractional *ablative* systems vaporize tissue in treated microthermal zones which produces a visible wound, whereas fractional *non-ablative* resurfacing systems deliver enough heat to denature collagen and cause cell necrosis, but the treated tissue remains intact without evidence of an external wound. Because fractionated technology can be applied to virtually any laser or optical device, an explosion of new wavelengths and devices has become available (Table 48.1).

The laser handpieces vary according to wavelength, beam pattern and width. The operator can manipulate the energy density (or percent tissue coverage) and energy/power (depth) of delivery. Fractional laser resurfacing enhances the number of treatment possibilities and improves the recovery time and safety profile of many skin resurfacing procedures. The applications for this technology continue to expand with the ability to

treat facial and non-facial skin in patients with a wide range of skin phototypes.^{2–7} Appropriate patient selection and operator experience remain crucial variables that ultimately determine treatment efficacy, patient satisfaction, and overall clinical outcome. Although the risk of complications with fractional resurfacing is lower than that observed after treatment with older ablative lasers, serious complications have been reported.⁸

Fractional ablative resurfacing

Fractional ablative resurfacing utilizes wavelengths that vaporize microscopic columns of tissue and induce surrounding areas of collagen denaturation, remodeling, and skin tightening. A detailed discussion of ablative wavelengths (10600-, 2940-, and 2790-nm devices) is presented in Chapter 47. *Superficial fractional ablative* procedures target the epidermis and superficial dermis to improve the appearance of dyschromia, fine rhytides, surface irregularities, and skin tone. Treatment density can be adjusted to affect variable amounts of the skin surface. For superficial ablative procedures, several devices incorporate a handpiece with a larger beam diameter (300–1300 µm) to achieve higher treatment densities. In contrast, device settings can be adjusted to achieve *deep fractional ablative* resurfacing by vaporization of discrete columns of skin extending 1.4 mm or deeper into the dermis, thereby resulting in dramatic dermal remodeling

and tightening (Figures 48.2 and 48.3). With higher energy ablation, it is essential to decrease treatment density in order to maintain an adequate reservoir of untreated skin to hasten re-epithelialization and optimize healing. Up to 40% ablation for moderately aggressive facial treatments is conventional, while non-facial sites

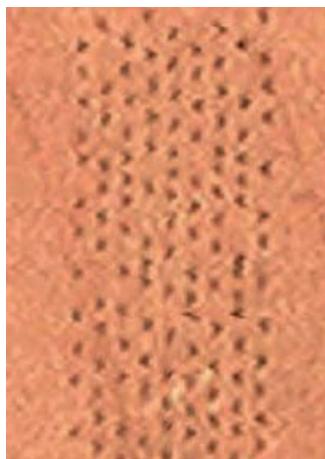


Figure 48.1 Fractional laser beam delivery: pixilated grid pattern of fractional ablative laser on a tongue depressor.

require much lower treatment densities (5–20%) because of the increased risk of complications with use of higher densities in skin with few pilosebaceous glands. Smaller beam diameters (120–350 µm) are better suited to deep fractional ablative procedures. Laser parameters can be adjusted and combined to individualize therapy to a growing number of clinical applications (Table 48.2 and Box 48.3). Recovery times vary greatly depending on the wavelength used, device settings applied, sites treated, and various patient factors. In general, the re-epithelialization process occurs within 1–3 days followed by a week of erythema and desquamation.

Fractional non-ablative resurfacing

The first fractional laser prototype utilized a 1550-nm wavelength to induce microscopic zones of thermal injury in an array pattern across the skin surface. A range of infrared resurfacing devices (1440-, 1540-, 1550-nm) have been created using fractionated technology that can selectively target water-containing skin. These wavelengths are poorly absorbed by melanin and are, thus, useful for non-ablative resurfacing in darker skin types. In contrast to ablative wavelengths which vaporize skin,

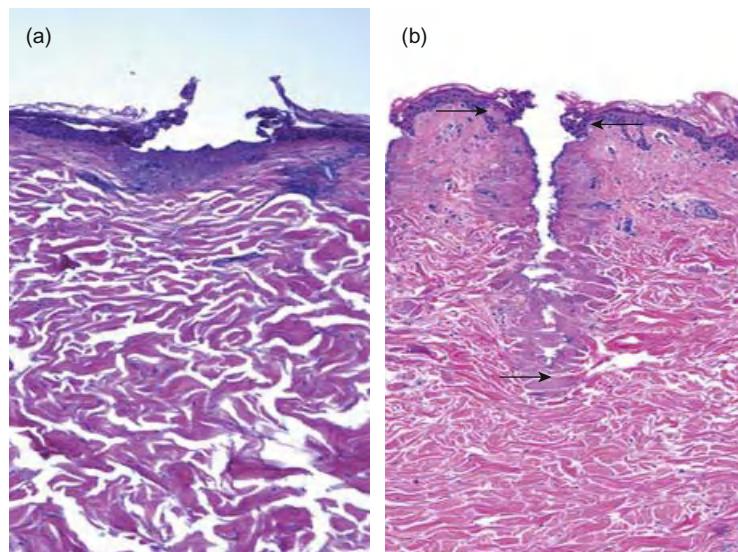


Figure 48.2 Histological comparison of microthermal treatment zones utilizing 10600-nm wavelength fractional ablative laser. Superficial (a) versus deep (b) cutaneous wounds result from decreasing or increasing the energy density respectively. Arrows showing the width and depth of the ablative column. © 2010 Solta Medical, Inc. Reproduced with permission.

Table 48.1 An overview of fractional laser devices

Manufacturer	System (trade name)	Laser type	Wavelength (nm)
Ablative			
Alma	Harmony High Power Pixel	Er:YAG	2940
	Pixel CO ₂	CO ₂	10600
	Pixel CO ₂ Omnifit	CO ₂	10600
Candela	QuadraLASE	CO ₂	10600
Cutera	Pearl Fractional	YSGG	2790
Cynosure	SmartSkin CO ₂	CO ₂	10600
Deka	SmartXide DOT	CO ₂	10600
Eclipsemed	Equinox CO ₂ Fractional	CO ₂	10600
Ellipse Inc.	Juvia	CO ₂	10600
Focus Medical	NaturaLase Er Fractional	Er:YAG	2940
Fotona	SP Plus	Nd:YAG/Er:YAG	1064/2940
	SP Dualis	Nd:YAG/Er:YAG	1064/2940
	XS Dualis	Er:YAG	2940
	XS Fidelis	Er:YAG	2940
Lasering	Mixto SX	CO ₂	10600
Lumenis	UltraPulse Active FX	CO ₂	10600
	UltraPulse Deep FX	CO ₂	10600
Lutronic	Mosaic CO ₂	CO ₂	10600
	eCO ₂	CO ₂	10600
Palomar	Lux 2,940	Er:YAG	10600
Quantel	EXEL O ₂	CO ₂	10600
	FX4 and FX12	Er:YAG	2940
Sandstone Medical	Matrix LS-25	CO ₂	10600
Sciton	Profractional	Er:YAG	2940
Sellas	Cis F1	CO ₂	10600
Solta Medical	Fraxel re:pair	CO ₂	10600
Non-ablative			
Cynosure	Affirm Nd:YAG		1440 ± 1320
Palomar	Lux 1,540	Er:Glass	1540
	Lux 1,440	Nd:YAG	1440
	Lux DeepIR	Infrared	850–1350
Sellas	True Fractional	Erbium fiber	1550
Solta Medical	Fraxel re:store	Erbium fiber	1550
	Fraxel re:store Dual	Erbium/Thulium	1550/1927
Syneron	Matrix RF	Diode/bipolar RF	915

CO₂, carbon dioxide; Er:YAG, erbium-doped yttrium aluminum garnet; Nd:YAG, neodymium-doped yttrium aluminum garnet; RF, radiofrequency; YSGG, yttrium scandium gallium garnet.

non-ablative systems create a zone of denatured collagen and cell necrosis without production of a visible wound. The treated zones of microscopic epidermal necrotic debris (MENDs) re-epithelialize within the first day after treatment, but the collagen remodeling process continues for weeks. The energy setting, measured in millijoules, can vary the depth of penetration of the laser depending on the target clinical application. The treatment of dyschromia requires higher density superficial treatment,

whereas deeper dermal processes such as rhytides and scars benefit from treatment depths of 1.4 mm or more.⁹ Periorbital rhytides, photoaging, dyschromia, and scarring are the most common indications for fractional non-ablative resurfacing treatments, but the applications for this modality continue to expand (Table 48.1 and Box 48.1). Clinical efficacy improves with the application of a series of three or more treatments. There is no acceptable data comparing the efficacy of one or two fractional

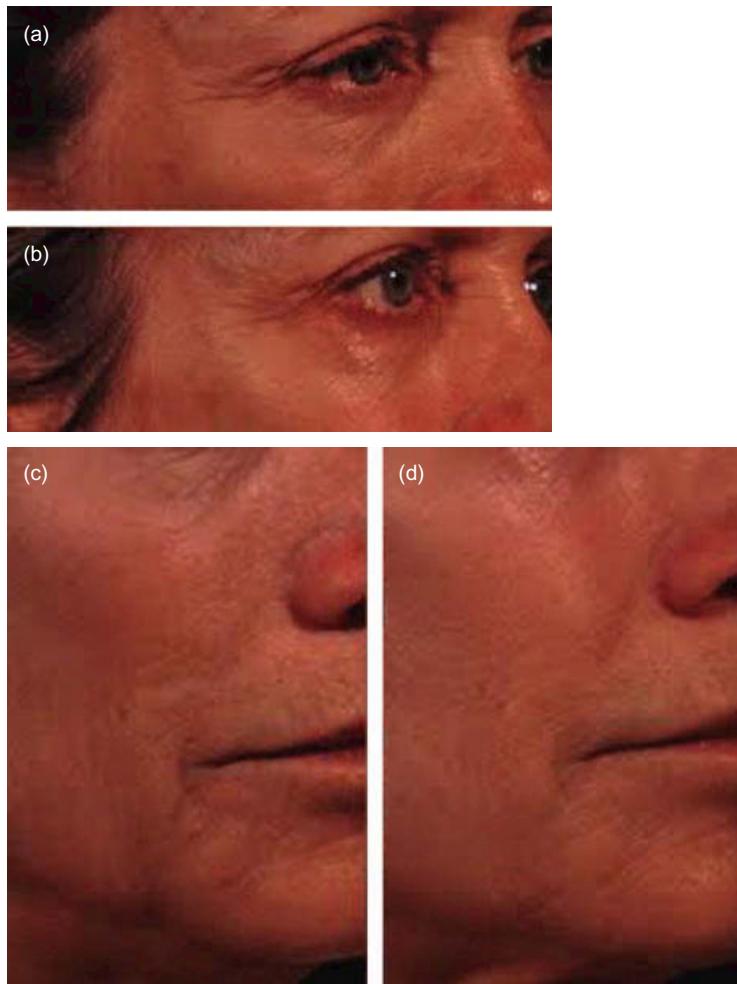


Figure 48.3 Photoaging and rhytides before (a,c) and after fractional ablative laser resurfacing (b,d).

ablative treatments with a series of six or more fractional non-ablative resurfacing sessions for any given indication; however, patients undergoing a series of non-ablative fractional resurfacing sessions experience a shorter recovery period and a significantly lower risk of complications.^{10,11} Depending on the laser parameters utilized, recovery from fractional non-ablative laser treatment using 1440-, 1540-, or 1550-nm wavelengths involves only 2–3 days of sunburn-like erythema and edema. Despite short recovery times, clinical improvement and collagen remodeling often continues for 6 months or longer following a series of treatments.

The newest fractional resurfacing modality is the diode-pumped thulium laser that emits a 1927-nm wavelength. It selectively coagulates the epidermis and creates

a split at the dermal–epidermal junction without vaporizing tissue (Figure 48.5). Depth of penetration is dependent on the energies used, but tends to remain focused in the epidermis and superficial dermis (150–250 µm), making it theoretically superior for treatment of superficial pigmentation, fine rhytides, and actinic keratosis associated with photoaging. The 1927-nm thulium laser can be used alone or in combination with a deeper (1550 nm) non-ablative fractionated device (Fraxel re:store Dual, Solta Medical). Post-treatment recovery involves epidermal necrosis and re-epithelialization manifested clinically as mild erythema and edema, followed by skin bronzing and sandpaper-like surface texture during the desquamation process that lasts for several days.

Table 48.2 Preoperative considerations and management

Preoperative consideration	Management
Dark skin phototype	Proper wavelength selection, caution regarding treatment density and postinflammatory pigmentation risk, consider test area
Non-facial site	Caution with ablative wavelengths, ensure proper energy/density selection, ensure meticulous postoperative care
History of HSV infection	Antiviral prophylaxis*
Acne prone	Empiric systemic therapy if recent history of inflammatory lesions
Smoking	Avoid or reduce smoking for fractional ablative resurfacing
Dermatographism	Consider pretreatment with antihistamines
Rosacea	Consider concomitant vascular laser treatment, anticipate postop flare
Atopic history	Anticipate and control dermatitis
Psoriasis or vitiligo	Consider potential for Koebner phenomenon
Pregnancy/nursing	Delay procedure
Isotretinoin use	Controversial, delay ablative treatment for 6 months
Concurrent infection	Avoid laser treatment to affected area, delay treatment until infection cleared
Keloids or abnormal scarring	Greater scar risk, avoid ablative LSR (exceptions possible)
History of radiation or scleroderma	Risk for poor healing, avoid ablative LSR (exceptions possible)

*All patients (regardless of HSV history) receive oral antiviral prophylaxis with perioral or full face fractional ablative laser resurfacing. HSV, herpes simplex virus; LSR, laser skin resurfacing.

Preoperative care

The preoperative evaluation should include a skin examination and a full discussion of the range of skin resurfacing techniques available. The ultimate treatment recommendation should be based on a number of factors in order to achieve the best clinical outcome with the lowest risk profile. Table 48.2 summarizes the essential components of the preoperative evaluation and management for fractional resurfacing procedures. An important part of the evaluation (one not typically included in a medical history) is to uncover personality traits and lifestyle characteristics that would influence the patient's candidacy for a moderately aggressive fractional ablative procedure. Patients should be questioned about their activities of daily living, including work, child care, and home responsibilities that could impact or interfere with the healing process. With such a wide array of treatment choices, physicians must learn about their patients and tailor treatment recommendations to suit each individual. Those who cannot tolerate or schedule for a

significant recovery period are better suited to a series of fractional non-ablative resurfacing procedures, even if clinical efficacy is somewhat compromised.

The best candidates for fractional ablative resurfacing are those with Fitzpatrick skin phototypes (SPTs) I–IV, although SPT III and IV should be aware of their higher risk of postinflammatory hyperpigmentation. Topical regimens including hydroquinone, glycolic acid, or topical tretinoin should be discontinued immediately prior to therapy and restarted only after complete healing has taken place as evidenced by resolution of postoperative erythema. If systemic anxiolytics, analgesics, or twilight sedation is planned for a more aggressive fractional ablative resurfacing procedure, an age-appropriate preoperative medical evaluation is required and reliable transportation home after treatment must be arranged. Preoperative baseline photographs with consistent lighting and head positioning (frontal view, lateral side profiles, oblique views) should be obtained prior to any laser procedure. Patients should have reviewed and signed the relevant consent forms, have had all questions

Box 48.1 Applications for fractional laser resurfacing

Photoaging/dyschromia

- Fine wrinkling of the face, neck, chest, hands, extremities
- Moderate rhytids and laxity
- Acne scarring
- Traumatic and surgical scars
- Hyper- and hypopigmented scars
- Actinic keratoses*
- Residual fibro-fatty tissue from hemangioma
- Residual lymphangioma circumspectum
- Residual professional or traumatic tattoo
- Melasma[†]
- Postinflammatory hyperpigmentation
- Striae atrophicae
- Poikiloderma of Civatte

Evidence limited to case reports

- Nevus of Ota
- Minocycline-induced pigmentation
- Colloid milium
- Granuloma annulare
- Telangiectatic matting
- Disseminated superficial actinic porokeratosis

*1927-nm thulium fiber resurfacing is FDA approved for the treatment of actinic keratoses

[†]Challenging/controversial

answered, prescriptions verified, and medications reviewed prior to the procedure.

Step-by-step surgical technique

Anesthesia

Fractional skin resurfacing with ablative (2790-, 2940-, 10 600-nm) wavelengths produces more significant intraoperative discomfort than non-ablative laser resurfacing. Small, localized areas or single cosmetic units can be sufficiently infiltrated with local anesthetic infiltration prior to fractional ablative resurfacing; although caution is necessary when treating traumatic or burn scars on the

extremities due to the risk of compartment syndrome. Fractional ablative resurfacing of more extensive skin areas (e.g., full face) requires additional consideration for adequate anesthesia and depends entirely on the device and intended treatment parameters. The use of lower energies and densities tends to correlate with less intraoperative pain and, thus, such treatments often can be performed with the use of topical anesthesia and forced air cooling alone. More moderate to aggressive treatment parameters, particularly with the CO₂ (10 600-nm) wavelength, tend to require a combination of systemic anxiolytics, analgesics, sensory nerve blockade, and additional local infiltration of the lateral face, mandible, and eyelids. Twilight sedation is an excellent alternative for these cases, but requires the presence of an anesthesiologist or nurse anesthetist, intravenous access, monitoring, and emergency equipment.

Fractional resurfacing with non-ablative (1440-, 1540-, 1550-, and 1927-nm) wavelengths is associated with mild to moderate discomfort that can generally be controlled with topical anesthetic for one hour prior to treatment and intraoperative use of forced air cooling. Few patients require oral anxiolytics (e.g., diazepam) or analgesics for full face fractional non-ablative resurfacing.

Safety

For any laser skin resurfacing procedure, the treatment room should have the appropriate eye protection for all persons present. A smoke evacuator should be used to remove aerosolized debris and surgical masks are also essential for operating personnel. External eye shields are sufficient for patient protection during most non-ablative procedures and the skin can be retracted and treated over the bony orbital rim. Any laser or light procedure that involves treatment within the orbital rim requires placement of ocular metal shields. The necessary supplies for fractional ablative resurfacing are listed in Box 48.1 in the previous chapter. No flammable solutions or materials should be present in the laser field.

Intraoperative considerations

Any/all topical anesthetic cream should be removed and the skin thoroughly dried prior to laser irradiation. Non-ablative resurfacing techniques vary, but generally involve a series of full-facial treatments delivered at 4- to 6-week intervals. Fractional ablative procedures involve the same preparation, supplies, and considerations as traditional

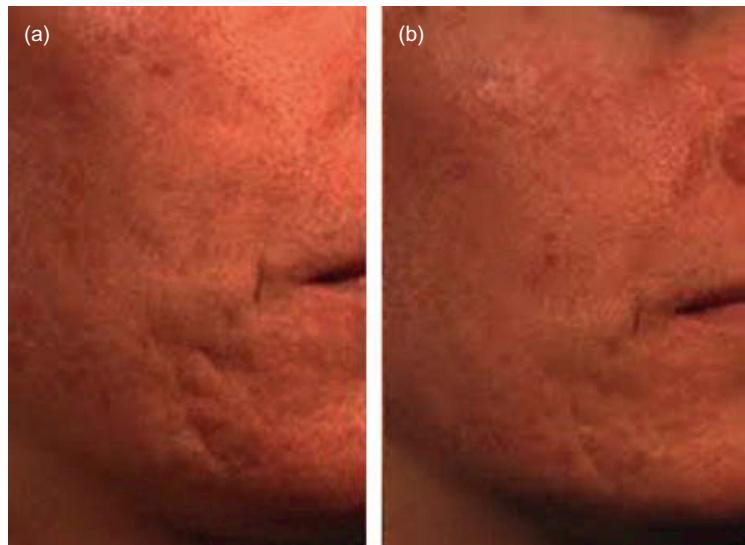


Figure 48.4 Acne scarring before (a) and after fractional non-ablative laser resurfacing (b).

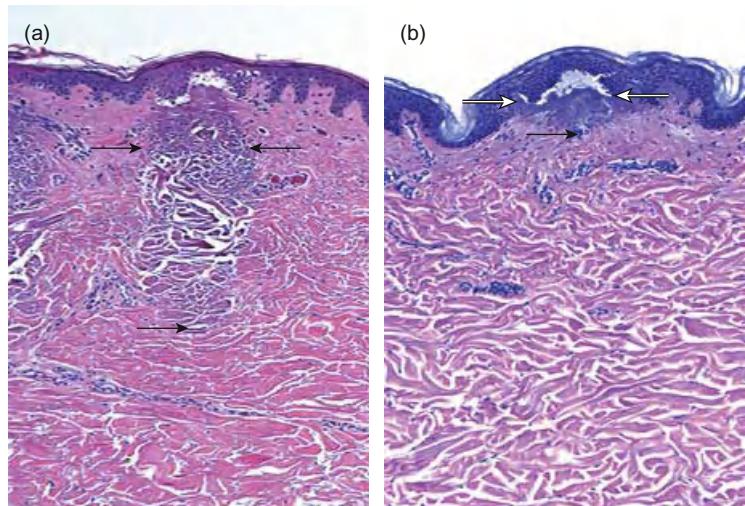


Figure 48.5 Histological comparison of microthermal zones created by 1550-nm (a) versus 1927-nm (b) wavelengths. Arrows show the width and depth of microthermal zone. Figures courtesy of Solta Medical. © 2010 Solta Medical, Inc. Used with permission.

ablative resurfacing. The patient should be positioned with drapes over the chest and a headband to secure the hair before prepping the skin to ensure a clean, dry surface. Intravenous or local anesthesia is administered as appropriate and gel lubricant (Surgilube) is applied to protect the eyebrows and hairline. Test laser pulses should initially be fired on a dampened tongue depressor to

ensure proper equipment functioning. The entire cutaneous surface is then treated using either a rolling or stamping handpiece. Multiple, non-overlapping passes should be used to achieve the target treatment density. For example, 30% density might be achieved with three passes at 10% density in order to minimize areas of high density overlap. Deeper rhytids are stretched to ensure

that the cutaneous base is treated evenly. Periorbital skin is treated with decreased fluences while using the Jaeger bone plate to protect the lashes and brows. The perioral area should be treated while covering the teeth with moist gauze to protect from laser-induced etching of dental enamel. The transition of the mandible to the neck should be feathered with lower fluence and/or fewer passes to prevent a sharp demarcation line between treated and untreated skin. When treatment is complete, the patient is comforted with cool, moist gauze, and forced air cooling or ice pack followed by the application of a petrolatum-based ointment.

Postoperative care and follow-up

Fractional non-ablative resurfacing methods require minimal postoperative care. Patients can expect variable amounts of erythema and edema, but the effects generally resolve within the first few days. Ice packs every hour reduce post-treatment edema and aggressive sun protection of the treated area is necessary. Light-emitting diode irradiation has been shown to reduce postoperative erythema following non-ablative procedures and can be a useful treatment adjunct.¹²

Recovery following fractional ablative resurfacing requires a clear understanding of postoperative care. Pain diminishes rapidly within the first few postoperative hours and only minimal discomfort is experienced thereafter. Water, saline, or 0.25% acetic acid-soaked compresses to the treated skin for 15–20 minutes assists in the removal of serous discharge and reduces crusting. The patient should repeat the process every 2–4 hours and follow with a generous application of petrolatum-based ointment. Icing regularly and maintaining head elevation helps to minimize edema, but in the case of severe edema, particularly when periorbital swelling is significant enough to impair vision, a 3- to 5-day course of systemic corticosteroids should be prescribed. After the first few days when re-epithelialization is complete, the transition from ointment to a cream-based moisturizer is possible. Depending on laser wavelength and treatment settings, one or more follow-up visits are required during the first postoperative week with regular (e.g., monthly) visits recommended until erythema resolves. Avid sun protection and good nutrition/sleep habits are essential during recovery.

Complications

Fractional laser resurfacing is associated with a much lower incidence of side effects and complications, although the same considerations and risks exist⁵ (see Chapter 47, Table 47.4). Fractional non-ablative modalities are associated with mild transient erythema lasting several days.^{10,11} The risk of postinflammatory pigmentation, herpes simplex outbreak, or acne flare is much lower than with fractional ablative resurfacing. Likewise, fractional ablative resurfacing has a much lower risk of infection, dyspigmentation, and scarring than older pulsed and scanned ablative resurfacing methods.⁸ Although hypertrophic scarring following fractional ablative resurfacing has been rare, the hypopigmentation associated with the older pulsed CO₂ laser systems has not been reported.^{13–15}

Prevention and management of complications

Postoperative erythema lasts approximately 2–3 days following fractional non-ablative resurfacing and 1–2 weeks following fractional ablative resurfacing.^{8,10,11} Erythema lasting more than 4 days after fractional non-ablative resurfacing is considered *prolonged erythema* and occurs in less than 1% of treatments.¹¹ Following fractional ablative resurfacing, prolonged erythema (lasting longer than 1 month) is more common but resolves within a few months. Treatment with a 590-nm wavelength light-emitting diode (LED) has been shown to reduce the intensity and duration of postfractional laser erythema,¹² and topical corticosteroids and/or pulsed dye laser treatments may also be useful to hasten resolution in more severe cases.

Following fractional resurfacing, *postinflammatory hyperpigmentation* occurs in 1–32% of patients and is highly dependent on the wavelength, device, settings, and SPT of the patient. The dyschromia is less common, less intense, and of shorter duration than that seen with older non-fractionated ablative lasers. In patients with darker skin phototypes at higher risk for developing this complication, lower treatment densities should be utilized. Aggressive sun protection is the best preventative measure. Topical hydroquinone, retinoic, azaleic, ascorbic, and glycolic acid as well as biweekly mild chemical

peels can be used to hasten its resolution. *Hypopigmentation* most commonly represents the relative color difference between lighter, treated skin and the adjacent photodamaged skin with actinic bronzing. The delayed hypopigmentation that was associated with older non-fractionated carbon dioxide lasers has not been reported following fractional therapy; however, it remains a potential risk with application of higher energies and more aggressive laser techniques.

Patients should have their acne well-controlled prior to resurfacing and those that are acne-prone should be aware that *acne* and *milia* can occur while healing from both non-ablative and ablative fractional resurfacing. The incidence rate of acneiform eruptions (approximately 2–10%) is much lower than with older resurfacing lasers^{10,11} and is likely related to the use of occlusive moisturizers in the postoperative period or to aberrant follicular epithelialization during the recovery process. Outbreaks should be treated with systemic antibiotics to prevent scarring.

Dermatitis can occur after laser resurfacing of any type because of impaired epidermal barrier function. Most episodes of dermatitis resolve with discontinuance of the offending agents, but topical corticosteroids may be used to speed resolution in more severe cases.

The incidence of *viral*, *bacterial* and *fungal infections* is much lower following fractional resurfacing compared to older pulsed and scanned ablative lasers. Herpes simplex infection occurs in 0.3–2% of patients treated with fractional resurfacing. All patients should be prescribed an oral antiherpetic prior to fractional ablative laser resurfacing regardless of history. Bacterial infection is even more rare (0.1% infection rate); thus, empiric antibiotic prophylaxis remains controversial. Other reported infections include *Candida albicans*¹⁴ and *Mycobacterium chelonae*.¹⁵ Early recognition and empiric, aggressive treatment of suspected infections is necessary in the immediate postoperative period to prevent scarring.

The most feared complication related to fractional ablative resurfacing is *scarring*. Scattered reports of hypertrophic scars, with most being located on the neck, have emerged following treatment with fractional ablative carbon dioxide laser resurfacing.^{13,15,16} Potential causes for scarring include poor intraoperative technique, use of unnecessarily high fluence, infection, and severe acne flare. Regardless of the fractional device used,

proper technique involves multiple non-overlapping passes at very low density (5–10%). For higher density treatments, multiple passes are applied in an attempt to reduce the density in small areas of overlap that can occur. This technique minimizes the risk of developing small areas of high-density deep ablation that would ultimately induce a scar. Subtle raised areas, papules, or tender areas should raise suspicion of impending scar formation, and treatment involves early initiation of corticosteroids and pulsed dye laser irradiation.

Other rare but reported side effects of laser resurfacing include eruptive keratoacanthomas, anesthesia toxicity, and recall phenomenon.

Conclusions

The advent of fractional laser technology has expanded the clinical applications of laser skin resurfacing and improved its safety profile. Physicians have the ability to choose and combine techniques and parameters to refine this procedure, individualize treatment protocols, and maximize efficacy. Complications are best prevented or minimized by ensuring proper patient selection, meticulous intraoperative technique, extensive pre- and postoperative care, and early intervention of suspected complications.

