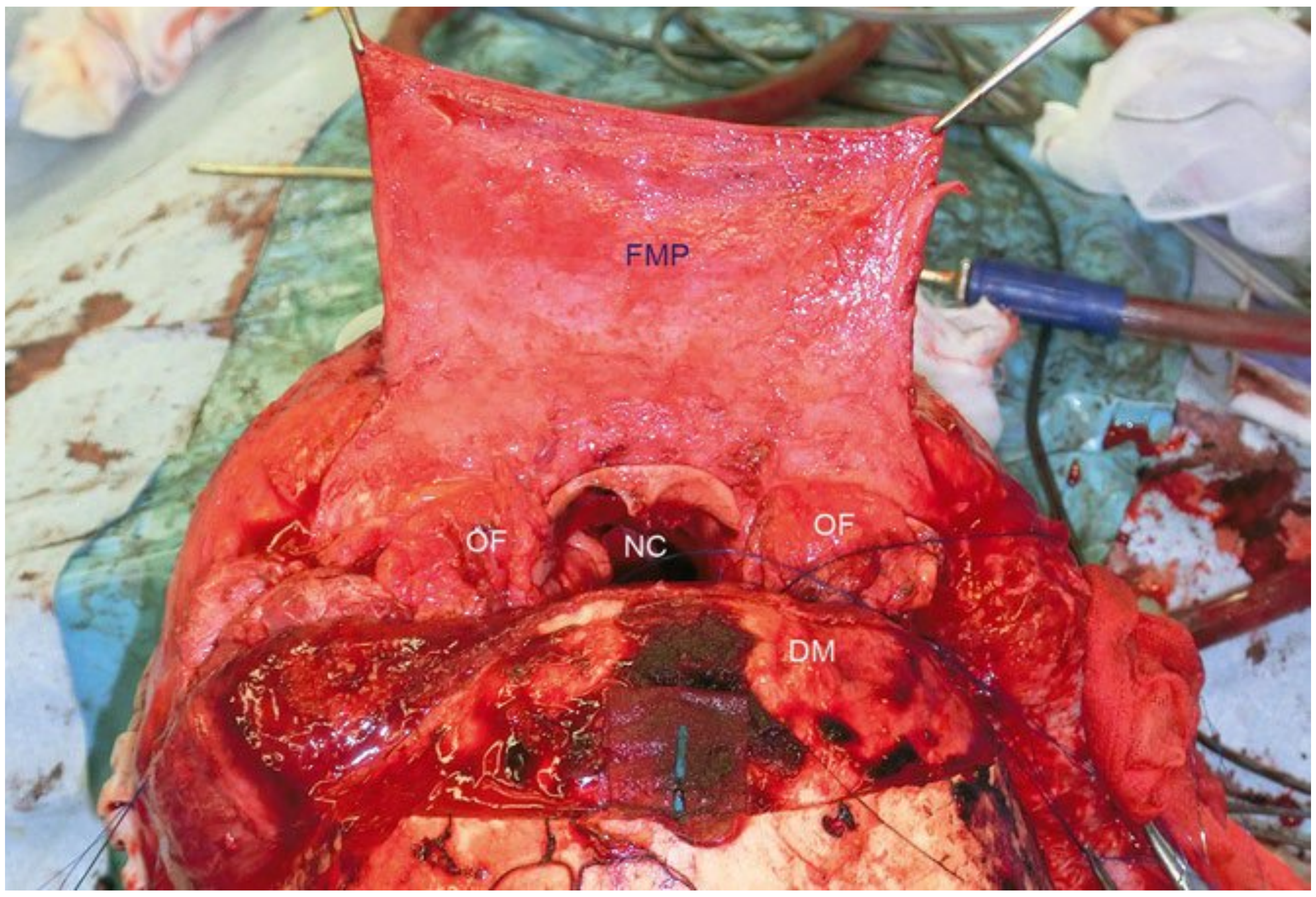

Fig. 4.4 Frontalis muscle-pericranial flap. A case of anterior skull base tumor. The anterior skull base reconstruction was performed by using the frontal musclopericranial flap. After frontal craniotomy and supraorbital bar osteotomy, the frontalis muscle-pericranial flaps were raised and transplanted to the anterior skull base tissue defect. FMP, frontalis muscle-pericranial flap; DM, dura mater; OF, orbital fat; NC, nasal cavity.

temporal artery. Thin fat tissue is observed between the subgaleal fascia layer and the deep temporal fascia. Regarding the structure of the layers around the suprazygomatic arch region, Moss et al reported a fibrous partition called the inferior temporal septum, which is located along a line connecting the external acoustic meatus and temporal ligamentous adhesion (near the forefront edge of the temporal line and the lateral margin of the orbit) and connecting to the deep temporal fascia and superficial temporal fascia. In addition to reporting that there is a triangular fibrofatty compartment on the caudal side, they found that the temporal branch of the facial nerve runs directly underneath the superficial temporal fascia in this fat tissue in the temporal region above the zygomatic arch.[7]

The deep temporal fascia is a fascia covering the temporalis muscle, which may be seen as a thick white-colored fascial layer. This layer is a single layer, the upper two-thirds, and it is continuous with the pericranium above the temporal line upward. It splits into two lobes: the superficial layer and deep layer downward above the zygomatic arch. Then these two layers of the deep temporal fascia are attached so as to cover the superficial and deep surfaces of the zygomatic arch (**Fig. 4.5**). The superficial temporal fat pad can be found in the space surrounded by these two layers of the deep temporal fascia and zygomatic arch. Opinions differ regarding the continuation of the temporal fascia to the pericranium. Casanova et al mentioned that the pericranium of the head transitions to a membrane of a thin connective tissue known as the innominate fascia, which is the layer between the layer underneath the galea aponeurotica and the temporal fascia.[8]

Beneath the deep temporal fascia, the deep temporal fat pad can be found, and this fat tissue is continuous with the buccal fat pad passing under the zygomatic arch. The aforementioned superficial temporal fat pad is bound fat tissue and does not continue to the deep temporal fat pad.[9]

The temporalis muscle can be found in the substratum of the deep temporal fascia. The temporalis muscle is a masticatory muscle; it arises from the infratemporal fossa and inserts into the coronoid process of the mandible (**Fig. 4.6**). The temporal fossa does not have periosteum as seen at the external skull base; therefore, the pericranium is not present on the underside of the temporalis muscle, this area being composed of thin, coarse connective tissue.

Blood Circulation Morphology of the Temporal Region

The superficial temporal artery, middle temporal artery, and deep temporal artery are mainly involved in blood circulation of the temporal region (**Table 4.2**). The superficial temporal artery is one of two terminal branches of the external carotid artery, which passes inside the parotid gland after the maxillary artery is separated below the neck of mandible, appearing from the deep part to the subcutaneous fat layer at the inferior border at the posterior end of the zygomatic arch and running toward the vertex perpendicularly in front of the auricle. The superficial temporal artery is distributed widely from the skin to the subgaleal layer. The middle temporal artery is a branch of the superficial temporal artery, which turns to the deeper layer and pierces the deep temporal fascia just after arising at the superior margin of the zygomatic arch, enters the deeper layer, and is

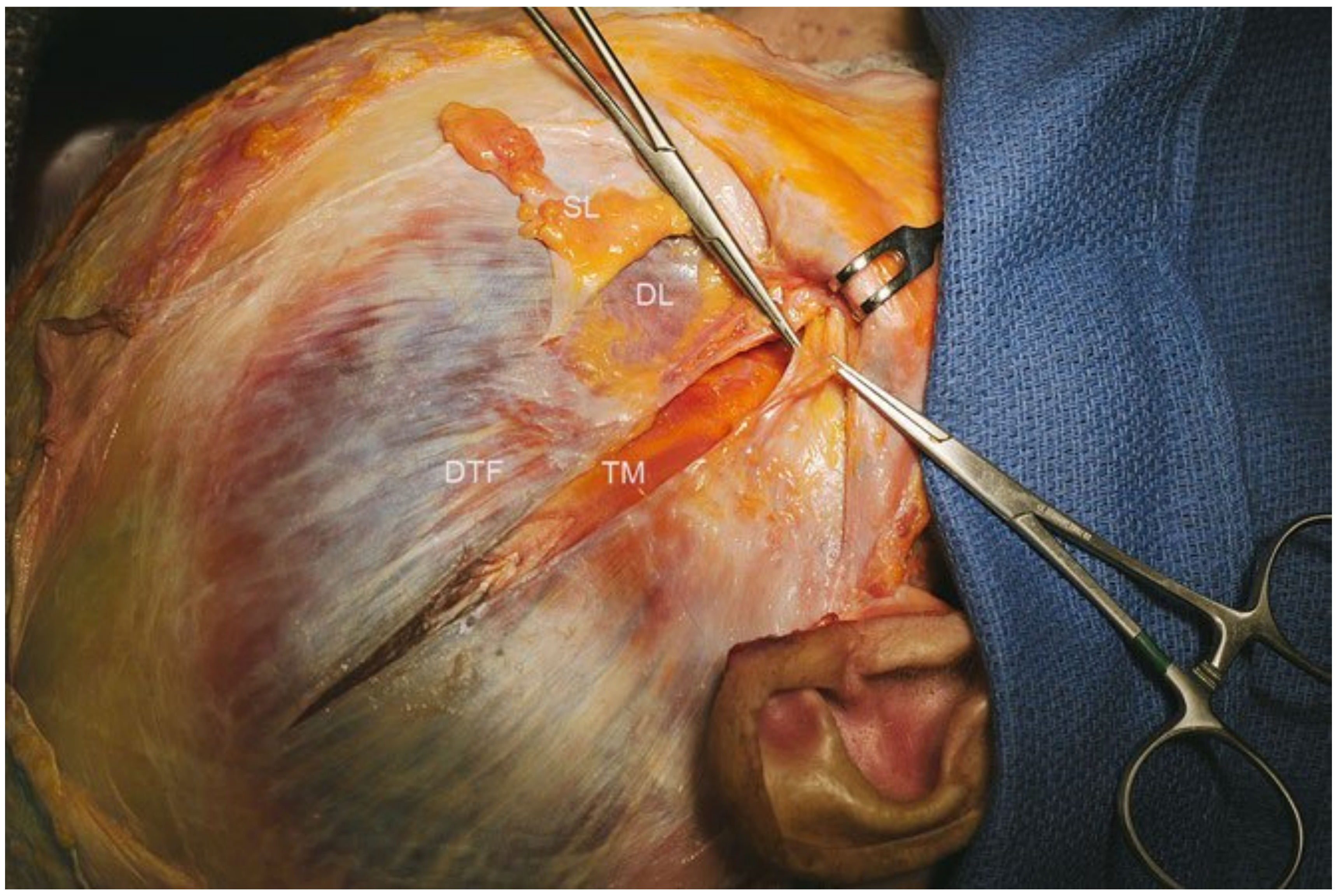

Fig. 4.5 Deep temporal fascia (cadaver dissection; right temporal region). Deep temporal fascia is cut, and the temporalis muscle is exposed. Each superficial and deep layer of the deep temporal fascia is held by Kocher forceps. The fat tissue between the superficial and deep layer of the deep temporal fascia is the superficial fat pad. DL, deep layer of the deep temporal fascia; DTF, deep temporal fascia; SL, superficial layer of the deep temporal fascia and superficial temporal fat pad; TM, temporalis muscle.

distributed mainly in the deep temporal fascia. Moreover, some branches of the middle temporal artery travel to the temporalis muscle and are distributed in the posterior region of the muscle. Usually, two branches arise from the maxillary artery and lead to the temporalis muscle. These are the posterior deep temporal artery and anterior deep temporal artery. These deep temporal arteries run on the surface of the superior head of the lateral pterygoid muscle after arising from the maxillary artery and enter the temporalis muscle on its deep surface, with the posterior deep temporal artery supplying the intermediate part of the temporalis muscle; the anterior deep temporal artery supplies the anterior part of the temporalis muscle. Three kinds of anastomoses between these arteries have been observed. Nakajima et al provide a detailed report.[10] These anastomoses include the following: (1) a connection between the vascular plexus of the superficial temporal artery branching from the skin to the superficial temporal fascia and the subgaleal vascular plexus via perforators, (2) a connection between the terminal branch of the middle temporal artery branching in the temporal fascia and vascular plexus inside the temporalis muscle, and (3) a connection near the temporal line between the vascular plexus of the lower layer of the galea aponeurotica and the vascular plexus inside the temporalis muscle over the temporal fascia. When forming the soft tissue flap of the temporal region,

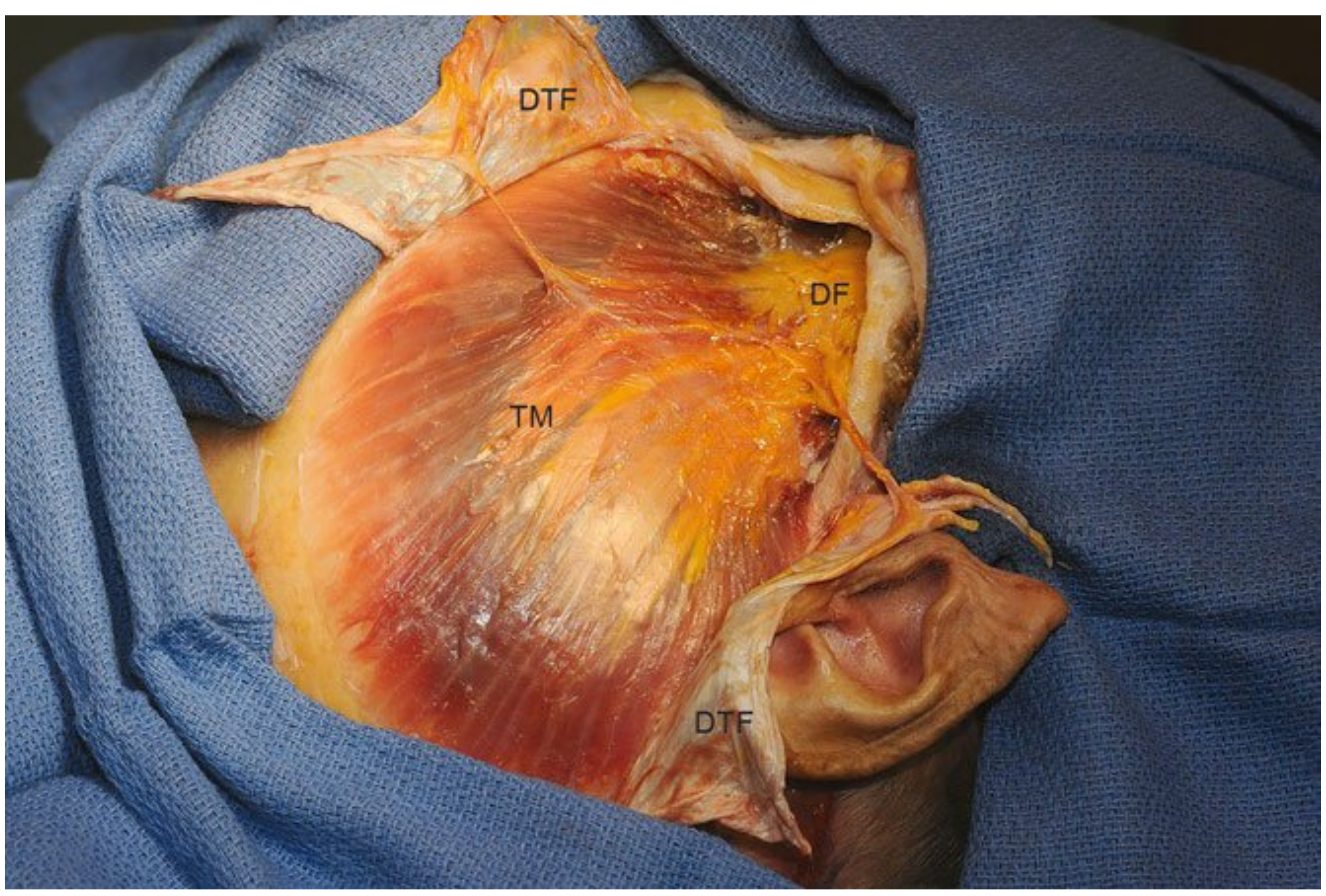

Fig. 4.6 Temporalis muscle (cadaver dissection; right temporal region). Deep temporal fascia was cut in the middle part and opened. The zygomatic arch was removed and the stump of the zygomatic bone can be seen. Deep temporal fat pad, which continues to the buccal fat pad, lies on the temporalis muscle. DF, deep temporal fat pad; DTF, deep temporal fascia; TM, temporal muscle.

Table 4.2 Blood circulation morphology of the temporal region

Artery	Origin	Distribution
Superficial temporal artery	One of the terminal branches of the external carotid artery	Skin to subgaleal layer
Middle temporal artery	A branch of the superficial temporal artery	Deep temporal fascia and posterior region of the temporalis muscle
Anterior deep temporal artery Posterior deep temporal artery	Branches of the maxillary artery	Anterior part of the temporalis muscle (anterior deep temporal artery) Intermediate part of the temporalis muscle (posterior deep temporal artery)

sufficient consideration is required regarding its blood circulation and the respective anastomoses.

Surgical Annotation

Superf cial Temporal Fascial Flap (Temporoparietal Fascial Flap)

The superficial temporal fascial flap is a thin muscle flap with superficial temporal arteries as a vascular pedicle. These are used for vascularization when reconstructing the face, auricle, and dura mater and for the reconstructing the limbs as a free flap.[11,12]

Deep Temporal Fascial Flap

This fascial flap involves the middle temporal arteries as a vascular pedicle. It can be used not only as a single fascial flap but also as a bilobed flap or combined flap together with the superficial temporal fascial flap with the superficial temporal artery as a vascular pedicle.[13]

Temporalis Muscle-Pericranial Flap

This thin, flexible pericranial flap uses the temporalis muscle as the pedicle (**Fig. 4.7**). The vascular pedicle of this flap is the deep temporal arteries supplying the temporalis muscle. When creating the flap, the parietal pericranium and the loose connecting tissue layers are raised along with the temporalis muscle so as not to detach the temporalis muscle and the deep temporal fascia in an area that is about 2 cm wide from the temporal crest down because there is a vascular plexus connecting the temporalis muscle and subgaleal fascial layer. Therefore, blood flow from the deep temporal arteries can reach the pericranium in the midparietal region via this vascular network.[14] Creating the bilateral pericranial flaps becomes possible by dividing the pericranium at the midparietal region, which is used for reconstructing the anterior cranial base and middle cranial base of the skull.

Temporalis Muscle Flap

The temporalis muscle flap is usually used as a pedicle flap for dynamic reconstruction of the eyelids and the lip for facial palsy.[15,16]

Fig. 4.7 Temporalis muscle-pericranial flap. Bilateral temporalis muscle-pericranial flap are raised after bicoronal skin incision. Bilateral pericranial flaps were raised with the temporalis muscles, and the deep temporal arteries, which supply the temporalis muscle, provide the blood circulation of this flap. TM, temporalis muscle; TMP, temporalis muscle-pericranial flap.

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5 Arterial Supply of the Facial Skin

Nobuaki Imanishi

Introduction

Arterial supply of the facial skin is chiefly provided by the facial and superficial temporal arteries and also by branches of the maxillary and ophthalmic arteries, which accompany the cutaneous branches of the trigeminal nerve. Branches from the source arteries run within the subcutaneous soft tissue and reach the dermis and then form the subdermal plexus. In this chapter, the detailed arterial vascularity of each region of the face on the basis of angiograms I have performed is described. Because the arterial supply of the face is substantial, necrosis of most local flaps here rarely occurs; however, knowledge of the arterial anatomy of the face is important when various local flaps of the face are elevated.

Arteries of the Facial Skin

The superficial temporal, facial, and ophthalmic arteries are three major source arteries of the facial skin. The superficial temporal artery gives off the transverse facial and zygomatico-orbital arteries and divides into the frontal and parietal branches. The facial artery gives off the submental, inferior labial, superior labial, and lateral nasal arteries and then becomes the angular artery. The ophthalmic artery gives off the supratrochlear, supraorbital, dorsal nasal, and medial and lateral palpebral arteries. The branches from the source arteries form an intimate vascular network in the face (**Fig. 5.1**). In addition, the infraorbital, zygomaticofacial, and mental arteries, which are derived from the maxillary artery, accompany cutaneous branches of the trigeminal nerve. The skin territories supplied by the zygomaticofacial and mental arteries are small and play only a supplemental role in the blood supply of the face.

Vasculature of Each Region of the Face

Forehead

Blood supply to the forehead is provided by the supratrochlear and supraorbital arteries and the frontal branch of the superficial temporal artery (**Fig. 5.2**). An intimate vascular plexus is formed by the arteries and their branches. The supratrochlear artery is dominant in the median forehead. The main trunk of the artery penetrates the orbital septum above the medial palpebral ligament and then ascends between the corrugator supercilii and orbicularis oculi muscles after sending vessels to the loose areolar tissue under the corrugator supercilii muscle.[1,2] It penetrates the frontalis muscle about 1 cm above the eyebrow and runs approximately a few centimeters just above the muscle to reach the subdermal plane (**Fig. 5.3**). During its course, small vessels branch off toward the dermis and frontalis muscle. The supratrochlear artery does not travel far into the frontalis muscle. The forehead flap originally included the frontalis muscle, but from the point of view of arterial anatomy, it is not essential to include the muscle itself. Therefore, the forehead flap is not a musculocutaneous flap but rather a fasciocutaneous flap.

Upper Eyelid

Blood supply of the upper eyelid is provided by four arterial arcades—the marginal, peripheral, superficial orbital, and deep orbital arcades—and by ascending and descending branches from these arcades[3] (**Fig. 5.4, Fig. 5.5**). Among these arcades, the marginal one along the margin of the upper eyelid and the peripheral one along the upper margin of the tarsus are formed by vascular anastomoses of medial and lateral palpebral arteries from the ophthalmic artery.

The marginal arcade runs along the front lower edge of the tarsus, giving off branches that ascend on the anterior and posterior surfaces of the orbicularis oculi muscle and tarsus. Among these ascending branches, the arteries on the anterior surface of the orbicularis oculi muscle and on the posterior surface of the tarsus pass under the lower margin of the muscle and tarsus. From the ascending branches, additional small vessels reach the skin, orbicularis oculi muscles, and tarsus. The margin of the eyelid is also supplied by small direct vessels from the marginal arcade.

The peripheral arcade runs along the attachment of Müller's muscle to the tarsus, giving off branches that descend on the anterior and posterior surfaces of the tarsus. These descending branches communicate with the ascending branches from the marginal arcade.

The superficial and deep orbital arcades run on the anterior and posterior surfaces of the orbicularis oculi muscle along the superior margin of the orbit. The main blood supply of the ar-

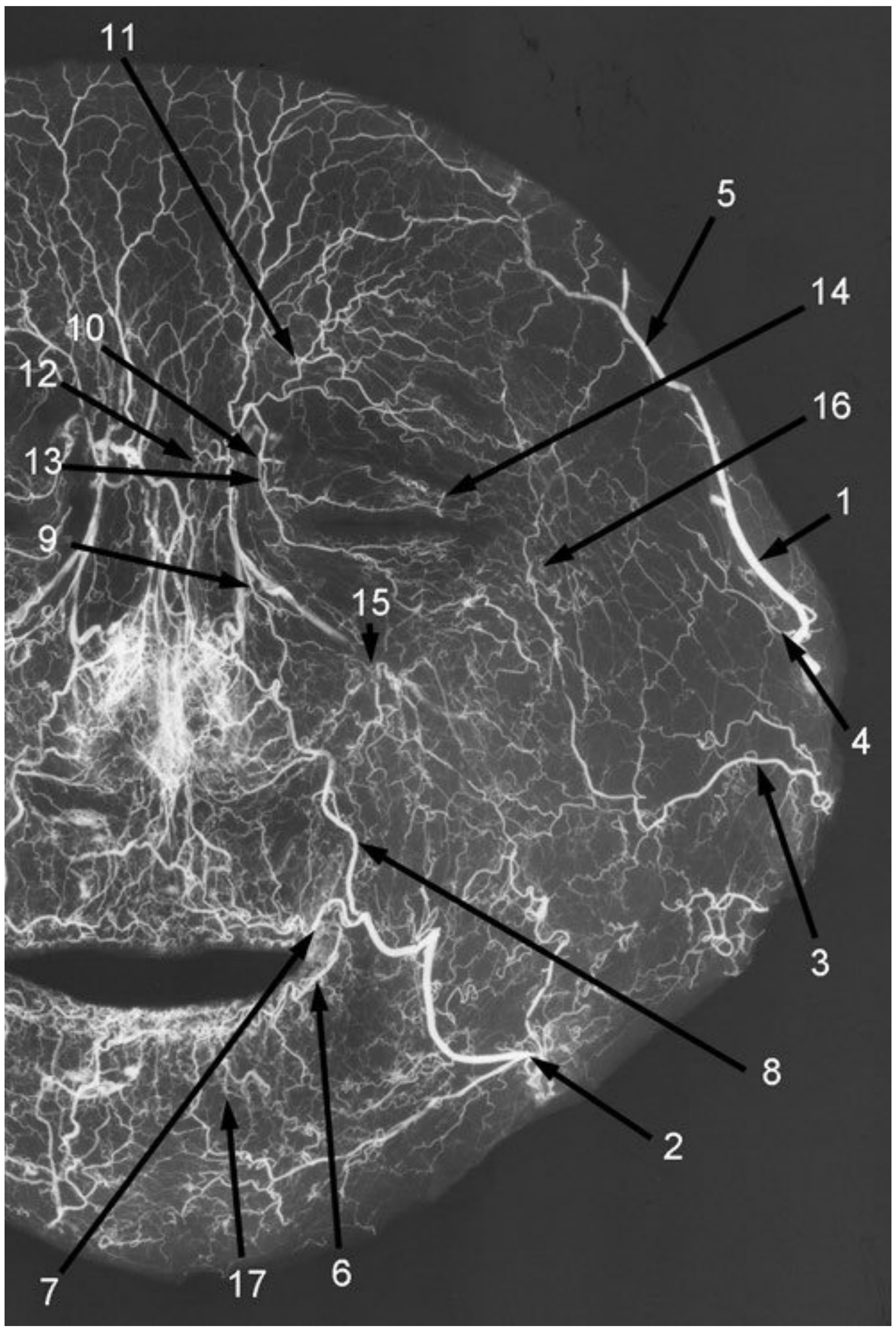

Fig. 5.1 Angiogram of the face. (1) Superficial temporal artery. (2) Facial artery. (3) Transverse facial artery. (4) Zygomatico-orbital artery. (5) Frontal branch. (6) Inferior labial artery. (7) Superior labial artery. (8) Lateral nasal artery. (9) Angular artery. (10) Supratrochlear artery. (11) Supraorbital artery. (12) Dorsal nasal artery. (13) Medial palpebral artery. (14) Lateral palpebral artery. (15) Infraorbital artery. (16) Zygomaticofacial artery. (17) Mental artery.