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Non-invasive devices for fat removal

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Introduction

Treatment modalities to eliminate excess body fat have burgeoned in recent years, as an increasingly overweight population seeks options for improving health and physical appearance. Heightened public awareness of the dangers of obesity, including cardiovascular disease, type II diabetes, musculoskeletal problems, and malignancy,¹ as well as dissatisfaction with body image have motivated the development of technologies to address this predicament. While liposuction has remained the most effective and common procedure for body contouring,² more recently there have been efforts to create safe and effective technologies for fat removal that are minimally invasive. Unfortunately, the field of fat removal devices and technologies has been hampered by false promises and poor results,³ making the need for critical assessment of available modalities all the more relevant. Non-invasive techniques that are currently available include focused ultrasound, high-intensity focused ultrasound, monopolar radiofrequency, bipolar radiofrequency, laser/light sources, and cryolipolysis. There have also been recent efforts to reduce the appearance of cellulite, an altogether distinct pursuit from fat removal, and therefore will not be addressed in this chapter.

Liposuction is the most common and effective procedure for body sculpting. More recently, laser-assisted liposuction techniques have emerged. Regardless of the involvement of laser, fat removal occurs via cannula

inserted into the subcutaneous adipose tissue through small incisions in the skin.¹ However, it still harbors risk of infection, sepsis, hemorrhage, potential scarring, perforation, and non-uniform fat reduction, as well as need for downtime. There is also evidence that the systemic benefits of surgical fat removal are limited. Klein *et al.*⁴ demonstrated no significant reduction in obesity-associated endocrine and inflammatory markers following large-volume liposuction, while another study by Matarasso *et al.*⁵ suggested the possibility of deleterious effects on fat distribution by increasing the proportion of visceral fat relative to superficial fat, at least in large-volume liposuction. These risks and limitations are unacceptable to some patients desiring less-invasive treatment options.

Some of the modalities used to meet these demands for minimally invasive fat removal include focused ultrasound, high-intensity focused ultrasound, monopolar radiofrequency, bipolar radiofrequency, low-level light therapy (LLLT), and cryolipolysis. Ultrasound technologies have not received FDA clearance. Focused ultrasound subjects adipose tissue to mechanical energy which purportedly ruptures adipocyte membranes while sparing neighboring tissue such as nerves, blood vessels, and connective tissue. Some studies have indicated a decrease in circumference after treatment.⁶ One study, however, demonstrated poor patient satisfaction and little improvement.⁷ High-intensity ultrasound is a different technology that has yet to receive FDA approval in

the United States, but recent data indicate this may be a potential future therapy for non-obese patients seeking modest adipose tissue reduction.⁸ Monopolar radiofrequency has been traditionally used to improve the appearance of facial rhytids, and may induce lipoatrophy with aggressive settings. This concept may be manipulated to treat excess body fat, but currently there are very limited data evaluating the safety and efficacy thereof. Bipolar radiofrequency, when combined with infrared light and vacuum massage, has shown efficacy in reducing the circumference of arms, abdomen, and thigh body sites.⁹ Nevertheless, circumference is a notoriously flawed marker of results and subject to manipulation, so efficacy remains to be established. Radiofrequency methods have been further hindered by complications such as burns, prolonged erythema, and scarring.¹⁰ There are also limited data on low-level light laser therapy for fat removal. Jackson *et al.* reported circumference reduction on waist, hip, and thigh body sites 2 weeks following low-level diode laser irradiation. This study, however, did not include any histology. Further, as stated above, circumference measurement can be an unreliable marker for improvement. Thus, further study is needed. There is no evidence that any of the above-mentioned technologies are harmful to circulating lipid levels.

Cryolipolysis is a more recent, novel mechanism for non-invasive treatment of excess adiposity, by using controlled exposure to cold to affect selective, gradual adipocyte elimination.² This method was developed following observations that cold exposure can yield a localized panniculitis, as has been described among infants in the phenomenon of “popsicle panniculitis,”¹¹ and among horseback riders in cold environments, known as “equestrian panniculitis.”¹² It has been demonstrated clinically and histologically that cold exposure in infants results in inflammation of fat, including perivascular infiltration of neutrophils, monocytic, and lymphocytic cells, most pronounced at the dermal–subdermal junction with extension into the subcutaneous adipose tissue.¹¹ This inflammation continues and pervades the adipocytes, some of which rupture. The inflammation resolves spontaneously within a few weeks. Other reports exist of female equestrians riding in cold and damp conditions who experienced cold panniculitis. These cases have also demonstrated histologic evidence of inflammation at the dermal–subcutaneous junction with fat cell rupture and subsequent formation of cystic spaces.¹³

These phenomena triggered the idea that adipose tissue is preferentially vulnerable to cold-induced damage compared with other surrounding tissues in the skin and subcutis. Further exploration in animal studies corroborated that inflammation, adipocyte dropout and fibrous thickening of septae, appearance of lipid-laden macrophages, and gradual loss of subcutaneous fat all occur with exposure to cold.¹ No evidence of injury to skin, scarring, or alteration in serum lipids has been noted in such studies. *Ex vivo* studies of cultured adipocytes have further shown that apoptosis occurs after cold exposure. Human subject studies have also been supportive of the efficacy of cryolipolysis, such that non-invasive cooling to elicit adipocyte apoptosis results in fat layer reduction as analyzed by objective photographic assessment and ultrasound measurements.¹⁴ Based on these observations, it is hypothesized that cold exposure induces adipocyte apoptosis, which stimulates an inflammatory response that mounts within a few days, peaks, and is markedly phagocytic approximately 15–30 days following treatment, with engulfment of dead cells and removal via lymphatics over several months, leading to clinical results of gradual loss of volume and improvement in body contour in the treated area.² However, why adipose cells are preferentially vulnerable to cold exposure, what triggers apoptosis, and the exact mechanism of adipocyte elimination all remain to be elucidated. Nevertheless, cryolipolysis has demonstrated more promising results than other non-invasive modalities for body contouring, and will be the focus of the remainder of the chapter.

Preoperative care

Currently, this device, manufactured by Zeltiq Aesthetics, is FDA cleared for skin cooling and non-invasive fat removal of the flanks. It is most effective for reduction of localized areas of fat accumulation. It is not ideal for obese patients or those with significant skin laxity. Patient selection should take these factors into consideration. Further, patients should be screened for a history of cryoglobulinemia, paroxysmal cold hemoglobinuria, and cold urticaria.^{10,12} Those patients who are appropriate treatment candidates should be informed of potential mild adverse effects such as immediate but transient erythema, bruising, and decreased pain sensation for several weeks. It must also be emphasized that results require 2–3

months to reach full potential, and patients should not expect to see immediate results nor should they anticipate large-volume fat reduction.

Step-by-step surgical technique

Cryolipolysis is performed in an outpatient setting. The device contains a control unit and a cup-shaped applicator into which tissue is drawn. A coupling gel sheet is applied to the intended treatment site, then the applicator is placed over it using moderate vacuum suction to position the tissue between two cooling panels.² Suction decreases the blood flow in the treated area and thereby allows for more efficient skin cooling. A cooling intensity factor (CIF) is then selected using the control console, which allows the operator to control the rate of heat flux into and out of the tissue, and treatment begins for a cycle of up to 60 minutes. During this time, no further operator intervention is required, as the energy extraction rate is monitored by the device, using thermoelectric cooling cells. Just prior to completion of the session, a pager summons the clinician, although the device automatically ceases the cooling exposure when the cycle time expires. The applicator is then removed and may be placed on other treatments sites, repeating the process for more thorough results.

Complications

Cryolipolysis thus far appears to be very well tolerated. It is common for patients to develop transient erythema at treatment sites that typically resolves within a few hours. Owing to the applicator's vacuum suction, some bruising may also occur, which can last approximately 1 week.¹² The treated site will also be cold and firm immediately after treatment. Rarely, some patients experience 2–3 weeks of significant pain that begins 4–7 days after treatment. This pain syndrome resolves completely within 10–21 days. Fortunately, there have been no reports of adverse events involving surrounding tissue, such as ulceration or scarring.

Cryolipolysis induces a transient decreased sensation in the treated area in human subjects, manifested as dulling and numbness for several weeks. Coleman *et al.*¹⁵ conducted a study investigating this phenomenon by

having subjects undergo full neurological evaluation following cryolipolysis treatment, during which light touch, two-point discrimination, temperature sensitivity, and pain sensitivity were measured. These evaluations were performed at baseline and weekly for several weeks after treatment. Patients reported 96% of treatment sites experienced numbness, 67% of patients reported transient reduction in sensation, and one patient underwent skin biopsy to evaluate the nerves histologically. All reported changes in sensation were resolved by 2 months after treatment, and the biopsy demonstrated no changes at 3 months compared with baseline. This study suggests that decreased sensation may occur following treatment but is transient and appears to improve without further intervention.

Klein *et al.*¹⁴ conducted a clinical study evaluating whether cryolipolysis induces changes in serum lipids, in light of concern that the adipocyte clearance process may liberate lipids and influence serum levels and possibly affect liver function. Forty subjects who received treatment for excess flank bulges underwent serial evaluation of lipids (total cholesterol, triglycerides, very low-density lipoprotein, low-density lipoprotein, and high-density lipoprotein (HDL)) and liver enzymes (AST, ALT) on day 1 of treatment and again after weeks 1, 4, 8, and 12 following treatment. No statistically significant alteration was noted in any of the lipid parameters; although HDL values showed a trend toward mean decrease, but was still maintained within normal limits. Liver enzymes similarly showed no statistically significant deviations at any time point. These data suggest that the theoretical risk of increased serum lipids in the setting of adipocyte clearance is not clinically substantiated.

Conclusion

Efforts continue to be made to establish treatment options to reduce body fat and improve body contour. Liposuction remains the gold standard for effective surgical fat removal, but presents risks and requires downtime. Thus, non-invasive modalities have garnered significant attention. Ultrasound, radiofrequency, laser, and cryolipolysis have all been attempted to provide minimally invasive fat reduction. The data to support some of these technologies are questionable. Cryolipolysis has demonstrated promising efficacy in animal and human trials.

This method can provide safe and effective non-invasive fat removal in appropriately selected patients.

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Laser and light treatment for wound healing

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Introduction

Understanding wound healing and the mechanisms of photobiomodulation are critical for successful phototherapy of wounds. Several *in vitro* and *in vivo* studies have demonstrated that low-level laser therapy (LLLT) has a significant influence on a variety of cellular functions and clinical conditions.^{1–10} Photobiomodulation influences a variety of biological processes, including the acceleration of wound healing.^{2–10} Photobiomodulation enhances collagen synthesis in the wound area, thereby increasing wound tensile strength.^{2,4–9} Stimulation of cell proliferation results from an increase in mitochondrial respiration and ATP synthesis.^{3,10}

Traditional clinical and experimental applications of phototherapy are based on the observation that photo-stimulatory effects are generally observed at fluences between 1 and 10 J/cm², whereas photoinhibitory effects are typically observed at higher fluences. Treatments are generally administered on a daily or every other day basis, and are most frequently given three to four times per week.^{2–9} Several different light sources including lasers, light-emitting diodes (LEDs), superluminous diodes, and other non-coherent sources are used. The most effective wavelengths appear to be clustered in the red and near infrared portions of the electromagnetic spectrum. Clinical wound treatment protocols often use 4–5 J/cm² treatment doses. Polychromatic sources have also been used in some instances.

Our laboratory demonstrated that cell proliferation and metabolism can be influenced by varying the dose frequency or the treatment interval *in vitro*.^{7,8} This suggests that unique dose frequency regimens may exist for tissues and cell lines in order to achieve maximal stimulation. The data also demonstrated that the use of other treatment regimens results in bioinhibition, despite the delivery of the same total energy.⁸ We found that two treatments per day were more effective than once-daily therapy in some cases. The empiric use of a single treatment per day dosing frequency as a treatment strategy might explain why conflicting results have been published and why the efficacy of LLLT remains controversial. The use of long exposures using 670-nm light at low intensities was ineffective in accelerating wound healing in an experimental pressure ulcer model,⁸ underscoring the fact that mathematically equivalent doses based on the concept of reciprocity of energy density (irradiance) and exposure time may not be clinically effective or appropriate. Skin pigmentation can also influence treatment efficacy due to absorption of energy by melanin.¹ This effect should be considered when treating darker skin types, and may warrant increasing the light dose delivered.^{1,7}

General wound care considerations

The successful use of light therapy depends upon appropriate patient selection and the use of generally accepted

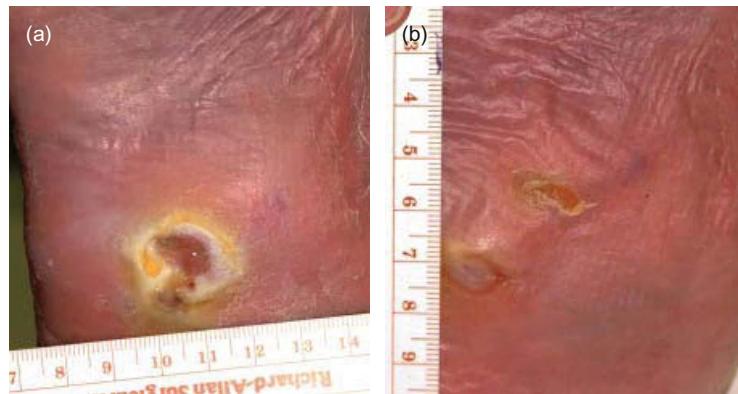


Figure 50.1 (a) Pretreatment appearance of a right foot ulcer of 10 months duration in a 62-year-old female with diabetes, hypertension, atherosclerotic cardiovascular disease, and renal failure. (b) Wound appearance after treatment under protocol 1 using the SpectraLife devices. The wound has healed completely.

clinical management standards. Patients typically present with a diverse array of lesions, comorbidities, and wound management strategies. A thorough history and clinical examination should be undertaken and attention to comorbidities such as diabetes, peripheral vascular disease, hypothyroidism, neuropathy, malnutrition, and underlying malignancy is advised. Phototherapy should be considered to be an adjunctive therapy. Correction of underlying conditions, if possible, will improve the potential for success. The wound should be carefully assessed. The wound area should be measured and its appearance documented using periodic digital photography and wound perimeter tracings. Standardized protocols for wound documentation are highly recommended and should be developed for the particular practice or clinical scenario. Figures 50.1 and 50.2 demonstrate photodocumentation of the pre- and post-treatment appearance of two wounds treated with LLLT. Note that each image contains a ruler placed in the field in order to mitigate any misinterpretation of results as a result of magnification or image size. Both of these patients achieved complete healing of their chronic wounds. Biopsy of any suspicious lesion should be undertaken to rule out malignancy and wound cultures, and appropriate antibiotic therapy should be initiated if indicated. The



Figure 50.2 (a) Pretreatment appearance of a lesion of the third toe in a 19-year-old male with an autoimmune disorder and vasculitis. (b) Post-treatment appearance of the wound following treatment under protocol 2 using the THOR-DD II device. The wound healed completely.

use of topical agents such as silver sulfadiazine should be based on the particular clinical situation. Wound debridement should be conducted as is necessary and wound dressings should be placed as clinical experience and the specific case warrants.

Clinical application of phototherapy

In our center, light therapy is currently provided 4 days per week, until the wound is healed. All patients continue their routine wound care and their chronic medications. Patients receive light therapy using LED sources under two protocols at our facility.⁷

The first uses SpectraLife devices (Quantum Devices, Barneveld, WI). These devices are intended for research, and the newer WARP10 and WARP75 versions may be better suited for office or home use. Patients undergoing light therapy have their wounds exposed to light at wavelengths of 670 and 880 nm for 1.7 minutes each to achieve a goal energy exposure of 4 J/cm^2 per wavelength (i.e., a total of 8 J/cm^2 combined) and at a power density of 50 mW/cm^2 per wavelength (Figures 50.3 and 50.4). It is advisable to use a stand or holder to maintain proper orientation, distance, and positioning of the LED arrays during the treatments (Figure 50.4). This is particularly important when working with LEDs since the light output typically is not spatially collimated as is the case with laser sources. Beam divergence can result in under-treatment of the desired target. The entire wound surface and its periphery should be treated. Large wounds may require treating the wound using multiple “spots” in order to assure that the correct parameters are applied to the entire wound. This is also dependent upon the delivery system of the specific devices used.

This protocol is part of a randomized controlled trial. Patients in the placebo control group are treated similarly. However, they receive “sham” light therapy at 5% of the dose used in the treatment group. Patients who have not healed after 60 treatments (i.e., approximately 14 weeks) continue treatment in an open-label fashion using the same parameters as the treatment group.

Patients in a companion protocol are treated by exposing their wounds to light emitted from a THOR-DDII device (THOR Photomedicine Ltd, Amersham, UK) at 660 and 850 nm with a power density of 50 mW/cm^2 and 150 mW/cm^2 per wavelength, respectively, and at a total



Figure 50.3 Treatment of a lower extremity lesion under protocol 1 using the SpectraLife devices. Note that the light-emitting diode source is positioned over the wound with a positioning holder. The physician and patient wear appropriate protective eyeglasses during treatment.

fluence of 4 J/cm^2 per wavelength (e.g., a 1.7-minute treatment time). This device contains LEDs producing both wavelengths in the same handheld delivery device (Figure 50.5). Proper positioning can be accomplished without the use of a separate stand or holder. However, it is important to maintain the proper distance from the wound surface at all times during therapy.

All patients have their routine wound care provided and receive light therapy in addition to their usual wound care regimen. Light therapy is provided 4 days per week, until the wound is healed, either through wound epithelialization or skin grafting. A total of 41 wounds have been treated to date in 36 patients. Light therapy-treated wounds achieved a partial response in 16.2% (6/37) and complete healing in 59.5% (22/37) cases. Of the remaining wounds, 4/37 (10.8%) were unchanged and 5/37 (13.5%) were worse after LLLT. The control group wounds ($n = 4$) were essentially unchanged (7% average



Figure 50.4 Close-up of wound treatment using the SpectraLife devices.

reduction in wound area). None of these wounds healed. These results are statistically significant ($p < 0.001$). There was no difference in outcomes based on the device used, nor was there a difference in the number of treatments required to achieve healing or improvement, which was 66 treatments on average.⁷

Our current study protocols do not allow for dose fractionation. However, the provision of phototherapy in two divided doses per day and/or on a daily basis would appear to be reasonable based on experimental studies.^{7,8} However, these paradigms are logically difficult in non-institutionalized patients and when the available devices are not well suited for home use.

Discussion

Successful use of phototherapy is critically dependent on understanding its mechanisms and strict attention to treatment parameters. Biological systems are complex



Figure 50.5 Wound therapy of a heel lesion under protocol 2 using the THOR-DD II device. Note that the light-emitting diode source is positioned over the wound by the physician. The physician and patient wear appropriate protective eyeglasses during treatment.

and varied, with feedback loops and processes that can be inhibited, stimulated, or provide critical components for other processes. Some processes can be bypassed or produce end products, given proper substrates. Some of the byproducts of the activity of neutrophils, lymphocytes, and other cellular components of the inflammatory cascade cause damage if left unchecked. Healing is affected by upregulation of specific substrates and inhibition of others. Collagen production is stimulated, various cytokines are upregulated, and inflammatory cytokines are downregulated by photobiomodulation. Upregulation of cytochromes, other transport, and energy compounds including NADH, ATP, and ADP, among others enhance the activities of various cellular components in the local wound milieu. These biologic underpinnings form the basis for the clinical use of

phototherapy as an adjunctive therapy in wound healing. Careful patient selection and attention to comorbidities and potentially correctable conditions are essential. Wound debridement as dictated by the nature and condition of the wound and the use of dressings and management strategies that are consistent with accepted clinical standards should be implemented irrespective of whether LLIT is being used. While phototherapy can indeed achieve good results, it is not a panacea and it should not be expected to improve every wound. This is particularly true in cases of excessive tissue loss such as stage IV decubitus ulcers. Successful closure of such cases requires a multimodal approach and often requires tissue rotation and transfer. Phototherapy should be considered for superficial wounds and as an early intervention in the wound management armamentarium.

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Laser for *in vivo* skin cancer diagnosis. Reflectance confocal microscopy

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Introduction

Dermatological diagnosis is mostly based on clinical examination. However, cutaneous tumors and some other skin diseases require additional diagnosis based on histopathology, which is considered the gold standard. Histopathological diagnosis of the skin requires collection of a biopsy sample, tissue processing, and microscopic examination of stained tissue sections. Biopsy collection is invasive and has aesthetic consequences. In addition, it is time-consuming and does not provide real-time information or permit evaluation of therapeutic responses.

New diagnosis methods are being developed, aimed to be (1) non-invasive; (2) fast and reproducible; (3) *in vivo* and *in situ* and capable of offering dynamic information about the skin over multiple examinations. These technologies include magnetic resonance imaging, high-frequency ultrasonography, optical coherent tomography, and reflectance confocal microscopy (RCM). In 1995, Rajadhyaksha *et al.*¹ laid the foundations of the use of reflectance-mode confocal scanning laser microscopy to examine human skin *in vivo*. Multiple technical improvements since that early report have boosted RCM to the

forefront of novel technologies used in skin diagnosis allowing a resolution similar to conventional histology (1 µm lateral and 3 µm axial). A limiting factor is the maximum depth that can be achieved with RCM, which is currently approximately 300 µm below the skin surface.

The last few years have witnessed the emergence of numerous scientific publications that have addressed in great detail the main confocal features of normal skin, setting the baseline for the description of a wide variety of inflammatory and tumoral skin conditions, particularly skin tumors.

Reflectance confocal microscopy. Basic principles. Confocal features of normal skin

A reflectance confocal microscope consists of a laser light source that illuminates a small area of the skin. Back-scattered light is detected by a point detector through an optically conjugated aperture (pinhole). Only the light in the focused plane reaches the detector, whereas out-of-focus light is eliminated. This yields high-resolution images. The differences in brightness and contrast are

Table 51.1 Refractive intensity of different cutaneous structures on reflectance confocal microscopy

High refractivity (from brightest to darkest)	Medium refractivity (from brightest to darkest)	Low refractivity (from brightest to darkest)	No refractivity
Melanin-containing cells	Spinous keratinocytes	Erythrocytes	Air
Melanocytes	Sebocytes	Lymphocytes	Serum
Melanophages	Keratohyaline granules	Skin folds	
Pigmented keratinocytes	Nucleoli	Nuclei	
Keratin-containing structures	Collagen		
Stratum corneum			
Infundibulum			
Hair shaft			
Acrosyringeum			
Activated Langerhans cells			
Granulocytes			

caused by local variations of the refractive index within the tissue, which is higher when the size of the skin structure is similar to the wavelength of the illuminating light. In summary, RCM renders grayscale confocal images based in “endogenous contrast.” The brightest structures are those containing melanin, haemoglobin, and certain citoplasmatic organelles (Table 51.1). Whereas traditional histopathology offers vertical cutaneous images, RCM visualizes horizontal sections parallel to the surface of the skin.

RCM examination of the skin usually starts from the surface, at the stratum corneum, and progresses in depth.² The stratum corneum appears as a variable refractile surface composed of polygonal, flattened, and anucleated keratinocytes. These cells are grouped in islands separated by dark-appearing skin folds. The dermatoglyphs are visualized in RCM as dark linear valleys (Figure 51.1a) that may penetrate the spinous layer depending on the skin region, phototype, and sun exposure. Next, the granular and spinous layers comprise cells whose nuclei appear to be dark central oval structures surrounded by bright cytoplasm with variable grainy appearance. The edges of these keratinocytes are well demarcated, forming a honeycombed pattern (Figure 51.1a). The dermoepidermal junction is located at 50–100 µm in depth. The basal layer is formed by only one layer of cuboid cells and dispersed melanocytes, roundish or dendritic. The basal cells appear smaller and brighter than suprabasal keratinocytes because of their high melanin content. Consistently, refractivity of the basal

layer varies according to the phototype and anatomic location. Confocal images of the basal layer in dark phototypes frequently visualize a cobblestone pattern (Figure 51.1b). In anatomic sites with rete ridges, basal cells are arranged in a “dermal papillary ring,” which is a circular pattern surrounding the dark dermal papilla (Figure 51.1c). Under this level, within dermal papillae, collagen bundles, capillaries, hair follicles, and sweat glands are often visualized.

Skin tumors

The confocal aspects of different benign tumors have been studied,³ including sebaceous hyperplasia, seborrheic keratosis, cherry angioma, dermatofibroma or trichoepithelioma (Table 51.2). More importantly, RCM has been employed to describe the confocal features of other melanocytic and keratinocytic tumors as well as their diagnosis and response to treatment (Table 51.3).

Squamous neoplasia

In the last few years, correlations between the histological and RCM findings in cases of squamous neoplasia have been established.⁴ However, confocal features may only be detected if the presence of hyperkeratosis does not interfere with the optical evaluation. The main confocal features of squamous cell carcinoma include

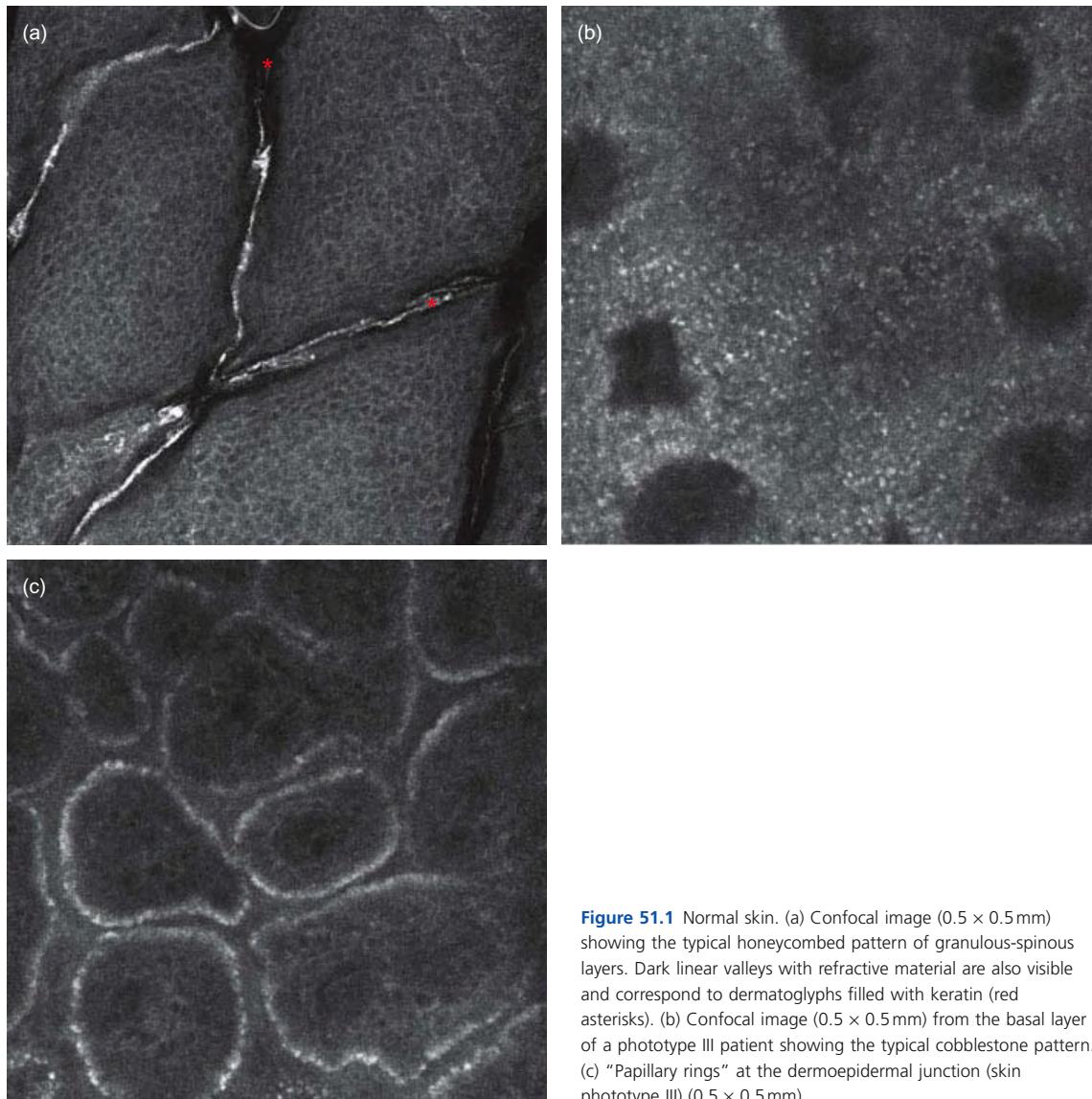


Figure 51.1 Normal skin. (a) Confocal image ($0.5 \times 0.5\text{ mm}$) showing the typical honeycombed pattern of granulous-spinous layers. Dark linear valleys with refractive material are also visible and correspond to dermatoglyphs filled with keratin (red asterisks). (b) Confocal image ($0.5 \times 0.5\text{ mm}$) from the basal layer of a phototype III patient showing the typical cobblestone pattern. (c) "Papillary rings" at the dermoepidermal junction (skin phototype III) ($0.5 \times 0.5\text{ mm}$).

scaling, which appears as refractive, amorphous structures at the stratum corneum. Parakeratotic cells are visualized at high magnification as polygonal nucleated cells with a refractive thin outline surrounding the dark nucleus at the stratum corneum. At the spinous-granular layer, the cells are irregular in size and shape and consequently the typical honeycomb pattern is altered, or not possible to visualize in cases of severe atypia (Figure 51.2).