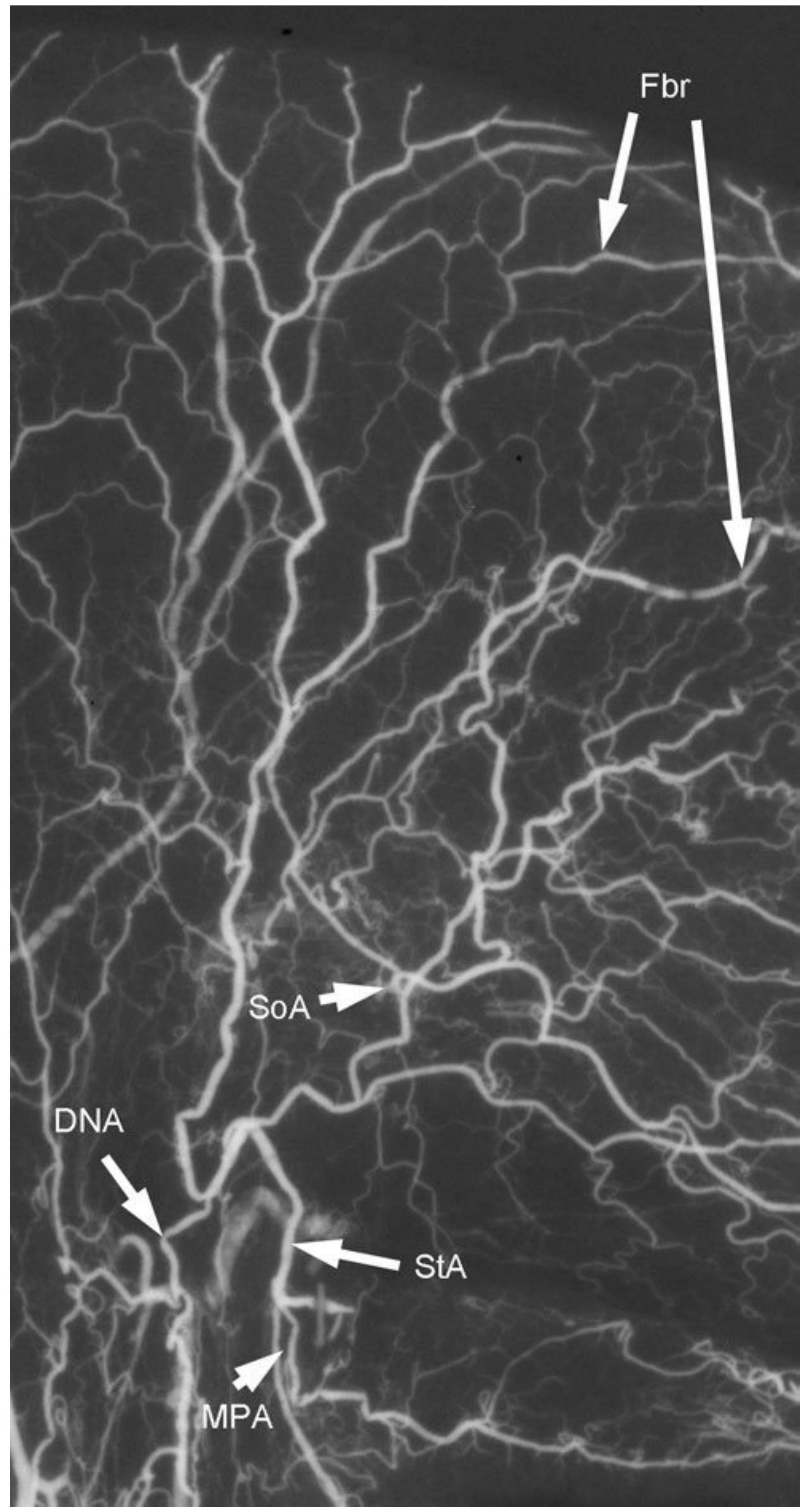

Fig. 5.2 Angiogram of the left forehead. Enlarged image of **Fig. 5.1**. DNA, dorsal palpebral artery; Fbr, frontal branch of the superficial temporal artery; MPA, medial palpebral artery; SoA, supraorbital artery; StA, supratrochlear artery.

cades is provided by the supratrochlear artery. The supraorbital and medial palpebral arteries on the medial side of the orbit and the zygomatico-orbital, transverse facial, and superficial temporal arteries on the lateral side participate in forming the superficial and deep orbital arcades. Descending vessels from the superficial orbital arcade on the anterior surface of the orbicularis oculi muscle and from the deep orbital arcade on the posterior of the muscle anastomose with the ascending branches of the marginal arcade.

Because the blood supply to the skin depends basically on the superficial orbital and marginal arcades and their connecting vessels, it is necessary for a local flap on the upper eyelid to be elevated just above the orbicularis oculi muscle, thereby preserving those vessels. There are no major arteries within the orbicularis oculi muscle, and blood supply of the muscle is provided by small branches from the ascending and descending vessels on the anterior and posterior surfaces of the muscle. In the case of a musculocutaneous flap, such as a V–Y advancement

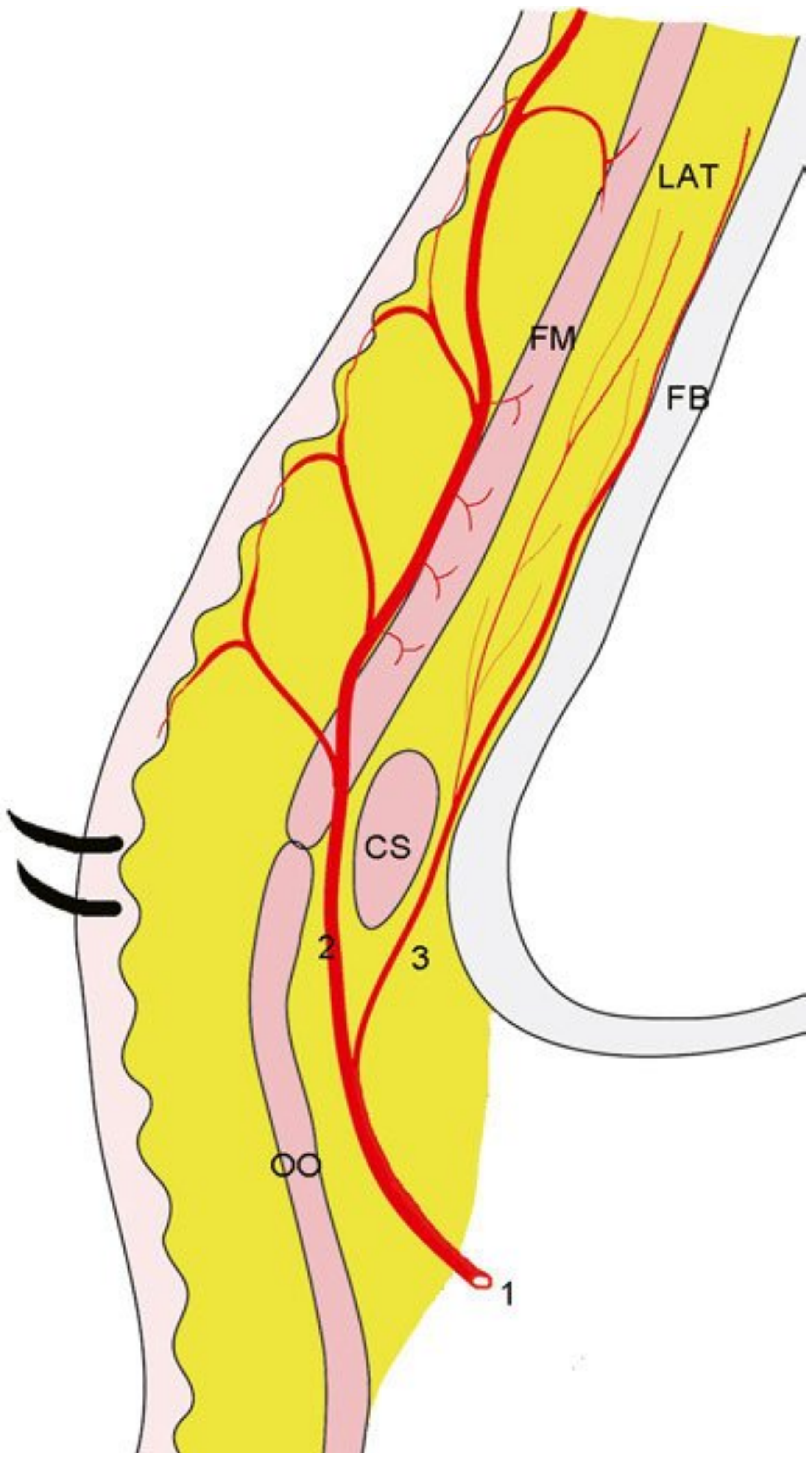

Fig. 5.3 Schematic sagittal section showing the course of the supratrochlear artery. (1) Supratrochlear artery. (2) Main trunk ascending between the corrugator supercilii and orbicularis oculi muscles. (3) Branch to the loose areolar tissue. CS, corrugator supercilii muscle; FB, frontal bone; FM, frontalis muscle; LAT, loose areolar tissue; OO, orbicularis oculi muscle.

flap, its blood supply depends on the deep orbital and marginal arcades and their connecting vessels. Accordingly, surgical operations must not extend behind the orbicularis oculi muscle.

Nose and Upper Lip

The facial artery gives off the superior labial artery about at the angle of mouth and becomes the angular artery toward the medial canthus.[4] In 12% of our cases, the peripheral portion of the facial artery can certainly be recognized as the angular artery with a slight decrease in its diameter.[5] In 88%, the facial artery ends at the alar base, and the terminal portion of the facial artery toward the alar base is called the lateral nasal artery (**Fig. 5.6**). In these cases, a thin vessel or a vascular plexus connects the lateral nasal artery with vessels from the supratrochlear artery near the medial canthus.

The lateral nasal artery divides into two vessels surrounding the alar base. One is called the inferior alar branch, and it runs toward the columella along the lower margin of the nostril, supplying blood to the alar base and nostril floor. A few branches travel toward the upper lip from the inferior alar branch. The other vessel is called the superior alar branch, which ascends along the lateral side of the alar, giving off branches to the lateral portion of the alar, nasal tip, and dorsum of the nose.

The superior labial artery runs between the labial mucosa and orbicularis oris muscle at the level of the upper margin of the red lip. The superior labial artery does not always consist of one vessel; in 35% of cases, it consists of two vessels. This artery runs medially, giving off ascending branches at both sides of the labial mucosa and skin, and then it anastomoses with the contralateral artery of the same name.

The ascending vessels toward the cutaneous side penetrate the orbicularis oris muscle at the level of the upper margin of the red lip and give off branches to the red lip, skin, and orbicu-

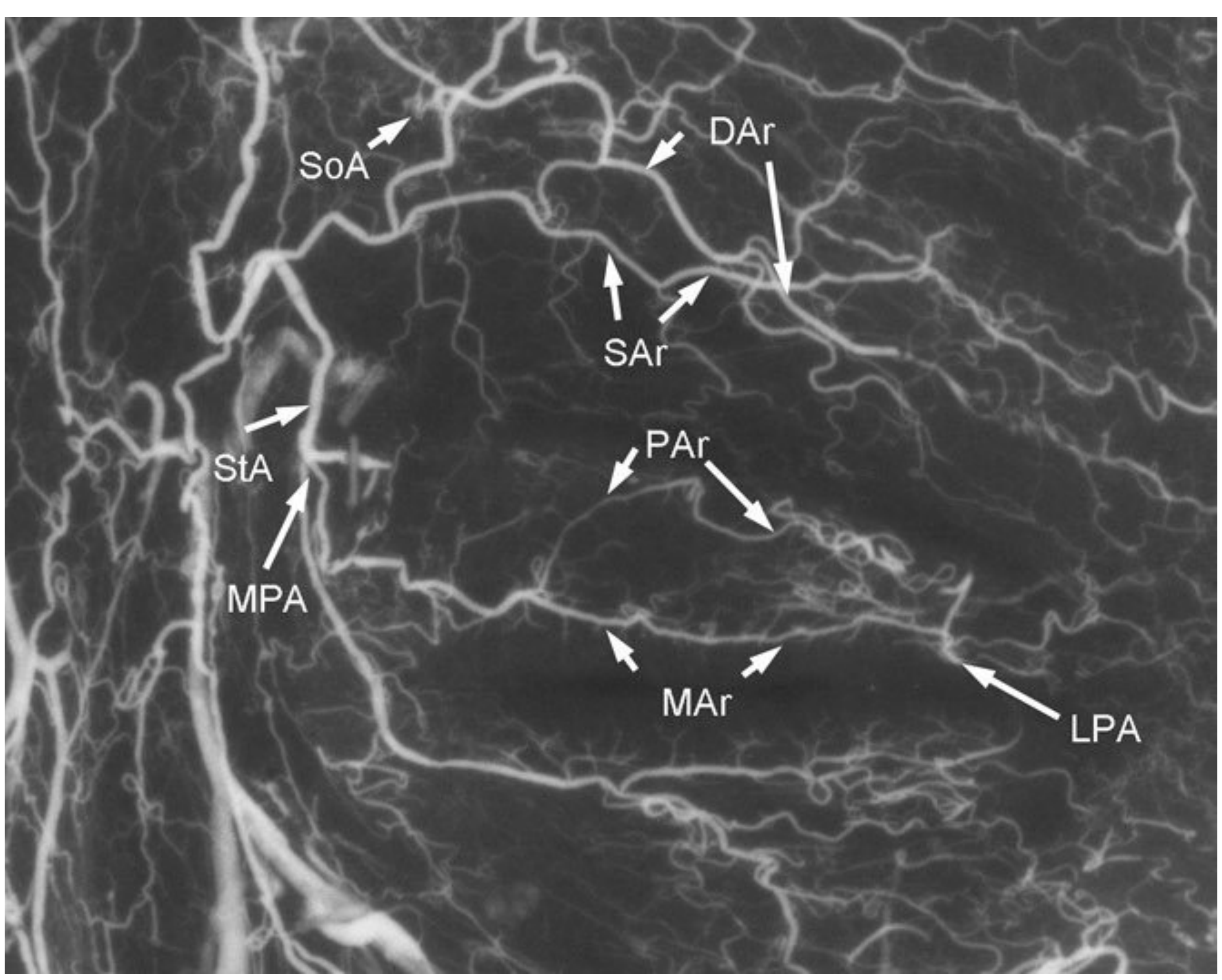

Fig. 5.4 Angiogram of the left eyelid; enlarged image of **Fig. 5.1**. DAR, deep orbital arcade; LPA, lateral palpebral artery; MAr. marginal arcade; MPA, medial palpebral artery; PAr. peripheral arcade. SAr, superficial orbital arcade; SoA, supraorbital artery; StA. supratrochlear artery.

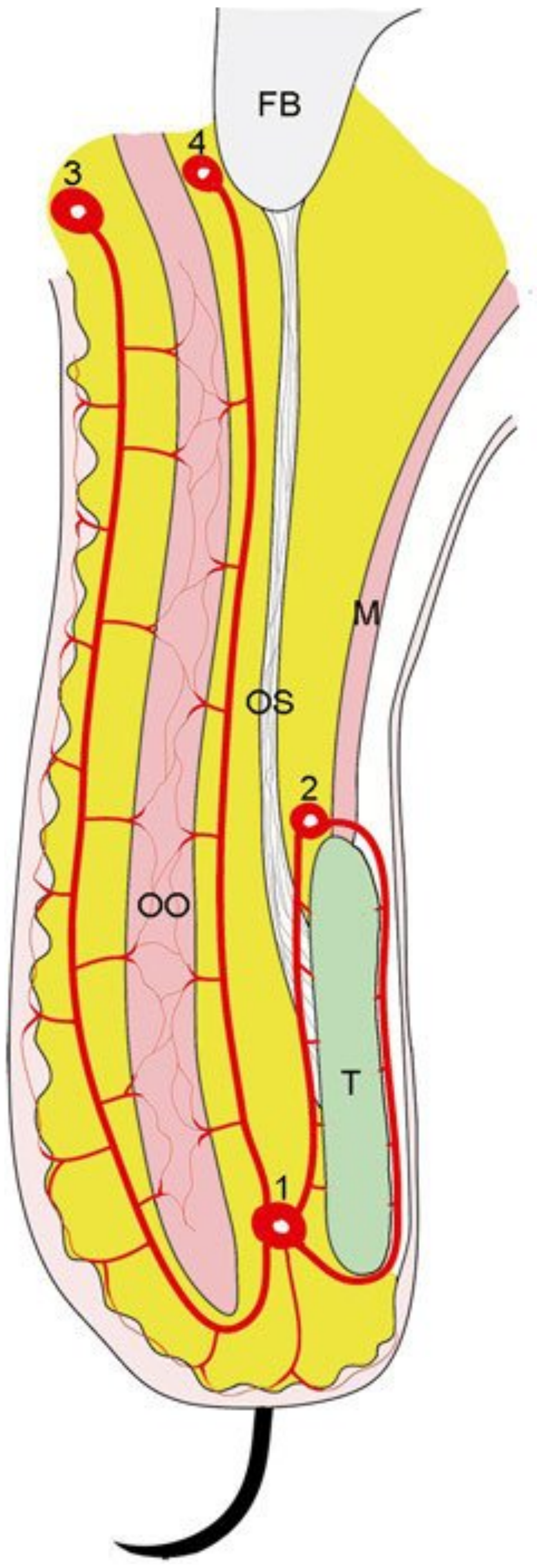

Fig. 5.5 Schematic sagittal section through the upper eyelid (1) marginal arcade. (2) peripheral arcade. (3) Superficial orbital arcade. (4) Deep orbital arcade. FB, frontal bone; M, Müller's muscle; OO, orbicularis oculi; OS, orbital septum; T, tarsus.

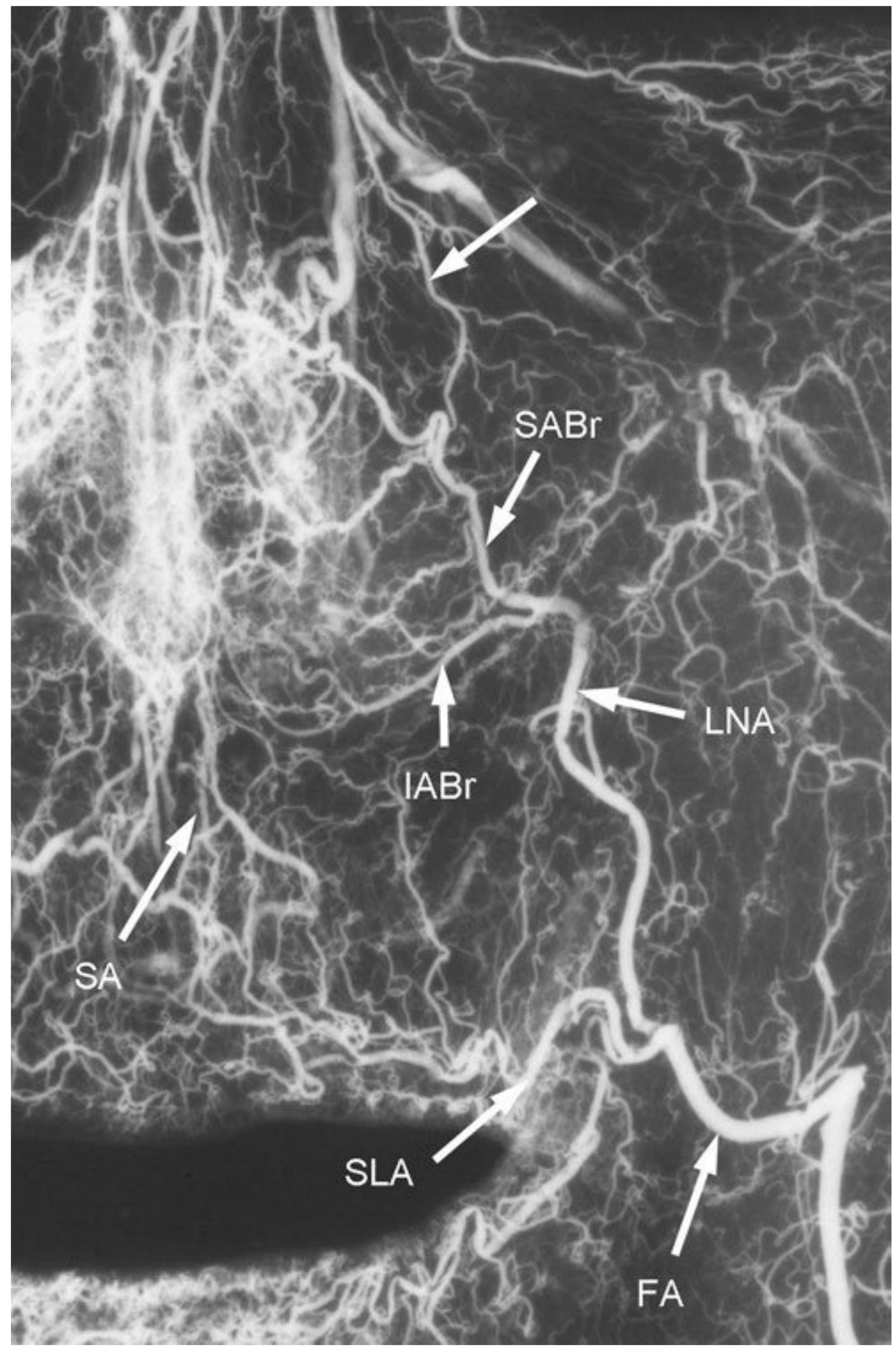

Fig. 5.6 Angiogram of the left upper lip and nose. Enlarged image of **Fig. 5.1**. FA. facial artery; IABr, inferior alar branch; LNA, lateral nasal artery; SA, septal artery; SABr, superior alar branch; SLA, superior labial artery. Artery: a thin vessel toward the medial canthus.

laris oris muscle (**Fig. 5.7**). A few vessels at the philtrum among the ascending vessels are sometimes large and are called the septal arteries. The ascending vessels at the mucosal side give off braches to both the orbicularis oris muscle and labial mucosa. At the base of the columella, the ascending vessels from both sides of the superior labial artery and the terminal portion of the inferior alar branch from the lateral nasal artery anastomose with each other and form a vascular network. At the columella base are two kinds of vessels from the vascular network that ascend toward the nasal tip. One is an artery that ascends within the columella and reaches vascular network at the nasal tip. The other is an artery that enters into the nasal septum and ascends along the anterior margin of the nasal septal cartilage. This artery also reaches the nasal tip vascular network through a small opening among the alar and lateral nasal cartilages. This artery gives off branches in both anterior and posterior directions. The anterior branches reach the medial crus of the alar cartilage and columella between the medial crura. The posterior branches reach the nasal septal cartilage. The vasculature of the skin of the upper lip and muscle is similar to that of the upper eyelid (**Fig. 5.3**).

Cheek

From the point of view of arterial anatomy, the cheek is roughly a region surrounded by the facial and superficial temporal arteries. Therefore, the blood supply of the cheek is chiefly provided by branches of the facial artery, transverse facial artery, and zygomatico-orbital artery (**Fig. 5.8**). A complementary relationship can be seen among these arteries. For example, when the zygomatico-orbital artery is small, the transverse facial artery is enlarged (**Fig. 5.1**). In addition, there are infraorbital and zygomaticofacial arteries. The zygomaticofacial artery plays the role of a supplementary blood supply.

A subdermal plexus is vessels in both the dermis and subdermal plane.[6] The subdermal plexus is not always random, but its vascular pattern shows some axiality.[7] In the nasolabial fold and its neighboring area, small branches from the facial or lateral nasal arteries ascend vertically.[8] The skin territory of each branch is also small (**Fig. 5.9**). Accordingly, a V-Y advancement flap on the nasolabial fold is suitable based on the vasculature by the small vertical vessels; however, branches of the transverse facial and zygomatico-orbital arteries and the proximal

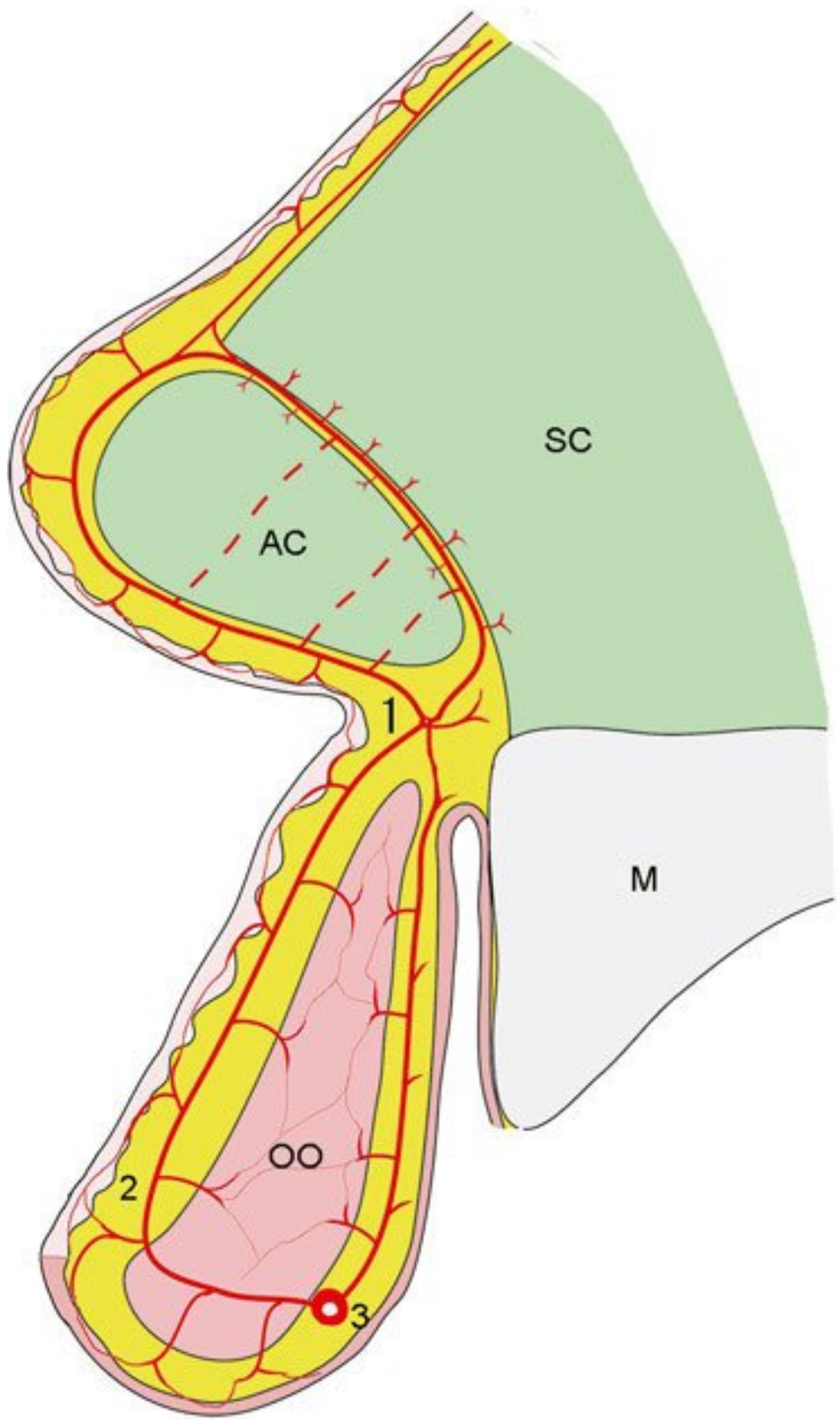

Fig. 5.7 Schematic sagittal section through the upper lip and nose. (1) Terminal portion of the inferior alar branch. (2) Septal nasal artery. (3) Superior labial artery. AC, medial crus of alar cartilage; M. maxilla; OO. orbicularis oris muscle; SC, septal cartilage.

portion of the facial artery are comparatively large, and vascular continuity by these branches is apparent. In this region, the subdermal plexus runs axially. In the infraorbital region, the infraorbital artery radiates just after passing through the infraorbital foramen, but the skin territory supplied by each branch is small.

Lower Lip

The blood supply of the lower lip is provided by the facial and submental arteries. There are two kinds of branches from the facial artery. One is the inferior labial artery, and the other is a branch that travels horizontally at a level between the lower lip and mentum.[9] In addition, ascending branches from the submental artery take part in this blood supply (**Fig. 5.10**).

The inferior labial artery is derived from the facial artery at the lower margin of the mandible in 67% of cases and at the corner of the mouth in 25% It is sometimes derived from the superior labial artery in 8% The inferior labial artery runs between the orbicularis oris and buccinator muscles and then reaches the lower lip. It passes transversely between the orbicularis oris muscle and labial mucosa at the level of the boundary of the red and white parts of the lips giving off descending branches at both sides of the skin and labial mucosa (**Fig. 5.11**). The descending branches of the cutaneous side cross over the upper margin of the orbicularis oris muscle or penetrate the muscle and descend, giving off small vessels to the skin and muscle. The descending branches of the mucosal side also give off small vessels to the muscle and mucosa.

The horizontal branch at the level between the lower lip and mentum is derived from the facial artery and arises at the lower

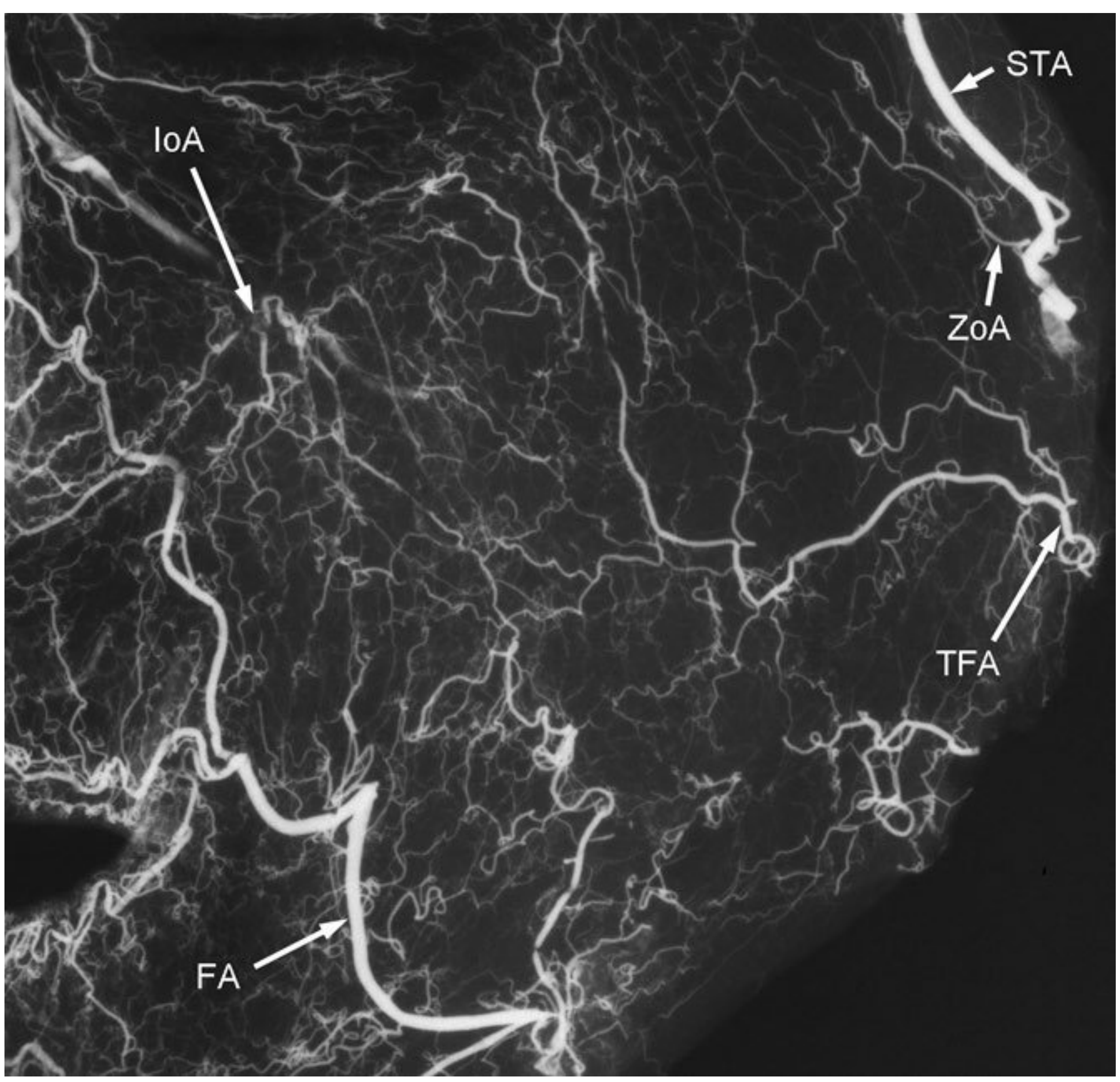

Fig. 5.8 Angiogram of the left cheek. Enlarged image of **Fig. 5.1**. FA, facial artery; IoA, infraorbital artery; STA, superficial temporal artery; TFA, transverse facial artery; ZoA, zygomatico-orbital artery.

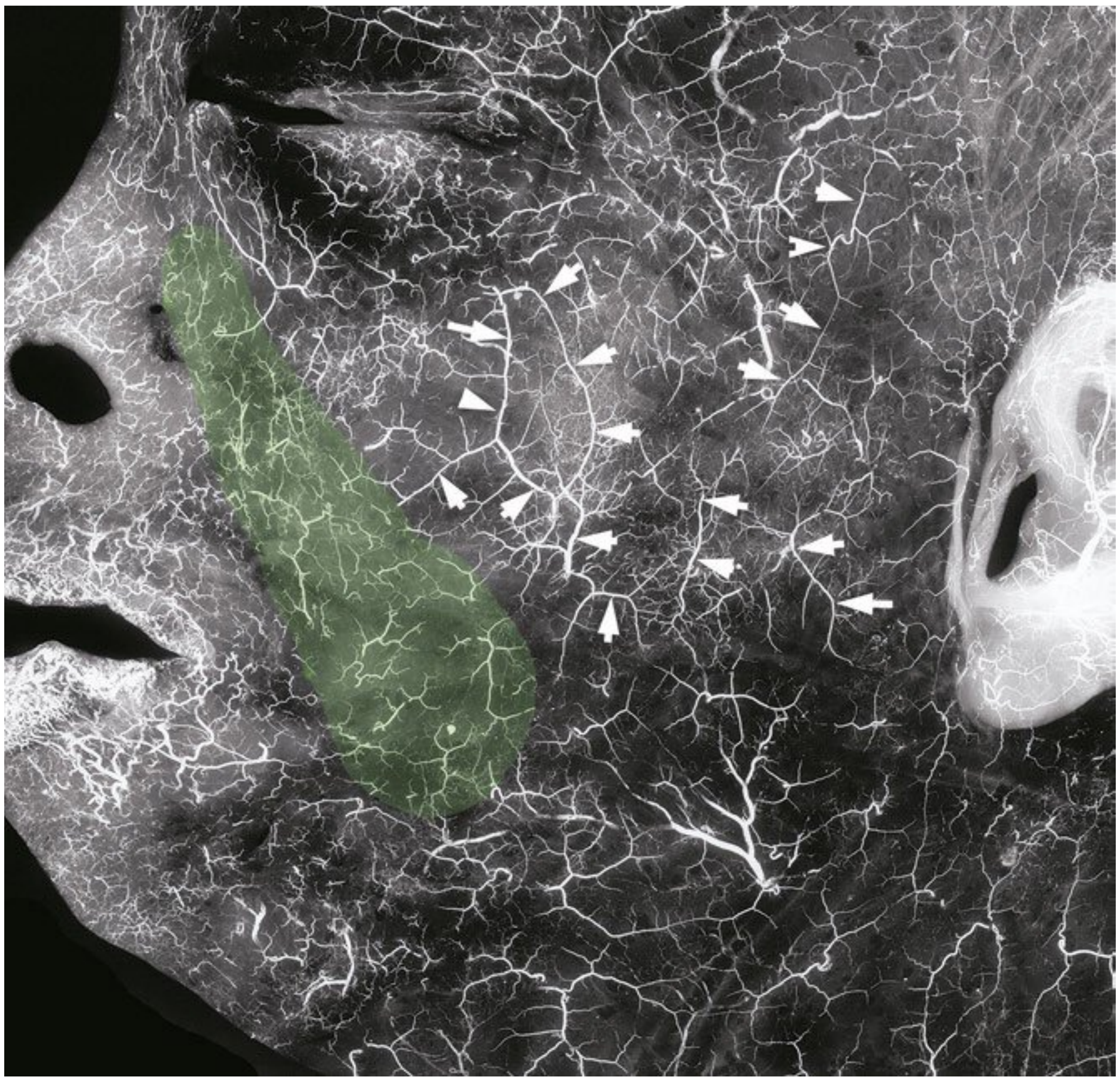

Fig. 5.9 Subdermal plexus of the cheek Angiogram shows the subdermal plexus of the cheek region. There are comparatively small vessels from the facial or lateral nasal arteries in the green area. Each small artery that enters the subdermal plane has a small skin territory. In other cheek regions, vessels that enter the subdermal plane are comparatively large, and their vascular continuity (arrows) is good.

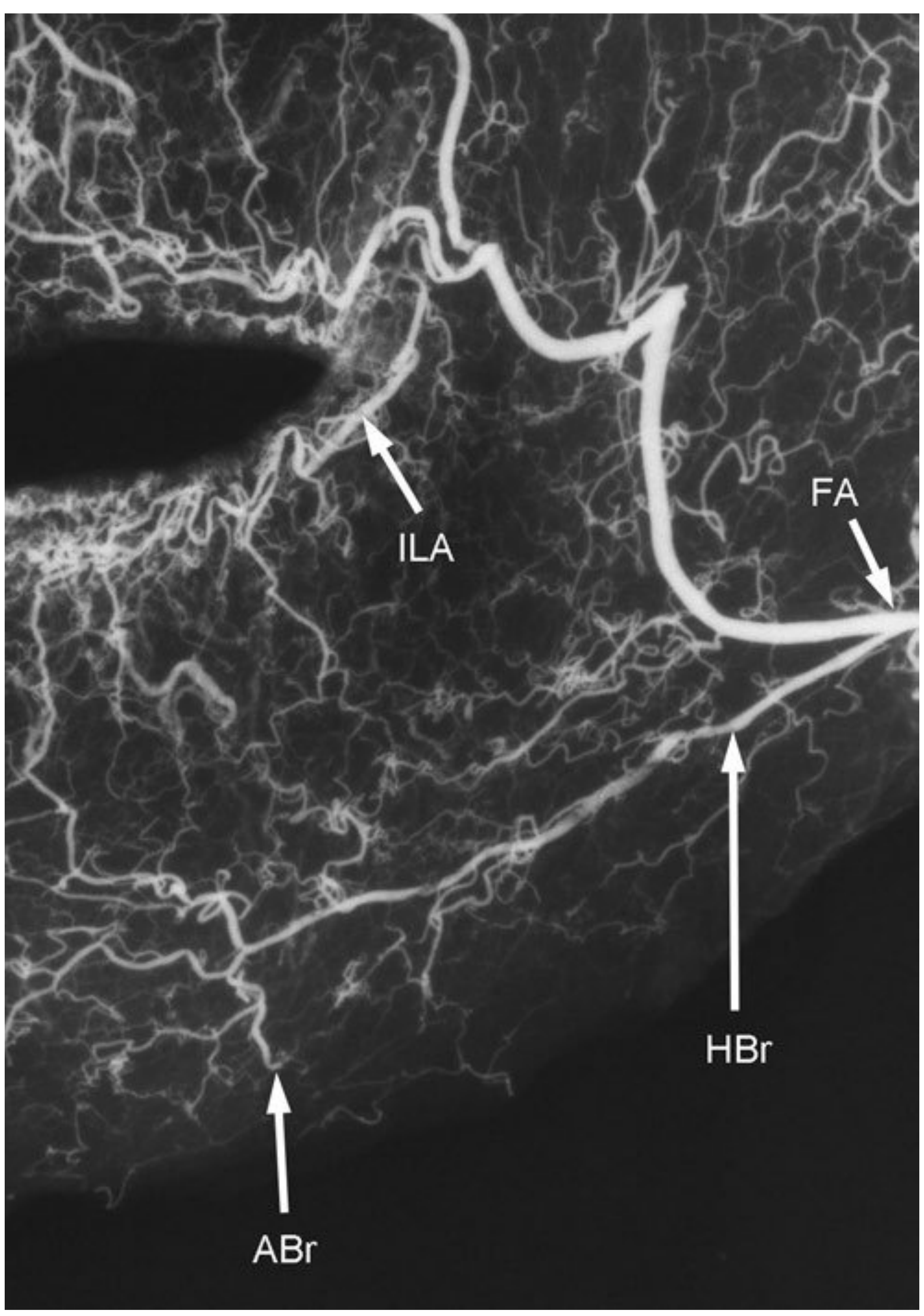

Fig. 5.10 Angiogram of the left lower lip. Enlarged image of **Fig. 5.1**. ABr, ascending branch from the submental artery; FA, facial artery; Hbr, horizontal branch at the level between the lower lip and mentum; ILA, inferior labial artery.

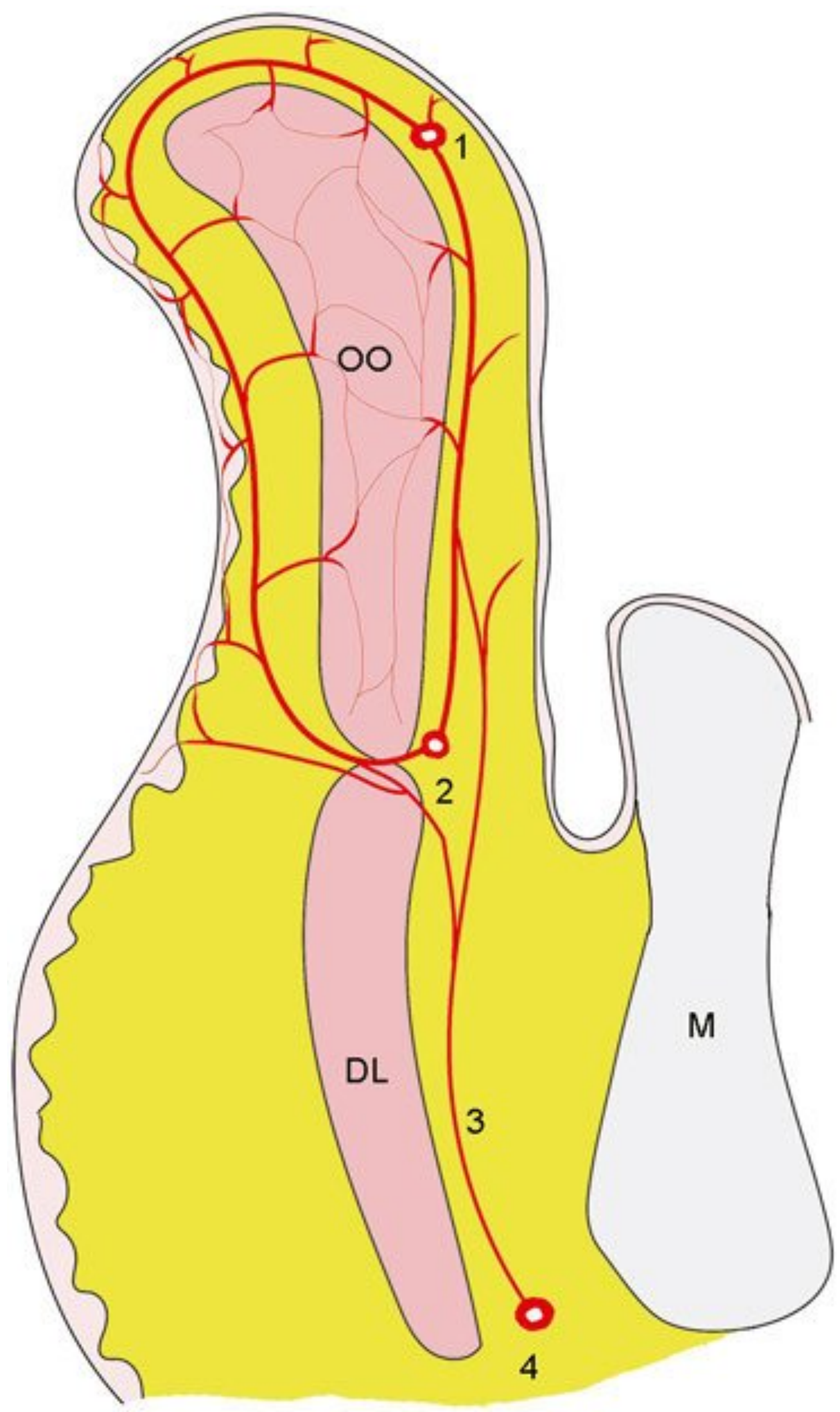

Fig. 5.11 Schematic sagittal section through the lower lip. (1) Inferior labial artery. (2) Horizontal branch at the level between the lower lip and mentum. (3) Ascending branch from the submental artery. (4) Submental artery. DL, depressor labii inferioris muscle; M, mandible; OO, orbicularis oris muscle.

margin of the mandible. The artery runs on the mucosal side between the orbicularis oris and depressor labii inferioris muscles. In 50%of cases, it anastomoses with the artery of the same name on the contralateral side without decreasing its diameter. In 33%of cases, its diameter decreases gradually, and it is not identified in the middle of the lower lip. In 17% of cases, its pathway changes from a horizontal direction to a vertical direction and it anastomoses with branches of the inferior labial artery. The artery is larger than the inferior labial artery in 50% of cases. The artery gives off ascending branches on both sides of the skin and labial mucosa behind the inferior margin of the orbicularis oris muscle. The ascending branches anastomose with the descending branches of the inferior labial artery. Ascending arteries from the mentum to the lower lip arise from the submental artery. At the beginning of their pathways, they run behind the depressor labii inferioris muscle. They bifurcate when they ascend near the orbicularis oris muscle. The bifurcating branches anastomose with the ascending branches from the horizontal branch of the facial artery. Blood supply of the lower lip and mentum is provided by not only the three dominant vessels, as mentioned, but also by direct branches from the facial artery and mental artery. Blood supply by the mental artery is only supplemental.

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6 Arteries of the Face and Neck

Yelda Atamaz Pinar, Figen Govsa, and Servet Celik

Introduction

Safe and effective reconstructive surgical procedures rely on a clear knowledge of facial and neck arterial anatomy. Cadaveric angiographic and dissection studies have demonstrated that the external and internal carotids are the main arterial sources for the head and neck regions.

The skin and soft tissue of the face receive their arterial supply from the branches of the facial, maxillary, and superficial temporal arteries, all of which are branches of the external carotid. The exception is a masklike area that includes the central forehead, the eyelids, and the upper part of the nose and is supplied via the internal carotid artery system via the ophthalmic arteries. The ophthalmic artery gives off branches to the face, including the lacrimal, supraorbital, supratrochlear, dorsal nasal, and external nasal arteries.

Because there are communications between the external and internal carotid artery systems around the eye, external nose, and forehead through several anastomoses, knowledge of the arterial territories is important in flap anatomy. Most flaps are based on vascularization of the arteries, and anatomical variations must be considered when individual flaps are planned for patients. To elevate an arterial flap safely, routine use of a Doppler probe preoperatively and intraoperatively is recommended.

The primary arterial territories of the head and the neck have been defined by mapping their three-dimensional territories in the skin, the deep soft tissues, and the bones.[1–3] The external carotid artery supplies the exterior of the head, the face, and much of the neck. The internal carotid artery supplies the central face, which contains the eyes, the upper two-thirds of the nose, and the central forehead[4] (**Fig. 6.1, Fig. 6.2, Fig. 6.3**).

There is a rich anastomotic network between the branches of the internal carotid and ophthalmic artery systems (supraorbital or supratrochlear vessels) (**Fig. 6.4a**) and the angular artery and superficial temporal artery via the transverse facial artery to the facial artery (**Fig. 6.4b**). There are also multiple anastomoses between the facial and maxillary artery territories via the infraorbital and mental arteries (**Fig. 6.4c**).[3,5]

Reconstruction methods for facial defects include skin grafts, local flaps, pedicled flaps, and microvascular tissue transfers[6]; however, remote tissues do not provide ideal tissue contour, thickness, texture, or shape for the facial structures; hence, they often require multiple revisions and result in donor-site morbidity.[1,7] Muscles and other tissues have a vital role because they provide anastomotic networks for preventing vascular compromise.

The many changes undergone by embryonic arteries, such as regression or reappearance, can result in variations of the origin points, the courses, and the anastomotic features of the vessels. Arterial variations can be explained by the persistence of channels that normally disappear or by the disappearance of normally persisting vessels. These anatomical variations arising from embryologic development can be significant.[8,9] Doppler ultrasound helps to define arterial features and provides information about backflow and the potential for reverse flow in the artery.[7,10]

External Carotid Artery

The cervical part of the common carotid is usually divided into the external and the internal carotid arteries at the level of the upper border of the thyroid cartilage. The carotid bifurcation is located 13.2 ± 5.6 mm below the tip of the greater horn of the hyoid bone. The external carotid artery is covered by skin, superficial fascia, platysma, deep fascia, and the anterior margin of the sternocleidomastoid muscle. It begins by taking a slightly curved course and then passes upward and forward.[11] After branching on its anterior (superior thyroid, lingual, facial arteries) and posterior (ascending pharyngeal, occipital, posterior auricular arteries) sides, the artery inclines backward to the space behind the neck of the mandible, where it is divided into its terminal branches, the superficial temporal and maxillary arteries (**Fig. 6.1, Fig. 6.2**).

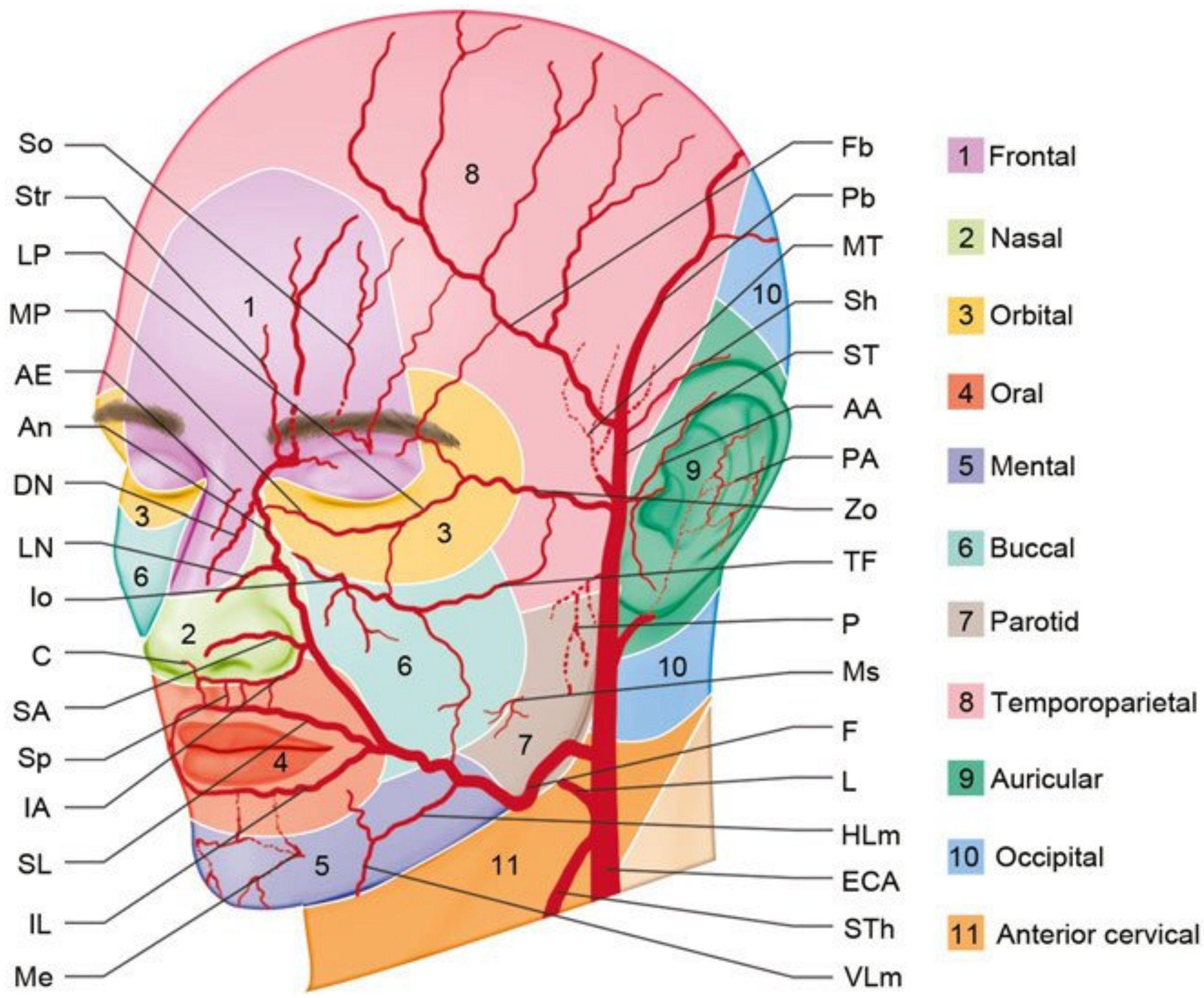


Fig. 6.1 The superficial arteries of the head and neck regions in anterolateral oblique view. Regions: Arterial territories include (1) frontal: Str, So, MP (O territory); (2) nasal: DN, AE, An (F-O territory); (3) orbital: MP, LP, Io (O-Max-Zo territory); (4) oral: SL, IL (F territory); (5) mental: Me, IL (Max-F territory); (6) buccal: Io, TF (Mx-ST territory); (7) parotid: TF, Ms (ST territory); (8) temporoparietal: Fb, Pb, MT (ST territory); (9) auricular: AA, PA (ST-ECA territory); (10) occipital: O (ECA territory); (11) anterior cervical: STh (ECA territory). AA, anterior auricular artery, AE: anterior ethmoidal artery; An, angular artery; C, columellar artery; DN, dorsal nasal artery; ECA, external carotid artery; F, facial artery; Fb, frontal branch of the superficial temporal artery; HLm, horizontal labiomental artery; IA, inferior alar artery; IL, inferior labial artery; Io, infraorbital artery; MP, medial palpebral artery; Ms, masseteric artery; Me, mental artery; Mx, maxillary artery; MT, middle temporal artery; L, lingual artery; LN, lateral nasal artery; LP, lateral palpebral artery; P, parotid branch; PA, posterior auricular artery; Pb, parietal branch of the superficial temporal artery; SA, superior alar artery; Sh, suprahelical artery; SL, superior labial artery; So, supraorbital artery; Sp, septal artery; ST, superficial temporal artery; STh, superior thyroid artery; Str, supratrochlear artery; TF, transverse facial artery; VLm, vertical labiomental artery; Zo, zygomatico-orbital artery.

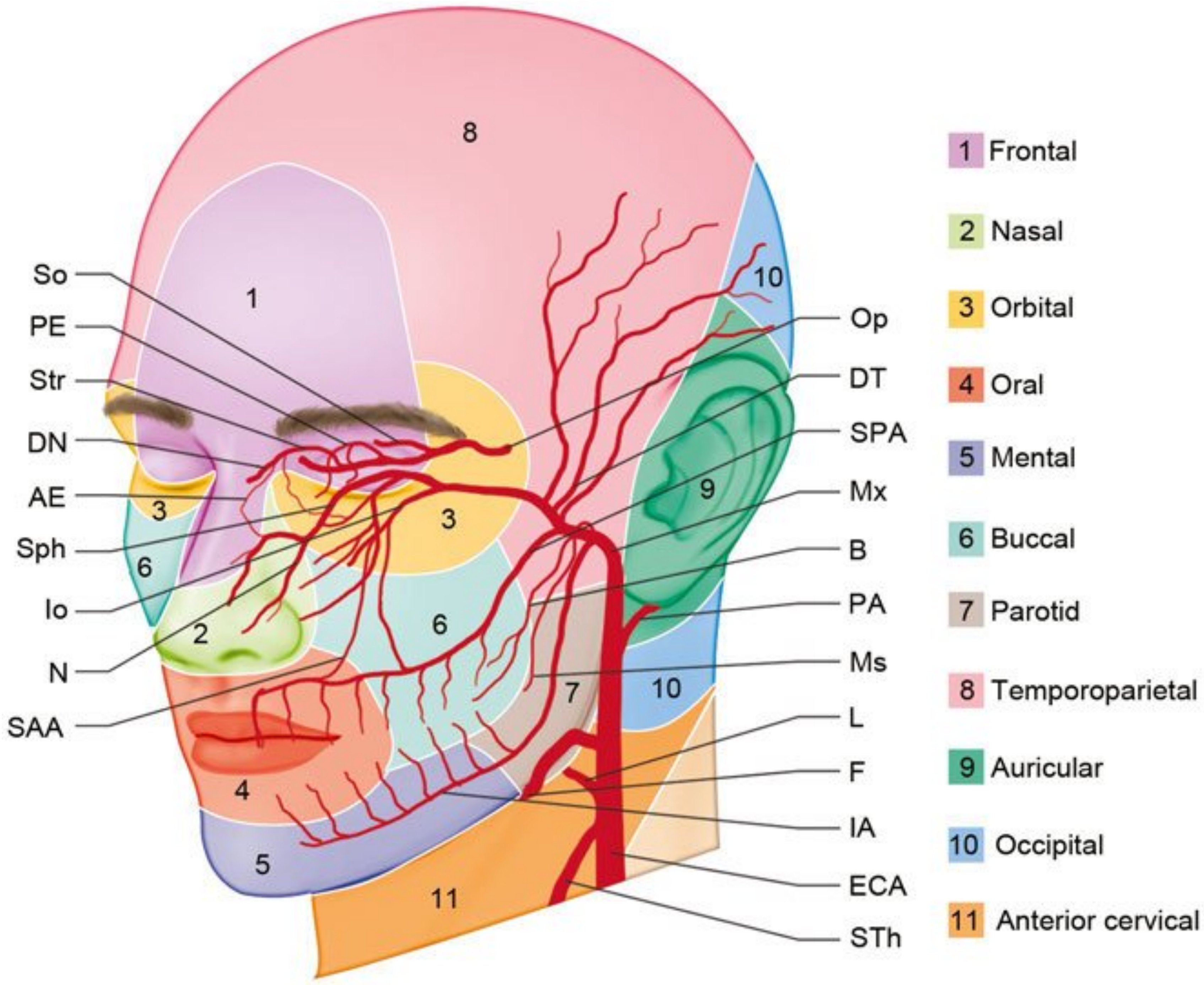


Fig. 6.2 The deep arteries of the head and neck regions in anterolateral oblique view. Regions: arterial territories: (1) frontal: Str, So, MP (O territory); (2) nasal: DN, AE, An (F-O territory); (3) orbital: MP, LP, Io (O-Max-Zo territory); (4) oral: SL, IL (F territory); (5) mental: Me, IL (Max-F territory); (6) buccal: Io, TF (Mx-ST territory); (7) parotid: TF, Ms (ST territory); (8) temporoparietal: Fb, Pb, MT (ST territory); (9) auricular: AA, PA (ST-ECA territory); (10) occipital: O (ECA territory); (11) anterior cervical: STh (ECA territory). AE, anterior ethmoidal artery; B, buccal artery; DN, dorsal nasal artery; DT, deep temporal artery; ECA, external carotid artery; F, facial artery; IA, inferior alveolar artery; Io, infraorbital artery; L, lingual artery; Ms, masseteric artery; Mx, maxillary artery; N, nasopalatine artery; PA, posterior auricular artery; PE, posterior ethmoidal artery; Op, ophthalmic artery; SAA, superior alveolar artery; SPA, superior posterior alveolar artery; Sph, sphenopalatine artery; So, supraorbital artery; Str, supratrochlear artery; STh, superior thyroid artery.