At high magnification, round nucleated cells are occasionally seen at the spinous-granular layer. These correspond to individual atypical keratinocytes or dyskeratotic cells. In some cases, deeper exploration is possible and enables evaluation of the dermal component of the tumor. In these cases, RCM reveals round blood vessels and solar elastosis. The blood vessels correlate well with typical dotted and glomerular vessels observed by dermoscopy.

Table 51.2 Key confocal features of different benign cutaneous tumors

Sebaceous hyperplasia	Dilated follicular infundibulum Mulberry-like nests of round cells with bright mottled citoplasm
Seborrheic keratosis	Cerebriform architecture of the epidermis Bright cystic structures Cobblestone pattern in pigmented seborrheic keratosis
Cherry angioma	High density of irregular blood vessels High blood flow Thin fibrous septae
Dermatofibroma	Increased density of bright dermal papillary rings Variable tethering of dermal papillary rings by sclerotic collagen bundles
Trichoepithelioma	Common feature with basal cell carcinoma: islands or cords of tumor cells composed of basaloid epithelial cells with elongated nuclei. Dermal tumoral proliferations connected to follicular structures Round, dark spaces filled with refractile material at the center of the tumor aggregates (keratinizing cysts) Thick, highly refractile parallel collagen bundles surrounding the tumor islands

Table 51.3 Key confocal features of the main melanocytic and malignant keratinocytic tumors

Squamous neoplasia	Polygonal nucleated cells at the stratum corneum Atypical honeycombing or disarranged epidermal pattern Round nucleated cells at the spinous-granular layer Round blood vessels traversing through the dermal papilla
Basal cell carcinoma	Polarization of elongated nuclei along the same axis: Streaming: entire aggregate of tumor cells Peripheral palisading: perpendicular to the tumor edge Variable epidermal disarray Increased vascularity and prominent inflammatory cell infiltrate
Acquired melanocytic nevi	Simetric and well-defined lesion (mosaic) Preserved epidermal architecture Regular edged papillary rings "edge papillae" Homogeneous dense cell nests Atypical nevi: atypical epidermal pattern, irregular dermal papillae, dishomogeneous cell nests and presence of a few typical cells
Melanoma	Pagetoid cells in superficial layers of epidermis Moderate to severe cytologic atypia in basal layer Ill-defined dermal papillae at dermoepidermal junction "non-edged papillae" Cerebriform nests in papillary dermis Nucleated cells within dermal papillae

Basal cell carcinoma

RCM has demonstrated several unique diagnosis features of basal cell carcinoma.^{5,6} A major feature is the "nuclear polarization" of tumor cells. These cells display elongated monomorphic nuclei along the same axis of orientation (Figure 51.3a). This polarization may manifest as a "peripheral palisading" when the tumor island presents an outer layer constituted by tumor cells which are oriented parallel to each other and perpendicular to the border (Figure 51.3b). Tumor aggregates are relatively refractive and frequently surrounded by a dark space that correlates to the typical separation of the tumor from the surrounding stromal tissue or "clefting" (Figure 51.3b). This is also visible by histology. In certain basal cell carcinomas, tumor islands display low refractivity compared with the surrounding tissue. This has been

termed the "dark silhouette" (Figure 51.3c). The stroma, constituted by thick collagen bundles, may be highly refractive. Besides, RCM also reveals swollen dermal blood vessels with intense leukocyte trafficking, sometimes accompanied by a prominent perivascular inflammatory infiltrate.

Pigmented basal cell carcinoma presents highly refractive dendritic and granular structures inside the tumor islands (Figure 51.3b), which correspond to dendritic melanocytes and melanin accumulations inside of melanosomes, respectively. Furthermore, RCM also reveals numerous bright and ill-defined structures located in the stroma. Correlation with histology suggests that these may be melanophages.

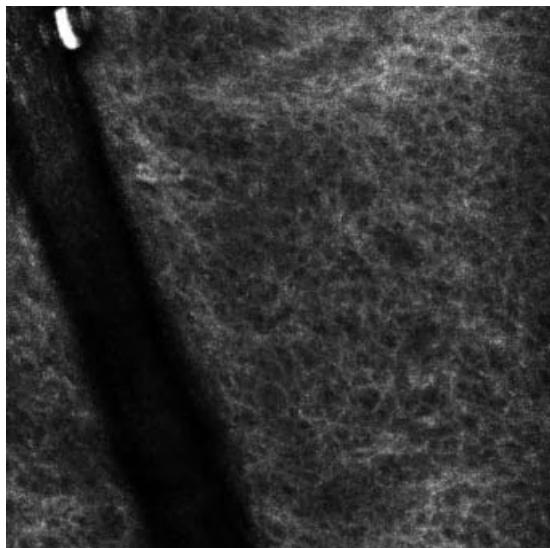


Figure 51.2 Squamous cell carcinoma. Confocal image (0.5×0.5 mm) at the spinous layer showing an atypical honeycombed pattern composed of keratinocytes of irregular size and shape.

- 🕒 Video 51.1 illustrates the procedure for confocal imaging acquisition of a basal cell carcinoma located on left forearm; the typical confocal features for basal cell carcinoma diagnoses are shown in Video 51.2.

Acquired melanocytic tumors

RCM constitutes a natural non-invasive link between dermoscopy and histopathology.⁷ Recent reports have revealed the correlation between certain confocal and dermoscopic findings, including pigment globules, pigment network, peripheral streaks, and blue-white veils. RCM examination of the epidermal architecture of acquired common melanocytic nevi shows regular honeycombed or cobblestone patterns comprising a homogeneous population of well-demarcated cells. Melanocyte nests are regularly distributed and formed by uniform aggregates of refractive, round to oval, nucleated cells. In contrast to common nevi, confocal microscopy of dysplastic nevi reveals a more heterogeneous population of

highly refractive cells at the dermoepidermal junction and poorly defined nests with individual, very bright atypical cells (Figure 51.4).

Melanoma

RCM has also been employed to visualize melanoma.⁸ RCM reveals alterations of the epidermal architecture, particularly the presence of pagetoid cells (Figure 51.5a); cytologic atypia at the dermoepidermal junction with ill-defined dermal papillae (non-edged dermal papillae) (Figure 51.5b); cerebriform clusters; nucleated cells in the superficial dermal compartment. These parameters have high sensitivity and specificity diagnostic value. At present, two different melanoma diagnosis algorithms based on some of these confocal aspects have been developed. Strikingly, several confocal features of melanoma are also found in amelanotic melanomas. It is possible to detect melanocytes in a clinically amelanotic tumor because of the presence of some melanin inside the premelanosomes, which have similar size to the wavelength that RCM uses for imaging. Furthermore, amelanotic tumors are not as highly refractive as other heavily pigmented lesions which makes them easier to be diagnosed with RCM than with dermatoscopy.

Clinical applications

The high resolution of RCM and the *in vivo* visualization of the skin are key advantages that make RCM an ideal tool in the diagnosis and management of certain dermatologic diseases. For example, RCM can be used to guide biopsy collection in complicated diagnosis situations, such as incipient mycosis fungoides, facial lentigo maligna, or atypical nevi syndrome. RCM has also been used in preliminary studies to delineate the tumor margins before surgery in ill-defined skin tumors, such as lentigo maligna and amelanotic melanoma, among others. Importantly, RCM has been successfully used to monitor the evolution and response to non-invasive treatments such as photodynamic therapy or imiquimod in *in situ* squamous cell carcinoma and basal cell carcinoma patients.⁹

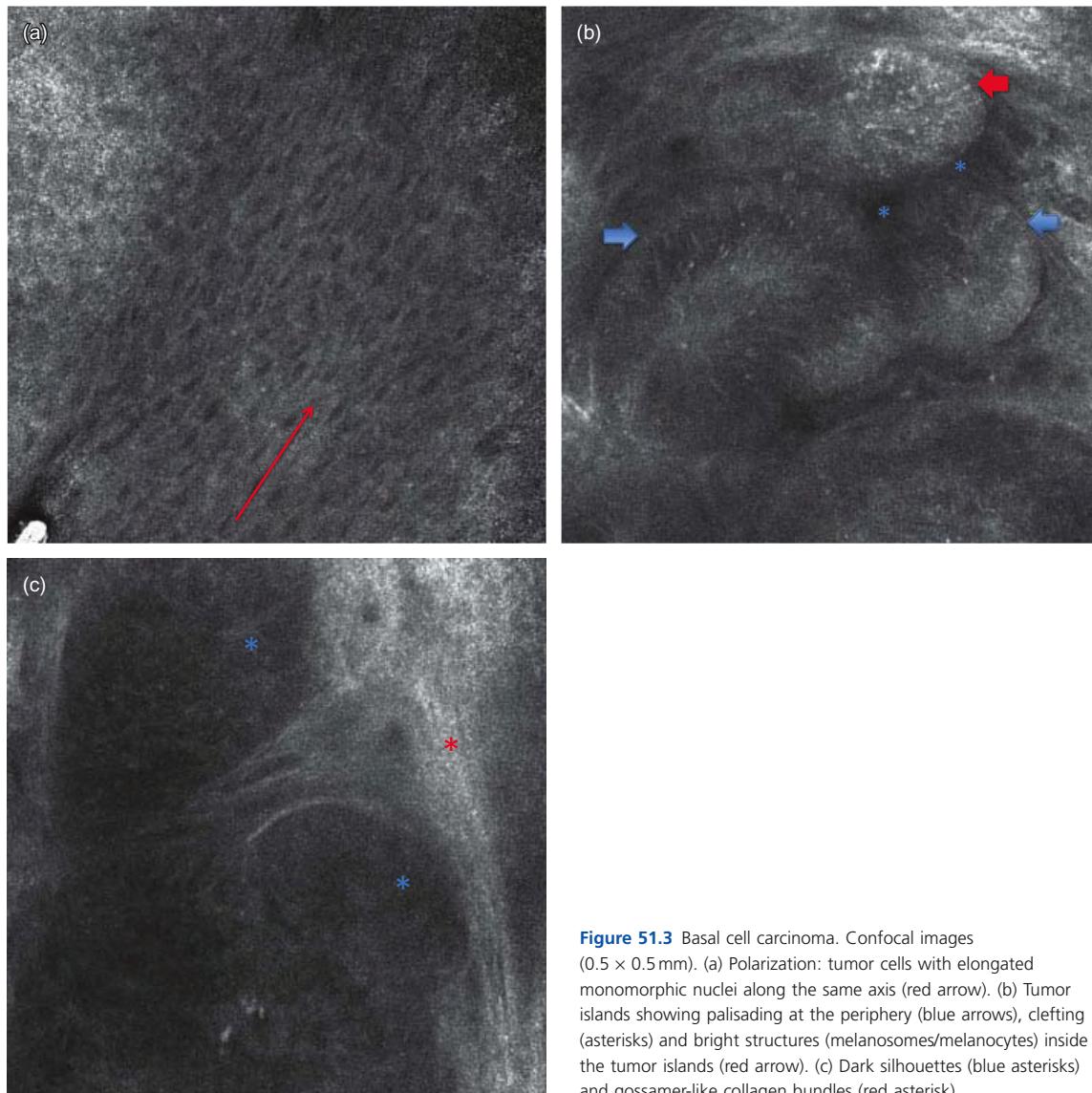


Figure 51.3 Basal cell carcinoma. Confocal images (0.5×0.5 mm). (a) Polarization: tumor cells with elongated monomorphic nuclei along the same axis (red arrow). (b) Tumor islands showing palisading at the periphery (blue arrows), clefting (asterisks) and bright structures (melanosomes/melanocytes) inside the tumor islands (red arrow). (c) Dark silhouettes (blue asterisks) and gossamer-like collagen bundles (red asterisk).

These findings postulate RCM as a novel non-invasive technique that provides *in vivo* images of the skin with microscopic resolution, which can be utilized for the diagnosis, management, and evaluation of numerous skin conditions, especially cutaneous tumors. Several hurdles remain, mainly to overcome the depth limitation, which is inherent to the technique. It is also critical to

extend its use to the quotidian clinical practice. The use of image-based techniques poses an “intimidation factor” for untrained operators. To overcome this problem a Tel-dermatology system is being developed (DICOM, Digital Imaging and Communications in Medicine) which will transfer digital images among experts in order to achieve an immediate evaluation of the processes.



Figure 51.4 Dysplastic nevus. Confocal image (0.5×0.5 mm) of the dermoepidermal junction. It shows papillary rings of irregular size and brightness. Dishomogeneous nests are also visualized (asterisks).

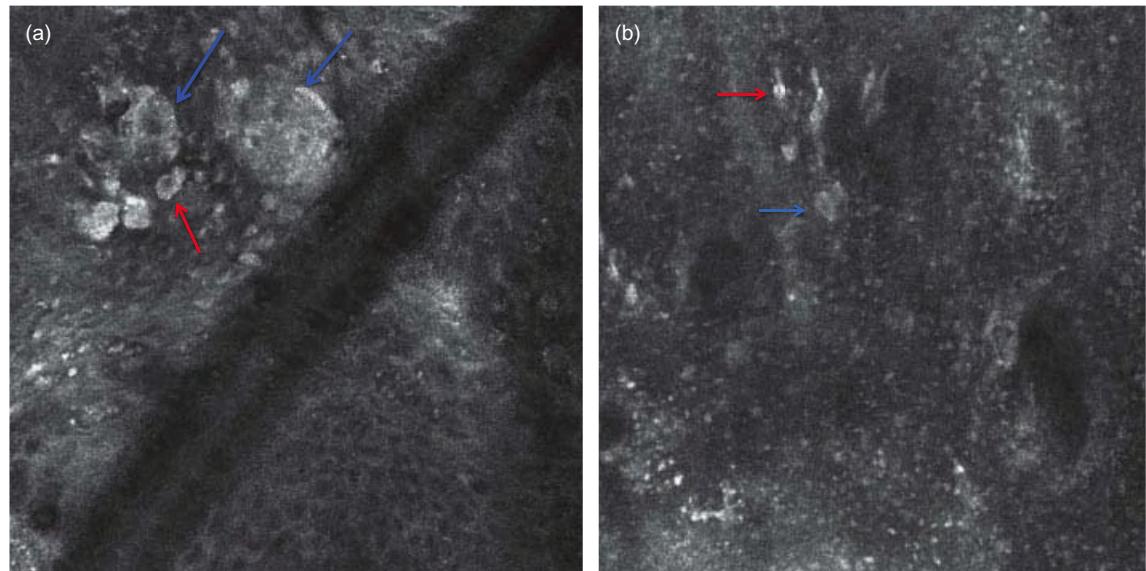


Figure 51.5 Melanoma. (a) Confocal image (0.5×0.5 mm) at the upper spinous layer where pagetoid cells are visualized as highly refractive roundish atypical cells (red arrow). Sometimes they tend to form nests (blue arrows). (b) Confocal image (0.5×0.5 mm) showing ill-defined dermal papillary rings with atypical cells at dermoepidermal junction (red arrow) and suprabasal location (pagetoid cell) (blue arrow).

Acknowledgments

This work has been partially supported by a grant from the Carlos III Health Institute, Ministry of Science and Innovation, Spain (PS09/01099).

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Video list

Video 51.1 Procedure for confocal imaging acquisition

Video 51.2 Vivastack video of a basal cell carcinoma

Intense pulsed light

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Preoperative care

Choose technology: Intense pulsed light versus lasers

Intense pulsed light (IPL) is a broadband light source that emits a continuous spectrum in the range 515–1200 nm.

The primary purpose of IPL devices is to destroy target structures through controlled thermal absorption in specific skin chromophores such as melanin and hemoglobin.

The main indications are long-term reduction of unwanted hair or the removal of benign vascular and pigmented lesions, but IPL wavelengths of 580–650 nm and in the red range may also be used to produce a photochemical effect together with topically applied photosensitive drugs such as 5-aminolevulinic acid in photodynamic therapy for actinic keratoses and in acne treatment as well as rejuvenation. In contrast to IPL, lasers emit high-intensity light of only one wavelength that is highly coherent. IPL systems emit polychromatic light in a broad wavelength spectrum that needs filtering to cut off wavelengths below and above defined ranges to become specific.

IPL device

IPL devices however differ significantly in the range of wavelengths, fluence, and evenness of distribution to be delivered when measured by independent technicians.¹ IPL is also used in combination with *radiofrequency* to deliver more heat at various depths; IPL can

be applied through a *vacuum*, created by spot treatment with a handpiece or by a separate applicator, stretching the skin and allowing wavelengths to penetrate deeper with less fluence. There are numerous devices on the market. A selection of FDA cleared and CE marked IPLs can be found in updated surveys on www.AestheticBuyersGuide.com, but worldwide there are many more available, and many come and go (Figure 52.1). Beware of unapproved devices with fake approvals or missing technical support in cheap devices via the internet.

Selection of parameters and indications

Parameters have to be selected individually and adapted to the clinical situation:

- wavelength
- beam diameter (spot size)
- pulse duration
- fluence (energy density per cm²).²

Usually manufacturers recommend parameters. Owing to the differences between devices, treatment parameters of one device must not be applied to another.

Specifically, in IPL the effective parameters are close to those resulting in possible side effects, so start with test spots (Figure 52.2).

Patients: selection, contraindications, and pretreatment

According to available equipment the physician has to decide between the use of a laser, IPL, or other



Figure 52.1 Intense pulsed light treatment tip.



Figure 52.3 Intense pulsed light clearing after test spots in photorejuvenation.



Figure 52.2 Intense pulsed light example displaying parameters to be selected.

technologies. Be careful with patients on *medication* with a risk of *photoreaction* and on anticoagulation drugs (purpura!). Explain that after one treatment not all the area will be cleared, some a second or third session may be required. Recommend sun protection, written consent and photodocumentation, avoid non-cooperative patients. Usually pretreatment is not necessary.

Step-by-step surgical technique

I. Before treatment

- a. Start with test spots according to recommended parameters, then wait 15–20 minutes or make a new appointment (Figure 52.3).



Figure 52.4 Intense pulsed light pre- and post cooling with ice packs.

- b. For pain control usually cooling is sufficient, also topical anesthetics help, but can cause some vasoconstriction in vessels (Figure 52.4).
- c. For pain reduction and to avoid burns never use IPL without *cooling*. Without cooling, hyperpigmentation, burns, crusting and erythema may be induced. Cooling can be achieved by contact cooling, air cooling, spray cooling, or application of vacuum on the skin. Use it before, during, and after treatment.
- d. Contact cooling: ice packs or cool pads, gel, cooled treatment tip, air cooling (e.g., Zimmer air flow device).³ Spray cooling will gradually disappear due to



Figure 52.5 Intense pulsed light vacuum cooling applicator.



Figure 52.6 Intense pulsed light indication poikiloderma: photorejuvenation of the décolletage.

- environmental hazard. Sometimes water spray can be sufficient (Figure 52.5) (Videos 52.1 and 52.2).
 - e. A vacuum is a new way to cool the epidermis.
 - f. Lowering the pressure means evaporation of the liquid on the skin's surface extracting large amounts of heat.
 - g. Thoroughly clean the IPL light tip and take care that the continuing reliability of the lamp and filter is assured by taking measurements (usually occurs in a programmed way).
- II. Treatment**
 - a. Clear optical coupling ultrasound gel without any air bubbles to ensure proper contact between the treatment tip and the skin. Place the treatment tip in a horizontal position with no overlapping; movement can result in an 8–10% difference. If in doubt do the test shots again (Figure 52.3) (Videos 52.3–52.8).
- III. Indications and specific requirements**
 - a. Depending on the target chromophore, certain wavelengths and cut off of filters have to be selected according the individual absorption spectra.

Hair removal (photoepilation)

IPL systems offer selective and non-selective wavelengths.

They allow the hair adnexa to “cook,” so as to achieve damage of the stem cells, as these cells are responsible for

hair follicle growth and regeneration. For selective photoepilation, the waveband starts in visible green (510 nm), includes yellow, and non-selective red and near infrared (1110 nm). The greatest efficacy is seen in coarse dark hair in darker skin, and least efficacy was noted in fine blonde hair in lighter skin. IPL sources applying a longer pulse width were found to provide a safer and more effective means of photoepilation in Asian patients.⁴ New combinations use IPL plus radiofrequency to heat up non-selectively and cause less PIH (postinflammatory hyperpigmentation). Depending on the area being treated, the sessions have to be repeated every 4–16 weeks up to a total of 6–12 sessions, as with lasers. One of the main mistakes is to increase the fluence higher than is suitable, resulting in burns .

Pigmentation

Lentigines and tattoo removal

Pigments can be destroyed by a wavelength within the spectrum 500–1100 nm. IPL penetrates more superficially than lasers but is very effective for superficial pigmentation such as lentigines, age spots, and photorejuvenation and can help in superficial melasma (Figure 52.6). It is less effective for deeper pigmentation such as tattoos, deep melasma or N. Ota. In many tattoos both IPL and a laser may be needed according to the layer where the pigment is located.



Figure 52.7 Intense pulsed light indication melasma.

Melasma

In epidermal-type melasma the therapeutic effect is relatively higher. IPL may induce subtle melasma itself.³ So the energy density should be rather low, plus efficient cooling.

In mixed-type melasma, melanin is located in the dermis (macrophages) and improvement is harder to achieve. Following treatment some darkening of the pigment occurs and lasts for a few days (Figure 52.7).

Vessels

Hemoglobin is the selective chromophore in vascular lesions.

Small superficial vessels as on the face contain oxyhemoglobin with a maximum peak absorption around 540 and 580 nm to a longer wavelength; deeper vessels on the legs contain more deoxyhemoglobin, with a maximum absorption of 800 nm to 1200 nm. The longer the wavelength the deeper its penetration into the skin.²

Since IPL light penetrates mainly superficially, small vessels are the best indication. For deeper vessels it is better to use a pulsed dye or Nd:YAG laser.

Because 500–670 nm and 870–1400 nm also target pigmented lesions, filtering between 670 and 870 nm aids in preservation of the melanin-rich epidermis and improves the ratio of vascular to pigment destruction. IPL is ideal for the redness of dilated capillaries, which are small,

superficial, and numerous. In order to improve the effect of IPL in spider veins, some devices combine IPL with radiofrequency, treating with non-selective heat. In some cases sclerotherapy still remains the best choice.

Indications for IPL in vascular treatments are:

- poikiloderma (erythrosis interfollicularis colli)²
 - sun-damaged skin⁵
 - spider angioma²
 - Fabry disease
 - rosacea erythematosa
 - superficial parts of port wine stains^{6,7}
- Usually lasers work better in:²
- blue rubber bleb nevus syndrome (BRBNS)
 - venous lakes
 - cherry angioma
 - leg veins and telangiectasias
 - hemangiomas.

Photorejuvenation and skin tightening

In specimens after treatment with IPL or Nd:YAG laser, there was expression of hsp70 and procollagen 1 in dendritic cells in the papillary dermis and upper reticular dermis.⁵

Medical indications

- Acne: treatment with light sources emitting light in the blue or red spectrum can be useful to treat acne lesions; however, there is no evidence that IPL is more effective than topical agents.
- Rosacea: redness and telangiectasia are one of the main indications for IPL: the inflammatory part of rosacea however will hardly improve. PDL and IPL treatments in rosacea performed with similar efficacy and safety.^{5,8,9}

Postoperative care and follow-up

Apply cold packs on the treatment day, topical steroids, or spa water spray, and sun protection for 1–6 weeks. In darker skin types, bleaching agents like hydroquinone can be applied before and after treatment; however hydroquinone may cause irritation.

Complications

The most frequent complications are

- pain
- erythema
- hypo- or hyperpigmentation
- bilateral ocular inflammation (iritis)
- retina damage
- paradoxical hypertrichosis, leukotrichia,
- folliculitis
- burns
- crusting
- scarring: atrophic and hypertrophic.

The most frequent reasons for complications are

- I. Device
 - a. poor cooling
 - b. uneven delivery of energy or even wrong wavelength
- II. Physician
 - a. darker skin type
 - b. no test spots
 - c. insufficient training
 - d. using protocols and parameters without customizing
 - e. poor quality management including untrained staff, wrong indication,
 - f. wrong device and parameters,
 - g. no pre- or post treatment
 - h. poor access to physician when early signs of complication occur
 - i. no or wrong protection goggles.
- III. Patient
 - a. Unknown risks in patient history such as a tendency for scarring, pigmentation, undisclosed drugs or natural medicine and herbs, poor compliance, inadequate manipulation or additional treatments after IPL.
 - b. Fluence should be administered carefully, so choose parameters in dark skin 15–20% below the given protocols, also for new devices or new patients, in sensitive areas, like the epidermis on the lower legs and in the face, neck and décolletage, and areas prone to scarring like chest or neck and periorbital region. Avoid overdoses and overlapping and pain, which indicates the risk of adverse effects. Repeat sessions rather than increase parameters. Intervals should be 4–6 weeks or even more.

c. Bilateral ocular inflammation (iritis) with permanent ocular damage may occur when eye shields are not sufficient during the procedures. Be careful around the eyes: IPL might reflect to the retina and there is risk of glaucoma, uveitis, iritis, and lens damage.

Prevention and management of complications

- Only use devices that are CE marked respectively FDA cleared.
- Be sure to update software and to perform regular safety checks by the manufacturer or their technicians.
- Abide by the rules of laser safety and confirm with your malpractice insurance company that they cover IPL.

Patient selection and compliance

Do not treat patients with unrealistic expectations; patients should be partners: the less a patient understands the treatment, the more likely he/she will complain. As a physician, it is better to under promise and over deliver. Avoid troublemakers. Keep your training up to date and give your staff clear instructions your.

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Video list

Video 52.1 Intense pulsed light: precooling with pads

Video 52.2 Intense pulsed light: gel (cool) before treatment

Video 52.3 Intense pulsed light: protection goggles and glasses

Video 52.4 Intense pulsed light: turn on device and select program

Video 52.5 Intense pulsed light: select parameters

Video 52.6 Intense pulsed light: treatments

Video 52.7 Intense pulsed light: during and after air cooling

Video 52.8 Intense pulsed light: PDT 039

Light-emitting diodes

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Introduction

Light-emitting diodes (LEDs) are a novel non-ablative, non-thermal light modality in the therapeutic armamentarium of dermatology. Ablative and non-ablative laser therapies are increasingly utilized to treat photoaging by creating photothermal damage in the dermis to stimulate collagen production. Although these are effective therapies, many patients find laser treatments unappealing because of the post-treatment care and potential side effects, such as pain, erythema, scarring, pigmentary alterations, and infection.¹ LED therapy, or low-intensity light therapy, has a peak power output in the milliwatt range compared with lasers, which produce exponentially higher powers.^{2,3} This gentle light delivery system is attractive for its ability to facilitate healing in a number of skin conditions and improve photoaging with no pain or downtime.

LEDs were developed in the 1960s as low-energy alternatives to incandescent lighting and are now commonly used in the digital displays of many household appliances. The therapeutic applications of LEDs arose from Endre Mester's investigations showing red light could improve wound healing.^{2,3} NASA research also confirmed narrow-spectrum light accelerated plant growth and improved wound healing in astronauts and Navy Seals.^{3,4} *In vitro* studies using human epithelial cells treated with LEDs showed cell growth increased 155–171% over controls.⁴ Since their development, LEDs have been adopted for a growing number of conditions, including chronic wounds, cosmetic indications, and acne.

Mechanism of action

LEDs use semiconductors to convert electrical current into narrow-spectrum, non-coherent light, ranging from ultraviolet to visible or infrared wavelengths (247–1300 nm). The LEDs manufactured for medical uses are often referred to by the color of the wavelength of light they emit; blue (415 nm), yellow (595 nm), or red light (630 nm).³

When tissue is exposed to low-intensity light it triggers intracellular reactions in a process termed photobiomodulation. The emitted light is absorbed by molecular moieties in the mitochondrial respiratory chain and the cell membrane called photoacceptors or chromophores. Examples of common chromophores are porphyrins, flavoproteins, and cytochromes.³ The absorption of a particular wavelength of light by a chromophore generates reactive oxygen species resulting in a cascade of cellular signaling pathways that can upregulate or downregulate genes.¹ Cells exposed to low-intensity light exhibit reduced apoptosis and increased angiogenesis. The net effect of irradiation is increased keratinocyte and fibroblast migration and proliferation.³

Selecting the appropriate wavelength is essential in order to achieve adequate tissue penetration and activate the appropriate chromophore. Cellular reactions are sensitive to irradiation of specific wavelengths of light, known as the chromophore's action spectrum. Longer wavelengths of light result in deeper tissue penetration. Light penetration depth is reportedly less than 1 mm at 400 nm, 0.5–2 mm at 514 nm, 1–6 mm at 630 nm, and

over 6 mm at 700–900 nm. Red light (630 nm) is more useful for targeting deeper tissues such as sebaceous glands, whereas blue light (400–420 nm) is better for treating more superficial pathology localized to the epidermis.³

Karu⁵ demonstrated that the wavelengths that promote cellular proliferation exist between 580 and 860 nm, with peaks in the 620–680 nm and 760–895 nm ranges. Cytochrome-*c* oxidase is believed to play a key role in the conversion of low light energy into adenosine triphosphate (ATP), which is used to fuel cellular processes. ATP production in mitochondria of cultured fibroblasts occurs following pulsing of 595-nm LED light corresponding to the action spectral peak of cytochrome-*c* oxidase.^{1,6} However, since melanin and blood are strong photoacceptors for 595-nm light, red light (633 nm), which penetrates deeper and is also absorbed by cytochrome-*c*, may produce a more optimal clinical response.¹ One of the advantages of LED therapy compared with lasers is the ability to combine wavelengths of light and simultaneously treat different targets in the skin.

Indications

LED phototherapy is a well-tolerated, painless therapy that is effective when used alone or in combination with ablative and non-ablative treatments such as fractional laser resurfacing, intense pulsed light, pulsed dye laser, KTP and infrared lasers, and radiofrequency energy.^{2,6} The benefits of LED treatment in decreasing inflammation and promoting wound healing are well documented. LEDs exert most of their effects on the cell proliferation stage of wound healing by stimulating respiratory metabolism in mitochondria, generating procollagen and other growth factors, and strengthening cellular adhesion to extracellular matrix.⁴

Shorter healing times have been reported in radiation and sunburn patients treated with LED photomodulation.³ In a split face trial of 10 sunburn patients, Weiss *et al.*⁶ reported an accelerated resolution of burning, redness, and swelling. Patients were treated once or twice a day for 3 consecutive days. The use of LEDs for photoprophylaxis prior to UV exposure may be another promising application. Barolet³ reported decreased UV-B induced erythema following treatment with a 660-nm

LED. Other potential indications include atopic dermatitis, bruising/burns, and scars.⁶

Photorejuvenation

As skin ages it develops morphologic changes such as rhytides, dyspigmentation, telangiectasias, and loss of elasticity. Both intrinsic factors and extrinsic factors such as ultraviolet radiation contribute significantly to skin aging. UV light promotes skin aging by downregulating gene expression for collagen production and increasing matrix metalloproteinases (MMPs), which degrade collagen and elastin. Histologically, photodamaged skin shows reduction and fragmentation in collagen, degeneration of elastic fibers, dilated dermal vessels, and epidermal atrophy.⁷

LED phototherapy for photoaging has been evaluated in several full-face and split-face trials with yellow (595 nm), red (633 nm), and infrared (830 nm) light treatments using objective instrumental measures such as profilometry, histology, and immunohistochemistry.^{1,3,7,8}

Lee *et al.*⁷ studied 76 patients using 830 nm, 633 nm, and 830 nm combined with 633-nm LED phototherapy. This split-faced, placebo-controlled trial examined peri-orbital wrinkle severity, skin elasticity, and melanin using serial photography, profilometry, and histological and biochemical evaluations. A statistically significant improvement was noted in wrinkles and skin elasticity in all treatment groups. However, the combined 830 nm/633 nm LED treatment resulted in the greatest reduction in wrinkle severity. In this group, 95.5% of subjects reported high satisfaction with the treatment results. Histology and transmission electronmicroscopy showed increases in collagen and elastic fibers and the presence of activated fibroblasts. This study confirmed collagen thickening and remodeling throughout the dermis following LED treatment. The authors reported an increase in proinflammatory cytokines, interleukin (IL)-1 β and tumor necrosis factor (TNF)- α , in treated skin suggesting an induction of a wound-healing cascade similar to what occurs following laser therapy.⁷ Increased levels of tissue inhibitors of metalloproteinases (TIMPs) were also noted, akin to prior evidence suggesting LED light down-regulates MMPs.^{7,8}

Other clinical studies using combined 633/830 nm LED irradiation have noted synergistic improvement in

photoaging. Red light increases procollagen synthesis whereas near infrared light is absorbed by the cell membrane and stimulates the fibroblast–myofibroblast transformation and mast cell degranulation. Light in the near infrared range also improves chemotaxis and phagocytic activity of macrophages, which is important in collagen remodeling.¹

Many clinicians utilize LED photomodulation to hasten recovery following ablative and some non-ablative therapies.⁶ Alster² reported a split-face trial of 20 patients treated with a 590-nm LED (Gentlewaves) following full-face fractional skin resurfacing with a 1550-nm erbium-doped laser. Patients were treated with 0.1 J/cm^2 at a fixed sequence pulsing for 35 seconds after the procedure. Treated sides were noticeably less erythematous 24 hours following treatment.

When LEDs are used for photorejuvenation, optimal results occur at 3–6 months after treatment.^{6,7} Some studies have reported improvement as early as six to eight treatments to 1 week following the last session.^{7,9} (Figures 53.1 and 53.2). Lee *et al.*⁷ noted statistically significant improvement in wrinkle severity and skin elasticity by treatment week 3, which continued to improve during an 8-week treatment-free follow-up.

Acne

Multiple studies utilizing blue and red light-emitting diodes have noted improvement in inflammatory acne and, to a lesser degree, non-inflammatory acne lesions. *Propionibacterium acnes*, the bacteria implicated in the pathogenesis of acne, synthesizes protoporphyrin and coproporphyrin which when irradiated with blue light (407–420 nm) results in reactive free radicals and bacterial destruction. Red light (633 nm) is a potent activator of protoporphyrin IX and penetrates deeper, possibly eradicating *P. acnes* in the sebaceous gland. Red light also exerts anti-inflammatory properties by stimulating local vasculature to increase the supply of oxygen and nutrients to the skin and activating macrophages to produce cytokines such as fibroblast growth factor.¹⁰

Both blue and red light can be beneficial in treating acne, but the combination of blue and red LED therapy appears to be superior. (Figures 53.3 and 53.4) A study of 24 patients with mild to severe acne, treated twice a week for 4 weeks with alternating blue (20 minutes,



Figure 53.1 Before combined red and near infrared light-emitting diode treatments.



Figure 53.2 After combined red and near infrared light-emitting diode treatment.



Figure 53.3 Blue light-emitting diode.



Figure 53.4 Red light-emitting diode.

Omnilux blue, 415 nm, 48 J/cm²) and red (20 minutes, Omnilux revive, 633 nm, 96 J/cm²) LED phototherapy, reported a 46% mean lesion count reduction at 4 weeks. Continual improvement was observed up to 12 weeks with an 81% reduction in mean lesion count.¹⁰

Preoperative care

Little pretreatment care is required prior to exposure with a low-intensity light source. Patients should cleanse with a gentle facial wash prior to LED treatment.

Parameters

Several medical LED systems are available including Gentlewaves (590 nm, Light BioScience LLC), Omnilux Revive (630 nm), Omnilux Blue (415 nm), Omnilux Plus (830 nm, Phototherapeutics), LumiPhase-R (660 nm, Opusmed).³

The parameters of LED treatment include wavelength, fluence, intensity, and pulse mode. LEDs have continuous wave and pulsed wave modes. Some evidence suggests that using a precise pulsing sequence may stimulate more collagen production than continuous wave light, possibly because the energy delivered by pulsed light may penetrate tissue deeper.^{3,6} However, the effect of sequentially pulsed light on cellular metabolism requires further study. The optimal treatment frequency, the intervals between sessions and the total number of treatments also require consideration.

Procedure

Patients are positioned close to the light source. Exposure time can vary from less than 60 seconds to 14–20 minutes depending on the indication and LED system (Video 53.1).

Postoperative care and follow-up

No significant aftercare is required following treatment. Patients should avoid sun exposure and practice sun protection with daily sunscreens and protective clothing. When it is used as an adjuvant to laser treatment, emollients such as petrolatum should be applied daily.

Safety

The light delivered by LEDs is low in power compared with the much higher powers produced by lasers.² This eliminates the risk of tissue damage that can occur with lasers. Eye protection can be worn for patient comfort. Since there is no thermal damage to the skin, LED

photomodulation is a painless therapy that is safe for all skin types.

Complications

There have been no reported complications involving LED photomodulation in the literature.

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Video list

Video 53.1 Red LED treatment of acne

Photodynamic therapy

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Introduction

Photodynamic therapy (PDT) is a relatively new treatment modality which involves use of photochemical reactions in a two-step procedure. First, a photosensitizing drug is administered (orally, topically, or intravenously) and is allowed to be taken up by target cells. Second, subsequent activation by a specific wavelength of light produces activated oxygen species that selectively destroy target cells.¹

Photosensitizers

The commonly used photosensitizers are aminolevulinic acid (ALA) or methyl aminolevulinate (MAL), which when applied to skin causes porphyrins to accumulate in the cells, more so in neoplastic cells.

- 5-ALA: available in prepackaged plastic tube that has two glass ampoules, one with the ALA powder and the other with hydroalcoholic solution (Levulan). The carrier ampule has a mixture solution containing ethanol, water, laureth-4, isopropyl alcohol, and polyethylene glycol. The applicator tube is encased in a cardboard sleeve and is provided with a cotton applicator. Just prior to application, the topical solution is prepared by crushing the glass ampules and mixing the contents by shaking. The final concentration of ALA to be achieved is 20%.
- MAL: available in cream form containing 168 mg/g of MAL, glyceryl monostearate, cetostearyl alcohol,

polyoxyxl stearate, methylparaben, propylparaben, disodium edetate, glycerin, white petrolatum, cholesterol, isopropyl myristate, refined almond oil, oleyl alcohol, and purified water. The final MAL concentration required is 16.8%. The tube needs to be stored at 2–8°C.

Light source

The photodynamic process is initiated with suitable application of light, laser or non-laser (non-coherent light sources), with suitable spectral characteristics and a high output absorption maximum of the photosensitizer.

Laser PDT

I. Advantages

- a. maximum effectiveness can be achieved if the wavelength of laser matches the peak absorption of the photosensitizer because of the monochromatic quality possessed by the lasers;
- b. high irradiance produced by lasers helps minimize the therapeutic exposure time;
- c. lasers can be delivered to internal organs, such as the gastrointestinal tract and lungs, when conjugated with fiberoptics.

II. Disadvantages:

- a. expensive modality
- b. high maintenance
- c. coupling with fiberoptics renders lasers useful only to small lesions on the skin.

Non-coherent light sources

I. Advantages

- a. owing to large illumination fields, useful in the treatment of large skin lesions
- b. low cost and easy availability
- c. different photosensitizers with varying absorption maxima can be used.

Currently, the only FDA-approved indication of ALA-PDT and MAL-PDT is treatment of actinic keratoses (AK). The off-label and alternative uses include treatment of basal cell carcinoma (BCC), photoaging, acne vulgaris, Bowen's disease, and hidradenitis suppurativa. Treatment of psoriasis, common warts, and cutaneous T-cell lymphoma has been tried, with varying results. The choice of light source may be influenced by intended applications. For dermatologic purposes, where the light has to penetrate the skin, the scatter is high and so the effective depth of ALA-PDT is 1–3 mm at 630 nm. The number and size of lesions, need for a portable compact source with a smaller field size source, flexibility, treatment times, and cost are the other important factors taken under consideration while choosing a light source.

Instruments and items required

I. Acetone

- a. ALA-containing sticks? MAL cream
- b. Occlusive material such as Clingfilm
- c. Light source
- d. Fan for cooling purposes
- e. Sunscreen and hats

Step-by-step surgical technique



(Video 54.1)

I. Discuss the procedure including the risk, benefits and possibility of variable phototoxic reactions with the patient.

II. Obtain informed signed consent.

III. Enquire from the patient about use of any prescription drugs, over-the-counter drugs, herbal medicines, or any procedures that could increase uptake of photosensitizers or photosensitivity.

IV. Prepare target area with rigorous scrubbing and degreasing with acetone and consequently reducing surface keratin.

V. Hold the Kerastick with the applicator cap pointing up.

VI. Crush the bottom ampule containing the solution vehicle by applying finger pressure at a point approximately 2 cm from the bottom end on the cardboard sleeve.

VII. Next, crush the top ampule containing the ALA HCl powder by applying finger pressure just below the applicator cap.

VIII. Continue crushing the applicator downward applying finger pressure to the first point.

IX. Holding the Kerastick between the thumb and forefinger, point the applicator away from the face, shake it gently for 3 minutes or more, to dissolve the drug powder in the solution vehicle completely.

X. Now, remove the applicator cap and dab the dry tip on the glove or on the gauze to make it evenly wet with solution.

XI. Dab the solution with the wet applicator tip onto the target lesions, uniformly wetting the lesion surface and edges.

XII. Repeat the application in the same manner once the initial solution application has dried. The product manufacturers recommend application of the ALA solution only to the lesions, whereas in practice many dermatologists treat the entire area, e.g., the scalp, the forearm or the face. This is based on the theory that patients with multiple AKs generally have photodamaged skin which may develop more AKs in the near future but are not visible at this time. It, therefore, is in accordance with the concept of "field of cancerization," which suggests that the entire epithelial surface of the regional skin has an increased risk for developing malignant lesions.²

XIII. Although the product brochure suggests light exposure 14–18 hours after ALA application, for ALA applied to large areas of sun-exposed skin, the light exposure should occur 30 minutes to 2 hours after ALA application to avoid intense and extensive phototoxic reactions.

XIV. Patients being treated for the first time with ALA can be started with a 30- to 60-minute incubation period if ALA is applied to wide areas and the incubation time can be adjusted at the subsequent session according to

the intensity of phototoxic reaction and clinical response of AKs under treatment.

XV. Just prior to light illumination, all ALA should be rinsed with water and patted dry.

XVI. Protective eyewear with the property of blocking the specific wavelength going to be used is worn by the patient, the operator, and any other person in the treatment room.

XVII. The patient is exposed to indicated intensity of light for 16 minutes and 20 seconds, given the patient's scabs fall within 2–4 inches (5–10 cm) of the device.

Variation in the technique when using MAL for the treatment of AK

I. The skin is first prepared by removing the crusts of hyperkeratotic portion of the AK with the curette, which probably enhances MAL penetration.

II. MAL is then applied under occlusion for a duration of 3 hours.

III. The lesions are exposed to red light of either 37 J/cm^2 or 75 J/cm^2 depending on the device being used.

III. As per the FDA-approved protocol, two MAL-PDT sessions can be conducted 7 days apart.

Postoperative care and follow-up

I. Avoid sun exposure of photosensitive treatment areas to sunlight or bright indoor light prior to at least 48 hours after PDT.

II. Apply sunblock of at least SPF 30 to treated area daily.

III. Use of physical sun barriers such as hats and umbrellas are essential specially in geographic areas with high sun exposure such as Miami, FL.

IV. Do not wax the face after treatment for at least 48 hours.

V. Do not shave after treatment for 48 hours.

VI. In case of slight discomfort, apply cold water compresses for 15 minutes up to 3 hours.

VII. Regular patient follow-up is essential.

Desired phototoxic reaction

When ALA PDT is used on large skin surfaces with shorter exposure durations, a low-intensity phototoxic reaction in the form of burning sensation and/or pruritis is observed. These sensations usually decrease if the light

source is paused or terminated. On AKs, the reaction may be marked by erythema, edema, crusting, vesiculation, or erosion and is desirable in order to achieve clearance of lesions which takes around 7–10 days.

This phototoxic reaction may be variable in intensity and enhanced in patients who expose themselves to the sun or to powerful artificial lights during the first 2 days after topical application.

Complications

- Excessive phototoxic reaction: excessive burning, vesicles, crusting and peeling.
- Pigmentary abnormalities: hyperpigmentation which tends to fade over a few months has been reported; so has hypopigmentation.
- Hypersensitivity reactions: allergic contact dermatitis and urticaria to MAL.
- Systemic absorption: a theoretical possibility, but practical potential is minimal.

Prevention and management of complications

- Do not apply the solution to the periorbital area. No contact of the solution should be allowed with the ocular or mucosal surfaces.
- The solution has very short-lived stability and should be used immediately following preparation.
- Advise the patient to remain indoors, avoid exposure to sunlight, bright artificial lights, or cold between ALA application and light exposure.
- ALA and MAL cream should be applied in the presence of a physician who possesses complete knowledge of PDT use.
- The procedure should be performed only in office or clinic setting. Patients should never apply the products by themselves.

Contraindications

For ALA and MAL use in patients with

- cutaneous sensitivity at 400–450 nm
- porphyria
- known allergies to porphyrins

- known sensitivity to any components of the ALA solution
- caution to be exercised in patients with sensitivity to other wavelengths

Both ALA and MAL belong to FDA pregnancy category C and are not approved for use in children.

Topical PDT has limited depth of treatment because of restricted depth of penetration of the photosensitizer. This can be enhanced by increasing the uptake of the product using penetration enhancers and modalities such as iontophoresis and electroporation.

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Video list

Video 54.1 Photodynamic therapy

Laser for skin tightening

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Introduction

The use of laser and light sources for skin tightening can be classified into three categories:

- non-invasive: involves the use of skin cooling to protect the epidermis, the laser/light source is then delivered to the deep dermis leading to deep tissue heating
- semi-invasive: involves the use of fractional resurfacing to achieve skin tightening
- invasive: involves the use of laser-assisted lipolysis to remove fat and also induce skin tightening at the same time

Non-invasive skin tightening with laser and light sources

It is generally accepted that by protecting the epidermis with cooling, lasers, and light sources can induce deep tissue heating and damage collagen at 2–4 mm in depth. The subsequent healing process can lead to new collagen formation and achieve skin tightening. The main issue with lasers and light sources is the degree of scattering associated with the use of these devices, implying that there is a relative lack of efficacy compared with others, such as radiofrequency or focused ultrasound. Near infrared laser or light sources have been used with some success in obtaining non-invasive skin tightening. For lasers (such as 1064-nm or 1320-nm Nd:YAG laser), because of their short pulse duration, multiple passes are necessary to obtain thermal diffusion to the deeper area

and to reduce the potential adverse effects and discomfort associated with such bulk tissue heating. Topical anesthetic such as EMLA cream is applied to area to be treated, e.g., the whole face, for at least 45 minutes before the procedure. Typically, three passes with or without pulse stacking are then performed. In a split-face study that compared a single treatment of monopolar radiofrequency versus long pulsed 1064-nm Nd:YAG laser for skin tightening, the overall facial improvement was found to be greater in the laser-treated side.¹ Laser parameters used in that study were 10-mm spot size (40 J/cm^2 for the cheek and $20\text{--}30\text{ J/cm}^2$ for other areas); and 40/20 ms setting for dynamic cooling. Three passes of double-stacked pulses were performed at 1.5 Hz without pulse overlap. More recently, another split-face study looked at the use of a 1064-nm Nd:YAG laser for the treatment of skin tightening and compared the role of dynamic cooling device with pneumatic skin flattening (PSF) in epidermal protection and pain reduction during such laser treatment.² The laser parameters used were 30 J/cm^2 , and 50-ms pulse duration. PSF was found to be associated with less pain without reduction in clinical outcome.

In addition, the 1064 nm Nd:YAG, 1310-nm laser in combination with contact cooling has also been used for the treatment of skin laxity. In one clinical study, improvement in the laxity of the face and neck was 78% and 61% at 1 month and 63% and 61% at 3 months, respectively, with short-term erythema and edema being the main side effects.³

An infrared device with contact cooling (Titan, Cutera, Brisbane, CA) has also been shown to be effective in the



Figure 55.1 (a) Before and (b) 3 months after treatment with an infrared device with contact cooling.

treatment of skin laxity, with ultrastructural changes observed that are similar to those observed following treatment with a monopolar radiofrequency device. A study that examined the use of this infrared device in the treatment of 25 patients indicated that it was effective in tightening skin with minimal discomfort.⁴ Another study that looked at the efficacy of this device in the treatment of Asian patients also confirmed its effectiveness.⁵ However, no control was included in either of the studies. A prospective, split-face, single-blinded study examined the efficacy and complications of an infrared device with contact cooling for the treatment of skin tightening.⁶ One hour before treatment, EMLA cream was applied to the half of the face that was receiving treatment. The forehead, cheek, and submental areas were treated with three passes of the infrared device (spot size 10 cm × 1.5 cm) with fluences that ranged from 36 to 46 J/cm². The fluence used was determined by the degree of discomfort of the patient: the patient was not to experience more than a moderate degree of discomfort. The fluence was decreased by 10–15% over bony areas such as the forehead. Thirteen patients were recruited for this study and 23% of patients reported mild improvement, 15% reported moderate improvement, and 54% reported significant improvement 3 months after their second (and last) treatment. In terms of objective assessment, 41% of

patients were identified to have some degree of improvement of the treated side 3 months after their second treatment. Compared with the untreated side, the treated side improved significantly ($p = 0.031$) at 1 and 3 months after the second treatment (Figure 55.1). Blistering occurred in one patient, which had resolved completely by the 3-month follow-up visit.

An infrared light source has been used in combination with bipolar radiofrequency and contact cooling for the treatment of skin laxity⁷ (Video 55.1). At least 3-monthly treatments are necessary to produce the desired effect. Once again topical anesthetic such as ELMA is applied for up to an hour to prevent discomfort associated with such a procedure. Water-based transparent gel is applied before treatment to hydrate the skin surface and to assure proper conductivity. The system handpiece is then applied to the skin using gentle but firm pressure to ensure adequate coupling along with generation of light and radiofrequency pulses. The whole treatment section is covered with 50% overlap until the clinical end point of tightening and edema can be observed. The radiofrequency fluence can be increased or decreased by 10 J/cm³ increments to achieve end points, or can be reduced if there is any sign of epidermal injury. In a study that examined the use of such devices for the treatment of skin laxity among 19 patients, objective improvement 3



Figure 55.2 (a) Before and (b) 3 months after three treatments with an infrared light source with bipolar radiofrequency and contact cooling.

months after treatment was found to be mild to moderate in 47.3%, 36.8%, 26.3%, 26.3%, and 26.3% in cheek, jowl, periorbital area, nasolabial fold, and upper neck patients, respectively (Figure 55.2).

The use of fractional resurfacing for skin tightening

Ablative laser skin resurfacing remains the gold standard for skin rejuvenation and skin tightening, and although such procedures are still performed, the downtime and potential complications associated with laser resurfacing have made this procedure less popular. Non-ablative fractional resurfacing has been proposed to induce skin tightening. A recent study looked at the role of non-ablative 1550-nm erbium-doped fiber scanning laser fractional resurfacing for skin tightening around the eyelid.⁸ Thirty-one patients had their upper and lower eyelids treated using 17–20 mJ and 500–750 MTZ/cm². Three to seven treatment sessions at 3–4 weekly intervals were performed. Three clinicians then assessed the before and after photographs using a standardize four-point scale, and their findings indicated skin tightening occurred in most patients and an increase in eyelid aperture was seen in 55.9% of the patients. In another study that looked at the 1540-nm erbium glass stamping laser for

the treatment of acne scars, 12 acne scar patients had treatment on a random half of the face using 45 mJ, three passes at 100 MTZs/cm², twice at 4-weekly intervals.⁹ Facial images of all patients were recorded using a Robo skin imaging system that converted the intensity of light reflection. The degree of intensity was correlated with the convexity of the face and was graded in five colors. The result revealed a significant degree of skin tightening 4 weeks after the first and second treatments.

While non-ablative fractional resurfacing had been used to induce skin tightening with some success, the degree of improvement tends to be mild. Ablative fractional resurfacing involves the use of an ablative laser to vaporize the volume of tissue in a fractional manner, leading to immediate tissue shrinkage. The subsequent healing process leads to significantly greater degree of skin tightening. A recent study looked at the role of a fractional ablative laser for the treatment of skin rejuvenation and indicated a significant degree of skin tightening.¹⁰ A similar study on skin of color confirmed the efficacy of such devices in skin tightening, but the risk of postinflammatory hyperpigmentation can be high if high energy and density are used. Pain can also be an issue¹¹ (Figure 55.3). In the author's practice, besides local anesthetic, nerve block and intramuscular injection of potent analgesic such as pethidine are used to reduce discomfort associated with such procedures. The typical parameters

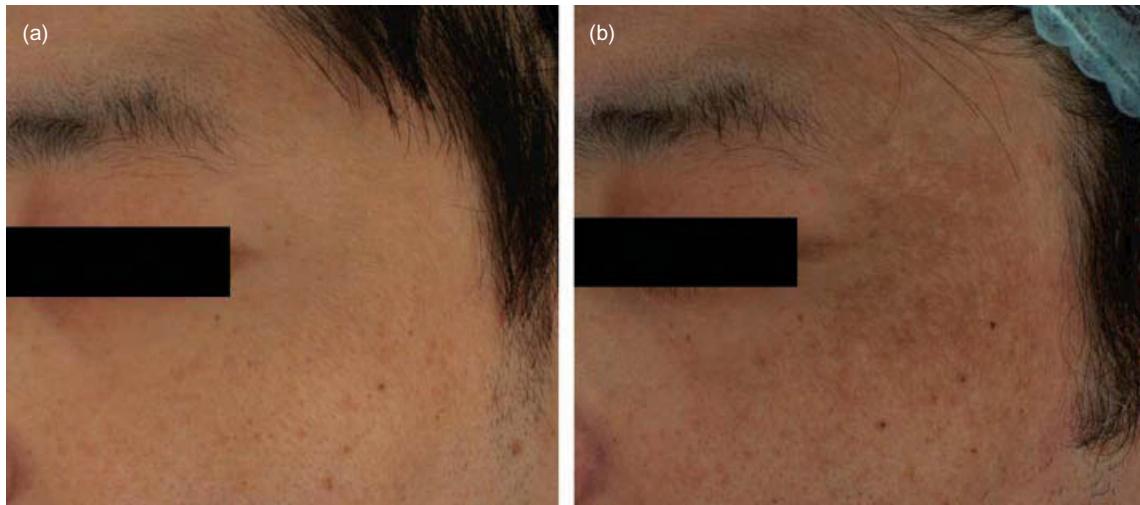


Figure 55.3 (a) Before and (b) postinflammatory hyperpigmentation after one treatment with a fractional ablative carbon dioxide laser.



Figure 55.4 Oozing and bleeding occurring 1 day after treatment with a fractional ablative carbon dioxide laser.

for the ablative scanning device is 70 mJ, treatment level 11, and four passes. Systemic antiviral (Famciclovir 500 mg bid) and a systemic antibiotic (cefuroxime 500 mg bid) are given the day of the procedure and are continued for 1 week. Hypoallergic cleanser (such as physiogel or cetaphil) is used and the patient is advised to wash his/her face every 4 hours during the initial 2 days when oozing and bleeding occur (Figure 55.4). Aquaphor is applied 4 hourly as a means to protect the barrier

function. The patient is followed up 1 day postoperatively and thereafter every other day for a week. For skin of color, bleaching agents and sun block are started 1 week after treatment to reduce the development of postinflammatory hyperpigmentation.

Laser-assisted lipolysis for skin tightening

In recent years, laser-assisted lipolysis has been used not only to remove fat, but also to induce skin tightening. Many lasers ranging from 924 nm to 1320 nm have been employed.^{12,13} More recently, combined lasers have been used to improve clinical outcome with the intention of utilizing one laser for lipolysis and another for skin tightening. The intention is to use such lasers to disrupt the adipocytes by a combination of photothermal and photoacoustic effects. After draining fat, further heating of the dermis can lead to skin tightening. A recent study examining the role of a sequentially firing of 1064-nm and 1320-nm Nd:YAG lasers for laser-assisted lipolysis indicated skin tightening of 18% 1 month after a single treatment.¹² Another study examining the use of a combined 924/975-nm diode laser revealed skin tightening to be excellent with retraction of up to 25% in a subject with a pretreatment umbilical tattoo.¹³ In all cases, tumescent anesthesia is performed using the Klein infiltration

method. The laser beam is then guided through the fat by an optical fiber that is seated within a small microcannula attached to the handpiece. After the procedure, a compression dressing is kept on for 24 hours, then the patient is advised to wear a compressive pad day and night for 3 days and thereafter daily for 4 weeks. Complications tend to be transient, including pain, erythema, edema, and bruising. Rarely, thermal burns occur, especially in inexperienced hands.