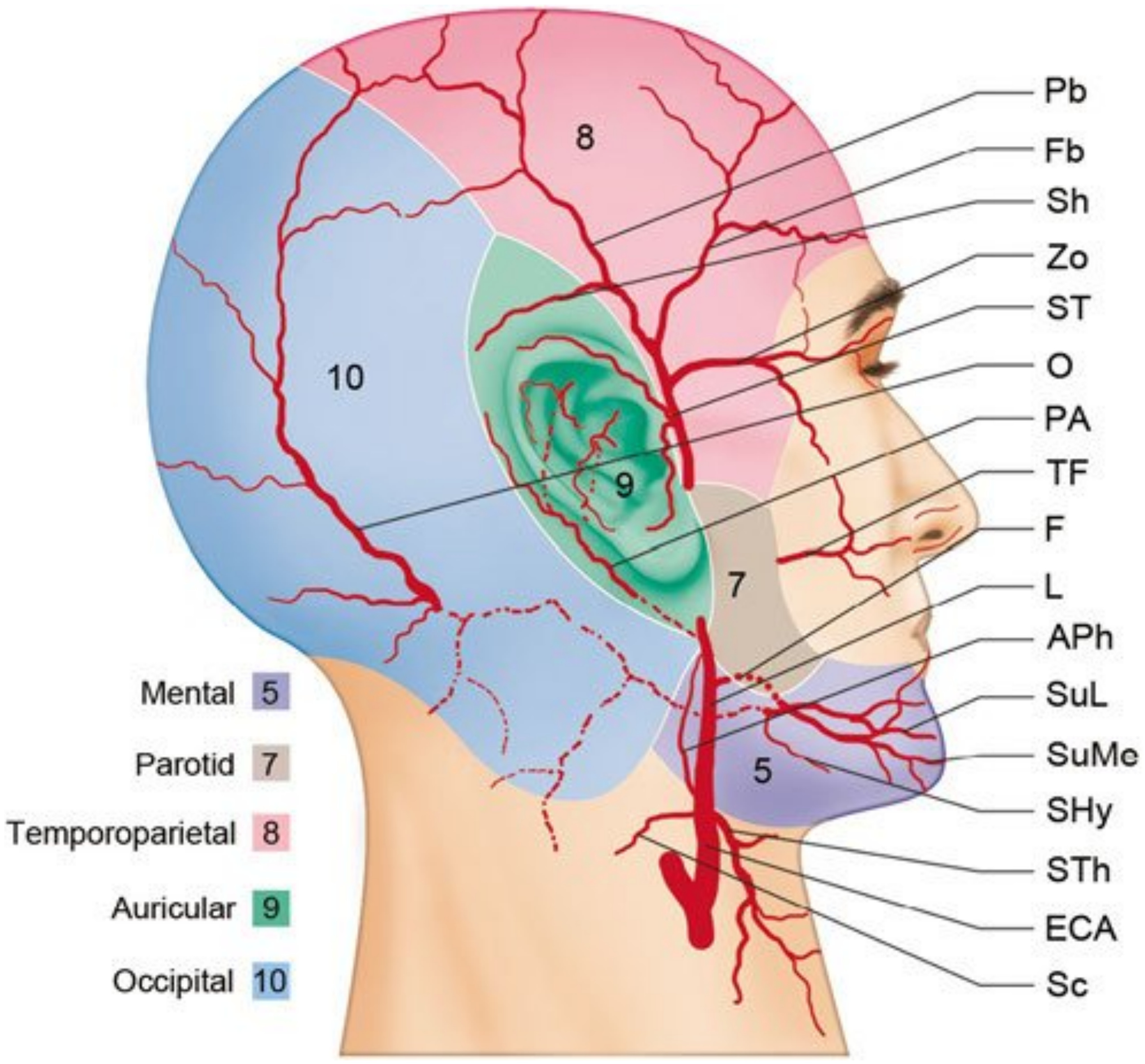


Fig. 6.3 Branches of the external carotid artery, posterolateral view. Regions: Arterial territories (5) mental: Me (Mx), Shy, SuL (L), SuMe (F) territory; (7) parotid: TF, Ms (ST territory); (8) temporoparietal: Fb, Pb, MT (ST territory); (9) auricular: AA, PA (ST-ECA territory); (10) occipital: O (ECA territory). APh, ascendening pharyngeal artery; ECA: external carotid artery; F, facial artery; Fb, frontal branch of the superficial temporal artery; L, lingual artery; PA, posterior auricular artery; Pb, parietal branch of the superficial temporal artery; O, occipital artery; Sc, sternocleidomastoid branch; SHy, suprahyoid artery; Sh, suprahelical artery; ST, superficial temporal artery; STh, superior thyroid artery; SuL, sublingual artery; SuMe, submental artery; TF, transverse facial artery; Zo, zygomatico-orbital artery.

Surgical Annotation

The superior thyroid, lingual, and facial arteries originate as separate branches in 50 to 80%, a linguloacial trunk exists in 18 to 31%, a thyrolingual trunk in 1 to 18%, and a thyrolingulofacial trunk in about 2.5% (**Fig. 6.5**).[8,9,11,12] The carotid bifurcation is commonly located at the superior border of the thyroid cartilage. The distance from the origin of the superior thyroid artery to the carotid bifurcation is 3.3 ± 4.3 mm, from the origin of the superior thyroid artery to that of the lingual artery is 10.5 ± 5.2 mm, and from the origin of the superior thyroid artery to that of the facial artery is 18.2 ± 8.8 mm.[8,9,12]

Superior Thyroid Artery

The superior thyroid artery typically arises from the anterior surface of the external carotid just below the level of the greater cornu of the hyoid bone, although there are variations (**Fig. 6.6**).[8,9,11,12] The superior thyroid artery usually has a sharp downward angle at its origin. From its origin under the anterior border of the sternocleidomastoid muscle, it runs upward and forward for a short distance in the carotid triangle; it then arches downward beneath the infrahyoid muscles (**Fig.6.5a**). It distributes twigs to the adjacent muscles and numerous branches to the thyroid gland, anastomosing with its fellow on the opposite side and with the inferior thyroid arteries.

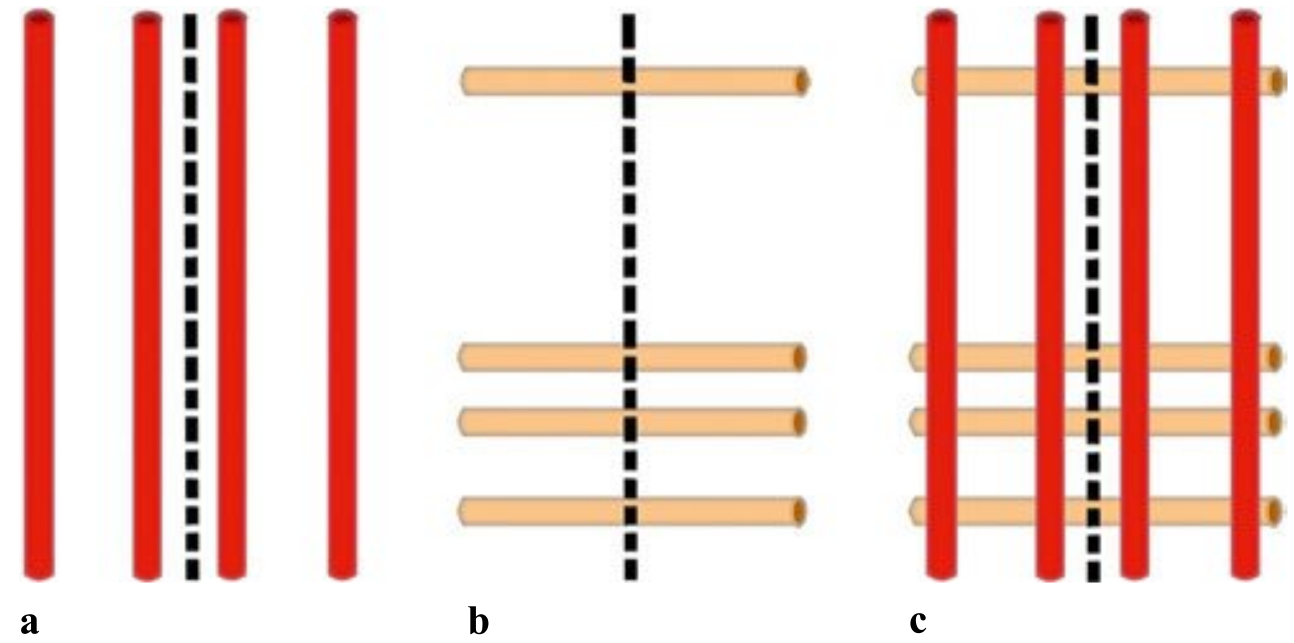


Fig. 6.4 Schematic representation of the arterial anastomoses in three patterns. **(a)** Intercarotid anastomoses (angular and dorsal arteries). **(b)** Transfacial anastomoses (radix, lateral nasal, marginal, and subnasal arteries). **(c)** Polygonal system (intercarotid and transfacial). Red: intercarotid; orange: transfacial interconnected arteries.

Surgical Annotation

The origin of the superior thyroid artery can be identified 13 ± 4.5 mm below the tip of the greater horn of the hyoid. The distance from its origin to the thyroid cartilage's upper edge is 7.1 ± 6.4 mm and to the horizontal plane passing through the upper edge of the thyroid gland is 26.1 ± 12.1 mm.[8,9,12]

Lingual Artery

The lingual artery arises from the external carotid artery between the origin of the superior thyroid and facial arteries. It first runs obliquely upward and medially to the greater cornu of the hyoid bone (**Fig. 6.5**). It then curves downward and forward and passes beneath the digastric and stylohyoid muscles. It runs horizontally forward, beneath the hyoglossus muscle, finally ascending as the deep lingual artery.

Surgical Annotation

The branching patterns can vary. These anatomical variations arise from embryological development and can be significant in clinical cases (**Fig. 6.5, Fig. 6.6**). The anatomical characteristics and variations of the external carotid, superior thyroid, lingual, and facial arteries, such as their branching patterns, lengths, and outer diameters, are crucial for safe implementation of intra-arterial catheterization for administering anticancer drugs to the head and the neck, surgical excision of benign and malignant tumors, and microsurgical arterial implantations.[8,9,12]

The distance from the origin of the lingual artery to the carotid bifurcation is 12 ± 5.9 mm, to the origin of the facial artery is 5.3 ± 5.2 mm, and to the thyroid cartilage's upper edge is 15.6 ± 7.7 mm.

Occipital Artery

The occipital artery arises from the external carotid (89–95%) or as a common trunk with the posterior auricular artery from the external carotid artery (5–10%). From the mandibular angle, the origin of the occipital artery is on average 13.4 mm (5–22 mm) above in 29% cases, 17.6 mm (4–32 mm) below in 57%, and

Fig. 6.5 The anterior branches of the external carotid artery. **(a)** Case of thyrolingual trunk, **(b)** case of linguloficial trunk, **(c)** case of separate branches, and **(d)** the branching types of the anterior branches of the external carotid artery. CC, common carotid artery; ECA, external carotid artery; F, facial artery; L, lingual artery; LFT, lingulofacial trunk; TLFT, thyrolingulofacial trunk; TLT, thyrolingual trunk; STh, superior thyroid artery.

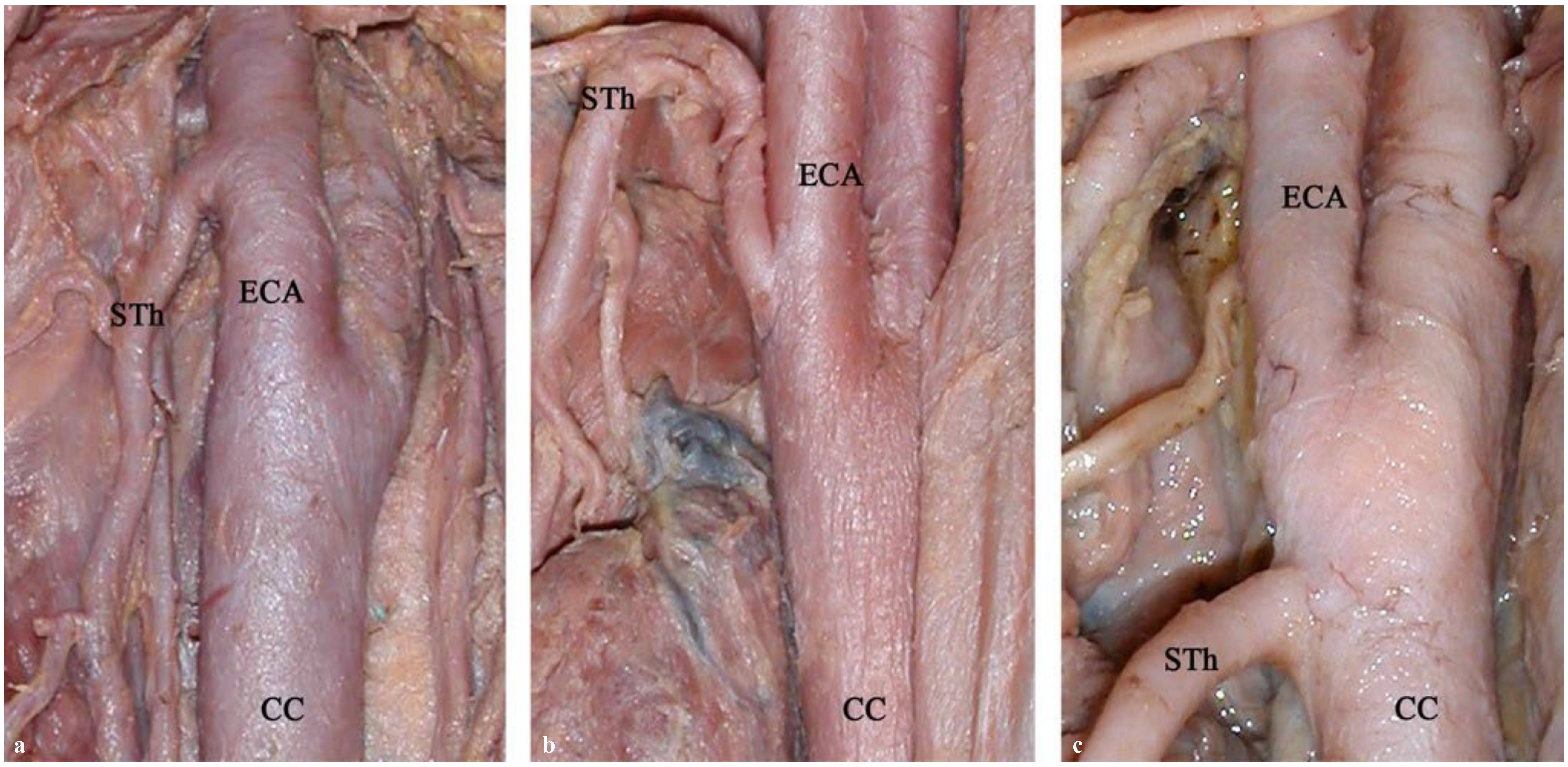


Fig. 6.6 Origin of the superior thyroid artery. **(a)** From the external carotid artery, **(b)** from the carotid bifurcation, **(c)** from the common carotid artery. CC, common carotid artery; ECA, external carotid artery; STh, superior thyroid artery.

at the same level in 14% From the external carotid artery, the artery emerges from the posterior side in 88%, from the lateral side in 8%, and from the medial side in 4% It takes a tortuous course superiorly and posteriorly toward the base of the scalp, traveling beneath the splenius capitis and the sternocleidomastoid muscles.[11,13,14] The mean length of the artery is 9 cm (3.4–12.5 cm). It is divided into descending, horizontal, and vertical branches (**Fig. 6.3**). The horizontal branch runs along the nuchal ridge, connecting across the midline to branches of the contralateral occipital artery. The vertical branch runs superiorly along the posterior skull and anastomoses with the posterior auricular, superficial temporal, and supraorbital arteries (**Fig. 6.7c,d**). The descending branch is divided over the trapezius, and it supplies the trapezius, splenius, and sternocleidomastoid muscles. The descending branch anastomoses with the deep cervical and the ascending branch of the transverse cervical arteries.[2,15]

The sternocleidomastoid artery generally arises from the occipital artery, but sometimes it springs directly as a separate branch from the external carotid artery (**Fig. 6.3**). The distance from the origin of the sternocleidomastoid branch to the external carotid artery is 14.4 mm. It passes downward and backward over the hypoglossal nerve and supplies the sternocleidomastoid muscle and the integument.[11]

Surgical Annotation

The occipital artery is the main artery of the suboccipital region. The vascular network of the cervico-occipital flap consists of the cutaneous and musculocutaneous perforators of the descending branch of the occipital artery anastomosing with the cervical arteries and the cutaneous branches of spinal arteries in the region around the nape of the neck. The cervico-occipital flap is used to reconstruct defects after resection of the mandible or the floor of the mouth and the tongue or to close pharyngoesophageal and tracheal fistulae. As the content of the cervico-occipital flap is richly vascularized and as the two-headed sternocleidomastiod muscle has minimal donor-site morbidity, it is preferred as a myocutaneous flap for stable and durable reconstruction. The upper third of the sternocleidomastoid muscle is supplied by branches of the occipital artery. The middle third receives a branch from the superior thyroid artery (42%), the external carotid artery (23%), or both (27%). The lower third is supplied by a branch arising from the suprascapular artery.[2,15] In the suboccipital region, the mean distance between the point at which the occipital artery pierces the sternocleidomastoid muscle and the inion is 4.8 cm (3.9–6.5 cm). The mean distance between the piercing point of the artery in the muscle and the lower part the mastoid process is 5.1 cm (3.9–5.9 cm). Classically, the occipital artery enters the sternocleidomastoid muscle 1.5 to 2 cm below the anterior margin. The point where the occipital artery enters the sternocleidomastoid and then comes out to the surface up to 4 cm under the process is determined as the reference point. Studies suggest that the greater occipital nerve crosses the occipital artery lateral to the inion. Occipital artery biopsy should be performed between 4 to 5 cm lateral and 1 to 3 cm proximal to the inion to avoid injury to this artery in vasculitis cases.[2,4,15]

Posterior Auricular Artery

The posterior auricular artery arises from the external carotid artery, above the digastric and stylohyoid muscles, opposite the apex of the styloid process.[7,16,17] It has a mean distance of 0.29 cm anterior to the mastoid tip, just deep to the lobule and in the posterior auricular sulcus. It ascends, under cover of the parotid gland, on the styloid process of the temporal bone and, immedi-

Fig. 6.7 Blood supply of the (**a, b**) forehead, (**c**) occipital, and (**d**) retroauricular regions. Red latex is injected into the common carotid arteries before dissection. Fb, frontal branch of the superficial temporal artery; LP, lateral palpebral artery; MP, medial palpebral artery; O, occipital artery; PA, posterior auricular artery; Pb, parietal branch of the superficial temporal artery; So, supraorbital artery; Str, supratrochlear artery; *, anastomoses.

ately above this point, divides into its auricular and occipital branches (**Fig.6.1, Fig. 6.2, Fig. 6.3, Fig. 6.7c,d**). The occipital branch passes backward, over the sternocleidomastoid muscle, to the scalp above and behind the ear. It anastomoses with the occipital artery (**Fig. 6.7c,d**).

Surgical Annotation

The arterial network in the upper ear is formed from the posterior auricular artery. The mean length of this artery before it penetrates the temporoparietal fascia measured from the mastoid tip is 75.6 mm. The posterior auricular artery gives off a retroauricular branch to the posterior surface of the auricle and an occipital branch to the postauricular skin, which travels in the postauricular sulcus. The mean distances from the mastoid tip is 8.4 mm to the occipital branch and 6.8 mm to the auricular branch. The arterial network of the triangular fossa and scaphoid fossa is provided by branches of the superficial temporal and posterior auricular arteries.

Facial Artery (External Maxillary Artery)

The facial artery arises at the level of the greater horn of the hyoid bone a little above the lingual artery’s origin from the external carotid. It can arise from various trunks from the external carotid (**Fig. 6.5**). Hence, the level of the origin is situated

19.6 ± 8.7 (10–35 mm) away from the bifurcation of the common carotid artery. The distance from the origin of the facial artery to a horizontal plane passing over the top side of the thyroid cartilage is 15.4 ± 8.4 mm. It ascends under cover of the posterior belly of the digastric and stylohyoid muscles and grooves the submandibular gland by making a loop. It curves upward over the body of the mandible at the anteroinferior angle of the masseter muscle. It then passes forward and upward across the cheek to the labial commissure. The distances from the facial artery are 13.5 mm (8–23 mm) to the labial commissure and 45 mm (28–60 mm) to the midline. It then ascends along the side of the nose and ends at the medial commissure of the eye as the angular artery (**Fig. 6.1, Fig. 6.8**).

The course of the artery can vary.[6,18–20] Branches to the face include the ascending palatine, inferior labial, tonsillar, superior labial, glandular, lateral nasal, submental, angular, and muscular arteries. The facial artery and its branches mainly supply the mental region, the lips, the inferior part of the parotidomasseteric region, and the buccal, orbital, infraorbital, and nasal regions (**Fig. 6.1, Fig. 6.3**).[3–5,7,11]

Submental Artery

The submental artery is usually the largest of the cervical branches (**Fig. 6.3**). The distances of the origin of the submental artery are 27.5 mm (19–41 mm) to that of the facial artery and 23.8 mm (1.5–39 mm) to the mandibular angle.[2,21] The artery is deep to the anterior belly of the digastric muscle in 70–80% It passes superficial to the mylohyoid nerve, 16.8 mm (9–34 mm) from its origin. A visible anastomosis between the two submental arteries is noted in 92%[20] It anastomoses with the sublingual artery and with the mylohyoid branch of the inferior alveolar artery; at the symphysis menti, it turns upward over the border of the mandible and then is divided into superficial and deep branches. The superficial branch passes between the integument and depressor labii inferioris and anastomoses with the inferior labial artery; the deep branch runs between the muscle and the bone, supplies the lip, and anastomoses with the inferior labial and mental arteries.[20]

Surgical Annotation

The axial myocutaneous platysma flap using the upper part of the mylohyoid muscle is supplied by the submental artery.[2,21] Dissection of the pedicle back to the origin of the facial artery and vein to extend the arc of rotation of the flap is recommended. The diameter of the submental artery is suitable for safe microvascular transfer (1.7–2.2 mm).[5,21] The length of the submental artery is 58.9 mm (35–108 mm); its length from the origin to the anterior belly of the digastric muscle is 31.5 mm (26–38 mm).[21]

The facial artery crosses the inferior border of the mandible obliquely to enter the face at the anteroinferior angle of the masseter muscle. The distance between the mandibular angle and the point where the facial artery crosses the lower border of the mandible is 26.6 mm (15.5–38 mm).[21] It is extremely tortuous. It gives off small muscular branches to the masseter and the depressor anguli oris muscles (**Fig. 6.8a**).

Inferior Labial Artery

The inferior labial artery arises near the angle of the mouth; it passes upward and forward beneath the depressor anguli muscle or penetrates the orbicularis oris muscle (**Fig.6.1, Fig. 6.8a**). The distance from the origin of the inferior labial artery from the labial commissure is 19.3 ± 10 mm (4–35 mm). It follows a tortuous course along the edge of the lower lip between the muscle and the mucous membrane. The length of the inferior labial artery is 34.5 ± 20.8 mm (29–67 mm).[18,20,21] It supplies the labial glands, the mucous membrane, and the muscles of

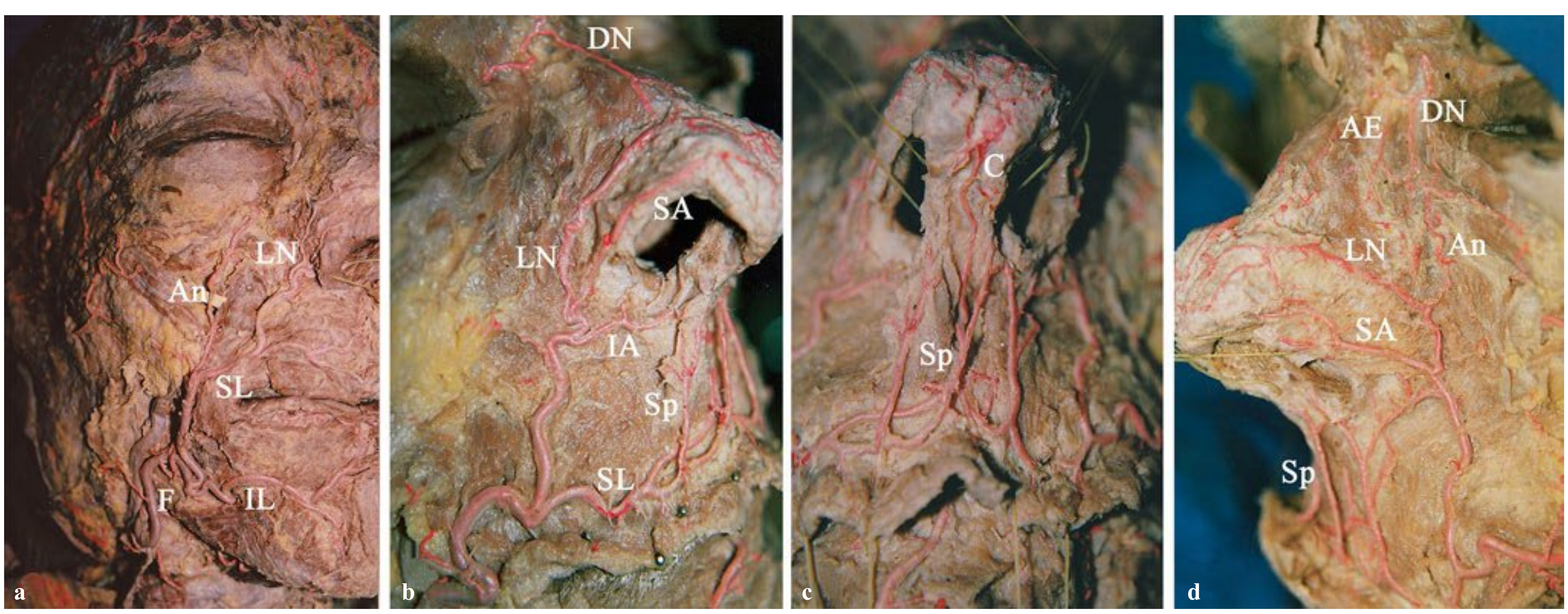


Fig. 6.8 Course of the facial artery and its branches. Red latex is injected into the common carotid arteries before dissection. **(a)** A doubled facial artery, **(b)** nasal-type facial artery. The anastomoses between alar branches and branches of the superior labial artery, and **(c)** septal branch are continued as the columellar artery. **(d)** Angular type facial artery. The anastomoses between the superficial ascending artery and inferior alar branch. AE, anterior ethmoidal artery; An, angular artery; C, columellar artery; DN, dorsal nasal artery; F, facial artery; IA, inferior alar artery; IL, inferior labial artery; LN, lateral nasal artery; SA, superior alar artery; SL, superior labial artery; Sp, septal artery.

the lower lip. It anastomoses with the artery on the opposite side and with the mental branch of the inferior alveolar artery.