In conclusion, although laser and light sources cannot achieve the same degree of deep tissue heating as other modalities, such as radiofrequency or focused ultrasound, they can be still be effective to a certain degree in the treatment of skin laxity in a non-invasive manner. Ablative fractional resurfacing and laser-assisted lipolysis can be used as a minimally invasive means to induce skin tightening.

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Video list

Video 55.1 Non-invasive skin tightening

Radiofrequency for skin tightening

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Introduction

Skin laxity is a problem that needs to be addressed in most cosmetic patients. Patients start to notice a difference in the elasticity of their skin even in their late twenties and definitely are concerned about loose skin once they reach their thirties. Surgery is undeniably effective in removing the redundant skin, but until a patient is mentally ready to take this step, non-invasive technology has evolved to the point that this definitive step can be delayed for years. Even in patients who have had more than one facelift, the prospect of facing the knife again is unpalatable, and they wish to find non-surgical rejuvenation methods, even if the change they see is modest at best.

Many innovations in non-ablative skin rejuvenation have been introduced into the marketplace since the Food and Drug Administration first cleared monopolar radiofrequency for rejuvenation of the periorbital area in 2002.¹ Two years later, it was cleared for tightening the entire face;² its use in cosmetic rejuvenation has continued to steadily increase. Initially, the protocols used for this procedure were painful, despite the use of topical anesthesia and sedatives, some patients were unable to tolerate the procedure, and the results were inconsistent or unpredictable.

Facts about radiofrequency

Heating the tissues causes tightening of the skin. Although lasers, infrared energy, radiofrequency, and

a combination of any of these will induce tightening through heat, this chapter will focus on how to best use radiofrequency to effect contour changes in the face or body.

Mechanism of action for skin tightening

- Lasers: target a specific chromophore, and the absorption of photons by the target tissue is responsible for the changes that are observed. Penetration into the dermis by this energy is limited due to scattering by melanin in skin.
- Infrared energy: direct heating of the tissues through a broadband light source. Penetration to dermis is also limited due to scatter from melanin. Newer devices have focused on attempting to improve this limitation.
- Radiofrequency: this causes heating of the tissues when ions flow through the dermis within a radiofrequency field. There is varying resistance to the flow of electrons by distinctive tissues (impedance). Bone and fat are more resistant to the flow of this energy; muscles and dermal collagen are more conductive. Fibrous septa within the dermis represent the path of least resistance; therefore, ions course through this tissue preferentially. In the human body, fibrous septa surround the less conductive fat lobules and represent 10–30 % of the tissue,³ depending on location. Immediately, contraction of the collagen fibers is evident. Subsequently, collagen remodeling ensues as the result of tissue repair, a process that is much slower and may take 4–6 months to be completed.

Comment about lasers and radiofrequency

- Radiofrequency can be used on any color skin, since the delivery of its energy is independent of the activation of chromophores within the epidermis.
- Protection of the skin via cooling is used during all of the above modalities to prevent epidermal damage.

- Discuss the benefits of alternate procedures such as surgery, intense pulsed light, etc.
- Their probability of getting a noticeable result
- The sequence in which you would incorporate this procedure into their treatment plan
- Determine if patient has realistic expectations
- Show examples of results other patients have achieved in your hands; if the patient can't see any difference in the photos, this is not someone who will be happy with radiofrequency.

Types of radiofrequency devices

- Monopolar: lead to greater depth of penetration
- Bipolar
- Unipolar
- Phased (bipolar device with phased delivery of energy within its six parallel electrodes)
- Tripolar
- Combination of any of the above with other sources.

Regardless of the manner in which the energy is delivered, all radiofrequency devices will essentially do the same thing. Some systems are better than others when it comes to treating a specific body part. Combining two or more of these systems will give the clinician a larger palate from which to choose when considering which device is most appropriate for treating a particular area (Video 56.1).

Radiofrequency is ideal for patients with mild to moderate facial and neck rhytids and who have mild structural ptosis, if they have realistic expectations from this type of procedure. When treating loose skin on the body or cellulite the same rules apply. In the best of situations, there is only a 20–25% likelihood that the patient will be very satisfied with change they see in their contour. When a patient has photodamage, is in poor health, or smokes, the probability of getting a noticeable result decreases. We also produce less collagen with advancing age, but great results can be achieved with radiofrequency in older patients if their skin is in good condition.

During the consultation

- Discuss the science behind tightening of the skin with radiofrequency

Preparation for radiofrequency procedure

- I. Documentation: good photographic documentation is paramount to having a successful cosmetic practice,⁴ especially if radiofrequency is going to be one of the tools used (Video 56.2). The results with radiofrequency are gradual, and it is very difficult for patients to remember their previous appearance accurately. Consistency in photographic technique, such as head, eye, and body position, camera settings, lighting, removal of jewelry and make-up, covering clothing with a dark bib, and a consistent background, all contribute towards allowing the surgeon and the patient actually see if any of the desired contour changes have been achieved.
- II. Point out facial asymmetries to the patient during consultation; they should be informed that this area would get special attention when the procedure is being performed.
- III. Weigh the patient before treatment. A 10-pound (4.5 kg) fluctuation in weight can certainly interfere with the evaluation of post-treatment photographs.
- IV. Be thoroughly familiar with doing the procedure before allowing others to perform radiofrequency. Although this is a procedure that can be delegated to office personnel, the physician in charge should have ample experience with the use of this type of device before assigning this task to others.
- V. Clean skin thoroughly
- VI. Give prophylaxis to patients with a history of herpes simplex
- VII. Remove all jewelry

Achieving predictable and reproducible results

Long-lasting, predictable skin tightening results with radiofrequency can be obtained in the majority of patients by using a technique that allows the use of multiple passes at lower energies, individualizing the treatments based on a patient's feedback on heat sensation, and by treating to a clinical end point.^{5,6,7}

Patients sometimes ask to only have a portion of their face treated with radiofrequency. This technology only causes a small amount of shrinkage per square inch in the treatment area. If the area in question is not large enough, there may not be an appreciable change in contour after collagen remodeling has taken place.

When tightening the eyelids, the forehead, temples, lids, and upper cheeks should be included as part of the cosmetic unit. If the energy is to be applied over the actual eyelid skin, a plastic eye shield must be inserted into the globe⁸ (Video 56.3). To avoid a feeling of claustrophobia in patients, insert the eye shield only in the eyelid that is being treated.

When using radiofrequency in the lower face, it is important to also treat the chin, upper lip, and the neck, so that the jaw line tightens from above and from below. This will make the difference in 4–6 months when collagen remodeling is finished.

If a Thermacool device is used, then the treatment only has to be done once, because of the way in which the energy is delivered to the tissues. With other devices, two or three treatments are worthwhile in order for your patients to see noticeable differences in their appearance.

- Pearl: start by treating the better side. Starting on the worse side may just make the patient symmetric; they will NOT see as much of a difference between the two sides.

Tips for monopolar radiofrequency with Thermacool

- Apply grid to face (Video 56.4)
- Connect the ground plate to the patient and calibrate the system
- Use gel provided liberally before every pulse
- Start your treatment over the central cheek area (this area is always less sensitive) then start alternating the

application of the treatment tip between squares/circles within the grid, always overlapping treated areas.

- Drop the energy being used *before* reaching the pre-auricular area, submental nerve, and jaw line.
- When treating the skin along the jaw, lift the cheek superiorly with the gauze. This will allow you to treat some of the submental skin while firing the tip over the skin on the cheeks. The patient will feel less discomfort even if you are using higher energy settings.
- Use a minimum of four staggered passes along the entire treatment area.
- Do additional passes in areas that are clinically worse.
- Let the patient guide you with the energy settings. They should feel some discomfort, never pain.
- When you reach a clinical end point (contour is smoother, skin is tighter when you pinch), show the patient the difference between the treated and untreated sides.⁹
- Then proceed to treating the second half of the face.

Treatment pearls for devices without disposable treatment tips

- Follow recommendations from the manufacturer when applying conductive gels.
- Length of treatment: with every radiofrequency device, the surface temperature of the treatment area must be heated to between 40°C and 44°C. Many devices do not measure surface temperature; it is interesting to note that patients will usually complain of discomfort during treatment when the therapeutic temperature is reached or exceeded. We must therefore rely on a patient's feedback of pain during the treatment. Even if the therapeutic temperature has not been reached at the recommended setting of the device being used, drop the energy being delivered so that patient comfort dictates the energy levels. Eventually, the therapeutic temperature will be reached. Side effects such as burns, small blisters, and irregularities in contour can be seen when unnecessarily high energy settings are used during treatments or when both treatment tips are not in contact with the skin when a bipolar device is used.
- Once this therapeutic temperature is obtained, then this level of warmth must be maintained for a minimum of 90 seconds. The approach to the adjacent areas should

be exactly the same. When the entire cosmetic unit has been treated properly, this sequence should be repeated once more, or until a visible tightening of the area is seen both by the treating physician and by the patient. Always treat one side of the face or body completely before treating the opposite side. Pinch the skin on opposite sides of the face or neck to ensure that there is a difference in the elasticity between the two sides. The patient should participate in seeing and feeling the immediate tightening and the difference in the contour between the treated and untreated halves.

Contraindications to the use of radiofrequency

- Pacemaker
- Insulin pump
- Pregnancy
- Careful if using over metallic implants such as braces, root canals, tattoos.

The above guidelines should be followed when treating the abdomen, buttocks, legs and arms.¹⁰ More treatment sessions are needed when treating the body in order for the patient to see an appreciable difference in their contour.

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Video list

Video 56.1 Combining two or more radiofrequency systems

Video 56.2 Good photographic documentation

Video 56.3 Plastic eye shield insertion

Video 56.4 Complete radiofrequency facial procedure with Thermacool

Lasers for treatment of ethnic skin

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Introduction

Ethnic skin typically falls within Fitzpatrick's skin types III–VI. Darker skin types differ from fairer skin in their photoaging features and cutaneous pathophysiology. The higher melanin content within the epidermis confers photoprotection, and pigmentary changes occur with a greater incidence than skin wrinkling in ethnic skin. Conditions like seborrheic keratosis, nevus of Ota, and Hori's nevus are more commonly seen, whereas the melanoma risk in ethnic skin is lower. Moderate to severe wrinkling also tends to manifest one to two decades later than in aged-matched Caucasians. Melanin has a broad absorption spectrum ranging from 250 to 1200 nm, and laser treatment on highly melanized skin can potentially lead to non-specific energy absorption with subsequent unintended thermal injury, causing untoward side effects including dyspigmentation, textual changes, atrophy, and scarring. Melanin can also act as a competing chromophore for vascular and pigment lasers, causing less energy to reach the underlying intended target, thus decreasing treatment efficacy. Furthermore, highly melanized skin also absorbs electromagnetic energy much more efficiently than fair skin. Safe and effective laser treatment in ethnic skin requires all these factors to be taken into account, so that individualized treatment parameters and approaches can be offered to patients.

Preoperative care

Accurate clinical diagnosis is essential before the initiation of laser treatment. Photographic assessment with ultraviolet images is especially useful for assessing pigmentary conditions in ethnic skin as it is not uncommon for some patients to have subclinical melasma, which can be accentuated with inappropriate laser and light source therapies.

Postinflammatory hyperpigmentation (PIH), although usually transient, is the most frequent side effect encountered in laser treatment of ethnic skin. The incidence can be up to 68–100% in Fitzpatrick skin types greater than III, and patients should be informed of this. Other potential adverse effects should also be discussed. The use of full-spectrum sunscreen of at least SPF 30 is essential for a minimum of 2 weeks before and after treatment. Pre-treatment with topical bleaching agent is not routinely required, but can be considered in patients with pre-existing melasma where the suppression of melanocyte activity prior to laser treatment may help decrease the risk of developing PIH.

Freckles and lentigines

Many pigment lasers and light sources have been shown to be safe and effective for treating freckles and lentigines

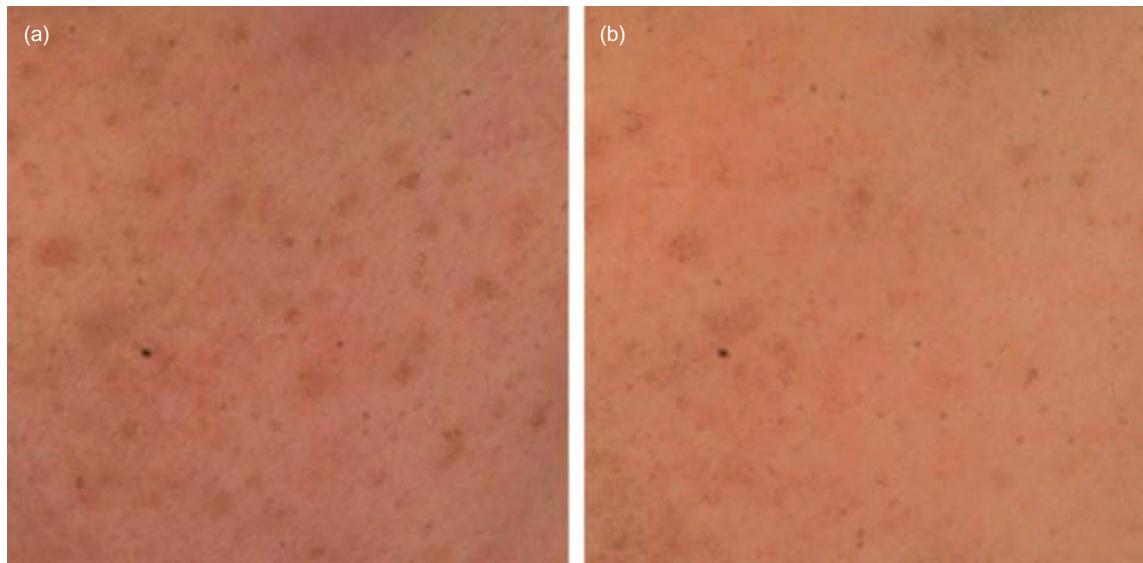


Figure 57.1 Freckles before (a) and after (b) one treatment with QS 532-nm Nd:YAG laser (repetition rate 10Hz, fluence 0.6J/cm², spot size 2 mm).

in ethnic skin. Different Q-switched (QS) lasers can be used, including the QS neodymium:yttrium-aluminum-garnet (Nd:YAG) laser (532 nm), the QS ruby laser (694 nm), and QS alexandrite (Alex) laser (755 nm). With QS lasers, complete or near complete clearance can be achieved with just one or two treatments (Figure 57.1). As for downtime, 1–2 days of erythema and swelling are to be expected, and crusting can persist for up to a week. Since QS lasers achieve their therapeutic effects through both photothermal and photomechanical destruction of melanin, the photomechanical effect can also cause undesirable damage to surrounding tissue, leading to excessive inflammation and the development of PIH. Studies have shown that the use of QS lasers on Asian skin carried a PIH risk of approximately 10–25%.¹ Furthermore, this risk was higher for lentigo than for freckles. To minimize the risk of PIH, the smallest spot size should be chosen to confine injury within the lesion; and the lowest fluence should be used to achieve the treatment end point of immediate whitening.

For patients who prefer less downtime and a lower risk of PIH, an intense pulsed light (IPL) source can be considered. IPL consists of a fixed wavelength spectrum, and hence also has the advantage of improving other photo-

aging features, including pore size and facial telangiectasia if used appropriately. Since IPL is less selective than lasers, it is more suitable for treating freckles and lentigines where the color contrast between the pigment lesion and the normal skin is great, for example dark lentigines in light skin patients. Several treatment sessions are usually needed, but the downtime is often less than QS lasers. For dark skin patients with light-colored lentigines, the large spot size of IPL is less favorable, since injury to the surrounding normal skin can potentially lead to hypo- or hyperpigmentation. In these patients, it would be best to use small spot size pigment lasers.

In treating freckles and lentigines in ethnic skin, long pulsed (LP) lasers have the advantage of a lower risk of PIH and downtime than QS lasers (Video 57.1 and Video 57.2). One study comparing QS 532-nm Nd:YAG lasers with LP 532-nm Nd:YAG lasers for facial lentigines in Asians showed that the clearance rate was similar for both lasers, but the QS laser was associated with a greater risk of PIH.² However, LP lasers in general require several more treatment sessions to achieve near complete or complete clearance (Figure 57.2). An ash-gray appearance of the lesion is taken as the end point. Other LP lasers that can be used include LP ruby, LP Alex, and LP

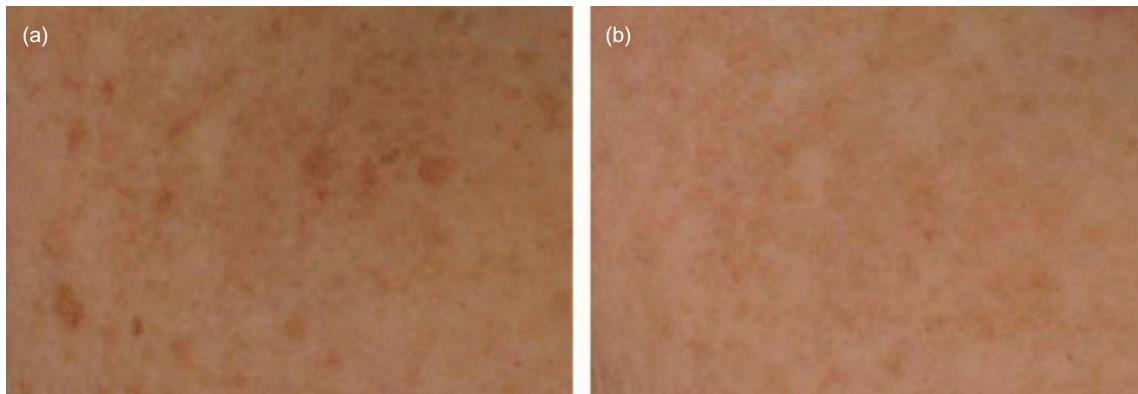


Figure 57.2 Freckles before (a) and after (b) three treatment sessions with long pulsed 532-nm KTP laser with compression (repetition rate 1 Hz, fluence 13 J/cm², spot size 2 mm, pulse duration 2 ms).

pulsed dye laser (PDL) (595 nm). For LP 532-nm Nd:YAG and LP 595-nm PDL lasers, hemoglobin absorption can lead to unwanted purpura. This can be overcome by diascopy using a handpiece with a flat glass window to compress the skin surface during laser treatment, which leads to emptying of blood vessels and hence reduces the risk of vascular damage, purpura, hemosiderin deposition, and subsequent PIH.

In a recent retrospective study performed by our group, we compared the efficacy and side effects of four pigment lasers for freckles and lentigines in Asians. The results showed that a small spot size LP 532-nm KTP laser with compression had a better efficacy and a lower complication risk than large spot size LP 595-nm PDL with compression, which in turn performed better than a QS 532 Nd:YAG laser and a large spot size LP 755-nm Alex laser without compression. This study indicated that LP laser with compression and small spot size achieved the greatest improvement with least complications in the treatment of freckles and lentigines in skin of color.³

Nevus of ota

Nevus of Ota is a dermal melanocytic hamartoma which is more commonly seen in Asians. Clinically, it is characterized by mottled dusky blue and brown hyperpigmentation, affecting the skin and mucous membranes innervated by the first and second branches of the

trigeminal nerve. Ectopic melanocytes are seen in the dermis histologically. QS ruby, QS alexandrite and QS 1064-nm Nd:YAG lasers have all been shown to be effective. Recently, fractional resurfacing was shown to be effective in one patient who failed to respond to a QS 1064-nm Nd:YAG laser.

The QS ruby laser is associated with the fewest number of treatment session but a greater risk of hypopigmentation. The QS Alex laser is well-tolerated by patients, especially when used with pre- and post-treatment cooling, but the QS 1064-nm Nd:YAG laser was shown to be more effective in lightening the lesion after three or more treatment sessions (Figure 57.3).⁴ In general, the treatment interval should be 6–8 weeks initially. When the lesion has lightened significantly, higher fluences are required and the treatment interval should be lengthened to several months. At least three treatment sessions are usually required before clinical improvement can be observed. Several factors have been shown to be related to the total number of treatment sessions required: patients whose treatment is initiated at a younger age require fewer treatment sessions, and periorbital involvement was found to be associated with more treatment sessions.

Besides hypopigmentation, other potential complications include erythema, PIH, textural change and repigmentation, which can occur in 0.6–1.2% of patients. All these factors need to be discussed with patients before the commencement of treatment.

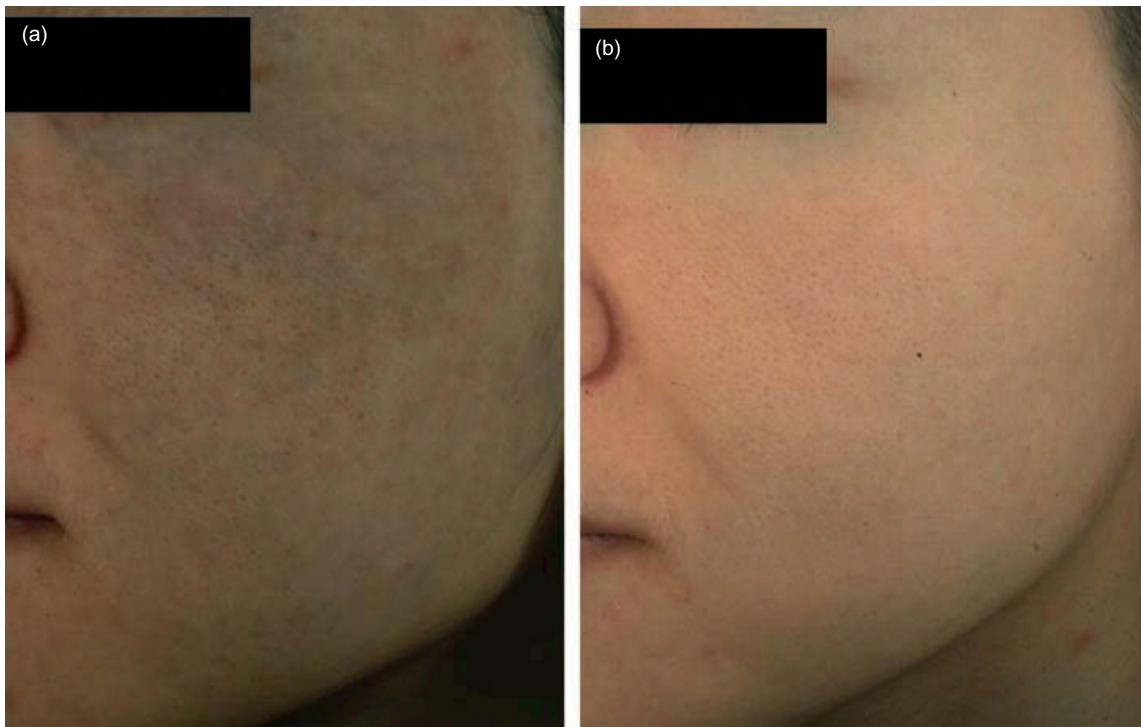


Figure 57.3 Nevus of Ota before (a) and after (b) seven treatment sessions with QS 1064-nm Nd:YAG laser (repetition rate 10 Hz, spot size 2 mm, fluence 12 J/cm²).

Acquired bilateral nevus of Ota-like macules (ABNOM or Hori's macules)

Hori's macules is another dermal hyperpigmentation condition which disproportionately affects ethnic groups with darker skin types. It typically presents as bilateral blue-gray macules located symmetrically over the malar regions, temples, upper eyelids, and the root and alae of the nose without mucosal involvement. Its pathogenesis remains poorly understood, and has been postulated to represent ectopic placement of dermal melanocytes which become activated by ultraviolet exposure and other triggers. In contrast to nevus of Ota, Hori's macules have a late onset in adulthood. QS ruby, QS alexandrite, and QS 1064-nm Nd:YAG lasers have all been shown to achieve 50% to complete clearance for Hori's macules with a PIH rate ranging from 7% to 73%.⁵ QS ruby was shown to have the best clearance rate with the lowest PIH risk among the different pigment lasers. Recently, a

low-fluence QS 1064-nm Nd:YAG laser at 1–2 weekly intervals has been studied for Hori's macules using a multiple pass technique with fine petechiae as the end point. Although the downtime was lower than previous QS laser approaches, up to 15 treatment sessions were needed to achieve 76–100% improvement in 46.7% of patients.⁶

Combination laser therapy has also been found to be effective for Hori's macules, such as scanned carbon dioxide laser followed by the QS ruby laser; and the QS 532-nm Nd:YAG laser followed by the QS 1064-nm Nd:YAG laser. Combination treatments appear to allow more effective eradication of dermal pigmentation by eliminating epidermal pigmentation, and thereby allowing better dermal penetration of laser. The treatment of Hori's macules remains challenging in some patients, since the condition often coexists with other dyschromia, such as melasma, and the post-laser PIH risk is higher than in nevus of Ota.

Melasma

Melasma is a common yet difficult to treat pigmentary disorder in ethnic skin. Clinically, it is often distributed symmetrically over sun-exposed areas in middle-aged women. The etiology is multifactorial, including sun exposure, genetic predisposition, hormonal therapies, pregnancy, phototoxic drugs, and vasodilatation. Previously, melasma was classified histologically into epidermal, dermal, or mixed types. However, it has been suggested that there is no true dermal type, and the dermal melanophages are in fact due to Hori's macules. For epidermal and mixed type melasma, the pigmentation is thought to be due to the increased number of melanocytes and an increased activity of melanogenic enzymes, leading to hyperactive melanocytes.

Despite recent advances in laser and light sources, the cumulative experiences in the literature to date suggest that the response of melasma to these treatments remains unpredictable, with the potential for unresponsiveness and risk of increase in pigmentation, rebound, and relapse. Sunblock, topical bleaching agents with topical retinoids therefore still remain the first-line treatment. For refractory cases, laser and light sources can be considered. As pretreatment, it is important to suppress the hyperactive melanocytes with sunblock and topical bleaching agents for at least 6 weeks prior to laser therapy. Furthermore, mid-potency topical corticosteroid cream can be applied immediately following treatment to decrease inflammation, which can lead to PIH. Despite these precautions, increased pigmentation is seen in 10–15% of patients and this should be clearly explained prior to treatment. Also, a laser test area can first be performed to assess for response before full-face treatment.

Ablative resurfacing lasers with carbon dioxide or erbium:yttrium-aluminum-garnet (Er:YAG) have been used with some success in the treatment of melasma. The aim is to remove the abnormal clones of melanocytes that are thought to reside along the basal layer of the epidermis. However, the potential risks associated with treatment, which include PIH, infection, and scarring, have led to their unpopularity among ethnic skin. Recently, fractional non-ablative resurfacing with 1550-nm erbium-doped lasers has been explored as an alternative to ablative resurfacing for melasma. In a small study by Rokhsar and Fitzpatrick⁷ fractional resurfacing (6–12 mJ at 2000–35 000 MTZ/cm²) was used to treat epidermal

melasma in 10 patients. Sixty percent of patients reported 75–100% clearing of melasma, while 30% reported less than 25% improvement. One case developed PIH. Lee *et al.*⁸ treated 25 Asian patients monthly for four sessions, and concluded that while some clinical improvement was seen at 4 weeks, most cases recurred at 6-month follow-up and a PIH rate of 13% was seen. Another new treatment being explored is the novel 1927 nm thulium laser. This laser has a high water absorption coefficient and hence allows for more superficial thermal injury. Our preliminary experience with this laser, however, suggests that further studies are needed to determine the optimal parameters before it can be considered to be an option for melasma treatment. Overall, the role of fractional resurfacing in melasma is mainly adjunctive and its judicious use is recommended.

Pigment lasers for melasma also appear to give variable results. Earlier studies found the 510-nm PDL and the QS ruby laser to be ineffective with a possibility of increased pigmentation. This can be explained by sublethal laser damage to labile melanocytes, thereby leading to an increase in melanin production and PIH. The LP 532-nm Nd:YAG laser and LP alexandrite laser are alternatives which can be used for melasma, with an ash-gray appearance taken as the end point. IPL has also been studied for melasma. A study by Wang *et al.* showed that patients who received topical treatment with IPL (570 nm and 590–615 nm filters) had an improvement of 39.8% compared with only 11.6% in the patients who received only topical treatment.⁹ More recently, Li *et al.*¹⁰ treated 89 patients with IPL with uniform pulse profile and achieved excellent results with only 3% PIH rate. In their study, 77.5% of patients had over 50% improvement 3 months after treatment without topical bleaching agent use. The variability in outcome observed in these studies suggest that multiple factors are likely to contribute to the results, including the pulse profile of the device, the geographical location, and ultraviolet exposure of the patients, as well as recruitment criteria.

Laser toning with a low-fluence QS 1064-nm Nd:YAG laser for melasma has gained much popularity in Asia in recent years. It involves the use of a large spot size (6–8 mm) and low-fluence laser (1.6–2.3 J/cm²) to achieve mild erythema as the end point. Previous studies advocated treatment every 1–2 weeks to achieve lightening through subphotothermolytic fragmentation of melanin granules. While melasma can be improved by laser

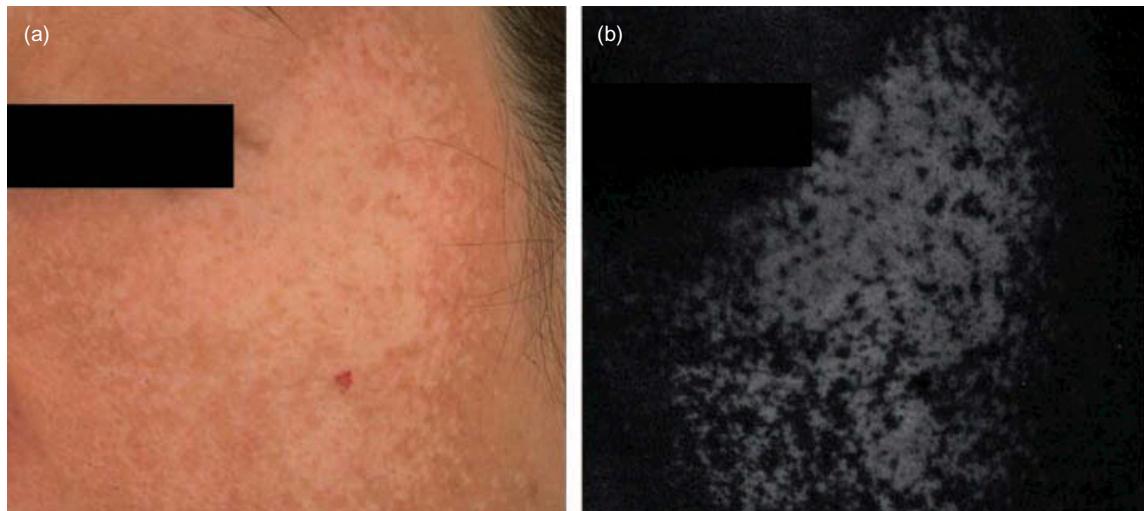


Figure 57.4 Cross-polarized (a) and ultraviolet images (b) showing depigmented macules after 14 sessions of QS 1064 nm Nd:YAG laser treatment for melasma.

toning, prolonged and frequent treatment can potentially lead to mottled depigmentation (Figure 57.4).¹¹ All patients should be monitored for this complication, and laser toning may be better considered as adjunctive therapy.

The latest development in melasma treatment includes the use of vascular lasers. It has been suggested that vascular endothelial growth factor (VEGF) with its angiogenic property may play a role in the pathogenesis of melasma. One study using copper bromide plus yellow laser (578 nm and 511 nm) to treat melasma with pronounced telangiectatic components in Asians showed dramatic decrease in the mean MASI score.¹²

Skin rejuvenation

Non-ablative laser treatment for skin rejuvenation has remained popular for treating early photoaging in ethnic skin because of the low downtime and fewer pigmentary complications. Mild rhytids, pore size, skin texture, erythema, and pigment irregularities can be improved through multiple treatments with a combination of lasers of different wavelengths, including PDLs, intense pulsed light devices, KTP lasers, Nd:YAG lasers, and mid-infrared lasers. The intention is to induce confined thermal injury to the dermis without epidermal damage,

in which fibroblast activation and neocollagenesis are initiated.

For patients with moderate to severe wrinkling, fractional non-ablative resurfacing can be considered for skin rejuvenation and for treatment of acne scars. The safety and efficacy of fractional non-ablative resurfacing has been demonstrated in several studies on Asian patients (Figure 57.5).¹³ Erythema after treatment is to be expected, which can last for up to a week. Compared with ablative resurfacing, fractional photothermolysis creates localized islands of thermal damage and hence has a lower incidence of PIH, ranging from 7.1% to 13%. Studies by Chan *et al.*¹⁴ showed that treatment density rather than pulse energy is a stronger determining factor in PIH risk for skin of color. Furthermore, increased density was more likely to produce edema and erythema with lower patient satisfaction than increased energy.

Fractional ablative resurfacing has also been used for skin rejuvenation, atrophic acne scars, and burn scar treatment in dark-skinned patients.¹⁵ The more robust inflammatory reaction induced through fractional ablation allows more significant skin tightening to be achieved than fractional non-ablative resurfacing. It is also intended to achieve better efficacy with fewer treatment sessions than non-ablative treatments. While clinical improvement in ethnic skin has been demonstrated even with just a single treatment, the downtime



Figure 57.5 Parallel-polarized images showing acne scars of an Asian patient before (a) and 1 month after (b) eight sessions of fractional non-ablative 1550-nm erbium-doped laser treatment (pulse energy 70 mJ, total energy 8.18 kJ, depth of treatment 1359 µm, treatment level 11, total density 384 MTZ/cm², density/pass 48 MTZ/cm²).

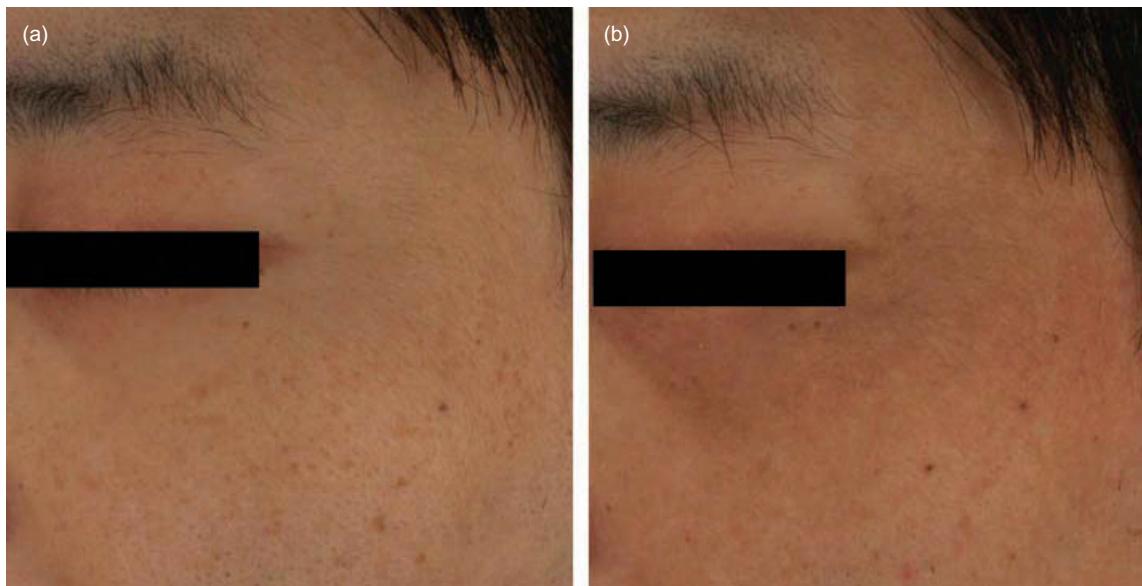


Figure 57.6 Postinflammatory hyperpigmentation (b) in an Asian patient 3 months after one treatment session with fractional carbon dioxide ablative laser treatment (pulse energy 50 mJ, total energy 10.68 kJ, depth 1247 µm, total coverage 40%, treatment level 10, coverage/pass 10%) compared with baseline (a).

is longer than with non-ablative lasers. Furthermore, the degree of improvement and the PIH risk seem to vary among studies, with PIH rate ranging from 0 to 55% at 1 month (Figure 57.6). This discrepancy is likely to be related to the energy and treatment density used. One can obviously employ lower energy and treatment density for dark-skinned patients to decrease the risk of complications, but this would also translate to reduced efficacy, and therefore the possibility of needing multiple treatments to achieve optimal results. Hence, in our opinion, fractional ablative resurfacing can be considered as first-line treatment in ethnic skin for an older population of patients with skin laxity, patients who desire a single treatment, or for scar revision.¹⁶

In conclusion, with appropriate treatment parameters and patient selection, the latest laser and light source treatments can be safely and effectively used in ethnic skin.

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Video list

Video 57.1 Long-pulse 532-nm KTP laser for freckles

Video 57.2 Q-switched 532-nm Nd:YAG laser for freckles

5

PART 5

Topics Pertinent to the Practice of Dermatologic Surgery

Wound dressings

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Introduction

Wounds are a major cause of significant morbidity, mortality, and economic cost. The main objective of successful wound healing is rapid wound closure. The wounded area can be closed by primary intention (e.g., by suturing or any equivalent method) to allow restructuring of the skin area without disturbing the surrounding tissue. In the case of large or chronic wounds, the goal is to provide the best environment for epithelialization and wound closure. Advances in the basic science of wound healing and its clinical application have led to numerous new therapeutic modalities that consistently change our approach to wound management.

George Winter¹ postulated that wound dressings that create and maintain a moist environment provide the optimal conditions for wound healing. Moisture under occlusive dressings enhances keratinocyte and fibroblast proliferation, the rate of epithelialization, collagen synthesis, angiogenesis, wound contraction, and autolytic debridement. Occlusion promotes low oxygen tension and the inflammatory phase. Decades of research support Winter's basic principle of occlusion and demonstrate that a moist wound environment provides growth factors for new cell and vessel formation, proteolytic enzymes to prevent necrotic tissue formation, white blood cells to protect against infection, and epidermal cells to freely migrate over the moist dermal surface.

In the 1980s wound dressings such as polyurethane foams, hydrocolloids, and iodine-containing gels with moisture-keeping, absorbing, and antibacterial characteristics were introduced. Others included vapor-permeable adhesive films, hydrogels, hydrocolloids, alginates, synthetic foams, anti-adhesives, silicone meshes, tissue adhesives, barrier films, and silver- or collagen-containing dressings.

In the 1990s more "combination" products emerged using smart matrices and allogeneic live cells, such as the first engineered skin substitutes.

There is currently a worldwide propensity to decreasing the number of dressings approved for use as there is a lack of randomized controlled trials to examine safety and efficacy of many new materials.

Types of dressings

Low adherent dressings

Low adherent dressings are manufactured in the form of tulles, which are open weave cloth soaked in soft paraffin or chlorhexidine, textiles, or multilayered or perforated plastic films. Most are inexpensive and widely available. They are suitable for use on abrasions, superficial wounds with low exudates. The dressings allow exudates to pass through into a secondary dressing while maintaining a moist wound bed. They are designed to reduce adherence

at the wound bed and minimize trauma upon removal and are particularly useful for patients with sensitive or fragile skin.

Gauze dressings

Gauze is a thin, woven fabric that has been used to support wound healing throughout history as a primary and/or secondary dressing. However, a gauze is not an adequate bacterial barrier, especially when wet. Gauze can be impregnated with nearly any solution, gel, or paste during manufacturing or during wound care. Impregnated gauze serves several purposes: protection of the wound bed, bacteriostatic or bacteriocidal environment, increased hemostasis, debridement, and managing moisture balance. Gauze dressings should be avoided in partial-thickness wounds where they may cause significant pain and trauma to tissue upon removal. There is little research conducted on use of gauze.

Wet to dry dressings (WTDDs) have been studied and found to delay wound healing through vasoconstriction, reduced leukocyte activity, increased oxygen binding and trauma to the tissue when removed. As the moisture evaporates from a WTDD, it becomes more hypertonic, desiccating the wound as it pulls fluid osmotically. Thus, WTDDs are not supported in modern wound care.²

Transparent film dressings

Transparent films are thin, clear, semi-permeable, adhesive dressings that are moisture retentive and are indicated primarily for superficial wounds with minimal exudates (abrasions, skin tears, stripping injuries, and split-thickness skin graft donor sites). They protect the wound from friction and bacterial contamination, are flexible and waterproof, and may be left on a wound for up to 7 days. They cannot handle high amounts of wound drainage and can cause skin maceration and breakdown in wounds with excess drainage. Transparent films have been shown to enhance healing of partial-thickness wounds compared with dry dressings and have demonstrated decreased pain.²

Hydrogel dressings

Hydrogel dressings contain hydrophilic polymers in a solution containing mostly water. Available as sheets or amorphous gels, they are used for dry to moderately draining wounds (shallow wounds, partial or full thickness wounds, burns, and chronic wounds). Hydrogels can

absorb or donate moisture to the wound, depending on the relative state of hydration of the tissue and the dressing. By increasing the wound moisture content, they have the ability to facilitate autolytic debridement of non-viable tissue and maintain a moist environment in granulating wounds. They have been shown to decrease pain and have a cooling effect on the wounds. Complications include over-hydration and subsequent peri-wound maceration and autolytic activity.

Foam dressings

Foam dressings are made of foamed polymer solutions and may be combined with polymeric film backings, impregnated with antimicrobial agents, or coated with surfactant. They are highly absorptive, although the rate of absorption depends on the foam characteristics. They maintain moisture balance, prevent maceration of surrounding tissue, local edema, wound debris, and bacterial contamination, and serve as a cushion to prevent further wound trauma. They cause less pain with dressing removal, reduce time to healing compared with traditional dressings, allow for less frequent dressing changes, decreased nursing time, and show improved patient tolerance.

There is a lack of evidential strength in the literature specific to foam dressings; however, they possess many characteristics outlined for ideal wound dressing (Box 58.1) which support the use of foams in clinical practice.²

Hydrocolloid dressings

Most hydrocolloid dressings are made of sodium carboxymethylcellulose, gelatin, pectin, elastomers, or adhesives bonded to a carrier of semipermeable film or foam sheet. This produces a flat, occlusive, self-adherent dressing that forms a gel on the wound bed surface, promoting a moist wound environment. They are used for partial thickness wounds, full thickness wounds, excluding those wounds with exposed tendon, necrotic wounds, and wounds with light to moderate exudate. They are impermeable to bacteria and protective against external contaminants. If transparent they allow observation of healing. Breakdown of the dressing may produce a residue of varying colors and possible foul odor from the wound if not changed properly. Caution should be taken when removing the dressing to prevent skin tearing. Clinical studies of hydrocolloid dressings show improved

Box 58.1 Characteristics of an ideal wound dressing**Desired properties of dressings**

- Capable of maintaining high humidity at the wound site while removing/absorbing excess exudate
- Sterile and free of particles and toxic wound contaminants
- Non-toxic and non-immunogenic
- Capable of protecting the wound from further trauma
- Easy to use
- Can be removed without causing trauma to the wound
- Impermeable to bacteria and posses antimicrobial effects
- Thermally insulating
- Allows gaseous exchange
- Available in a range of forms and sizes
- Comfortable and conformable
- Require infrequent changes
- Cost effective with long shelf life

Unwanted effects of dressings

- The use of a highly absorptive dressing on a dry wound can lead to disruption of the tissue on the wound surface causing pain when removed
- Maceration of the skin surrounding a wound
- Allergic reactions to tapes used to keep dressings in place are not uncommon.

healing rate, increased epithelialization, reduced infection, and enhanced collagen synthesis compared with the traditional gauze dressings.²

Alginate and hydrofiber dressings

Alginate and hydrofiber dressings are indicated for wounds with moderate to high levels of exudates and can be used as either primary or secondary dressings.

Alginate dressings are made of soft, non-woven fibers derived from seaweed. They are biodegradable and highly absorbable, absorbing up to 20 times their dry weight of wound fluid. They have hemostatic and antibacterial properties, are most often offered in sheet, rope, or combination forms, and are appropriate for wounds of various sizes/depths. Their use requires a secondary dressing and are drying if the wound has low exudates. Hydrofiber dressings absorb up to 30 times their weight

and provide less risk of maceration (due to vertical fluid absorption properties). They are preferred for use in deeper cavity wounds and sinuses and exuding lesions (leg ulcers, superficial pressure ulcers, partial-thickness burns, and most other granulating wounds). They are easy to remove without causing pain or trauma and leave minimal residue on the wound. Bacterial trapping inside the fibers has been documented indicating their role in infection control.

Antimicrobial dressings

Bacteria in the wound bed can impede wound healing, especially when the host immune capacity is compromised. Bacterial colonization of wounds requires the use of topical antimicrobial agents. Topical applications augment the effects of systemic antibiotics that may not reach sufficient levels in the wound tissue.

Topical antimicrobial agents including silver, iodine, and honey are incorporated in various dressing categories and there are numerous antimicrobial dressings available. It is important to account for specific factors such as a wound shape and size, phase of wound healing, amount of exudates, and number and type of bacteria present in the wound when selecting the most effective antimicrobial dressing. Therefore, the antimicrobial characteristics of the dressings are very important in combating bacterial burden often present in wounds or tissue surrounding the wound.

Types of antimicrobial dressings**Silver dressings**

Silver is incorporated into antimicrobial topical dressings as it has been shown to be effective against a range of aerobic, anaerobic, Gram-positive and Gram-negative bacteria as well as filamentous fungi and viruses in practice.³ Ionic silver has the ability to bind to the bacterial wall and damage membranes, leading to cytoplasm leakage. It also binds to cell proteins and cell DNA, interfering with cell replication. Silver can discolor surrounding skin, but a permanent coloration, argyria, can occur when cells uptake silver salts. Dressings with higher concentrations of silver are advised for wounds that are clinically infected, and dressings with lower concentrations may be effective on wounds that are not healing, suspected of bacterial colonization, or as prophylactic treatment in immunosuppressed patients.

Iodine dressings

Iodine is both bactericidal and bacteriostatic, is effective against a broad spectrum of microbes, and may inhibit some biofilm formation. No reports of iodine resistance have been published. Any iodine product is contraindicated in patients with iodine sensitivity and should be used with caution in patients with a history of thyroid dysfunction or full-thickness burns, children, pregnant women, or lactating mothers. Iodine dressing will change color from dark yellow to white when its antimicrobial activity is exhausted.

Polyhexamethylene biguanide

Polyhexamethylene biguanide (PHMB) also known as polyhexanide and polyaminopropyl biguanide is a known antiseptic. The positively charged PHMB attaches to the negatively charged bacterial cell wall and compromises the integrity of the outer membrane. It is also known to bind to bacterial DNA, alter its transcription, and cause lethal DNA damage. PHMB is available in cotton-blended gauze, biosynthesized cellulose, and non-woven drain sponge. The biosynthesized cellulose delivers the PHMB with the sterile water contained in the dressing, and unlike other antiseptic dressings, does not rely on wound fluid to deliver the agent. Dry gauze dressings containing PHMB demonstrated reduction in bioburden and showed the effectiveness in an *in vitro* bactericidal assay.⁴

Methylene blue/gentian violet

Methylene blue and gentian violet incorporated in a polyvinyl alcohol hydrophilic sponge are available on the market. The sponge pulls bacteria-laden exudates away from the wound bed where the methylene blue generates singlet oxygen and free radicals that directly attack the plasma membrane, resulting in bacteriolysis. Although effective as a bacteriostatic agent, it has been shown *in vitro* that methylene blue may inhibit wound healing in early phases by its effects on the nitric oxide pathway.⁵

Honey

Topical honey helped clear malodor from wounds, reduced pain, and led to positive wound-healing outcomes after a 4-week treatment period.⁶ There are no standardized protocols for the frequency of topical honey application and the type of secondary dressing that should be used.

Conclusion

As our understanding of wound healing advances, it becomes clear that no single modality will heal a wound. Wounds should be evaluated systematically to identify needs to find the optimal dressing. The most effective treatment is influenced by many parameters, including exudates, dressing changes, pain, wound bed condition, infection, and the size and shape of the wound.

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Medicolegal aspects

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Introduction

The current healthcare climate places much emphasis on the fundamental rights of a patient and the profound responsibilities of the physician. Enforcing these rights and responsibilities in the United States is a complex legal system that has done much to protect patient wellbeing.

However, just as with most well-intentioned policies, there are unexpected consequences. Physicians are becoming aware of their exposure to legal action, and, not uncommonly, responding by limiting the scope of their practice or leaving the field altogether.^{1,2} Other physicians respond by practicing in such a defensive manner that they focus more on what is said rather than what is done, thereby compromising patient care and safety.^{1,2}

Whether for better or for worse, the reality is that the legal system will forever be intertwined with healthcare delivery. However, by understanding the most fundamental legal issues facing our field today, dermatologists can practice in a manner that simultaneously allows them to fulfill their professional aspirations, maximize patient safety, and mitigate their legal exposure.

It is important to remember that the legal responsibilities of patients and physicians are governed by Federal and State laws and may vary from state to state. While this chapter can serve as an introductory guide, it is by no means a substitute for the counsel of an attorney when dealing with an actual or potential medico-legal issue.

Medical malpractice

The dermatologic surgeon should have a special awareness of medical malpractice exposure. While one in five dermatologists will face a malpractice claim in their career, a significant number of these claims are related to surgical procedures and skin cancer management.^{2,3}

Regardless of their merit, responding to malpractice claims requires a physician to invest substantial amounts of time and resources. It is not difficult to imagine a situation where even a favorable outcome for a physician has less than favorable repercussions on the physician's practice. Even if the case is dropped or dismissed in favor of the physician, as occurs in 35% of dermatology claims, the impact on the practice can be substantial.^{3,4}

Thus, there is clear value in understanding the basic tenets of malpractice law so as to help minimize the initiation of lawsuits. Central to this discussion is the Tort Law of Negligence, which compensates individuals for losses they suffer due to the unreasonable acts of another person.² Negligence is the result of a breach of duty from the standard of care which results in harm to another person.⁵ For a physician to be held liable for negligence, four critical elements must be satisfied (Box 59.1).

Duty

A physician owes a duty to his patients to act with knowledge, care, and skill exercised by reasonable and prudent practitioners with similar training under similar circumstances.^{2,6} It is important to recognize that the scope of a physician's duty is held to the standard of others in the

Box 59.1 Negligence: critical elements

- Duty
- Breach of duty
- Causation
- Damage

“community” in which the physician practices. Increasingly, however, technological advances in communications have blurred the boundaries of a particular physician’s “community.”^{7,8} Also, if a physician performs a procedure usually performed by a specialist, the physician will very likely be held to the standard of that specialty.

To see how duty is established, consider Example 59.1.

Example 59.1

You, the dermatologic surgeon, are serving on a committee at your child’s school. One of the other parents recently had a benign growth on her neck surgically removed by another physician. She realizes you are a skin specialist, and asks you to quickly look at the treated area, since she feels warmth in the area and wants to make sure an infection isn’t developing. She asserts that if you just tell her everything is okay it will save her the hassle of going back to see the doctor who performed the procedure. She shows you the surgical wound, which appears to be healing well.

Despite the informal setting of the above example, some courts may consider that providing medical advice can establish a duty to the patient. After all, a duty to a patient exists when a physician–patient relationship is created. Usually, what is necessary to establish a physician–patient relationship is some form of interaction with the patient where the patient reasonably relies on the advice given by the physician. This can even consist of gratuitous service or advice, without any physical contact.^{9–11} An appropriate response to the above situation would be to confirm the features of the wound that make you suspect it is healing well, but to let the patient know that your assessment is limited by the informal setting, and that this issue would be best evaluated in the clinic, where you can also perform an appropriate history and physical examination. This would meet the physician’s social obligation while putting the patient on notice that she should not reasonably rely on this one interaction.²

Breach of duty

Breach of duty by a physician requires deviation from the standard of care.^{2,5,7,8} The standard of care is largely determined by expert testimony, and is subject to change constantly as the study of medicine evolves. It is therefore in the best interests of physicians to stay current with evidence-based medicine and current treatments and practices.

One cannot overlook the fact that the community in which a physician practices greatly influences the standard of care. There may be instances where the community standard surpasses national guidelines. For example, in a certain community, it may be customary for dermatologists to perform full skin examination for all patients on all initial visits, despite the lack of national guidelines to do so.

The standard of care is also of particular importance for the innovative dermatologic surgeon. Supportive expert witnesses may be difficult to locate for non-traditional treatments or procedures. It would be wise for a physician to ensure that other reputable doctors in the community have adopted, or are familiar with, similar treatment approaches and can be called upon as expert witnesses.

Damages

For a physician to be held liable for medical malpractice, a patient must prove damages have been sustained. Even if a breach of duty can be shown, damages must have occurred for negligence to be proven.

Example 59.2

Prior to performing a surgical excision, a physician mistakenly marks an incorrect site and injects a small amount of lidocaine into it and the patient suffers no adverse effect. Immediately, the error is discovered, and the correct site is located, marked, and anesthetized. The surgery is then performed on the correct site without procedural or postprocedural complications.

In this example, the patient has suffered no material physical damages, so it would be difficult to prove damages from that standpoint.

However, not all damages have to be physical. Psychological damages, such as anxiety and depression, are

important considerations. In the example above, the physician would be best advised to communicate fully with the patient, to alleviate any fear and anxiety, and to clarify any misunderstandings. Thereby, the physician can provide good patient care while simultaneously preempting possible legal damages.

Causation

For negligence to be proven, not only must a patient establish that an injury (damage) resulted from a breach of duty, but it must also be established that there was a causal link between the breach and injury to the patient. The jury is vital for this step, as the jury decides if and how much of a link exists between the physician's breach of standard of care and any injury sustained by the patient.

Consent/refusal for treatment

Frequently, an improper consent process is the cause for litigation.¹² If the consent process is defective or absent, the patient may not have a chance to participate in decisions regarding his or her healthcare. Consent for simple services, such as routine skin examination in the office, may be implied. However, a physician would be best served by not relying solely on implied consent when performing anything but the most basic services.

Informed consent

With dermatologic treatments, obtaining consent may help avoid litigation.¹³ It is best to document the consent process, whenever possible. At 1 week, patients have been shown to remember roughly one-third to one-half of the information told to them.¹⁴ Without documentation of the consent, the physician will be forced to rely on others to accurately remember details of the consent process. Clearly, this approach can be fraught with risk.

A written consent process is clearly useful, especially for complicated procedures, or procedures that pose significant risk to the patient. The advantage of the written consent is that it ensures a framework for addressing key information, fosters better patient understanding, and constitutes a record in the patient's chart for documentation.^{2,14} However, oral consent is valid but will need to be proven to have occurred.

Informed consent is best if it contains the following elements:

- discussion of the nature of the procedure or treatment, including risks, benefits and alternatives
- assessment of patient understanding
- acceptance or refusal of the intervention by the patient.

Checklist: informed consent/refusal elements

- Competent adult or an authorized decision maker
- Common risks discussed, even if risks are not serious
- Uncommon, but serious, risks are addressed. If risk is rare, then its discussion needs to be balanced.
- Commonly known information or highly unlikely, non-material risks are less needed in the consent
- Benefits of a procedure should be covered
- Viable alternatives to the procedure should be addressed

Medical records

In a legal situation, medical records serve as the primary credible evidence.¹⁵ Complete and accurate medical records not only allow a physician to provide the best patient care possible, but also are vital for malpractice defense. Box 59.2 contains a useful checklist for maintaining medical records.

These authors prefer to maximize the use of the patient's chart for patient care, not risk management purposes. One way to accomplish this is to record a brief note in the chart that reflects that the risks (R), benefits (B), and alternatives (A) of a particular diagnosis or treatment were discussed with the patient, and that consent to, or refusal of, treatment was obtained. When documenting such informed consent, a physician should try to strike a balance between documenting too much and too little. It is impractical to write voluminous notes attempting to document every possible outcome. It is also unwise to document too little, thereby creating the appearance the note was perfunctory and not indicative of the interactive process of informed consent. In addition, the note should reflect any unique risks or complication a particular patient may have. For example, in a dark-skinned person prone to keloid formation, "R, B, A of surgical excision were discussed with the patient with emphasis on this patient's high risk of hypertrophic scar/keloid or pigmentary changes." The point is to convey

Box 59.2 Checklist for maintaining medical records

- Records should be complete but concise
- Avoid disapproving or self-serving comments
- Notes should be consistent (avoid long notes in response to risk management, as this may provoke unwanted suspicion, especially in the setting of customary brief notes)
- Describe facts, but avoid premature conclusions (e.g., in event of wound separation, describe the wound, but avoid speculating as to why, unless pertinent to patient care)
- Alter records only if essential to patient care by neatly lining out items, initialing and dating the changes, or, if possible, adding a new note or entry that refers to the correction without altering the initial entry
- Release records only upon obtaining proper authorization and according to HIPAA guidelines. Release only copies of records unless a subpoena for the original records is issued, as original records can get lost, and it is the responsibility of the physician to keep medical records safe
- Consider keeping billing records separate from patient care records to avoid confusion
- Always document from a patient care perspective (e.g., if documenting a threat, explain the potential effect on physician-patient relationship, etc.)

information that is helpful for patient care and to make it clear that the specific patient was addressed.