Surgical Annotation

The origins of the inferior labial artery vary between the labial commissure and the lower margin of the mandible. The inferior labial artery can arise from the facial artery above the labial commissure (8%), below the labial commissure (22%), and at the labial commissure (60%).[10,18,20] The inferior labial and labiomental arteries come off at the level of the inferior border of the buccinator muscle and run anteriorly, passing deep to the depressor anguli oris. Different arterial distributions exist in the lower lip such as end-to-end anastomosis between the bilateral inferior labial arteries and the inferior labial arteries anastomose with the submental artery. The vertical and horizontal labiomental arteries are situated between the lower lip and the submental region (transfacial anastomosis). The distances from the labial commissure are 29.1 ± 24.2 mm (7–71 mm) to the origin of the horizontal labiomental arteries and 28 ± 12.1 mm (10–52 mm) to the origin of the vertical labiomental arteries. The lengths of the horizontal labiomental arteries are 26.8 ± 10.7 mm (16–49 mm) and the vertical labiomental arteries are 13 ± 4 mm (1–17 mm).[10,18,20,21] The labiomental arteries, which form anastomoses between the facial, inferior labial, and submental arteries, vary in their course in the labiomental region (**Fig. 6.1**).[10,18,20,21] To elevate a labiomental arterial flap safely, routine use of a Doppler probe preoperatively and intraoperatively is recommended.[7,10]

Superior Labial Artery

The facial artery passes deep to the risorius and zygomaticus major muscles but superficial to the buccinator muscle. It gives off one of its major branches, the superior labial artery. Near the labial commissure, it gives off three to five branches to the anterior part of the buccinator and zygomaticus major muscles (**Fig. 6.8**).[20]

The arterial supply to the lips is based on the superior and inferior labial arteries at the level of the labial commissure, where it terminates in the form of a perilabial arterial network (**Fig. 6.4b**, transfacial anastomosis). The arterial supply to the upper lip arises mainly from the superior labial artery and from the subseptal and subalar arteries. The arterial supply to the lower lip arises from the inferior labial artery and the branches of the mental artery.[11,18]

Surgical Annotation

The superior labial artery is larger and more tortuous than the inferior labial artery. It originates as follows: at the level of the labial commissure in 5% of cases, superior to the commissure in 25%, and inferior to the commissure in 70%. It can be identified usually 8 ± 4.4 mm (1–18 mm) lateral to the medial labial commissure. Its length is 4.8 ± 12.2 mm (29–67 mm). In 84.8%, the artery travels exclusively between the orbicularis oris muscle and the oral mucosa; in 15.2%, it travels partially invested by the orbicularis oris. It supplies the upper lip and gives off two or three vessels that ascend to the nose: a septal branch ramifies on the nasal septum, and an alar branch supplies the ala of the nose (**Fig. 6.1, Fig. 6.8**).[10,18,20,21] A relatively large branch that courses along the inferior margin of the nostril on its ascent toward the columellar base is called the inferior alar branch, and the artery running to the nasal tip over the ala nasi is called the superior alar branch. The inferior alar branch supplies the alar base, the nostril floor, and the upper lip; the superior alar branch participates in the vascular plexus of the nasal dorsum and the tip. The length of the superior alar branch is 14.6 ± 5.9 mm (7–26 mm), and that of the septal branch is 15.6 ± 6.2 mm (10–27 mm).[10,18,20]

The superior labial artery runs between the mucosa and orbicularis oris at approximately the border between the white and the red parts of the lips and anastomoses with the opposite artery in the middle of the lip.[6,7] The distances from the superior labial artery at midlip are 6.9 ± 2.5 mm (0.7–11 mm) to the inferior border of the red upper lip, 5.4 ± 1.8 mm (3–9 mm) to its anterior border, and 3.2 ± 0.7 mm to its posterior border.[10,18,20]

These branches are named as two groups: those running between the skin and the muscle are called superficial ascending branches, and those running through the muscle or between the muscle and the mucosa are called deep ascending branches. At the columellar base, there are anastomoses among the superficial ascending and inferior alar arterial branches. Ramifications of the deep ascending and inferior alar branches pass to the nasal septum and ascend along the anterior margin of the septal cartilage. Columellar branches are the continuation of the superficial ascending branches and become part of the vascular plexus of the nasal tip (**Fig. 6.8b–d**). The columellar artery is observed as a single branch in 48.9% and a double pattern in 38.7%.[20]

Lateral Nasal Artery

The lateral nasal artery arises from the facial artery at the nasolabial sulcus level. It runs 2 to 3 mm superior to the alar groove, extends between the nose and the cheek, and gives off the superior and inferior alar arteries to supply the nose (**Fig. 6.1, Fig. 6.8**). The lateral nasal artery anastomoses with its fellow, with the septal and alar branches, with the dorsal nasal branch of the ophthalmic, and with the infraorbital branch of the maxillary arteries (**Fig. 6.1**). The facial artery continues as the angular artery and proceeds to the medial palpebral commissure.[6,7]

Surgical Annotation

Small distal branches of the lateral nasal artery form several anastomoses with contralateral have branches and with the columellar arteries.[5,6,18] Some studies demonstrated the existence of an anastomotic system, situated in the superior musculoaponeurotic system plane, connecting the external and the internal carotid artery systems and the transfacial nasal vascular blood supply, which gives rise to the subdermal plexus. This network explains why many different pedicles can be safely used for local flaps in nasal reconstruction (**Fig. 6.4c,** polygonal system anastomosis). Furthermore, after skin tumor resections, the presence of these anastomotic vessels enables a large vessel ligation to be performed without skin necrosis; however, the presence of so many anastomotic vessels in the nasal area can be easily injured during injections, and creates a risk of embolism or microembolism, especially with rhinoplasties using fillers (**Fig. 6.4a,** intercarotid anastomosis).

Angular Artery

The angular artery is the terminal part of the facial artery; it ascends to the medial angle of the orbit and is accompanied by the angular vein. It is easily found on a vertical line about 6 to 8 mm medial to the medial canthus and 5 mm anterior to the lacrimal sac. In 60% of specimens, the terminal branch is formed by the lateral nasal artery, and in 22% it is formed by the angular artery. It anastomoses with the infraorbital artery on the cheek after supplying the lacrimal sac and the orbicularis oculi. The angular artery ends by anastomosing with the dorsal nasal branch of the ophthalmic artery (**Fig. 6.1, Fig. 6.8c**).[11] Its branches are a communicating branch with the dorsal nasal artery (96%), a communicating branch with the supratrochlear artery (67%), the infratrochlear artery, and the paracentral artery. The paracentral artery originates from the angular artery as the main continuation into the forehead (71%) or from the communicating branch with the supratrochlear artery (30%).[7,11,20,22]

Surgical Annotation

Difficult oronasal mucosal defects, including defects of the palate, alveolus, nasal septum, antrum, upper lip and lower lip, floor of the mouth, and soft palate, can be reconstructed using an axial musculomucosal flap based on the facial artery and its branches. Their diameters are suitable for microvascular anastomosis.[6,7,11,20] Most of these flaps are based on local axial vascularization via the labial arteries, but anatomical variations can lead to problems; its branching pattern shows great variability (**Fig. 6.8a, Fig. 6.9**). The distribution patterns of the artery are categorized into six types, A–F (**Fig. 6.9**).[6,7,11,20] In type A (47–78%) the artery bifurcates into the superior labial and lateral nasal arteries (the latter gives off the inferior and superior alar and ends as the angular artery). Type B (38–60%) is similar to type A except the lateral nasal terminates as the superior alar (the angular artery is absent). In type C (8–12%), the facial artery terminates as the superior labial artery. In type D (3.8%), the angular artery arises directly from the facial arterial trunk rather than as the termination of the lateral nasal, with the facial artery ending as the superior alar. In type E (1.4–3%), the facial artery terminates as a rudimentary twig without providing significant branches. Type F presents a doubled facial artery.[23] On the basis of anatomical studies, the degree of vascular territory lost as a result of vessel damage during the myocutaneous flap procedure can be estimated. For example, ligation of the superior labial artery in a patient with type A, B, or C would not result in ischemic injury to the nose, as the blood supply is provided by a separate lateral nasal artery. In contrast, ligation of the superior labial artery in a patient with type D or E distribution is more likely to result in loss of the vascular supply to the lateral nose.[7,10]

The facial musculomucosal flap is an axial flap based on the superior labial artery in an anterograde fashion or the angular artery in a retrograde fashion.[3,7,10] The nasolabial flap can be based on the angular artery either inferiorly or superiorly in an anterograde or retrograde fashion, respectively. Doppler ultrasound helps to locate the facial vessels and provides information about backflow and the potential for inverted flow in the facial artery.[7,10]

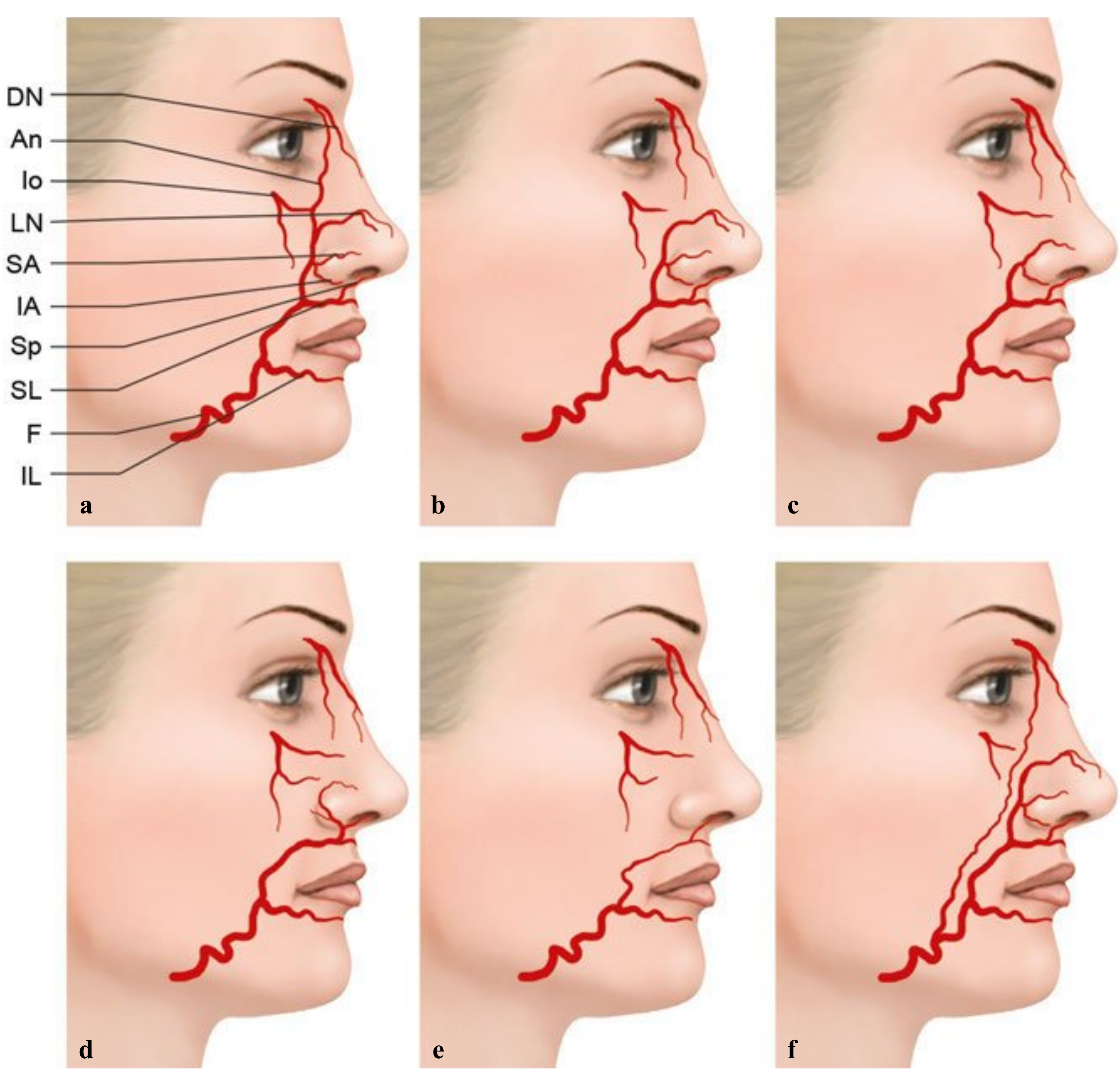


Fig. 6.9 Schematic drawing of the types of facial artery. **(a)** Angular, **(b)** nasal, **(c)** alar, **(d)** labial, **(e)** hypoplastic, **(f)** double type. An, angular artery; DN, dorsal nasal artery; F, facial artery; IA, inferior alar artery; IL, inferior labial artery; Io, infraorbital artery; LN, lateral nasal artery; SA, superior alar artery; SL, superior labial artery; Sp, septal artery.

Maxillary Artery

The maxillary artery, the larger of the two terminal branches of the external carotid artery, arises behind the neck of the mandible (**Fig. 6.2**). It runs in the infratemporal fossa superficial to the lateral pterygoid muscle and is easily found about 6.64 ± 6.33 mm from the infratemporal crest. It supplies the deep structures of the face and can be divided into mandibular, pterygoid, and pterygopalatine parts.[11] Its total length is 57.38 ± 7.1 mm.

Its first, or mandibular, part lies deep behind the mandibular ramus. From this part, the inferior alveolar artery arises. The distance between the origin of the maxillary artery and the inferior alveolar artery is 10.8 ± 6 mm.[11] It descends with the inferior alveolar nerve to the mandibular foramen on the medial surface of the ramus of the mandible. As it enters the foramen, it runs along the mandibular canal. The mental artery is the terminal branch of the inferior alveolar artery that passes with the nerve through the mental foramen to supply the chin and the lower lip. The mental branch anastomoses with the submental and inferior labial arteries.

The second, or pterygoid, part runs obliquely forward and upward under the cover of the ramus of the mandible. It runs either superficially or deep to the lateral pterygoid to the pterygopalatine fossa. Branches of this second part are the deep temporal, the masseteric, the pterygoid, and the buccinator arteries.[7,20,21] The deep temporal branches (i.e., three branches) ascend anteriorly and posteriorly between the temporalis muscle and the pericranium; they supply the muscle (**Fig. 6.2**). These arteries anastomose with the middle temporal artery; the anterior communicates with the lacrimal artery via small branches perforating the zygomatic bone (polygonal anastomosis). The masseteric artery passes laterally through the mandibular notch to the deep surface of the masseter muscle.[11] It supplies the muscle and anastomoses with the masseteric branches of the facial arteries and with the transverse facial arteries (**Fig. 6.2**). The buccinator artery runs obliquely forward, between the pterygoid and the insertion of the temporal muscles, to the outer surface of the buccinator muscle. It anastomoses with branches of the facial and with the infraorbital arteries (**Fig. 6.2**).

The third, or pterygopalatine, part lies in the pterygopalatine fossa near the pterygopalatine ganglion. The branches of this third part are the posterior superior alveolar artery; the artery of the pterygoid canal; and the infraorbital, pharyngeal, descending palatine, and sphenopalatine arteries (**Fig. 6.2**). The infraorbital artery appears, from its direction, to be a continuation of the trunk of the maxillary artery.[11,24] It runs along the infraorbital groove and canal with the infraorbital nerve. The infraorbital artery reaches the face through the infraorbital foramen and supplies the lower eyelid, the cheek, and the lateral nose (**Fig. 6.1, Fig. 6.2**). On the face, some branches pass upward to the medial angle of the orbit and the lacrimal sac. It anastomoses with the angular branch of the facial artery (**Fig. 6.2**); some run toward the nose, anastomosing with the dorsal nasal branch of the ophthalmic artery (**Fig. 6.4a**), and others descend between the levator labii superioris and the levator anguli oris and anastomose with the facial, transverse facial, and buccinator arteries (**Fig. 6.4c**).

Surgical Annotation

The location of the masseteric artery is easily determined in relation to three points in the anterioposterior plane between the mandibular condyle and the coronoid process: (1) the anterosuperior aspect of the condylar neck, (2) the most inferior aspect of the articular tubercle, and (3) the inferior aspect of the sigmoid notch. The mean distance of the masseteric artery to the most anterosuperior aspect of the condylar neck is reported as 10.3 mm; to the most inferior aspect of the articular tubercle, 11.4 mm; and to the most inferior aspect of the sigmoid notch, 3 mm.[25]

The temporalis muscle flap has been widely used for surgery of the skull base and the reconstruction of oral cavity and oropharyngeal defect. The vascular network of the temporalis muscle flap comes from three main pedicles: the anterior deep artery, the posterior deep artery (both collateral branches of the maxillary artery), and the middle temporal artery (a collateral branch of the superficial temporal artery).[25] The distance between a temporalis muscle flap and a temporalis muscle split on its superficial artery is 57 mm. The flap allows the midline to be crossed easily, thus broadening its indication. The gain obtained is greater than that obtained with a flap split on the deep temporal pedicles, and it can easily cross the midline; this is an important point.

Superf cial Temporal Artery

The superficial temporal artery arises from the external carotid artery deep to the parotid gland. It ascends behind the condyle of the mandible.[25–27] The important branches of the superficial temporal artery are the transverse facial, anterior auricular, middle temporal, frontal and parietal arteries (**Fig. 6.1, Fig. 6.3**). Just before it reaches the zygomatic arch, the superficial temporal artery gives off the transverse facial artery.

The transverse facial artery arises from the superficial temporal artery in the parotid gland after branching off the maxillary artery. Its number ranges from one to three (mean, 1.34). It runs parallel about a finger's breadth inferior to the zygomatic arch (**Figs. 7.3, Fig. 6.10**). It passes transversely across the side of the face, between the parotid duct and the lower border of the zygomatic arch, and is divided into superior and inferior trunks after coursing 1 to 11 mm within the gland. The superior trunk is usually larger than the inferior trunk. The superior trunk is located below the level of the glandular border, 5.0 to 26.1 mm from the zygomatic arch (mean, 14.0 mm). Most perforators (76.8%) arise from the superior trunk, which can be useful when the structures are visible during surgery. The transverse facial artery is crossed by the temporal and zygomatic branches of the facial nerve. It anastomoses with the facial, masseteric, buccinator, and infraorbital arteries (**Fig. 6.10**, transfacial anastomosis).

The middle temporal artery arises immediately above the zygomatic arch and perforates the temporal fascia. It gives branches to the temporalis muscle and anastomoses with the deep temporal branches of the maxillary artery.

Fig. 6.10 Course of the superficial temporal artery and its branches. Red latex is injected into the common carotid arteries before dissection. **(a, b)** Bifurcation of the artery above the zygomatic arch, the anastomoses between the zygomatico-orbital artery and transverse facial artery; **(c)** bifurcation of the artery over the zygomatic arch; the frontal branch is larger than the parietal branch. F, Facial artery; Fb, frontal branch; G, parotid gland; H, helicial artery; Pb, parietal branch; Sh, suprahelical artery; ST, superficial temporal artery; TF, transverse facial artery; Zo, zygomatico-orbital artery; *, interfacial anastomosis.

The anterior auricular arteries run to the helix and the tragus. They reach the helix by passing under the superficial temporal vein at the level of the arch. The arteries are distributed to the anterior portion of the auricle, the lobule, and part of the external meatus, and they anastomose with the posterior auricular artery. The helical artery arises from the parietal branch of the superficial temporal artery where it bifurcates over the arch (**Fig. 6.10a, b**).

Surgical Annotation

An arterial anastomosis formed in the shape of an arcade has clinical importance in providing a longer flap for reconstruction. For instance, the anastomosis between the superficial temporal and the posterior auricular arteries is used as the Ishio flap when postauricular skin is pedicled on the superficial temporal vessels to reconstruct the nose.[1,10]

The zygomatico-orbital artery is present in 78 to 92%, and it originates from the superficial temporal artery and sometimes from its frontal branch. It courses anteriorly parallel to the upper border of the zygomatic arch between two layers of the temporal fascia to the lateral orbital region.[19,26] In the lateral face, it supplies the parotid gland and duct, facial nerve, facial muscles, and skin of the lateral canthus.[19,26] It anastomoses with the lacrimal and palpebral branches of the ophthalmic artery (**Fig. 6.1, Fig. 6.3, Fig. 6.10**).

Entering the temporal fossa, about 2 cm above the zygomatic arch, the superficial temporal artery is divided into frontal and parietal branches. In various studies, the bifurcation point of the artery has been observed above the zygomatic arch in 61 to 88% of cases, directly over the arch in 3.8 to 26%, and below the arch in 7 to 11.5%.[11,26–28]

The parietal branch (posterior) extending posteriorly curves upward and backward on the side of the head as the continuation of the superficial temporal artery. The parietal branch has anastomotic connections with the ipsilateral and contralateral arteries with the epicranial aponeurosis (**Fig. 6.7, Fig. 6.10**). The sub-branches coursing toward the front anastomose with the frontal branch in the temporoparietal region. Those going backward anastomose with the posterior auricular artery and occipital artery in the back of the head. Its perforating branches pass the deep fascia.

The frontal branch (anterior) runs tortuously upward and forward to the forehead, parallel to the upper corner of the orbicularis oculi muscle. Its perforating branches pass the deep fascia and the frontalis muscle. The frontal branch supplies the muscles, the integument, and the pericranium in this region. It anastomoses with the opposite frontal branch on the galea, with the supraorbital and supratrochlear arteries on the forehead, and with the zygomatico-orbital artery around the orbit and the forehead (**Fig. 6.7, Fig. 6.10**).

Surgical Annotation

Temporoparietal, parieto-occipital, galeopericranial, or forehead flaps are prepared on the superficial temporal artery and its branches. Face and neck reconstructions performed by using the superficial temporal artery with flaps have some advantages.

First, an end-to-end microanastomosis technique is practical. Dissecting the artery distally makes it possible to turn it over cranially or caudally to facilitate anastomosis. The diameters of the superficial temporal artery and its branches make them suitable for microvascular anastomoses.[5,17,25,26] The diameter of the superficial temporal artery is 2.03 to 2.14 mm, that of the frontal branch is 1.61 to 2.1 mm, and that of the parietal branch is 1.44 to 2.1 mm.[5,17,25,26] An atrophic frontal branch is present in 2%, either the parietal branch or the frontal branch is atrophic in 4%, an atrophic superficial temporal artery is present in 2%, and double parietal branches are present in 4%.[5,17,25,26] Second, even if the superficial temporal artery has been ruptured during previous procedures, the zygomatico-orbital artery may be available and is easily identified using Doppler or ultrasonography and can readily be accessed by following the superficial temporal artery.[19] Third, the preserved superficial temporal artery can be used another time.

The distance between the superficial temporal artery and the tragus is important for designing preauricular flaps. A rotation of the flap is successfully performed to include the parietal branch according to the anterior hairline and the course of this branch.[25,26] Some landmarks are chosen on the head: the middle point to the bony lateral canthus (A), the tragus (B), the superior attachment of the ear to the head (C), and a point 2 cm directly above this attachment (D). These points are joined to the bony lateral canthus by straight lines: AB, AC, and AD. The DF line, which takes Juri's original flap as a base, begins at the point 2 cm above the ear and is directed anterosuperiorly 45 degrees above the AD line to the anterior hair line. The F point is over the anterior hairline. Whether the parietal branch has passed the DF line is checked. According to Juri's design, the DF line builds the base of the parieto-occipital flap, and the parietal branch has to be located in the flap.[27] Line A–B is 80 ± 5 mm (65–87 mm), line A–C 81.8 ± 5.3 mm (66.2–88 mm), line A–D 83.6 ± 4.7 mm (72–90 mm), and line D–F 11 ± 7.7 mm.

Knowing the location of the transverse frontal artery can be of value for designing a galeal frontalis flap. If it is low, then a hairline incision would be adequate for the transverse forehead flap. If it is higher in the forehead, a superior incision in the hairline would be needed to capture the veins, which are more superior or posterior to the arteries, and in order to avoid venous congestion in this flap. The level at which the transverse frontal artery enters the forehead is often easily palpable, and the frontal branch of the superficial temporal artery is often easily seen weaving tortuously in the temporal area and the lateral forehead. The frontal branch of the superficial temporal artery and the transverse frontal artery are always anterior to the frontalis muscle.[16,23,27] At this point, the transverse frontal artery or the frontal branch of the superficial temporal artery often bends. The anastomosis of the oblique branch of the supraorbital artery is clinically significant; therefore, the distinction between the transverse frontal artery and the frontal branch of the superficial temporal artery is important. This arcade is crucial for planning flaps.

On the basis of anatomical studies, the retroauricular free flap pedicled on the superficial temporal vessels has advantages over the retroauricular free flap pedicled on the posterior auricular artery because the superficial temporal vessels are more reliable in course and caliber when the posterior auricular artery and its comitantes are compared.[16,23,27]

Ophthalmic Artery

The ophthalmic artery provides blood supply to the eyes, the upper two-thirds of the nose, and the anterior part of the forehead. Its branches include the lacrimal, ethmoid, supraorbital, supratrochlear, and external nasal arteries (**Fig. 6.2**). It arises from the internal carotid artery and enters the orbital cavity through the optic foramen. It then passes to the medial wall of the orbit, and then forward beneath the lower border of the obliquus superior muscle, and divides into branches.

The supraorbital artery exits the orbit with the supraorbital nerve through the supraorbital foramen, or notch, to supply the skin and the muscles of the forehead and scalp (**Fig. 6.1, Fig. 6.2, Fig. 6.7a,b**). Its terminal branches anastomose to the opposite side via the supratrochlear and the frontal branch of the superficial temporal arteries. The supratrochlear artery supplies the medial forehead and scalp as well as the root of the nose. The dorsal nasal artery anastomoses with the lateral nasal and infraorbital arteries. It provides blood supply to the medial eyelids and dorsal nasal skin. The external nasal branch, a branch of the anterior ethmoidal artery, supplies the skin of the nasal dorsum and tip.

Surgical Annotation

There is significant communication between the external and internal carotid artery systems around the eye through several anastomoses. These anastomoses run between the collateral branches of the internal carotid—the ophthalmic, supraorbital, supratrochlear, dorsal nasal, and lacrimal arteries (**Fig. 6.4c**, intercarotid anastomosis)—and the collateral and terminal branches of the external carotid—the facial artery (angular artery), superficial temporal, transverse facial and middle temporal arteries, and the frontal and parietal branches (**Fig. 6.4c**, transfacial anastomosis).

The supraorbital and supratrochlear vessels are described as an "intricate system of anastomosing vessels" between the angular, the supratrochlear, and the superficial temporal arteries.[13,29] Inadvertent intra-arterial injection of soft tissue augmentation around the eye can lead to occlusion of the central retinal vessels and potentially to blindness.[7,19] To avoid this complication, fillers should be injected in small volumes via blunt cannulas, implementing a careful retrograde injection technique (**Fig. 6.4c**, polygonal anastomosis).[10,30]

Lateral Palpebral Artery

The lateral palpebral arteries arise from the lacrimal artery and distribute to the eyelids and conjunctiva. They run medially in the upper and lower lids respectively and anastomose with the medial palpebral arteries, forming an arterial circle. The medial palpebral arteries leave the orbit to encircle the eyelids near their free margins, forming a superior and an inferior arch, which lie between the orbicularis oculi and the tarsus (**Fig. 6.1, Fig. 6.11**). The lacrimal artery gives off one or two zygomatic branches, one of which passes through the zygomaticotemporal foramen to reach the temporal fossa and anastomoses with the deep temporal arteries. Another branch appears on the cheek through the zygomaticofacial foramen and anastomoses with the transverse facial artery.[10,11,30]

Medial Palpebral Artery

The medial palpebral arteries are usually divided into branches for the upper and lower lids as the superior and inferior medial palpebrals.[10,30] The superior branch passes under the medial palpebral ligament to enter the upper eyelid. The inferior branch courses downwards behind the medial palpebral ligament to enter the lower lid (**Fig. 6.11b,c**).

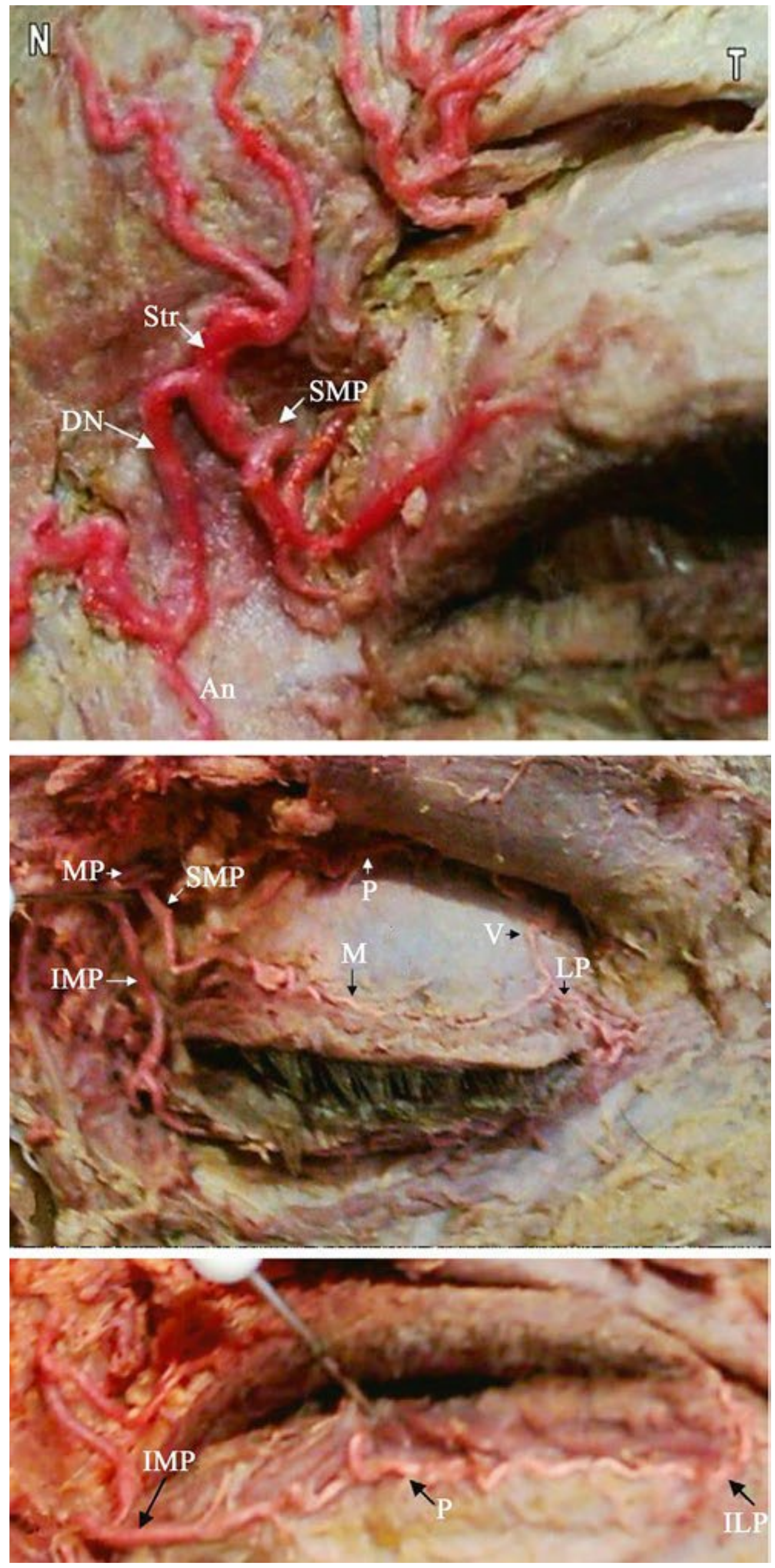
The main blood supplies to the upper and lower lids are provided by arterial arcades. The superior palpebral arcade is situated at the lateral angle of the orbit with the zygomatico-orbital artery and the upper two lateral palpebral branches from the lacrimal artery.[11,24] The inferior palpebral arcade is at the lateral angle of the orbit, with the lower of the two lateral palpebral branches from the lacrimal, transverse facial artery, and at the medial part of the lid, with a branch from the angular artery (**Fig. 6.11c**).