Adverse events and complications in dermatologic surgery

In the practice of dermatologic surgery, complications are inevitable. However, a physician must remember that not all complications lead to adverse events resulting in patient dissatisfaction and litigation.^{2,16} In the course of management of a complication, a physician has the potential to restore the desired initial clinical outcome and curb any activation of the legal process.² There are several important aspects to remember when dealing with a potential complication or adverse event.

Trust building

Erosion of a patient's trust can result in litigation.¹⁷ Medical mistakes pose a significant challenge to patient trust in his or her physician. Be candid, considerate, and

Box 59.3 "AAA" mnemonic

A – **Acknowledge** the patient complaint. Empathize, but don't accept premature blame. Do accept responsibility to help the patient

A – Make sure you or a designated member of your staff is accessible to **Answer** patient questions or concerns

A – **Alter** Not! Do not alter the patient records unless it is for the patient's benefit, and if so, document what was altered, why and by whom the alteration was done

show empathy toward the patient if a mistake occurred. A 1996 study published in *Archives of Internal Medicine* reviewed patient attitudes toward physician mistakes.¹⁸ Patients were presented with three scenarios of mistakes made by a doctor: mild, moderate, and severe mistakes. The responses revealed that patients want the physician to disclose mistakes, no matter how minor, but still lose trust in the physician with any disclosure. This should not be interpreted to mean that physicians are best served by disclosing or not disclosing mistakes. Instead, the study emphasizes that discovery of a mistake by a patient when a physician failed to disclose was even more damaging, and was more likely to lead the patient to sue or report the doctor.

Remedying the adverse event

When an adverse event occurs, the physician can take productive positive measures to minimize the impact of the event on the desired clinical outcome. Be forthright about the adverse event. Discuss the facts of the event and try to avoid offering premature opinions as to why it occurred. Also, make sure that the patient's medical needs are addressed. Follow up with the patient frequently. Avoid delaying care or delaying appropriate referrals. Not delaying care helps the patient, and may avoid them potentially turning to an ill-suited practitioner for help, who may have an unfavorable, premature opinion of your care. Comments by other healthcare providers have been shown to be a strong force in undermining the physician-patient trust and initiating litigation.^{2,16}

A handy mnemonic summarizes the physician's approach to dealing with medico-legal complications (Box 59.3).²

Summary

Many physicians wait to acquaint themselves with the legal issues surrounding medical malpractice until a complication/adverse event occurs. However, by familiarizing themselves with the key aspects of medico-legal issues, physicians can avoid some damaging errors, and can be better prepared to act proactively and remedy the situation. Physicians must remember that not every complication leads to litigation. There is much a physician can do both before and after an unexpected event occurs to help the patient and avoid litigation. We welcome tort reform. Until then, however, the physician will have to rely on his or her own skills to help mitigate the chances of legal action if and when a complication arises.

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Introduction

The myriad ethical challenges encountered by a dermatologic surgeon should come as no surprise considering the diversity of medical and cosmetic procedures offered by a typical practitioner. It is not unusual for a dermatologic surgeon to see, in the same day, patients coming in for skin cancer surgery, medical dermatology, excision of benign lesions, and laser treatments, as well as cosmetic treatments such as fillers and botulinum toxin injections. In the course of providing treatment for these patients, the physician must balance many factors, including the needs of the patient, the safety of the proposed treatment, the economics of providing the service, time constraints, and the limits of the physician's own training and experience. Against this backdrop, the physician must also deal with the realities of modern healthcare, where there is a trend for lower reimbursement of medically necessary procedures, and increasing competition for the profits of elective aesthetic treatments.

It is not difficult to think of numerous potential ethical challenges that may arise in this setting on any particular day. While an entire textbook could easily be devoted to the subject of ethics in medicine, there are core concepts that are pertinent to our field and are worthy of mention and discussion.

Core values

Medical ethics is founded on four basic principles which act as a framework to guide the physician's behavior,

responses, and understanding of conflicts.¹ These principles are as follows:

Autonomy

This principle relates to a person's freedom to make his or her own decisions. It is based on the concept of respect for patients as individuals, patients' decision-making capacity, and patients' full understanding of their clinical situations. The role of physicians is no longer one of "parentalism," where the doctor acts on the patient's behalf based on what the doctor feels is best for the patient. Rather, in today's times, a physician's role is to provide guidance, educate patients, discuss risks, benefits, and alternatives of various treatment options, while allowing for patients' self-determination without undue influence or coercion. This principle of autonomy is represented in the process of informed consent.

Beneficence

Physicians must promote patient welfare and act in patients' best interests.

Non-maleficence.

Physicians must act so as not to intend harm to their patients.

However, the concept of non-maleficence must be considered in combination with beneficence, because many procedures intended to help patients often present with measurable risks.¹ Thus, the dermatologic surgeon must balance beneficence and non-maleficence in such a way as to provide the patient with a net benefit over the

risk of harm. This is an important concept to discuss with patients during the process of informed consent.

Justice

Physicians must practice fairness and equality, justly allocating healthcare resources.

Medical necessity: blending economics with patient needs

The dermatologic surgeon must achieve a delicate balance between patient care, patient preferences, social concerns, and economic survival. It is not unethical for a physician to seek profit from the delivery of medically necessary care, so long as he practices justly and equitably. However, when profit motives cloud a physician's decision-making capacity, ethical issues become paramount.

Physicians are often presented with patients whose conditions may justify several possible treatments. The different treatments may have significantly different rates of reimbursement by third-party payers, setting up a potential ethical issue. The ethical dilemma gets even more acute if the patient says to the doctor: "I trust you, and I will go with whatever you decide." Almost every physician faces a similar statement from a patient sometime during his or her career. In the current model of healthcare practice and delivery, patients are often shielded from the true costs of medical procedures, and therefore often do not focus on cost when presented with different treatment choices. The physician must then abide by the principle of beneficence and select and present the best treatment plan to the patient without letting the difference in reimbursement rates unduly sway his or her own opinion.

Consider a patient with non-melanoma skin cancer seeking treatment from a dermatologic surgeon. Appropriate management of such a patient must take into account both surgical and non-surgical options, regardless of reimbursement rates. Treatments should be tailored to tumor type, location, size, and histological pattern.² Primary surgical excision and Mohs micrographic surgery are two fundamental treatment options for the treatment of skin cancer, and are often the treatment of choice. However, topical, non-invasive, patient-administered modalities such as imiquimod and 5-fluorouracil have been shown to be effective in

treatment of superficial basal cell carcinoma (BCC), for example.^{2,3} Implementing the use of these topical agents may provide a more favorable cosmetic outcome, or present a better treatment option for patients who are poor surgical candidates.^{2,3}

If the skin cancer patient is elderly, a physician is presented with a unique set of ethical concerns. Currently, it is not unusual for people to live well into their ninth and even tenth decades of life, and elderly patients represent an increasing percentage of the dermatologic surgeon's workload.⁴ Caring for elderly patients highlights some ethical dilemmas facing today's dermatologists. For example, the aged population often presents with comorbid disease processes and physiologic impairment, and may be anticoagulated or have implanted cardiac devices.⁵ These factors must be taken into consideration when considering surgery and counseling elderly patients or their caretakers on treatment options. Furthermore, elderly patients can be limited by decreased cognitive capacity, emotional lability, and anxiety,⁴ at which time issues of informed consent come to the forefront. Ultimately, clear and realistic communication between the surgeon, patient, and the patient's family or care-givers must take place prior to making a management decision, taking into account the best option for the patient based on the diagnosis and the patient's ability to tolerate a given treatment.

Clearly, the first step in an ethical dilemma is to identify what is best for the patient. While respecting the patient's autonomy, the physician must act within the principles of beneficence and non-maleficence. If the patient has multiple options, as in treatment of a superficial BCC of the trunk or extremity, then the physician should present the patient with the risks and benefits of all reasonable treatments. If the patient cannot come to a decision, it is not improper for the physician to offer his or her opinion. However, the physician must make sure to explain the reasoning for the selection, and the risks, benefits, and alternatives. Also, in today's healthcare climate, the physician is encouraged to at least consider other, less easily quantifiable factors, such as the social cost of the procedures. The physician may begin by telling the patient that while surgery is considered the gold standard for treatment of non-melanoma skin cancer, a non-surgical approach, using topical chemotherapy (i.e., 5-fluorouracil) or topical immune-modulating agents (i.e., imiquimod) may be an option, as well as other less

invasive approaches such as curettage and electrodesiccation. If the patient understands the options and implications and chooses surgery after all, and the physician agrees with the medical necessity of the selection, it would not be unreasonable for the physician to oblige.

Cosmetic procedures: rhetoric versus reality

In a society that places such a high emphasis on appearance and beauty, it is no wonder that cosmetic surgery is a rapidly growing field in the United States and around the world.⁶ Cosmetic procedures now play an integral role in the dermatologist's practice and are even a part of residency training programs across the nation.⁶ Given the elective nature of cosmetic procedures and potentially high profitability for the physician,⁷ ethical issues come to the forefront.

The field of cosmetic surgery has made considerable advances in recent years, especially in the areas of laser surgery, liposuction, phlebology, botulinum toxin, and fillers.⁶ Anyone attending an American Academy of Dermatology meeting can see that manufacturers and distributors of products in these categories have clearly targeted dermatologists for marketing. Some of these companies promote new treatments for which the long-term safety and efficacy may not yet be known. Physicians may seek to gain an edge on their competition by being the first to offer the "newest" or "hottest" treatments. However, in such cases where a new treatment has not yet been tested by objective, randomized trials,⁸ it is the physician's ethical duty to act so as to protect the patient from potential harm.

The physician may be tempted to believe that FDA approval of a particular product is evidence enough that the product is totally safe. However, it is wise to remember that FDA requirements for approval of devices, such as dermal fillers, are not as vigorous as the requirements for approval of medications.⁹ Also, approval by the FDA is reassuring, but should not supplant the physician's own decision-making process. After all, most physicians can think of at least one recall of a previously FDA-approved drug or device. If a physician thinks a product is too risky, it is best to wait for more data such as well-designed trials to be done and published, and not be seduced by promotional materials supplied by the manufacturer. A

physician has an ethical obligation to critically review each procedure or service offered to his or her patients. Rhetoric must be separated from the reality of the procedures and devices. The ethical physician must not be coerced by financial pressure, nor by the pressure of patients or manufacturers to offer procedures that go against his or her own prudent judgment.

Lasers

Ethical issues that arise in the use of lasers include the high cost of devices, their rapid depreciation, and the need to treat as many patients as possible to recover the financial investment before the laser is made obsolete by a newer device. This can create an obvious conflict of interest, as the physician may purchase a laser, and subsequently feel economic pressure to utilize the machine, even when it is not the best or most cost-effective option for a patient's given condition.¹⁰ Consider the following hypothetical ethics issues involving lasers.

- A physician charges a patient for CO₂ laser ablation of actinic keratoses when cryotherapy, topical 5-fluorouracil, or imiquimod would be less expensive and no less effective.
- A dermatologist buys a device for "skin tightening" that is eventually proven, in multiple studies, to offer no significant benefit. The device is fairly safe, but is painful when used and has a small risk of scarring. Patients have seen the marketing, and continue asking for the treatment. Does the physician continue offering it?
- A physician buys a laser that can be used for acne treatment. The laser treatment is an out-of-pocket service, not covered by insurance. He instructs his staff to offer the laser as a recommended treatment to all his patients, even ones with nodulocystic acne, that could otherwise be treated and helped with isotretinoin.
- A physician has a laser demonstration scheduled for his office and performs the procedure as instructed by the device representative without due diligence to research the proper use of the device beforehand

There is no clear right or wrong issue to these scenarios, and obviously the correct approach has to be individualized to each patient. However, the point these scenarios all highlight is that physicians must be careful not to let economic benefit or personal benefit (to gain

experience or otherwise) come first in deciding what is best for their patients.

Lasers are expensive, and the physician purchasing such a device must first analyze the ability of the practice to generate enough revenue with the device to justify its cost. Also, by applying the four principles of autonomy, beneficence, non-maleficence, and justice, the physician can solve or avoid transgression of the major ethics issues that can plague laser medicine.

Credentials and training

The notion that “practice makes perfect” holds some relevance when it comes to surgical procedures. One good determinant of a physician’s ability to safely perform a procedure is the number of similar procedures he or she has performed. For example, there is support in the literature for the view that more surgical experience leads to better outcomes for certain procedures (i.e., pancreatic surgery, esophageal surgery, hernia repair).^{11,12} However, there are no absolutes, and outcomes vary widely among physicians, hospitals, certain medical conditions, and patient populations. Physicians have an ethical obligation to accurately assess and understand the limits of their own innate ability and training. If a patient is best served by another specialist, a physician should refer the patient to that specialist.

A physician may be limited by the extent of his or her innate talent, hand–eye coordination, or by training. Lack of training can be remedied by taking courses in the subject. Lack of innate ability is difficult to remedy, and can subject the patient to complications and the physician to malpractice risk. It is important for physicians to honestly assess their abilities.

However, every physician must continue training to remain up to date, and initially he or she may not have much experience with a particular device or procedure. If a patient asks how many of these procedures the physician has done, how does the ethical physician answer without alienating the patient, yet answer ethically? An example of how to deal with such a situation is in the following answer:

I have seen this done in my residency, also during multiple training courses, and I have performed this on a prior patient. However, I do want you to know

that you are one of the first patients to whom I am offering this treatment. Yet, I do have confidence in my ability to safely perform this procedure, or else I would not offer it.

Such an answer provides an honest response, but portrays confidence that can put the patient at ease. Ultimately, if the physician is secure in his or her ability to perform a given procedure and has an accurate understanding of his or her capabilities and limitations, then it is reasonable to proceed.

Yet, what if the patient doesn’t ask about prior training experience? What is the physician’s obligation at that point? Legally, the physician is not required to disclose his or her inexperience, but he or she also cannot hide it or seek to obfuscate. Ethically, the physician must follow the four core principles described above. This translates to deciding what to disclose on a case by case basis. For example, if the physician has plenty of experience with similar devices or surgery, then the probability of success is high and need for disclosure less. Conversely, if the physician has limited or no experience with the device or similar devices, the need for disclosure and/or restraint in performing the service is higher.

Conclusion

Although authors of this chapter are not experts in medical ethics, we have as much responsibility to discuss the topic as any physician can and should. Fortunately, many talented physicians have tried to address these issues, and good resources for all dermatologists to review are the ethics guidelines from the American Academy of Dermatology (AAD),¹³ the American Society of Dermatologic Surgery (ASDS), the American Society of Laser Medicine and Surgery (ASLMS), and the American College of Mohs Micrographic Surgery and Cutaneous Oncology (ASMMSCO). In addition to ethics principles, treatment guidelines by these same societies may also be very helpful. These treatment guidelines are really meant as ethical and good practice suggestions for physicians and are not meant to set legal standards of care. Referring to these guidelines in our practice promotes a safer, more effective, and more ethical practice of medicine.

While many difficult ethical questions arise frequently, the answer to these problems lies in a simple formula:

When an ethical conflict arises, it is best to remember the four core principles of medical ethics. With these principles in mind, the physician will be better able to maximize benefit over risk, while respecting patients' autonomy in making their own healthcare decisions. It should go without saying that physicians must resist economic temptation when deciding on a patient's care, but it does not mean that physicians should ignore the economics of health delivery. Dermatologists also have a responsibility to maintain their competence in the specialty and seek out the new knowledge and experience required to act in their capacity. Finally, dermatologists must recognize their position as role models for the next generation of dermatologists,¹³ paving a path of moral standards and upholding the integrity of our profession.

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Psychiatric aspects of cutaneous surgery

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Introduction

The understanding of psychiatric issues is a critical part of managing patients undergoing cutaneous surgery. There are two situations in which this skill is especially important. The first involves the patient who demands a cosmetic surgical procedure for an alleged cosmetic defect that is minimal or non-existent. The second arises when a patient who has undergone an extensive cutaneous surgical procedure, such as removal of a large neoplasm, experiences significant psychological problems because of the disfigurement that resulted from the surgery. These two different situations will be discussed in detail with an emphasis on understanding the psychiatric differential diagnoses and their management, along with advice as to how to best interact with these patients.

Patients who exaggerate their cosmetic defects

When a patient demands a surgical procedure for the correction of a “cosmetic defect” that is minimal or non-existent, the first step required to manage such a case involves attempting to understand the nature of the underlying psychopathology. Although many psychiatric conditions can create an exaggerated perception of an alleged cosmetic defect (Box 61.1), five disorders are most commonly seen in clinical practice. These are

monosymptomatic hypochondriacal psychosis (MHP), body dysmorphic disorder, somatization of depression, chronic anxiety disorder, and borderline personality disorder.

Monosymptomatic hypochondriacal psychosis

MHP refers to a group of disorders characterized by an encapsulated delusional belief system that is hypochondriacal in nature (Box 61.2).¹ The term MHP is most often used in Europe, and in American psychiatric sorting this group of disorders can be classified under delusional disorder, somatic subtype, or atypical psychosis.² A delusional disorder is characterized by patients who have a fixed, false belief that is not shared by other people in the same social or cultural group. In MHP, the delusion is constricted to a single, firmly held idea.

MHP is usually a chronic condition but is easily distinguished from other forms of chronic psychosis, such as schizophrenia, by its encapsulated nature. For example, patients with MHP may otherwise appear, reason, and function quite normally except when expressing concern about the hypochondriacal delusional idea. This is in contrast to schizophrenic patients who, in addition to a delusional belief system, may have many other psychiatric symptoms such as auditory hallucinations, flat or inappropriate affect, and deterioration in interpersonal relationships.²

Dysmorphophobia, one type of MHP, is a condition in which the patient is preoccupied by an exaggerated or

Box 61.1 Common psychiatric conditions characterized by an exaggerated perception of cosmetic deficiencies

- Monosymptomatic hypochondriacal psychosis
- Body dysmorphic disorder
- Chronic anxiety disorder
- Borderline personality disorder
- Dysmorphophobia
- Major depression with somatization
- Schizophrenia
- Schizoaffective disorder
- Bipolar disorder
- Gender identity disorder

Box 61.3 Major depressive symptoms

- Prevailing depressed mood
- Significant weight loss or weight gain
- Diminished interests
- Reduced pleasure in daily activities
- Insomnia (or hypersomnia)
- Psychomotor agitation (or retardation)
- Fatigue
- Feelings of worthlessness
- Excess guilt
- Diminished ability to concentrate
- Suicidal ideation (or plans)

Box 61.2 Features of monosymptomatic hypochondriacal psychosis

- Hypochondriacal complaints
- Chronic in nature
- Encapsulated delusional belief system
- Patient is relatively normal in other respects

imaginary cosmetic defect. However, in phobias, patients are able recognize that their fear is exaggerated or irrational.³ Conversely, delusional patients truly believe in the distorted perception and exhibit very little psychological insight. Therefore, concern has been raised that this term is actually a misnomer since most patients who present with a “cosmetic defect” are actually delusional and not phobic.⁴ Therefore, the preferred term to describe this subset of MHP patients is “delusions of dysmorphosis.”

In general dermatology practices, many other subsets of MHP can be seen such as delusions of parasitosis (bugs living in the skin), delusions of bromosis (emitting bad smell), and possibly also Morgellon’s syndrome (fibers and other materials coming out of the skin). However, in a cutaneous surgical practice, delusional concerns regarding the cosmetic appearance typically predominate.⁵

Body dysmorphic disorder

In body dysmorphic disorder, normal-appearing persons develop a preoccupation with some imagined defect in

their appearance. Sometimes a slight physical anomaly may be present, but the patient’s concern is grossly excessive. This condition can be distinguished from MHP because the patient’s belief system is not of delusional intensity. In other words, the patient can acknowledge the possibility that the complaint may be exaggerated or that there may be no defect at all. Because their insight is relatively retained, these patients can be reassured that their concerns are exaggerated and that surgical correction is neither necessary nor advisable.⁶

Somatization of depression

Patients may develop exaggerated physical complaints when suffering from major depressive episodes. This phenomenon, in which the depressed patient presents to the physician with an overstated physical problem without recognizing its relationship to the underlying depression, is called somatization of depression.⁷ To make this diagnosis, it must first be ascertained that the patient has sufficient depressive symptoms (Box 61.3) to meet the diagnostic criteria for a major depressive episode (i.e., the patient must exhibit symptoms and signs such as a prevailing depressed mood, markedly diminished interests or pleasure in daily activities, significant weight loss or weight gain, insomnia or hypersomnia, psychomotor agitation or retardation, fatigue, feeling of worthlessness, excessive guilt, diminished ability to concentrate, and possible suicidal ideation (or plans)).⁸ Not every patient will exhibit all of these psychological symptoms and physiologic signs of major depression. Moreover, some

Box 61.4 Physiologic manifestations of anxiety disorders

- Trembling
- Twitching
- Restlessness
- Shortness of breath
- Palpitations
- Tachycardia
- Sweating
- Dizziness
- Nausea
- Diarrhea
- Difficulty Swallowing
- Hyperreactivity

Box 61.5 Features of borderline personality disorder

- Affects young women most frequently
- Poorly defined sense of identity
- Boredom
- Chronic feelings of emptiness
- Inappropriate anger
- Impulsiveness
- Unstable affect
- Wide mood swings
- Unstable interpersonal relationships
- Distorted body image
- Ill-defined long-term goals
- Self-destructive behavior
- Micro-psychotic episodes
- Splitting
- Idealization versus demonization

patients may consciously or unconsciously deny some of the subjective symptoms, such as depressed mood. However, even in these cases, the diagnosis of major depression can be postulated if enough symptoms and signs of depression can be detected during evaluation.

Anxiety disorder

Patients with chronic anxiety disorder frequently experience physical complaints (Box 61.4).⁹ These complaints can be either psychophysiologic or purely psychiatric in nature. Psychophysiologic disturbances are exemplified by conditions such as a stress-induced gastric ulcer or migraine headaches, in which a real physiologic abnormality is exacerbated by anxiety. However, in psychiatric situations there is no demonstrable physiologic abnormality and the physical complaint merely represents a psychological fixation by the anxious patient. It has been speculated that a patient experiencing chronic recurrent anxiety finds the anxiety most unbearable when it is undefined and “free floating” in character. One way for these patients to make this amorphous anxiety more psychologically manageable is to “fixate” the anxiety onto some visible, concrete physical complaint which allows them to minimize the psychological discomfort by focusing on the physical complaint and thereby denying anxiety or at least making anxiety secondary to the physical complaint.

To confirm the diagnosis of underlying anxiety, the physician should question patients about any symptoms

of generalized anxiety disorder. Just as in the case of depression, the manifestations of underlying anxiety can be either subjective or physiologic.¹⁰ Subjective symptoms of anxiety are manifested by an excessive amount of anxiety that is often chronic and recurrent in nature. The physiologic manifestations of anxiety may include motor tension such as trembling, twitching, muscle tension, restlessness, and a feeling of “shakiness.” Hyperactivity of the autonomic nervous system, usually consisting of shortness of breath, palpitations, tachycardia, sweating, clammy hands, dry mouth, dizziness, nausea, diarrhea, hot flashes, frequent urination, and trouble swallowing, may also be observed. At times, the patient may also exhibit hyperreactivity (e.g., an exaggerated startle response or irritability). If enough symptoms and signs are present, the physician can be certain that an underlying anxiety disorder is present.

Borderline personality disorder

Borderline personality disorder is a commonly encountered chronic personality disturbance that more frequently affects young women (Box 61.5).¹¹ One of the central deficits in the disorder consists of a sense of identity that is poorly defined, precarious, and unstable in nature. This instability of the sense of self may be manifested by chronic feelings of emptiness and boredom,

inappropriate or intense feelings of anger, impulsiveness, and instability of affect whereby the patient may shift quickly from baseline mood to depression, irritability, or anxiety. This vague sense of self can also lead to a pattern of unstable and intense interpersonal relationships characterized by alternating extremes of overidealization and devaluation of the people with whom emotional attachments have been formed.

In addition to the characteristic problems with personal identity and interpersonal relationships, these patients frequently experience difficulties in regard to their body image. In this context, body image refers to patients' mental or psychological representation of their body. There are several well-known psychiatric disturbances (e.g., anorexia nervosa or bulimia) in which patients' body image diverges from their actual physical appearance. For example, anorectic patients typically engage in extreme forms of diet and exercise to lose weight, even though they are already emaciated.^{12–14} This maybe because, in their body image, they see themselves as through the eyes of a person with borderline personality disorder. Hence, borderline patients may externalize their core problem and try to define their amorphous sense of self by altering their physical appearance.

Patients with borderline personality disorder can be classified into those with a high psychosocial functional level and those with a low psychosocial functional level. High functioning borderline patients may appear fairly normal, except for a pattern of unstable and intense relationships, uncertainty regarding self-image, ill-defined long-term goals, unknown preferred personal values, and a chronic feeling of emptiness. Low-functioning borderline patients may chronically engage in self-destructive behavior such as promiscuous sex, binge eating, reckless spending, repeated suicidal gestures, or other self-mutilating behaviors. With experience, it is not difficult to identify patients with borderline personality disorder merely by observing the way they look or talk to the physician. Their look is typically intense, with a touch of adoration, and the content of their verbal expression idealizes the physician. Borderline personality disorder is most frequently seen in young women and consequently male physicians are more susceptible to becoming the focus of attention of these patients. Needless to say, the chronic sense of defective identity cannot be repaired by surgical correction of the exaggerated or imaginary cosmetic defects.

Alternative psychiatric diagnoses

Even though most patients with exaggerated complaints regarding real or imaginary cosmetics defects fall into one of the five psychiatric diagnoses previously described, a minority of patients may fall into some other psychiatric diagnostic category, such as schizophrenia, schizoaffective disorder, bipolar disorder, and gender identity disorder.

Schizophrenia

In schizophrenia, patients may develop delusions concerning their physical appearance that are often bizarre in nature. However, it is relatively easy to diagnose schizophrenic patients because of their multiple psychological impairments, which often include auditory hallucinations, flat or inappropriate affect, bizarre delusional belief system, and failure to establish any interpersonal rapport with the physician.¹⁵

Schizoaffective disorder

Schizoaffective disorders are characterized by both schizophrenic and depressive symptoms.¹⁶

Bipolar disorder

Patients with a bipolar disorder, such as manic-depressive illness, may also develop somatization during their depressive episodes. However, the diagnosis can usually be determined by asking about previous episodes of mania during which patients experienced symptoms that are the opposite of depression. During an episode of mania, patients may experience grandiosity with inflated self-esteem and exaggerated self-confidence, flight of ideas, racing thoughts, psychomotor agitation, pressured speech, distractibility, and recklessness manifested by spending sprees, sexual indiscretion, or involvement in unrealistic business ventures.¹⁷

Gender identity disorder

Patients who suffer from gender identity disorder are unsure whether they are psychologically male or female and may request a variety of cosmetic surgical procedures. However, the underlying diagnosis usually becomes apparent when the nature of gender confusion is generalized, and the patient's complaint represents only one small manifestation of this underlying confusion.¹⁸

Management

General concepts

In the ideal situation, management of patients with some form of psychopathology would simply involve making a referral to a mental health professional. However, in reality many of these patients may refuse to recognize the psychological nature of their condition or refuse a referral to a mental health professional, even if they do recognize the existence of their psychiatric disturbance. Therefore, it is useful for the cutaneous surgeon to have a general knowledge of how to manage these patients and of the forms of treatment available. This does not imply that the cutaneous surgeon must take the responsibility for treating the psychiatric disorder. However, even partial treatment administered by the surgeon may benefit the patient more than no treatment at all. Ultimately, each cutaneous surgeon must decide whether to treat those patients who refuse a referral to a mental health professional. Regardless, it is important to recognize that ways to manage these conditions differ greatly, depending on the psychiatric diagnosis.