The blood supply to the upper eyelid is composed of three arcades: marginal, supratarsal, and preseptal, which communicate by an anastomotic network of vertical branches. These small vertical branches run under the orbicularis oculi muscle in the submuscular fibroelastic layer.[30] The preseptal arcade is supplied by the branches of the ophthalmic artery (supraorbital, supratrochlear, and medial palpebral arteries). The marginal arcade is supplied by an anastomotic network connecting the supratarsal (60%) and preseptal (20%) arcades. Small vertical branches arising out of these arcades provide a richer and more complex anastomotic network.[24]

Surgical Annotation

The color match, contour, thickness, and mobility of the skin flap must be similar to the normal upper eyelid. Upper eyelid flaps, whether they have a medial or lateral pedicle or are bipedicled or with island flaps, are centered on the supratarsal arcade or the preseptal arcade.

Hematomas can arise because of injury to a perforating branch of the marginal arcade. The marginal arcade is easily found on the tarsus just 3 mm from the lid margin. Unexpected bleeding may be due to variants of an artery communicating between the peripheral and marginal arcades.[30] If artery variants are anticipated, bleeding can be prevented during blepharoplasty by more careful dissection of the eyelid around 4.5 mm from the lateral canthus.



a

b

c

Fig. 6.11 Arteries of the **(a)** medial canthus, **(b)** upper eyelid, and **(c)** lower eyelid. Red latex is injected into the common carotid arteries before dissection. An, angular artery; DN, dorsal nasal artery; ILP, inferior lateral palpebral artery; IMP, inferior medial palpebral artery; LP, lateral palpebral artery; M, marginal arcade; MP, medial palpebral artery; P, peripheral arcade; SMP, superior medial palpebral artery; Str, supratrochlear artery; V, variant artery; N, nasal side, T, temporal side.

Ethmoidal Artery

The two ethmoidal arteries are posterior and the anterior. The posterior ethmoidal artery passes through the posterior ethmoidal canal. Its branches descend into the nasal cavity through apertures in the cribriform plate, anastomosing with the branches of the sphenopalatine artery. The anterior ethmoidal artery accompanies the nasociliary nerve through the anterior ethmoidal canal. It then descends into the nasal cavity, running along the groove on the inner surface of the nasal bone. Its terminal branch appears on the dorsum of the nose between the nasal bone and the lateral cartilage (**Fig. 6.1, Fig. 6.2**).

The frontal artery, one of the terminal branches of the ophthalmic artery, leaves the orbit at its medial angle with the supratrochlear nerve and, by ascending on the forehead, supplies the integument, the muscles, and the pericranium by anastomosing with the supraorbital artery and with the artery of the opposite side.

Supratrochlear Artery

The supratrochlear artery is relatively constant around the medial canthal vertical line and appears from the superomedial orbit (**Fig. 6.11a, Fig. 6.12**). The supratrochlear artery exits the orbit in a position 1.7 to 2.2 cm lateral to the midline. The course continues vertically in the forehead 1.5 to 2.0 cm lateral to the midline and goes across a transverse unnamed vessel to anastomose with the contralateral artery (**Fig. 6.1, Fig. 6.8d, Fig. 6.11a**).[11,29] The branches visible in the dissection are the medial communicating branch in 60%, lateral communicating branch in 23%, superior palpebral artery in 26%, periosteal branches in 7%, and cutaneous branches. Numerous additional muscular branches are present as oblique branches in 19%, medial and lateral vertical branches in 53%, and a single vertical branch in 47%(**Fig. 6.11a**).

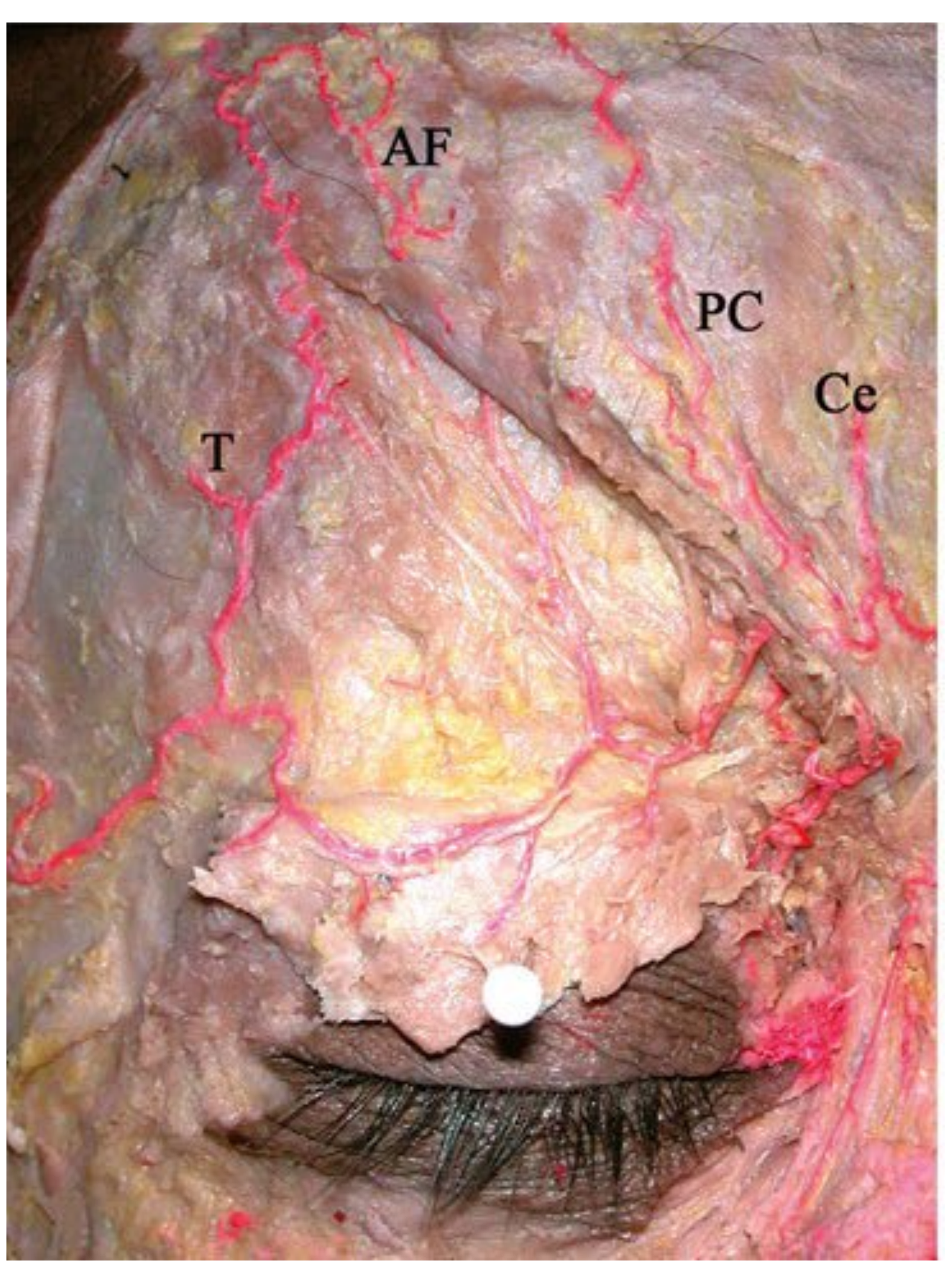
Surgical Annotation

The supratrochlear artery travels under the orbicularis oculi muscle and over the corrugator muscle and then becomes superficial. The cutaneous branch is easily found at a position 11.8 to 3.6 mm superior to the supraorbital rim and 13.5 to 3.4 mm lateral to the midline (**Fig. 6.12**).[29] The supratrochlear artery enters a subcutaneous plane at average distances of 35 mm superior from the supraorbital rim and 56 mm from the supraorbital artery.[5,14] The superior one-third of the cutaneous branch travels under the dermis and over the fat layer.[29] The inferior two-thirds portion travels under the fat layer and over the frontalis muscle and gradually becomes superficial. The muscular branch travels through the frontalis muscle, but the cutaneous branch travels subcutaneously. The cutaneous branch anastomoses with the muscular branch or the supraorbital artery and the supratrochlear artery of the opposite side (**Fig. 6.12**).[5,29]

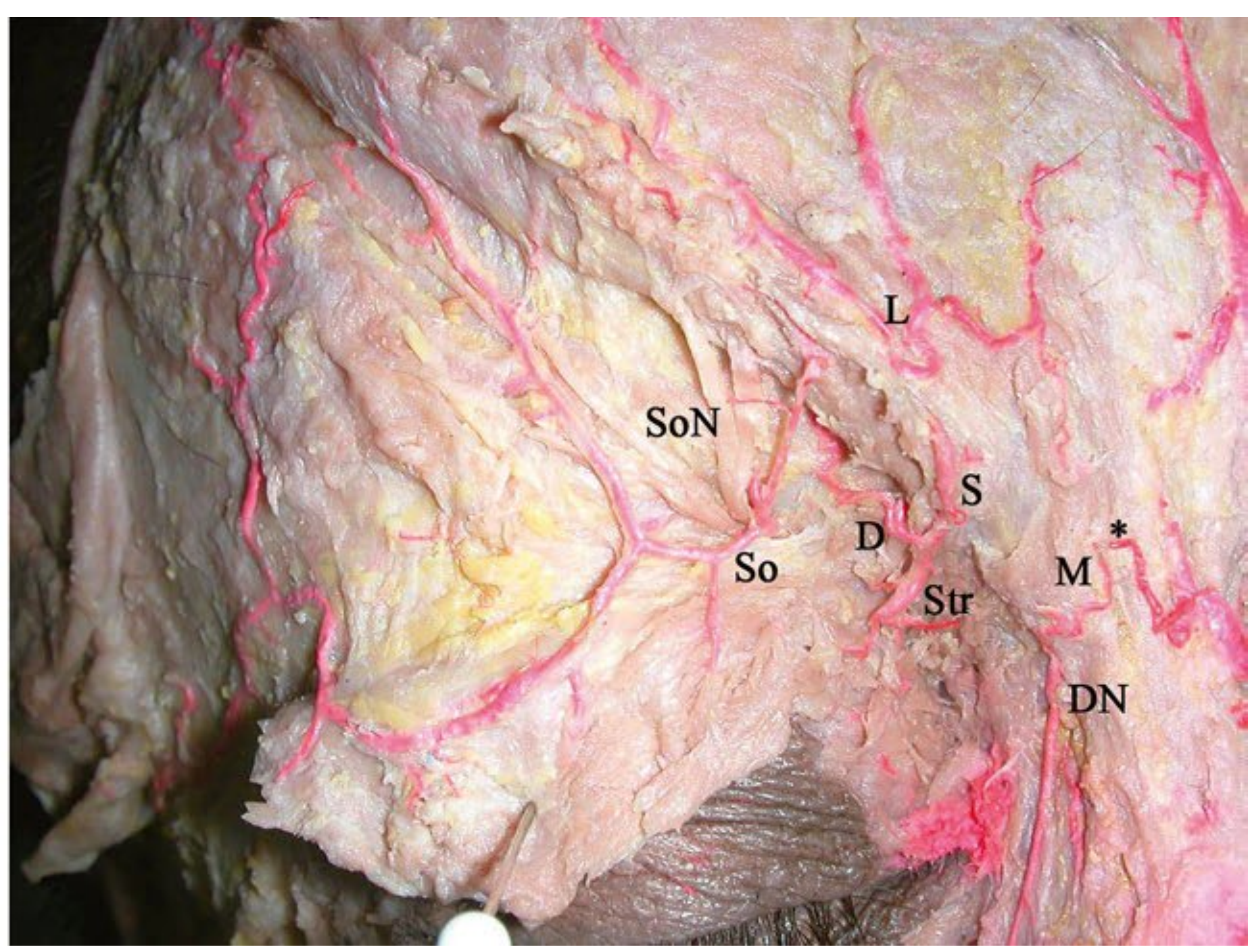
The artery can possibly have a periosteal course from the middle third of the forehead superiorly, which has clinical importance in flap planning. The paramedian forehead flap is supplied by the supratrochlear artery.[1,13] The common practice of removing fat from the superior third of the paramedian forehead flap could be quite risky if not done under direct vision because a variation has been reported in which the supratrochlear artery dives to a periosteal level in the middle third of the forehead and continues superiorly at the periosteal level. To avoid any possible risk of tip or distal partial necrosis or epidermolysis, the distal third flap should not be defatted at the first stage. The blood supply to the medial forehead is primarily from the supratrochlear and supraorbital arteries, ignoring the important contribution from the angular artery (dorsal nasal, central and paracentral arteries).[13,29]

Supraorbital Artery

The supraorbital artery appears over the supraorbital rim on a vertical line corresponding to the medial limbus of the cornea. It runs from medial to lateral over the supraorbital rim as it exits the orbit (**Fig. 6.1, Fig. 6.12**). The supraorbital artery passes through the supraorbital foramen and then divides into superficial and deep branches.[5,28] Five branches of the supraorbital artery are seen: the lateral rim (91%), oblique (91%), vertical (100%), medial, and brow (5%) branches. The medial, oblique, and lateral rim branches are always deep (periosteal or submus-



a



b

Fig. 6.12 Distribution of the neuroarterial structures on the orbitofrontal region (**a, b,** closer). Red latex is injected into the common carotid arteries before dissection. Photograph showing anastomosis of superficial temporal and supraorbital arteries; anastomosis of superficial temporal and supratrochlear arteries. AF, ascending frontal artery; Ce, central artery; D, deep (muscular) branch of the supratrochlear artery; DN, dorsal nasal artery; L, lateral communicating branch supratrochlear artery; M, medial communicating branch supratrochlear artery; PC, paracentral artery; S, superficial (cutaneous) branch of the supratrochlear artery; So, supraorbital artery; SoN, supraorbital nerve; Str, supratrochlear artery; T, transverse frontal artery; *, transfacial anastomosis.

cular). Often more than one vertical branch is present, or it subbranches soon after its origin.[7,13,29] The oblique branch runs on the periosteum toward either the frontal branch of the superficial temporal artery or the transverse frontal artery at the lateral orbital rim. The supraorbital artery is accompanied by the supraorbital nerve and the supraorbital vein. It supplies the integument, the muscles, and the pericranium of the forehead, anastomosing with the frontal branch of the superficial temporal and the artery on the opposite side.[16,28]

Surgical Annotation

The superficial arterial branches of the face cannot be recommended as the basis for any planned flap. The consistent presence of deep branches of the supraorbital artery makes them suitable for planning supraorbital artery–based flaps.[7,13] Potentially, a vascularized frontal bone flap could be developed using these deep branches. This flap could be useful for orbital roof or medial wall reconstruction.

Dorsal Nasal Artery

The dorsal nasal artery, the other terminal branch of the ophthalmic artery, emerges from the orbit above the medial palpebral ligament. It then gives off a twig to the upper part of the lacrimal sac. The artery is divided into two terminal branches, one of which crosses the root of the nose and anastomoses with the angular artery; the other runs along the dorsum of the nose, supplies its outer surface, and anastomoses with the artery on the opposite side and with the lateral nasal artery.[29,31]

Surgical Annotation

The dorsal nasal artery can be identified usually 5 to 7 mm above the medial canthal horizontal line. It gives off a superior central artery 3 to 5 mm after its origin.[32] It has many anastomoses with the angular artery, supratrochlear artery, alar branch of the facial artery, and superior labial artery (**Fig. 6.9, Fig. 6.12**). Two constant paramedian longitudinal branches from the dorsal nasal artery communicate freely across the midline.[1,28]

The central artery originates from the dorsal nasal artery. It supplies the glabella and inferior and middle transverse thirds of the central forehead. The central artery also has lateral anastomoses with the supratrochlear artery.

With an extensive surgical defect, such as eyelid trauma, periorbital cancer excision, cicatricial secondary healing, congenital anomalies, or nerve paralysis, a flap can be considered for eyelid reconstruction. Among the periorbital options, the goal of the reconstruction is to obtain functional and esthetic results.[31,33]

The branches of the ophthalmic artery (e.g., the dorsal nasal and supratrochlear arteries and the terminal branch of the angular artery) are responsible for the nutrition of the inner canthus region.[22,30] Dorsal nasal and angular artery flaps are repaired with a midline forehead flap, a paramedian forehead flap, a single-stage midline forehead flap, an interpolated melolabial flap, or a local nasal flap.[10,31–33]

Dual perfusion at the midline is consistent in the regions of the skin and soft tissue of the nasal dorsum, the forehead, and the lips. The vessels of the face form a series of plexuses, such as the deep facial, subcutaneous, and subdermal plexus. The deep facial plexus provides deep circulation to the anterior face lying deep behind or passing through the mimetic muscles.[6] This plexus communicates with the subdermal plexus via a dense population of small musculocutaneous penetrating branches of the facial, infraorbital, and supratrochlear arteries. The fasciocutaneous perforators of the transverse facial, submental, and posterior auricular arteries reach the subdermal plexus by passing through the deep facial planes and subcutaneous layers (**Fig. 6.4c**).[10]

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7 Veins of the Face and Neck

Yusuke Shimizu

Introduction

In this chapter, the venous system of the head and neck is categorized into the veins of the face, scalp, and neck. The main venous drainage pathway of the face is through the hemiloop-like vein that surrounds the orbit. The vein can be formed by the supraorbital, angular, or facial veins, depending on its location. It collects most of the blood from the face and connects mainly to the zygomatico-temporal, superior ophthalmic, deep facial, and internal jugular veins. The main venous drainage pathway of the superficial parts of the scalp is through the superficial temporal, middle temporal, occipital, and posterior auricular veins. These veins drain into the external jugular vein. The internal jugular vein is the main venous drainage pathway of the head and neck; the external and anterior jugular veins are the pathways from the superficial layers of the region. The vertebral vein collects blood from the prevertebral muscles and drains into the brachiocephalic vein.

Veins of the Face

The main venous drainage pathway of the face is primarily the facial vein. In the middle of the face, the hemiloop-like vein surrounds the orbit.[1] This vein can be contributed to by the supraorbital, angular, or facial veins, depending on its location (**Fig. 7.1**). These veins are connected to the zygomatico-temporal vein in the upper lateral region of the orbit, to the superior ophthalmic vein in the medial canthal area, to the deep facial vein in the nasolabial area, and to the internal or external jugular veins in the lower lateral area (**Fig. 7.2**). As with most superficial veins, these veins have many variations. Common patterns are discussed here (**Fig. 7.3**).

Supraorbital Vein

The supraorbital vein passes medially above the orbital rim under the orbicularis oculi muscle to connect to the angular vein in the medial canthal area. A branch of the supraorbital vein also connects to the superior ophthalmic vein at the supraorbital notch or foramen. Laterally, it connects to the zygomatico-temporal vein arising from the middle temporal vein near the zygomatic process of the frontal bone. There, it also connects with radicles of the superficial temporal veins.

Surgical Annotations

The zygomatico-temporal vein is known as a *sentinel vein*. The vein is located in a 10-mm zone above which the temporal branch of the facial nerve passes.[2]

Supratrochlear Vein

Basically, one or two large veins arise from the medial canthal area and run toward the forehead. The supratrochlear vein connects to the tributaries of the superficial temporal veins to form a large venous network in the forehead. Both the deep veins from the pericranial layer and the superficial veins from the galea frontalis layer empty into the vein.[3] The supratrochlear vein finally joins the angular or nasal root vein near the medial canthus.[1]

Nasal Root Vein

Arising superficially from the angular vein, the nasal root vein pierces the procerus muscle and anastomoses with its contralateral counterpart to form a large communicating vein under the skin of the nasal root.[1] The nasal root vein is convex toward the nasal tip. It is a bridge of the bilateral hemiloop-like veins. Several tributaries from the external nose connect to the nasal root vein (**Fig. 7.4**).

Angular Vein

The angular vein is formed by the union of the supratrochlear and supraorbital veins. It runs inferiorly across the medial margin of the medial canthal tendon approximately 8 mm from the medial canthus of the eye.[4] It becomes the facial vein at its

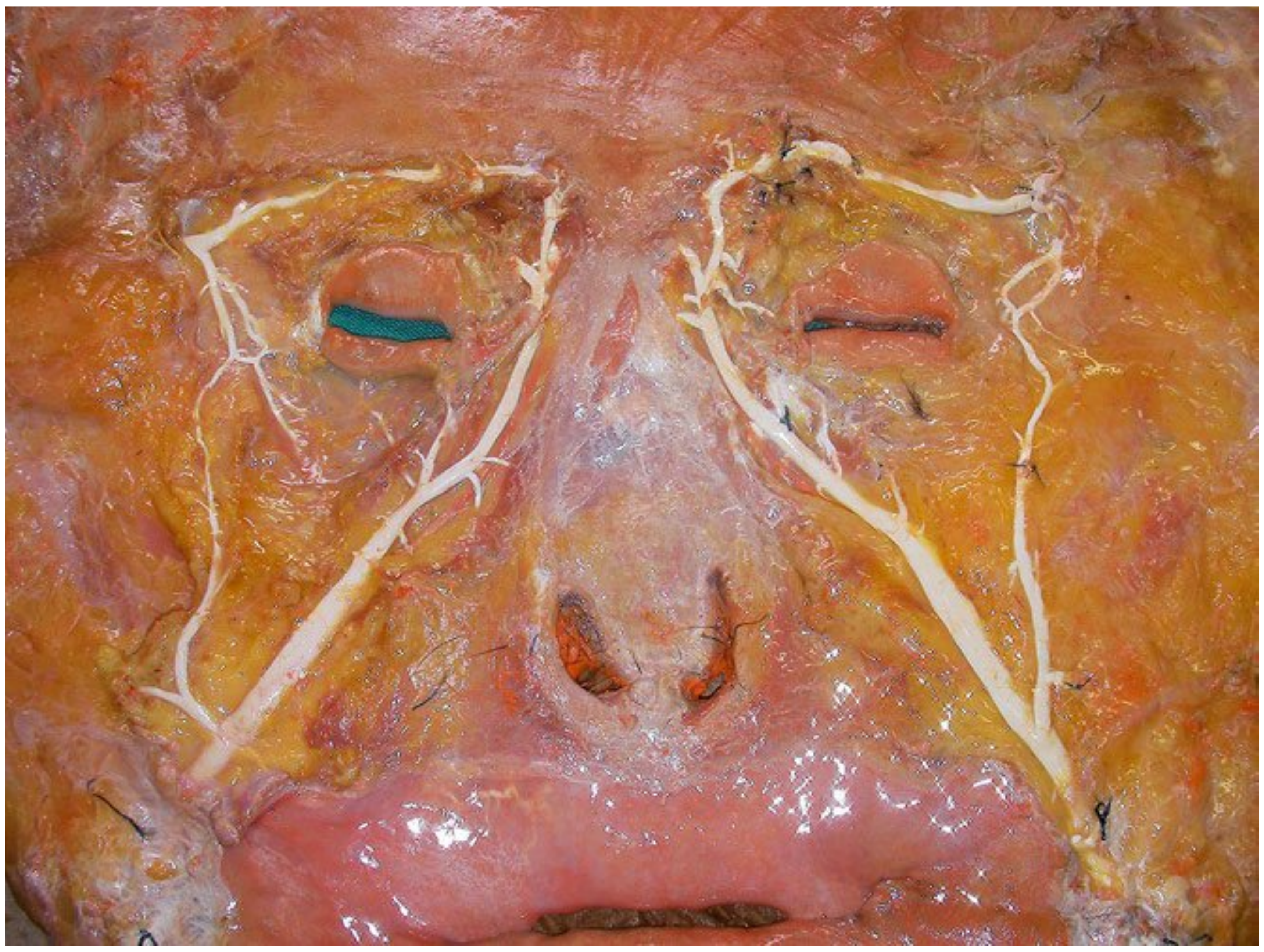

Fig. 7.1 Fresh cadaver specimen with white contrast medium inside the veins. The hemiloop-like vein surrounds the orbit. The vein can be formed by the supraorbital, angular, or facial injected into veins, depending on its location.

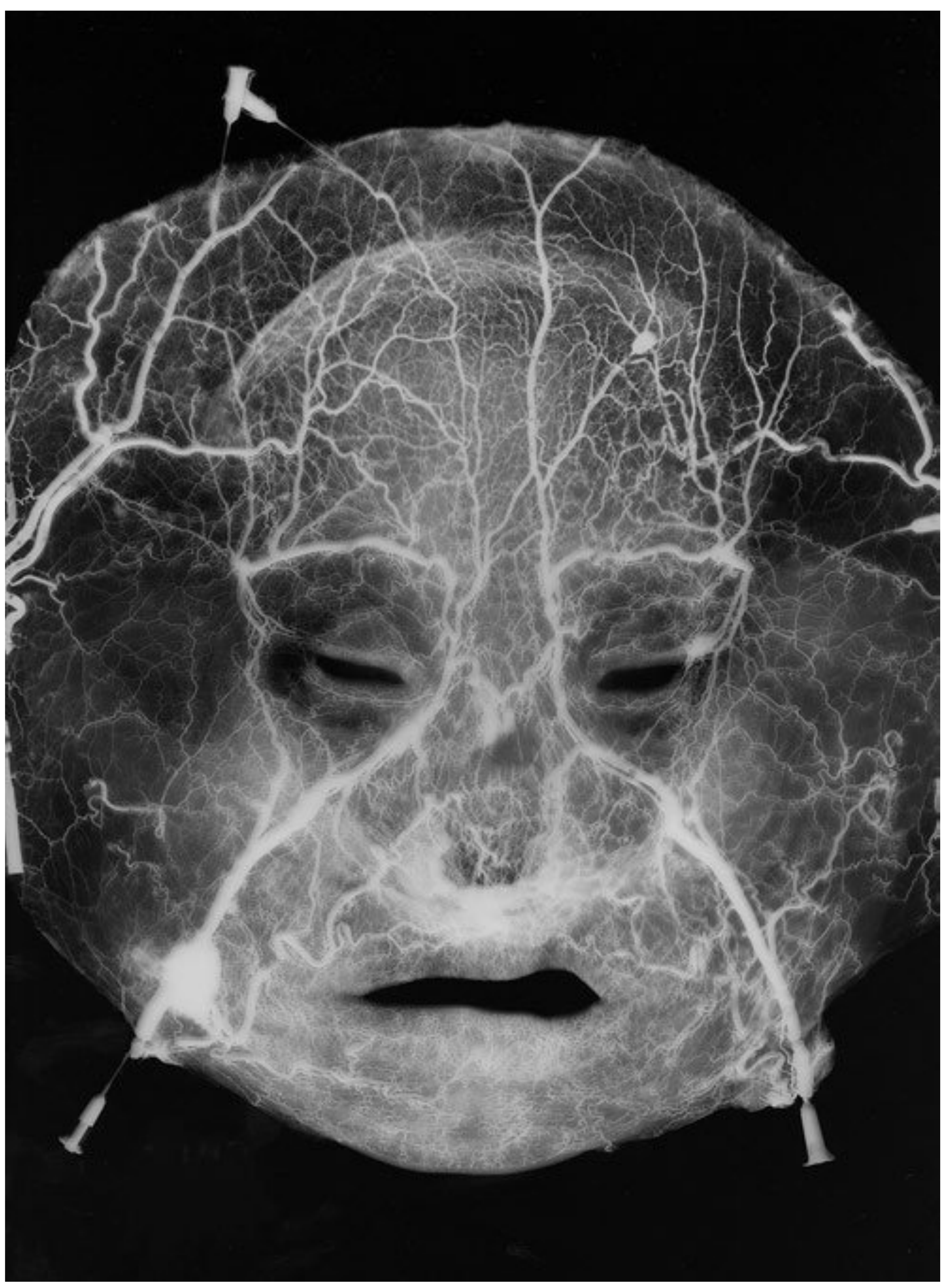

Fig. 7.2 Arteriovenogram of the face. The hemiloop-like vein surrounds the orbit. The tributaries of the superficial temporal vein connect to the vein in the forehead area. The supratrochlear vein connects to the vein in the medial canthal area. The vein drains into the facial vein.

junction with the superior labial vein.[5] The two major veins arise from it, namely, the transverse nasal root vein (superficial) and a branch to form the inferior root of the superior ophthalmic vein (deep). Several tributaries from the external nose and lower eyelid also connect to the angular vein (**Fig. 7.5**).