Monosymptomatic hypochondriacal psychosis

By definition, patients with delusional beliefs cannot be persuaded to forget their delusion. Therefore, explanations and reassurance are unlikely to be helpful. Delusions of dysmorphosis and other forms of MHP were thought to be almost untreatable until an antipsychotic medication, pimozide (Orap), was discovered to be efficacious in the treatment of these conditions.¹⁹ Because of the possibility of extrapyramidal side effects, such as stiffness and restlessness, the clinician can start with a dose of 1 mg daily. If that patient experiences sedation, pimozide should be given at bedtime. On the other hand, if that patient experiences increased energy levels, the medication should be taken in the morning. The dosage of pimozide can be increased by 1 mg every 3–4 days as tolerated until its clinical efficacy becomes evident. In the literature, dosage up to 10 mg per day have been used for psychocutaneous conditions. However, 4 mg or less per day is effective in most cases in decreasing the intensity of the somatic delusions. Once the patient shows improvement in his or her clinical state and becomes non-delusional or “quietly delusional” (where the delusion or formication no longer significantly interferes with

the capacity to work or enjoy life), this clinically effective dosage is maintained for at least 1 month. Should the patient persist in his or her improvement, the dosage of pimozide can be gradually decreased by 1 mg decrements every 2–4 weeks until either the minimum effective dosage is determined or the patient is successfully tapered off pimozide all together.

In Europe, there have been case reports of sudden death in patients with chronic schizophrenia who were treated with high-dose pimozide, possibly resulting from pimozide's potential for cardiac toxicity. So far, in the past 25 years, the author (JK) at UCSF Department of Dermatology has never seen any ECG changes from low-dose pimozide used to treat MHP. However, a pretreatment ECG maybe considered for patients before starting pimozide to make sure that the patient does not have an underlying dysrhythmia or prolonged QT interval.

The main side effects of pimozide are identical to those of other antipsychotic medications such as haloperidol. The most frequently encountered complaint involves an inner feeling of restlessness or akathisia. Stiffness in the joints and muscles is one of the manifestations of pseudoparkinsonism, an extrapyramidal side effect of pimozide. These side effects are easily controlled by concurrent use of a medication with anticholinergic effect (e.g., benztropine mesylate (Cogentin), 1–2 mg orally four times daily) as needed. Medications such as diphenhydramine hydrochloride can also be used; however, benztropine mesylate has an advantage in that it has no sedative side effects. It must be noted that it is often difficult to convince this group of patients to take pimozide. Even if they do agree to take it, they may still have considerable ambivalence about doing so. As a consequence, if they experience any side effects and have no means to control them, they may refuse to continue taking pimozide. Therefore, even though many patients with MHP tolerate pimozide without experiencing akathisia or any extrapyramidal side effects, it may be advisable to prescribe a small supply of either benztropine mesylate or diphenhydramine hydrochloride so that they can control these side effects if they arise.

Other rare side effects of pimozide include acute dystonic reaction and tardive dyskinesia. In acute dystonic reaction, the patient experiences the onset of muscle spasms, especially of the neck and around the mouth. These spasms usually respond promptly to the administration of either benztropine mesylate or

diphenhydramine hydrochloride. Cases of acute dystonic reaction involving the oral pharynx are very rare. However, this condition may constitute an emergency if the patient's respiration becomes compromised. For this reason, the patient should be instructed to go to an emergency department if a dystonic reaction is accompanied by respiratory difficulties. Tardive dyskinesia is extremely rare with short-term use of pimozide. However, this condition may develop with long-term use, especially at high dosages. Tardive dyskinesia is manifested by involuntary movements, especially involving the oral musculature. Withdrawal dyskinesia is identical to tardive dyskinesia, except that the involuntary movements are of very mild intensity and typically appear as the medication is being tapered in dosage or discontinued. This reaction is extremely rare and is usually self-limiting. The only reason the physician should know of its existence is to be spared the anxiety resulting from mistaking the self-limited withdrawal dyskinesia with tardive dyskinesia.

Somatization of depression

Somatization of depression can be suspected both from the depressive symptoms and from the fact that patients who somatize may not hold their belief system as rigidly as patients with true delusion. Therapy for somatization of depression is directed at treatment of the underlying depression. There are many ways to treat depression, including individual psychotherapy, group therapy, and psychopharmacotherapy. Therefore, even if patients recognize the presence of depression but refuse to see a psychiatrist or other mental health professional, they may still be helped by antidepressant medications. However, before embarking on pharmacotherapy for depression, it is useful to determine to what extent the depression results from some difficulties in the patient's life and to what extent it might be endogenous in origin. If difficulty precipitated the episode of depression, an extra effort should be made to try to refer the patient to a psychotherapeutic setting where counseling can be provided.

Pharmacologic treatment of depression consists of both tricyclic and non-tricyclic medications. Among the tricyclic antidepressants, newer agents such as desipramine hydrochloride (Norpramin, Pertofrane) have considerably fewer anticholinergic, sedative, and cardiac side effects than older agents such as amitriptyline hydrochloride (Elavil, Endep).²⁰ This advantage is especially important for the management of older patients who may have

conditions that may be exacerbated by the anticholinergic properties of tricyclic antidepressants (e.g., chronic constipation, acute-angle glaucoma, and urinary hesitation). Moreover, older patients are more susceptible to sedative side effects and also more likely to have coexisting cardiac disorders. The dosage of desipramine hydrochloride should be titrated, beginning with 25 mg orally per day and increasing by 25 mg every 4–5 days as tolerated up to the usual adult dosage of ~100 mg per day. The optimal dosage for psychocutaneous patients may be lower than this dosage, since patients who have never taken psychotropic medications tend to require less medication than chronic psychiatric patients. After the therapeutic range for the medication has been reached, 2 weeks or more may be required for the antidepressant effect to become evident. Once the depressive symptoms are under control, the therapeutic dosage should be maintained for several months before the medication is gradually tapered. Side effects of desipramine hydrochloride, except for weight gain, are relatively rare and include orthostatic hypotension, constipation, urinary hesitation, and sedation. If the dosage is adequate and the patient shows no clinical response, the serum desipramine level should be determined to evaluate the adequacy of absorption and patient compliance.²¹

One non-tricyclic antidepressant is paroxetine (Paxil), a selective serotonin reuptake inhibitor (SSRI) which offers the advantage of having little or no anticholinergic activity, and is also not associated with weight gain.²² The recommended oral dosage of 10–20 mg per day is generally well tolerated. Gastrointestinal effects such as nausea and diarrhea are the most common adverse reactions. Taking the medication with food can often prevent nausea and nausea usually improves over several days. Sedation may occur and if this happens, the medication should be given at bedtime. The SSRIs can also be associated with sexual dysfunction and therefore patients should be educated about this before determining treatment. Also, when the medication is being discontinued, patients may experience dizziness, lethargy, nausea, irritability, and headaches, which can be prevented by slowly tapering the medication over several weeks.

Chronic anxiety disorder

When the exaggerated cosmetic complaint is a manifestation of an underlying chronic anxiety disorder, the intensity of the mental fixation usually diminishes when the

anxiety level is brought under control. It is again important to ascertain whether some outside psychosocial stress is causing the increased anxiety level. If an identifiable psychosocial stress is present, the patient might be directed to seek professional counseling to help solve those problems. Two types of antianxiety medications are used to lower anxiety levels. One type is quick acting but sedating and potentially addicting; the other is slow in onset but non-sedating and non-addictive. One example of a rapid-action medication in the United States is alprazolam (Xanax), which differs from the older benzodiazepines such as diazepam (Valium) in three respects. First, alprazolam has both antidepressant and antianxiety effects.^{23,24} This is in contrast to other benzodiazepines which, like alcohol, tend to have depressant rather than antidepressant effects. Second, the half-life of alprazolam is shorter and more predictable than that of diazepam, and therefore there is less risk of accumulation in the body when the medication is used for long periods. Third, alprazolam is the first medication in the United States to be approved for treatment of panic attacks.²⁵ A panic attack is distinguished from other forms of anxiety by tremendous intensity.²⁶ In short-term use (2 weeks or less), the side effects of alprazolam are generally limited to sedation. However, sedation can be avoided by carefully titrating the dose. The safest approach is to start with a low dose and gradually increase it until the dose is sufficient to control the anxiety but not result in sedation. Alprazolam may be started at an oral dosage 0.125–0.25 mg three times a day and gradually increased by 0.125–0.25 mg per day, if necessary, until effective control of the anxiety is obtained on a dosing schedule of three or four times per day. Once the anxiety is under control, the dosage can be gradually tapered. It is not recommended that alprazolam or any other benzodiazepine be abruptly discontinued, since this may result in a recurrence or exacerbation of the anxiety disorder. In addition, with long-term use, as with other benzodiazepines, there is a risk of addiction. Therefore, a psychiatrist should be consulted if usage beyond a 2- to 4-week period is required.

Buspirone hydrochloride (Buspar) represents the second type of antianxiety medication, which is not addictive or sedating. However, this medication must be taken on a regular (three or four times per day) basis, since it does not work well when taken "as needed." Two weeks or more may be required for the clinical effect of

buspirone hydrochloride to become evident, and therefore it is used ideally for patients with a chronic anxiety disorder that is expected to last longer than 2–3 weeks per episode. The oral dosage of buspirone hydrochloride ranges from 5 to 10 mg three or four times daily. However, this must be individualized for each patient, beginning with the lowest dosage and titrating upward until the optimal dosage is reached. The side effects of buspirone hydrochloride include dizziness, nausea, headache, nervousness, lightheadedness, and excitement.

Other alternatives for the treatment of anxiety includes low dose antidepressants used as anti-anxiety agents such as doxepin 10–30 mg qhs or paroxetine 10–20 mg qhs.

Borderline personality disorder

Borderline personality disorder represents a chronic psychological deficit that is not expected to change over a short period. For this reason, medications are of only limited usefulness in this condition and are generally used to treat anxiety or depression symptoms if they are present. The cutaneous surgeon cannot be expected to conduct long-term psychotherapy, which is the mainstay of treatment for these patients.²⁷ Therefore, this discussion will be limited to those aspects of the doctor–patient relationship that are important to recognize so that interpersonal problems can be minimized when dealing with borderline personality disorder patients. There are three issues that the clinician should watch for when dealing with a patient with this disorder: idealization, devaluation, and splitting.²⁸

Patients with borderline personality disorder have a characteristic deficit: they can perceive people only in an idealized or devalued mode. Their perception is "black and white," with no gray zone. In idealization these patients, who are usually young women, idealize the physician. There is a seductive and flattering quality to this idealization that can sometimes result in the physician making an error in judgment by consenting to perform a surgical procedure that has no medical justification.

Devaluation is the opposite of idealization. If there is the slightest deviation from expectations, the patient with borderline personality disorder may suddenly shift behavior and treat the physician as if he or she is the worst physician ever encountered. This intense expression of devaluation and anger by the patient can also catch the physician off guard. In turn, the physician may

respond with personal rage against the patient and not exercise proper medical or legal judgment.

The third characteristic of the patient with borderline personality disorder is a mental process called splitting. Splitting refers to the way the patient creates confusion and antagonism among different physicians or between the physician and the medical staff. This is partly accomplished by the process of idealization and devaluation and also partly by lying. For example, by flattering the physician while demonizing the office staff, the patient simultaneously idealizes and bitterly criticizes different members of the provider team. Different stories are told to different staff members with the intention of splitting the caretakers and creating intense conflicts among them. One way to counter this divisive effect is for the staff to meet periodically and exchange information to make sure that everyone is in agreement on how to deal with these patients. Once the physician learns the characteristics of borderline personality disorder and the way havoc can be created in the office, interactions with the patient and the physician become easier and the physician is less vulnerable to these types of manipulation.

Other psychiatric disorders

Detailed discussion regarding the management of other, less frequently encountered psychiatric disturbances such as schizophrenia, schizoaffective illness, and bipolar disorder is beyond the scope of this chapter but can likely be found in any standard psychiatric textbook.

Psychiatric disorders resulting from disfigurement

Most patients who undergo significant cutaneous surgical procedures for the treatment of skin cancer or other disease make reasonable psychological adjustment to their cosmetic defects. However, a few patients develop significant psychiatric problems because of their disfigurement. This is understandable in light of the fact that society has been oriented to a very narrow standard of beauty.²⁹ Many psychological studies indicate that appearance correlates with the personality traits that people attribute to strangers. Attractive persons of both sexes are presumed to have more socially desirable traits, to be kinder and more intelligent, to have greater internal control and competence, and to have made greater

achievements.³⁰⁻³⁶ Many studies show that people respond differently to those who are physically handicapped, such as an amputee, and those who are visibly disfigured, who are more frequently negatively characterized.^{37,38} For example, studies have demonstrated that people are less likely to help a facially disfigured person than a non-disfigured person.³⁹ Therefore, it is understandable that patients who have extensive disfigurement from skin cancer surgery or trauma may encounter many difficulties, not only in terms of their personal emotional equilibrium, but also as a victim of negative perceptions from others.

Patients who develop significant psychiatric morbidity secondary to disfigurement may manifest their problem in terms of clinical depression, anxiety, and social phobia. Secondary psychiatric complications include social withdrawal and occupational difficulties. It is important to recognize the psychiatric consequences of surgical disfigurement, since many of these patients can be encouraged to seek professional help for their psychological difficulties. Moreover, unlike some chronic psychiatric patients, many of these patients have had reasonable premorbid psychological adaptation levels, and if they can be helped through the current crisis, they can become quite functional in society again.

Social phobia

Social phobia refers to a condition in which the patient develops a persistent fear of social situations where he or she is likely to be scrutinized by others.⁴⁰ Sometimes even something as minor as receiving an invitation to attend a party may trigger phobic avoidance. Once social phobia has begun, it gradually becomes worse because of two factors. First, anticipatory anxiety gradually develops whenever the person is confronted with the necessity to enter a social gathering. Second, the patient's social performance can be impaired by this underlying anxiety, resulting in the development of a vicious cycle. At times, some patients with social phobias try to force themselves to endure the social situation despite their intense anxiety. Through this process, some may actually overcome their fears. However, many others with this condition will require professional counseling to cure their phobias. Otherwise, they may become progressively socially isolated to the point where they suffer serious social or occupational impairment. These patients usually retain their insight and recognize that their fears are excessive or

unreasonable, even in view of their cosmetic disfigurement. Therefore, these patients tend to be receptive to the suggestion that they should obtain professional help from a psychiatrist or other mental health professionals.

Generally speaking, there are three types of therapies available for the treatment of social phobia. One is a behavioral therapy technique involving “exposure” or “flooding.” In exposure, patients are presented with increasingly anxiety-provoking social situations, first in imagery and later in real life. At each stage of exposure, care is taken to make sure that the patient’s anxiety level does not go out of control. In this process, known as systematic desensitization, the patient gradually learns not to fear the social situation.⁴¹ In flooding, also known as implosion, the patient is exposed to an enormous volume of phobic material to try to overwhelm the phobic response. This technique can also be used either in imagery or in real life situations.

The second approach involves psychotherapy, in which the patient explores different psychological issues with the therapist. This approach can take many different forms, depending on the particular orientation of the therapist. Some therapists may be psychodynamic (i.e., emphasizing the use of Freudian principles), while others may be cognitive (i.e., actively trying to change the patient’s thinking habits by challenging existing semiautomatic or automatic thought patterns).

The third approach is the use of medications, including antianxiety drugs to treat anxiety symptoms and antidepressants to treat phobic symptoms. However, the efficacy of medications such as tricyclic antidepressants and monoamine oxidase inhibitors in the treatment of social phobia has not been studied systematically.

Summary

Many different psychiatric issues may arise in the practice of cutaneous surgery. Two such conditions include psychiatric disorders presenting as a cutaneous surgical problem and the psychiatric consequences of traumatically or surgically induced disfigurement. Some treatment modalities have been described in detail, but cutaneous surgeons should not be expected to treat psychiatric problems on a regular basis. For these types of patients, referral to a psychiatrist should be made whenever feasible. If the patient refuses such a referral, as is

frequently the case, it may still be possible to obtain a consultation from a psychiatrist or other mental health professional if the referral is presented to the patient as an extra assistance to help the patient cope with the primary psychiatric chief complaint. The information provided here, the authors hope, should help the cutaneous surgeon more effectively handle the psychological problems that may arise in the clinical setting.

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New frontiers in photodynamic therapy

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Introduction

Topical photodynamic therapy (PDT) has, to date, been approved by regulatory authorities in 34 countries worldwide and PDT has received status as an effective treatment of premalignant actinic keratoses (AKs), Bowen's disease, and superficial basal cell carcinoma (BCC).¹ PDT involves a topical sensitizer, exposure to light and oxygen to create reactive oxygen species that destroy target cells. Two photosensitizers are licensed, 5-aminolevulinic acid (ALA) and its methylated ester, methyl aminolevulinate (MAL), both of which are prodrugs that are endogenously converted by the heme biosynthetic pathway to protoporphyrin IX (PpIX). Photoactivation can be obtained with a range of light sources, including lasers, xenon, and fluorescent lamps, as well as light-emitting diodes (LEDs). In the United States a blue fluorescent lamp is routinely used for PDT whereas red LEDs typically are used in Europe. The use of PDT is well-established and well-described in international guidelines.² However, disadvantages may be associated with PDT, i.e., it is a time- and resource-consuming procedure that is associated with pain and it is an important fact that less efficient efficacy rates are reported for thick AKs and nodular BCCs than for more superficial lesions.^{3,4} It is therefore obvious that further steps are taken to refine the PDT treatment technique.

This chapter discusses new frontiers in PDT and covers two new ways of delivering PDT: (1) a simplified PDT

procedure by using daylight for photoactivation, and (2) a refined PDT procedure, fractional laser-assisted PDT, in which the skin is pretreated with ablative fractional resurfacing (AFR) before application of topical photosensitizer, thus aiming at an intensified photochemical reaction due to an increased drug biodistribution.

Daylight-mediated PDT

The concept of using daylight for a simplified PDT procedure was developed by Professor Hans Christian Wulf and the landmark studies published by Dr. Stine R Wiegell, Copenhagen, Denmark.⁵⁻⁷ The spectrum of daylight includes blue and red light, both of which are used to activate PpIX for conventional PDT. Exposure to daylight therefore also activates PpIX formed after MAL application. Home-based daylight-mediated PDT has the potential to facilitate the PDT process and also to reduce treatment-related pain due to a continuous photoactivation of small amounts of PpIX instead of activating the larger amounts of accumulated PpIX that are formed during the occlusive incubation period. The following summarizes the current knowledge of daylight-mediated PDT for AKs based on three recently published randomized clinical trials.⁵⁻⁷

In the first study from 2008, patients were treated in a split-site fashion on the face or scalp with daylight-mediated PDT given in a hospital setting versus

conventional red light LED-mediated PDT.⁵ Daylight-mediated PDT was found at least as effective as conventional PDT (79% and 71% reduction of AK lesions at 3 months postoperatively) and significantly less painful (mean maximal pain score of 2.0 versus 6.7 on a 10-point scale).⁵ In the second study from 2009, patients were effectively treated in a home-based setting with 8% and 16% MAL application and subsequent daylight exposure during the rest of the daytime (76.9% cure of AKs at 3 months for 16% MAL and 79.5% for 8% MAL).⁶ A recent multicenter study based on a large patient population ($n = 120$ patients with 1572 thin AKs of the face and scalp) has substantiated the treatment concept that is especially suitable for patients with superficial, single or multiple AKs located in areas, which can easily be exposed to light.⁷ The procedure for daylight-mediated PDT is initiated with application of a sunscreen with SPF 20 and organic filter to protect against sunburn, lesion preparation is performed the same way as for conventional PDT, and exposure to daylight is recommended within 30 minutes after MAL application and to continue for 2 hours (Box 62.1). In the Nordic countries, treatments can be given from April to October under all weather conditions except continuous rain. The instructions are simple and easy to follow for the patient. In Figure 62.1(a) an older gentleman receives daylight mediated PDT while having a relaxing time in his garden. Figure 62.1(b) illustrates the postoperative reaction that is similar to the

well-known postoperative reaction from conventional PDT. Postoperative care and follow-up regimens follow the same recommendations as for conventional PDT.

Fractional laser-assisted PDT

Ablative fractional resurfacing (AFR) creates microscopic vertical holes of ablated tissue that are surrounded by a

Box 62.1 Step-by-step procedure for daylight-mediated MAL-PDT of superficial actinic keratoses in areas easily exposed to daylight

- Application of a sunscreen SPF 20 with organic filter
- Curettage of target lesions and target skin area at approximately 15 minutes after sunscreen application. Use same procedure as for conventional PDT
- Application of MAL without occlusion
- Exposure to daylight within 30 minutes after MAL application
- Continuous exposure to daylight (including sunlight) for 2 hours. This recommendation is given from April to October in Nordic countries
- Wipe off reminiscences of MAL cream at the end of daylight exposure and spend the rest of the day indoors



Figure 62.1 Daylight photodynamic therapy in a home-based environment (a) and postoperative skin reactions at 2 days after treatment, illustrating erythema, edema, sterile pustules and crusting (b).

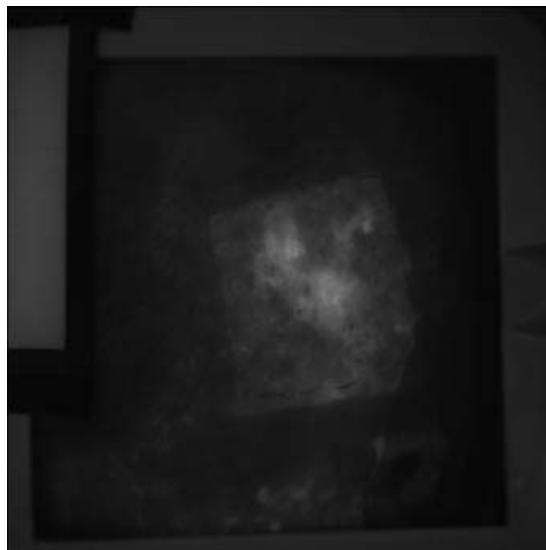


Figure 62.2 Fluorescent photograph after 3 hours of methyl aminolevulinate incubation of actinic keratoses on the scalp. Pretreatment with ablative fractional resurfacing was given to the squared area resulting in intensified protoporphyrin IX fluorescence intensity compared with the surrounding treated skin that was prepared by conventional curettage.

thin layer of coagulated tissue.⁸ A recent *in vivo* porcine study demonstrated that these vertical channels facilitate the biodistribution of topically applied MAL into deep skin layers and promote an intensified PDT response in the deep dermal compartment.⁹ At the mid-dermal level corresponding to 1-mm skin depth, MAL-induced fluorescence intensities were approximately 50 times higher in hair follicle epithelium when AFR pretreatment was performed and dermal fluorescence intensities approximately 15 times higher than non-AFR treated samples.⁹ Also on human skin, AFR pretreatment results in an increased uptake of MAL. Figure 62.2 shows that highly accentuated fluorescence intensities are induced when MAL-incubated AKs on the scalp are pre-treated with AFR, thus constituting the basis for an intensified PDT response. Histology has demonstrated that vertical ablated laser channels can reach down to the deepest layers of a nodular BCC (Figure 62.3). Initial clinical attempts have been taken to investigate the feasibility of fractional laser-assisted PDT for nodular BCC. Clinical before and after pictures are illustrated in Figure 62.4

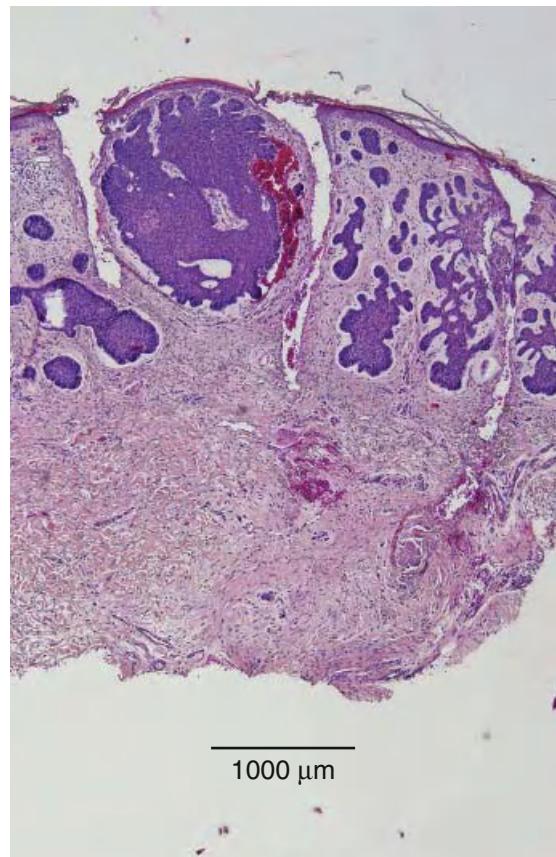


Figure 62.3 Histology section of a nodular basal cell carcinoma (BCC) exposed to ablative fractional resurfacing. Laser-ablated channels penetrated the BCC down to approximately 900-μm depth. Histology was kindly performed by professor Uwe Paasch, Leipzig, Germany.

from a patient with a periorbital histology-proven nodular BCC of 5 mm that was treated with fractional laser-assisted PDT, resulting in clinical cure and an excellent cosmetic outcome. The procedure was initiated with tumor debulking as prescribed for conventional PDT and subsequently AFR was exposed to tumor and adjacent skin, leaving the skin with characteristic microspot pattern (Figure 62.5). Immediately after the laser treatment, MAL was left under occlusion for 3 hours and the skin was irradiated with red LED light (Aktilite at 37 J/cm²). Fractional laser-assisted PDT is currently being examined in IRB-approved clinical trials for the



Figure 62.4 Clinical photos illustrating a nodular basal cell carcinoma (BCC) before (a) and 8 weeks after two sessions of fractional laser-assisted photodynamic therapy (b). Laser procedure was performed with UltraPulse fractional CO₂ laser system, DeepFx handpiece at 0.12-mm spot size, 40 mJ/pulse, 5% density (Lumenis Inc., Santa Clara, CA).

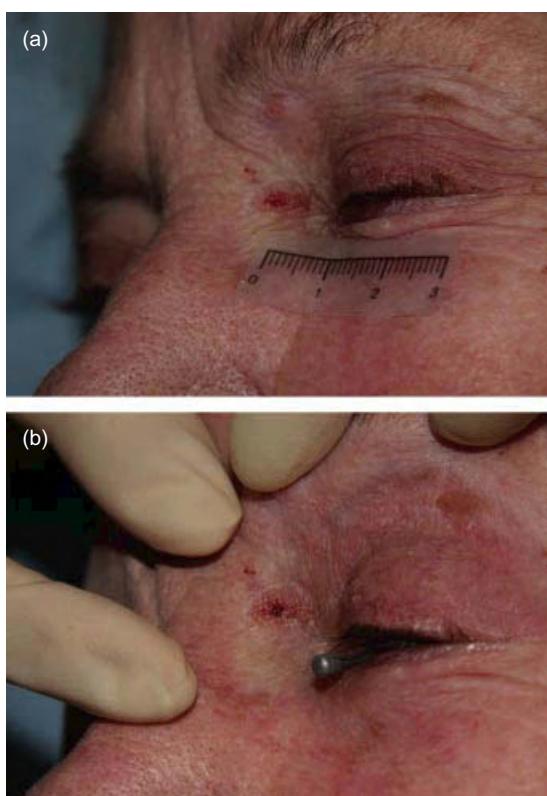


Figure 62.5 The procedure for fractional laser-assisted photodynamic therapy was initiated by curettage of the nodular basal cell carcinoma (a) followed by fractional CO₂ laser (b). Same patient as in Figure 62.2.

possibility of delivering an intensified PDT response to difficult-to-treat thick dysplastic lesions. The fractional laser-assisted PDT technique is not FDA approved and so far constitutes a research-based off-label indication where routine treatments have to await long-term data from clinical trials.

Complications

Pain is a common feature during light exposure in PDT and an acute inflammatory reaction is observed during the days after illumination. The phototoxic reaction presents with erythema, edema, micropustules, excudation, and crusting that usually heal within 7–10 days (Figures 62.1 and 62.6). Less frequent complications include wheal and flare reactions, skin infection, contact dermatitis, pigment changes, and scarring.¹

Final thoughts

In Europe, the standard protocol for delivery of topical PDT is MAL and red LED light, in the United States ALA in combination with blue light. New ways of delivering PDT are available with daylight and fractional ablative lasers. Future PDT regimens may implement these recent advances to individualize PDT regimens based on the individual type of skin lesion being treated.



Figure 62.6 Nodular basal cell carcinoma before treatment (a, arrow) and phototoxic skin reaction with inflammation, erythema, edema, pustules, exudation, and crusting at 2 days after laser-assisted photodynamic therapy (b). Bacterial cultures were negative and the skin healed completely at day 7.

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