Superior Ophthalmic Vein

The superior ophthalmic vein is formed at the superomedial margin of the orbit immediately posterior to the trochlea by the union of two contributing roots, namely, a superior root from the supraorbital vein and an inferior root from a branch of the angular vein. It runs with the ophthalmic artery and links the facial and intracranial veins. It traverses the superior orbital fissure to end in the cavernous sinus. The superior ophthalmic vein has venous valves; the blood flows toward the cavernous sinus.[6]

Inferior Ophthalmic Vein

The inferior ophthalmic venous plexus is formed by veins with abundant interconnections.[7] It originates in a network of minute veins in the anterior region of the orbital floor and receives veins from the inferior rectus muscle, inferior oblique muscle, lacrimal sac, and eyelids. It usually joins the superior ophthalmic vein. Rarely, the vein can drain directly into the cavernous sinus.[8] It connects with the pterygoid venous plexus by a small branch that passes through the inferior orbital fissure.

Facial Vein

The facial vein is the main venous drainage pathway of the face. It starts from the angular vein and descends obliquely near the

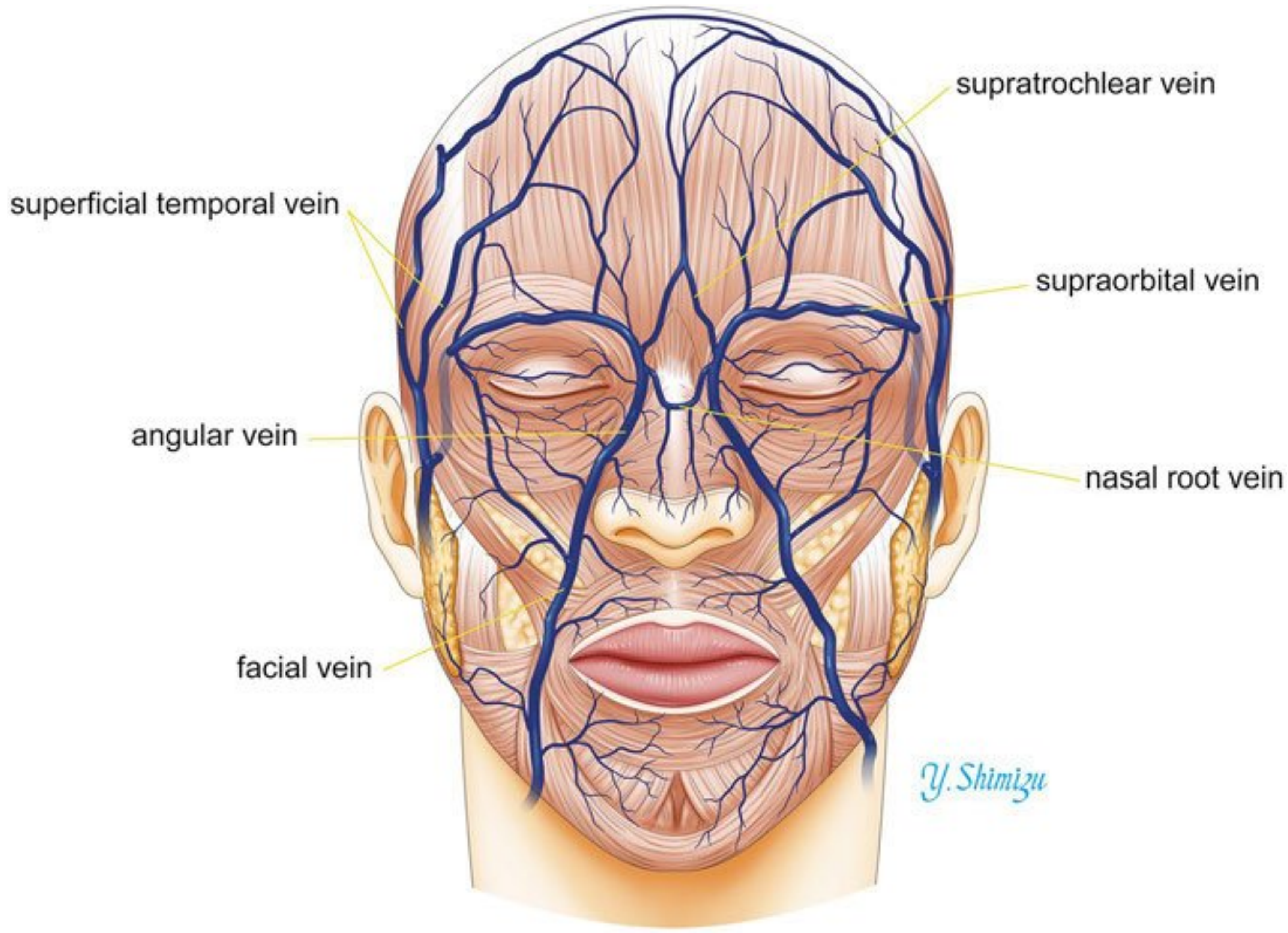

Fig. 7.3 A common pattern of the facial veins. The facial vein begins at the angular vein and descends obliquely near the nasolabial fold.

side of the nasolabial fold. The facial vein and artery lie in close proximity at the level of the lower edge of the mandible. Thereafter, however, the artery takes a tortuous course among the facial muscles, whereas the vein has a direct path from the angular vein to the lower mandibular border.[9] It passes under the facial muscles and crosses the body of the mandible and runs obliquely back under the platysma but superficial to the submandibular gland and digastric and stylohyoid muscles. The facial vein is joined by the anterior division of the retromandibular vein near the mandibular angle and finally drains directly or indirectly into the internal jugular vein.

Cranial to the mandible, the deep facial vein from the pterygoid venous plexus and the inferior palpebral, superior and inferior labial, buccinator, parotid, and masseteric veins join the facial vein. Caudal to the mandible, the submental, tonsillar, external palatine, and submandibular veins join the facial vein.

The facial vein has valves, particularly around the level of the mandible (**Fig. 7.6**).[10] The distribution of venous valves indicates that the blood flow is caudal toward the internal jugular vein in the lower part of the facial vein and normally toward the cavernous sinus in the superior ophthalmic vein.[6]

Fig. 7.4 The nasal root vein. The nasal root vein connects the bilateral hemiloop-like veins at the nasal root. Several tributaries from the external nose connect to the vein.

Fig. 7.5 The angular vein. Several tributaries from the external nose and lower eyelid connect to this vein.

Surgical Annotations

The facial vein connects with the cavernous sinus by two major routes, that is, through the superior ophthalmic vein or through the deep facial vein to the pterygoid plexus and, finally, the cavernous sinus. Thus, infection may spread from the face to the intracranial venous sinuses.

Pterygoid Venous Plexus

The pterygoid venous plexus is an extensive network of small vascular channels that are located between the temporalis and lateral pterygoid muscles (**Fig. 7.7**). The sphenopalatine, deep temporal, pterygoid, masseteric, buccal, alveolar, greater palatine, and middle meningeal veins and a branch from the inferior ophthalmic vein join the plexus. The plexus connects with the facial vein through the deep facial vein and with the cavernous sinus through the sphenoidal emissary foramen, foramen ovale, and foramen lacerum. Its deep temporal branch often connects with tributaries of the anterior diploic vein and thus with the middle meningeal veins.

Fig. 7.6 The valve in the facial vein. The facial vein commonly has valves around the level of the mandible.

Surgical Annotations

In reduction malarplasty, which is common in Asian patients, osteotomy should be performed cautiously and not too deep in reaching the periosteum of the posterior side of the maxillary sinus to avoid injuring the deep facial vein, which lies just behind the posterior side of the maxillary sinus.[11]

Maxillary Vein

The maxillary vein consists of a short trunk that serves as the main drainage pathway of the pterygoid venous plexus. It passes backward between the sphenomandibular ligament and neck of the mandible with the mandibular segment of the maxillary artery.[12] It forms the retromandibular vein by connecting with the superficial temporal vein.

Retromandibular Vein

The retromandibular vein is a deep drainage pathway of the face formed by the union of the superficial temporal and maxillary veins. It runs caudally in the parotid gland. It divides into two major branches: (1) an anterior branch that passes forward to join the facial vein to form the common facial vein and a (2) posterior branch that joins the posterior auricular vein to form the external jugular vein.

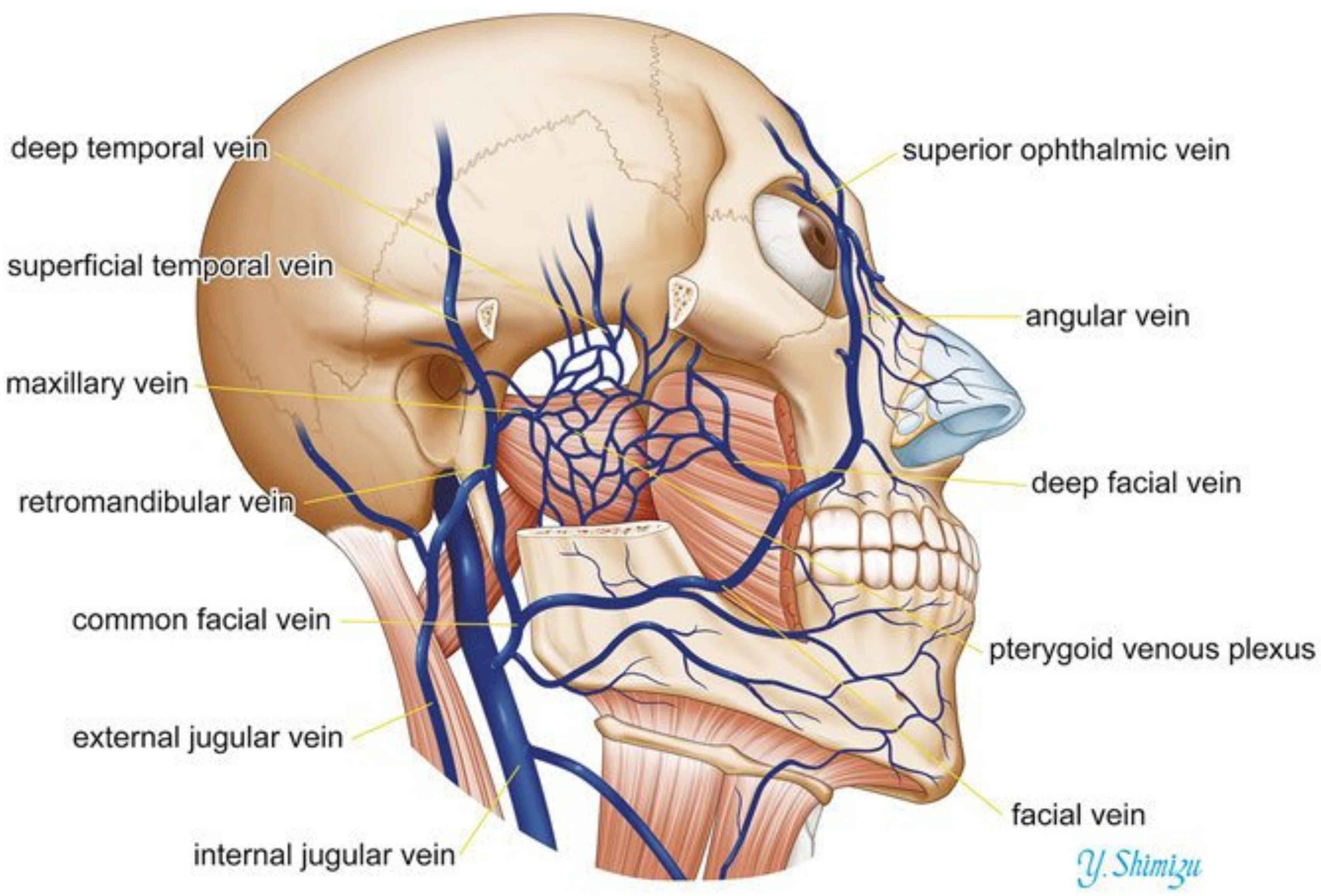

Fig. 7.7 The pterygoid venous plexus. The pterygoid venous plexus is an extensive network of small vascular channels that are located between the temporalis and lateral pterygoid muscles. The sphenopalatine, deep temporal, pterygoid, masseteric, buccal, alveolar, greater palatine, and middle meningeal veins and a branch from the inferior ophthalmic vein join the plexus.

Veins of the Scalp

The main venous drainage pathway of the superficial part of the scalp is through the superficial temporal, middle temporal, occipital, and posterior auricular veins (**Fig. 7.8**).

Superficial Temporal Vein

The superficial temporal vein begins in a widespread network of the scalp. It joins the corresponding vein of the contralateral side, the ipsilateral supratrochlear, supraorbital, posterior auricular, and occipital veins. The vein divides into one, two, or three major branches in the scalp. The pathways are basically independent from the frontal and parietal branches of the superficial temporal artery, except for its proximal portion.[13] The proximal portion of the vein crosses the zygomatic arch and enters the parotid gland to unite with the maxillary vein to form the retromandibular vein. The superficial temporal vein receives blood from the parotid veins, articular veins from the temporomandibular joint, anterior auricular veins, and the transverse facial vein from the side of the face.

Middle Temporal Vein

The middle temporal vein lies beneath the superficial layer of the deep temporal fascia and is distributed in the superficial temporal fat pad between the superficial and deep layers of the deep temporal fascia.[14] The vein connects the supraorbital vein

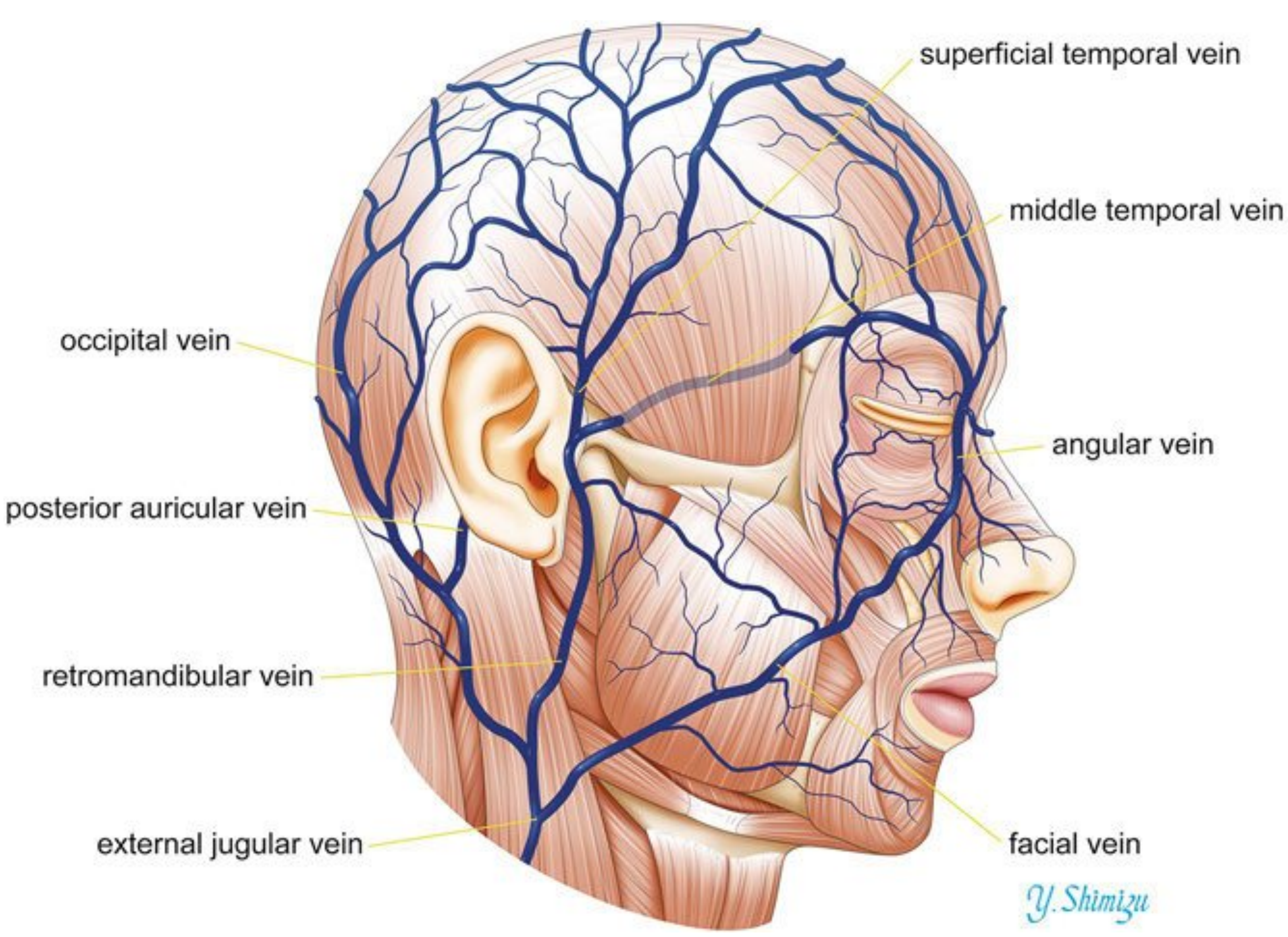

Fig. 7.8 The veins of the scalp. The main venous drainage pathway of the superficial part of the scalp is through the superficial temporal, middle temporal, occipital, and posterior auricular veins.

through the zygomatic temporal vein near the zygomatic process of the frontal bone. As the vein passes back to the proximal side, it pierces and runs several millimeters over the surface of the superficial layer of the deep temporal fascia. Finally, the vein joins the superficial temporal vein approximately 1 cm below the upper aspect of the zygomatic root.

Surgical Annotations

The caliber of the middle temporal vein is significantly greater than that of the superficial temporal vein.[14] The vein can be safely used as a recipient vessel in case of free-tissue transfer.

Occipital Vein

The vein begins as a plexus in the posterior scalp at the external occipital protuberance. It pierces the cranial attachment of the trapezius muscle, turns into a venous plexus in the suboccipital triangle, and joins the deep cervical and vertebral veins. It finally joins the posterior auricular vein. Occasionally, it accompanies the occipital artery and ends in the internal jugular vein. The parietal and mastoid emissary veins link it with the superior sagittal and transverse sinuses.

Posterior Auricular Vein

The posterior auricular vein begins from the parieto-occipital venous network, which communicates with the occipital and superficial temporal veins. It descends behind the auricle to join the posterior branch of the retromandibular vein to form the external jugular vein. It collects the blood from the stylomastoid vein and some tributaries from the cranial surface of the auricle and also often receives a mastoid emissary vein from the sigmoid sinus.

Surgical Annotations

Inadvertent injury of the mastoid emissary vein poses a significant problem not only because of difficulty with hemostasis but also because of its bidirectional flow and close proximity to the sigmoid sinus.[15]

Veins of the Neck

Basically, the internal jugular vein collects most of the blood from the head and neck (**Fig. 7.9, Fig. 7.10**). It drains all but the subcutaneous structures. The external and anterior jugular veins collect blood from the superficial layer of the head and neck. They drain a much smaller volume of tissue than do the deep veins.[16] Some veins connect directly to the subclavian veins, which collect blood from the upper limbs. The internal jugular and subclavian veins connect to form the brachiocephalic vein. The bilateral brachiocephalic veins drain into the superior vena cava.

Subclavian Vein

The subclavian vein is a continuation of the axillary vein that runs from the outer border of the first rib to the medial border of the anterior scalene muscle. From here, it connects with the internal jugular vein to form the brachiocephalic vein. The vein follows the subclavian artery and is separated from the artery by the insertion of the anterior scalene muscle. Hence, the vein

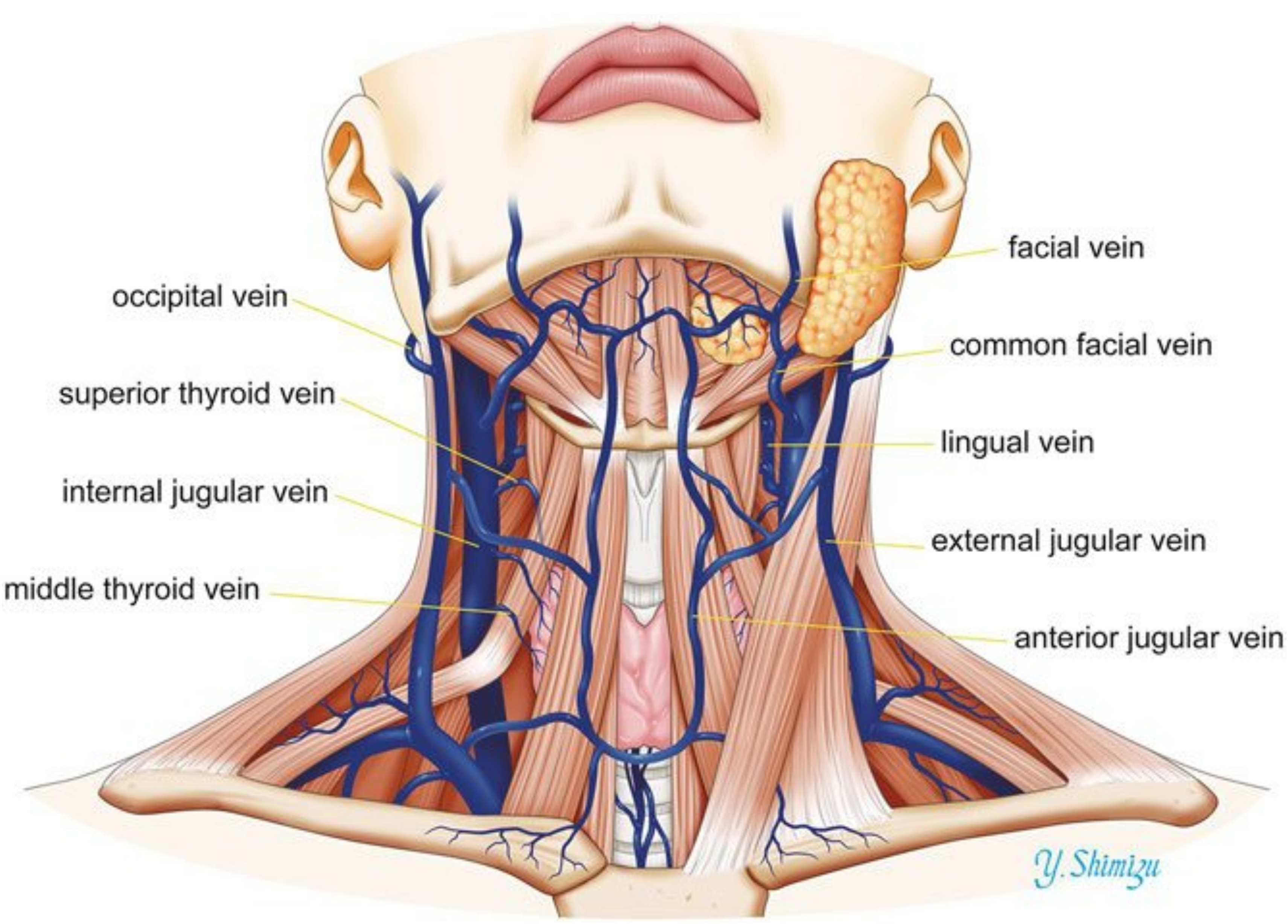

Fig. 7.9 The veins of the neck (anterior view). The internal jugular vein basically collects most of the blood from the head and neck. The external and anterior jugular veins collect blood from the superficial layer of the head and neck. Some veins connect directly to the subclavian veins.

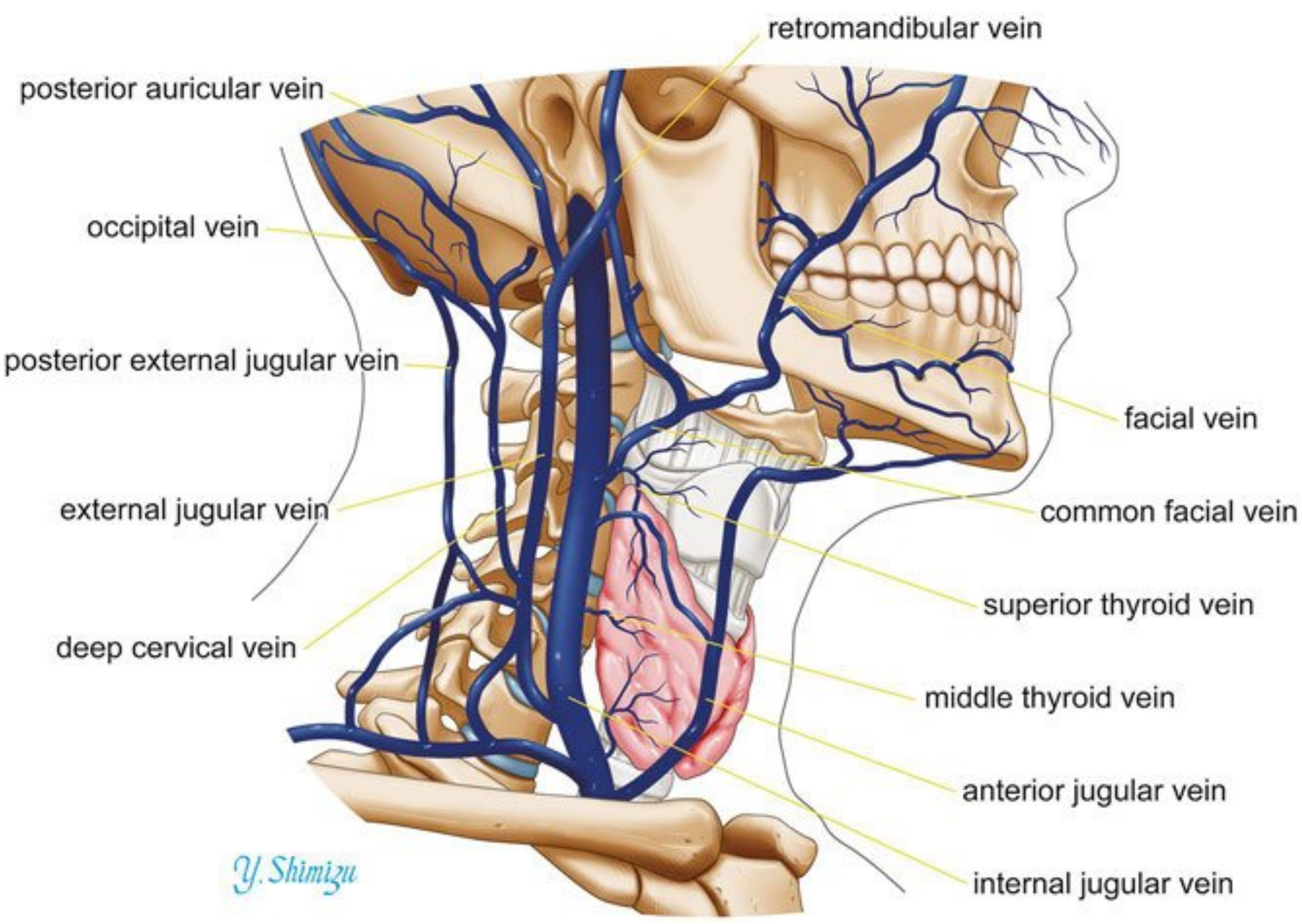

Fig. 7.10 The veins of the neck (lateral view).

lies anterior to the muscle, whereas the artery lies posterior to the muscle. The thoracic duct drains into the left subclavian vein near its junction with the left internal jugular vein (i.e., venous angle), and the right lymphatic duct drains into the junction of the right internal jugular and right subclavian veins.

Internal Jugular Vein

The internal jugular vein collects blood from the skull, brain, face, and most of the neck. The inferior petrosal and sigmoid sinuses unite to form the internal jugular vein, which begins in the jugular foramen at the cranial base. At its origin, there is the so-called superior bulb. The vein runs caudally in the carotid sheath, lying just lateral to the arteries, uniting with the subclavian vein to form the brachiocephalic vein near the sternal end of the clavicle. At its end, there is the so-called inferior bulb, which contains a pair of valves above it. Generally, the left vein is thinner than the right vein.

The posterior aspect of the vein consists of the rectus capitis lateralis muscle, transverse process of the atlas, levator scapulae muscle, middle scalene muscle, cervical plexus, anterior scalene muscles, phrenic nerve, thyrocervical trunk, vertebral vein, and first part of subclavian artery. The medial aspect of the vein is bordered by the the internal and common carotid arteries and vagus nerve. The vagus nerve is usually found between the artery and vein. Superficially, the vein is overlapped above and then covered below by the sternocleidomastoid muscle and crossed by the posterior belly of the digastric muscle and superior belly of the omohyoid muscle. The deep cervical lymph nodes lie along the vein, mainly on its superficial aspect. At the root of the neck, the right internal jugular vein is separated from the common carotid artery; the left usually overlaps its artery. At the cranial base, the internal carotid artery is anterior and is separated from the vein by the ninth to the twelfth cranial nerves. The facial, lingual, pharyngeal, superior, and middle thyroid veins, and sometimes the occipital veins, join the internal jugular vein. It may communicate with the external jugular vein.

Lingual Veins

The lingual veins begin on the dorsum, sides, and undersurface of the tongue and pass back along the course of the lingual artery and end in the internal jugular vein. The dorsal lingual veins drain the dorsum and sides of the tongue and join the lingual veins between the hyoglossus and genioglossus muscles. The deep lingual vein begins near the tip and passes back near the mucous membrane on the inferior surface of the tongue. Near the anterior border of the hyoglossus muscle, it joins a sublingual vein that drains the salivary gland to form the vena comitans of the hypoglossal nerve, which passes back between the mylohyoid and hyoglossus muscles to join the facial, internal jugular, or lingual vein.

Pharyngeal Veins

The pharyngeal veins begin in a pharyngeal plexus posterolateral to the pharynx. After communicating with the pterygoid venous plexus and receiving meningeal veins, they end in the internal jugular vein

Superior Thyroid Vein

The superior thyroid vein begins in the substance of the thyroid gland and passes cranially along with the superior thyroid artery. The vein receives the superior laryngeal and cricothyroid veins and ends in the upper part of the internal jugular vein.

Middle Thyroid Vein

The middle thyroid vein drains the lower part of the thyroid gland, the larynx, and the trachea. It crosses anterior to the common carotid artery to join the lower part of the internal jugular vein.

External Jugular Vein

The external jugular vein largely drains the scalp and face. It lies superficial to the sternocleidomastoid muscle and can be represented by a line that starts just below and behind the angle of the mandible and descends to the clavicle near the posterior border of the sternocleidomastoid muscle. The union of the posterior division of the retromandibular and posterior auricular veins begins near the mandibular angle. It runs caudally in the direction of a line drawn from the angle of the mandible to the middle of the clavicle at the posterior border of the sternocleidomastoid muscle. It is covered by the platysma, superficial fascia, and skin, separated from the sternocleidomastoid muscle by deep cervical fascia. The external jugular vein varies in size, bearing an inverse proportion to the other veins in the neck. The vein is occasionally doubled.[16] It has valves at its entrance into the subclavian vein approximately 4 cm above the clavicle between which it is often dilated. The external jugular vein receives the posterior external jugular vein and, near its end, the transverse cervical, suprascapular, and anterior jugular veins. In the parotid gland, it is often joined by a branch from the internal jugular vein. The occipital vein occasionally joins it.

Anterior Jugular Vein

The anterior jugular vein begins near the hyoid bone by the confluence of the superficial veins from the submaxillary region. It descends between the midline and anterior border of the sternocleidomastoid muscle and turns laterally in the lower part of the neck. It joins the end of the external jugular or subclavian vein directly. The size of the vein is usually in inverse proportion to that of the external jugular vein. It communicates with the internal jugular veins and receives the laryngeal veins and sometimes a small thyroid vein. There are usually two anterior jugular veins and they are united by a large transverse jugular arch above the sternum. The arch receives tributaries from the inferior thyroid veins.

Posterior External Jugular Vein

The posterior external jugular vein begins in the occipital scalp and drains the skin and superficial muscles in the upper and back parts of the neck, lying between the splenius and trapezius muscles. It descends at the back part of the neck and usually joins the middle part of the external jugular vein.

Deep Cervical Vein

The deep cervical vein accompanies its artery between the semispinalis capitis and colli muscles. It starts from veins from the occipital and suboccipital muscles and from the plexuses around the cervical spine. It passes forward between the seventh cervical transverse process and neck of the first rib to join the lower part of the vertebral vein. It receives tributaries from the plexuses around the spinous processes of the cervical vertebrae.

Vertebral Vein

The vertebral vein is formed in the suboccipital triangle by numerous small tributaries from the internal vertebral venous plexuses, which leave the vertebral canal above the posterior arch of the atlas. They unite with small veins from the local deep muscles to form a vessel that enters the foramen in the transverse process of the atlas to descend around the vertebral artery as a plexus. This plexus ends as the single vertebral vein, emerging from the sixth cervical transverse foramen. It descends to join the brachiocephalic vein. A small accessory vertebral vein usually descends from the vertebral plexus. It traverses the seventh cervical transverse foramen and turns forward between the subclavian artery and cervical pleura to also join the brachiocephalic vein. The vertebral vein receives branches from the occipital vein, prevertebral muscles, and internal and external vertebral plexuses. It receives the anterior vertebral and deep cervical veins and sometimes the first intercostal vein.

Anterior Vertebral Vein

The anterior vertebral vein begins as a plexus around the upper cervical transverse processes. It descends with the ascending cervical artery between the attachments of the anterior scalenus and capitis longus muscles and connects with the vertebral vein.

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8 Facial Nerve and Temporal Bone

Orlando Guntinas-Lichius

Introduction

The facial nerve has a complex course from the brainstem to the periphery. The nerve crosses critical and frequently accessed surgical structures in cranial-base surgery, otoneurologic surgery, head and neck surgery, and cosmetic surgery. During transtemporal approaches, the surgeon has to drill the temporal bone to avoid injury to the facial nerve. When performing approaches to the regions involving the facial nerve, it is mandatory to understand the topographic anatomy of the facial nerve from different surgical perspectives. This chapter provides an overview of the facial nerve from the brainstem through the temporal bone. The extratemporal course of the facial nerve is presented in Chapter 9. All portions and segments of the facial nerve, its blood supply, surrounding structures, radiologic anatomy, and relation to typical surgical approaches are presented in detail to guide the surgical management of this important structure.

Segments of the Facial Nerve

Because of the intricate course of the facial nerve from the brainstem to the periphery, the course is divided into three different portions. Topographically, the portions of the facial nerve are divided into segments. The portions and segments are summarized in **Table 8.1**. The facial nerve is composed of branchiomotor, parasympathetic, visceroafferent, and somatic-efferent fibers. Facial-nerve branches with different fiber qualities are leaving or entering the nerve during its course to the periphery. The facial nerve has internal branches leaving and entering the nerve in the temporal bone, and all external branches leave the nerve after its exit from the stylomastoid foramen.[1] **Table 8.2** gives an overview of the facial nerve branches.

Intracranial Portion

Three primary brainstem nuclei contribute to the function of the facial nerve: (1) the facial motor nucleus for somatic motor function (in a stricter sense, the facial nerve is an exclusive motor nerve), (2) the superior salivatory nucleus for secretomotor (autonomic) function, and (3) the nucleus of the tractus solitarius for taste. All three nuclei are located in the brainstem (**Fig. 8.1**): (1) the facial motor nucleus in the lower third of the pons in the floor of the fourth ventricle, (2) the superficial salivary nucleus directly next to the facial motor nucleus, and (3) the nucleus of the tractus solitarius lateral to the dorsal vagus nucleus in the medulla oblongata. It is important, when treating a patient with a brainstem lesion and facial palsy, to differentiate the localization of the nuclei of the facial nerve. Depending on the lesion site, the patient can have a supranuclear, nuclear, or infranuclear (peripheral) facial-nerve palsy or a combined lesion; this consideration is important in the prognosis of the palsy and valuable in planning facial-nerve reconstruction surgery. Moreover, a lesion of the superior salivatory nucleus or of the nucleus of tractus solitarius can explain nonmotor deficits of the patient related to the facial nerve.

Medullary Segment

The facial motor nucleus contains the facial motoneuron soma, the axons of which form the facial motor nerve. Here the medullary segment begins. The axons leave the nucleus first in a dorsomedial direction, pass around the nucleus of the abducens nerve to form the internal facial genu (knee) (cf. **Fig. 8.1b**), and leave the brainstem from the anterior pons lateral to the abducens nerve and medial to the vestibulocochlear nerve. The facial motor nerve is joined by the intermediate nervus (nervus intermedius, nerve of Wrisberg) containing sensory and parasympathetic fibers. The parasympathetic fibers of the nervus intermedius arise from the salivatory nuclei, and the taste fibers terminate in the nucleus tractus solitarius. The nervus intermedius is lateral to the facial motor nerve when both leave the brainstem in the cerebellopontine angle (CPA). The medullary segment of the facial nerve ends here, and the cisternal segment begins.

Cisternal Segment

Within the CPA cistern, the facial nerve is most anterior and superior, the vestibulocochlear nerve most posterior, and the nervus intermedius—giving the nerve its name—between the two. This is important when orientating for vestibular schwannoma surgery or facial-nerve repair should be performed in the CPA. The cisternal segment ends when the facial nerve enters the porus acusticus of the internal acoustic meatus. The facial nerve and the nervus intermedius resemble the nerve roots of the spinal cord within the cistern.[2]

Table 8.1 Classification of the course of the facial nerve

Portion/segment	Length (mm)
Intracranial portion	
Medullary segment	3.5–6
Cisternal segment	18–21
Intratemporal portion	
Meatal segment	8–12
Labyrinthine Segment	3–5
Geniculate ganglion segment	3–3
Tympanic segment	8–11
Mastoid segment	13–14
Extratemporal portion (see Chapter 9 for details)	15–20

Intratemporal Portion

Meatal Segment

The facial nerve enters the temporal bone via the internal acoustic meatus. The meatal segment is congruent with the internal acoustic meatus. The facial and vestibulocochlear nerves pass through the internal acoustic meatus on the posteromedial surface of the petrous ridge. The facial nerve is joined by the nervus intermedius. Both are located in the anterior superior quadrant of the internal acoustic meatus above the falciform crest and anterior to Bill's bar. These are important landmarks when approaching the facial nerve via a translabyrinthine, transcochlear, or middle cranial fossa approach.

Labyrinthine Segment

As the facial nerve enters the fallopian canal, the labyrinthine segment begins (**Fig. 8.2**). The fallopian canal houses the labyrinthine, tympanic, and mastoid segments. The nerve takes an anterolateral course between and superior to the cochlea (anterior) and vestibule (posterior). Then the nerve turns back posteriorly at the geniculate ganglion. The labyrinthine segment is short and is the narrowest segment. The facial nerve occupies up to 83% of the labyrinthine canal cross-sectional area compared with only 64% of the more distal mastoid segment.[3] Therefore, it is said that the labyrinthine segment is especially susceptible to vascular compression, which might play a role in treating patients with idiopathic facial palsy (Bell's palsy).

Geniculate Ganglion Segment

The geniculate ganglion segment is equated to the geniculate ganglion (**Fig. 8.3, Fig. 8.4**). Some authorities include the geniculate ganglion with the labyrinthine segment. Following this definition, the geniculate ganglion would reside within the distal part of the labyrinthine segment. The ganglion consists of first-order pseudounipolar nerve cells related to taste sensation from the anterior tongue via the chorda tympani and the greater petrosal nerve. The latter reaches the ganglion from the greater petrosal canal. At the ganglion, the nerve has to bend down to reach the tympanic segment; this bend is called the external genu.

Tympanic Segment

After the geniculate ganglion, the nerve becomes the tympanic segment. The junction to the tympanic segment is formed by an

Table 8.2 Major branches of the facial nerve

Branch	Location	Function
Greater petrosal nerve	Geniculate ganglion segment	Parasympathetic fibers for lacrimal gland and salivary glands and visceroafferent fibers for sensation of palate
Nerve branch to the stapedius muscle	Mastoid segment	Branchiomotor fibers innervating stapedius muscle
Chorda tympani	Mastoid segment	Visceroafferent taste fibers from the anterior third of the tongue
Posterior auricular nerve	Mastoid segment or extratemporal portion	Branchiomotor fibers innervating ear muscle, may contain also sensory fibers
Nerve branch to stylohyoid muscle	Mastoid segment or extratemporal portion	Branchiomotor fibers innervating stylohyoid muscle
Nerve branch to posterior belly of digastric muscle	Mastoid segment or extratemporal portion	Branchiomotor fibers innervating posterior belly of digastric muscle
Parotid plexus	Extratemporal portion	Branchiomotor fibers innervating muscles of facial expression (details in Chapter 9)

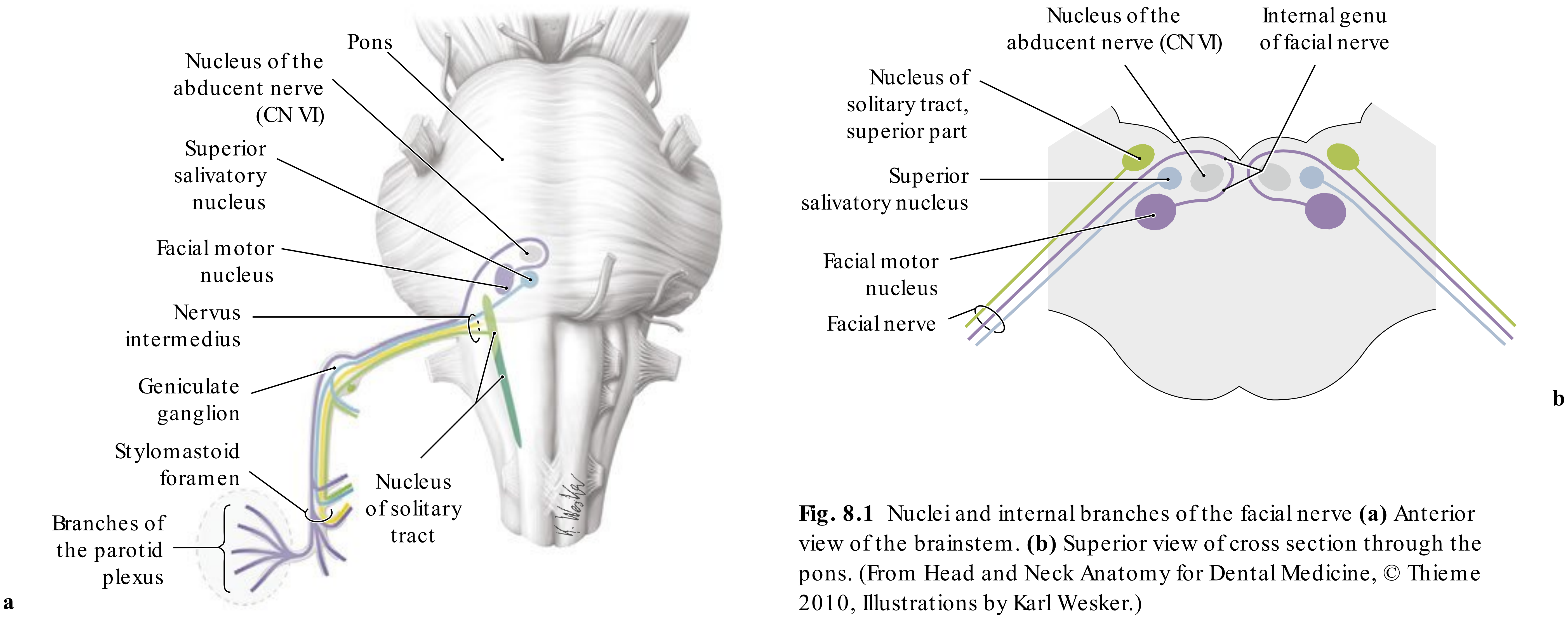


Fig. 8.1 Nuclei and internal branches of the facial nerve **(a)** Anterior view of the brainstem. **(b)** Superior view of cross section through the pons. (From Head and Neck Anatomy for Dental Medicine, © Thieme 2010, Illustrations by Karl Wesker.)

acute angle, and shearing of the facial nerve commonly occurs as the nerve traverses this genu.[4] The facial nerve runs posteriorly beneath the lateral semicircular canal in the medial wall of the middle ear cavity (**Fig. 8.5**). The fallopian canal is often dehiscent, especially in the area near the oval window.[5] This is important during middle ear surgery because the absent bony protection can allow for direct invasion of the facial nerve by chronic infection and because the nerve is at greater risk for iatrogenic injury in such situations. Duplication of the facial

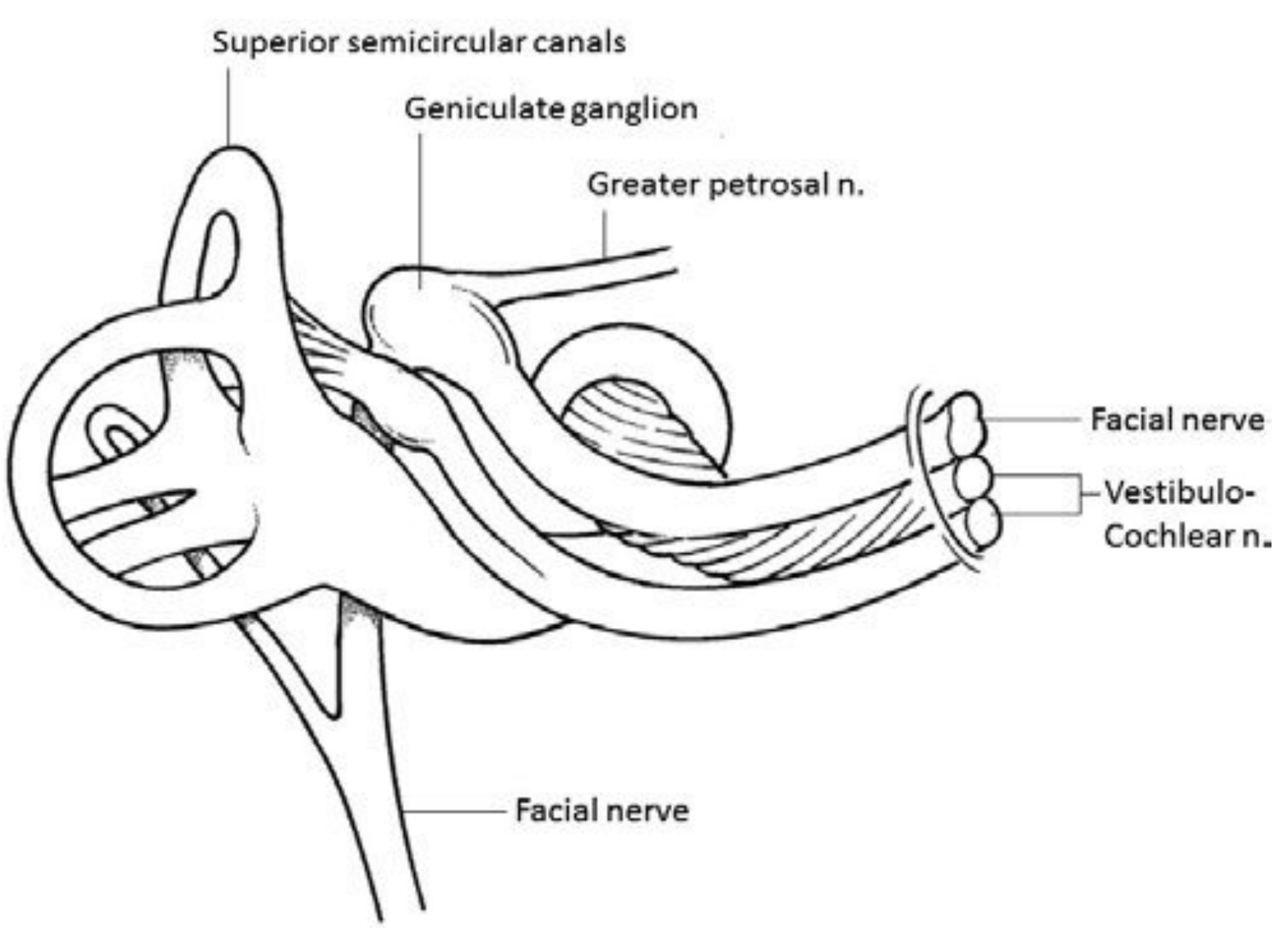


Fig. 8.2 Relation of the meatal, labyrinthine, and geniculate ganglion segments to the inner ear. As the facial nerve exits the internal acoustic meatus at the fundus, it turns gently anteriorly and runs in the otic capsule for 3 to 6 mm between the cochlea and superior semicircular canal.

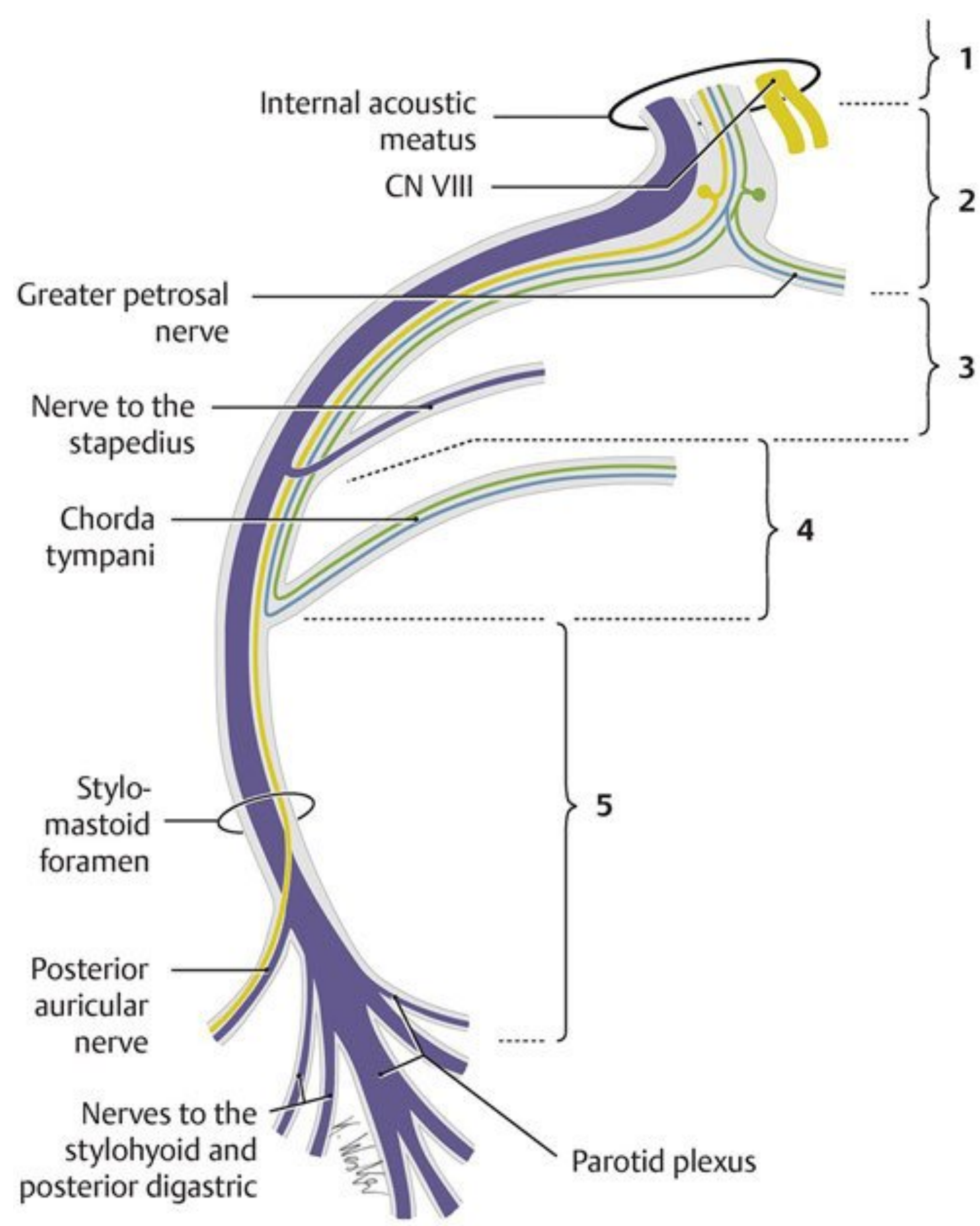


Fig. 8.3 Course and branches of the facial nerve. (1) Internal acoustic meatus. (2) External genu of facial nerve. (3) Proximal mastoid segment. (4) Distal mastoid segment. (5) Extratemporal portion. (Reproduced from Head and Neck Anatomy for Dental Medicine, © Thieme 2010, Illustration by Karl Wesker.)

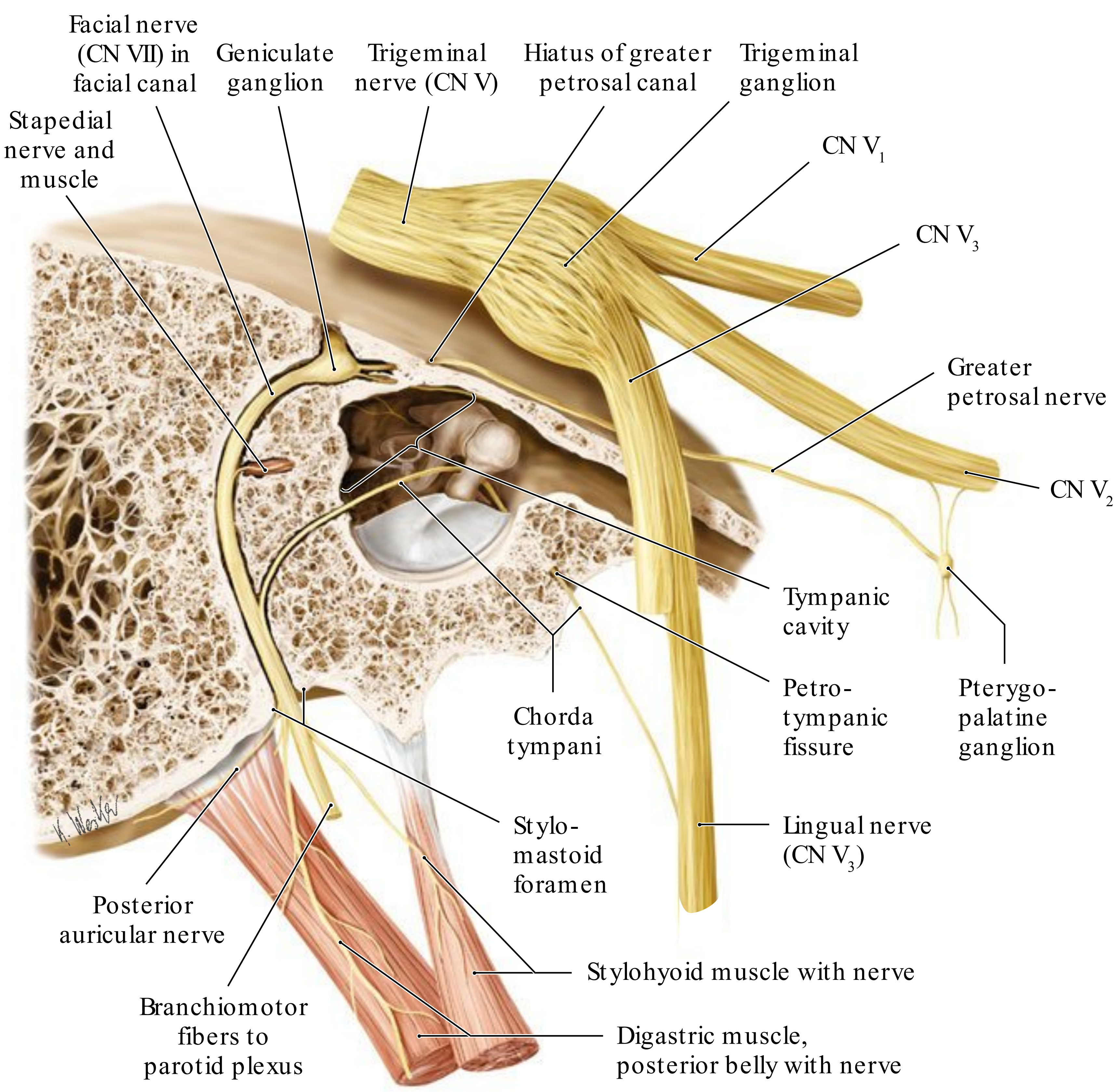
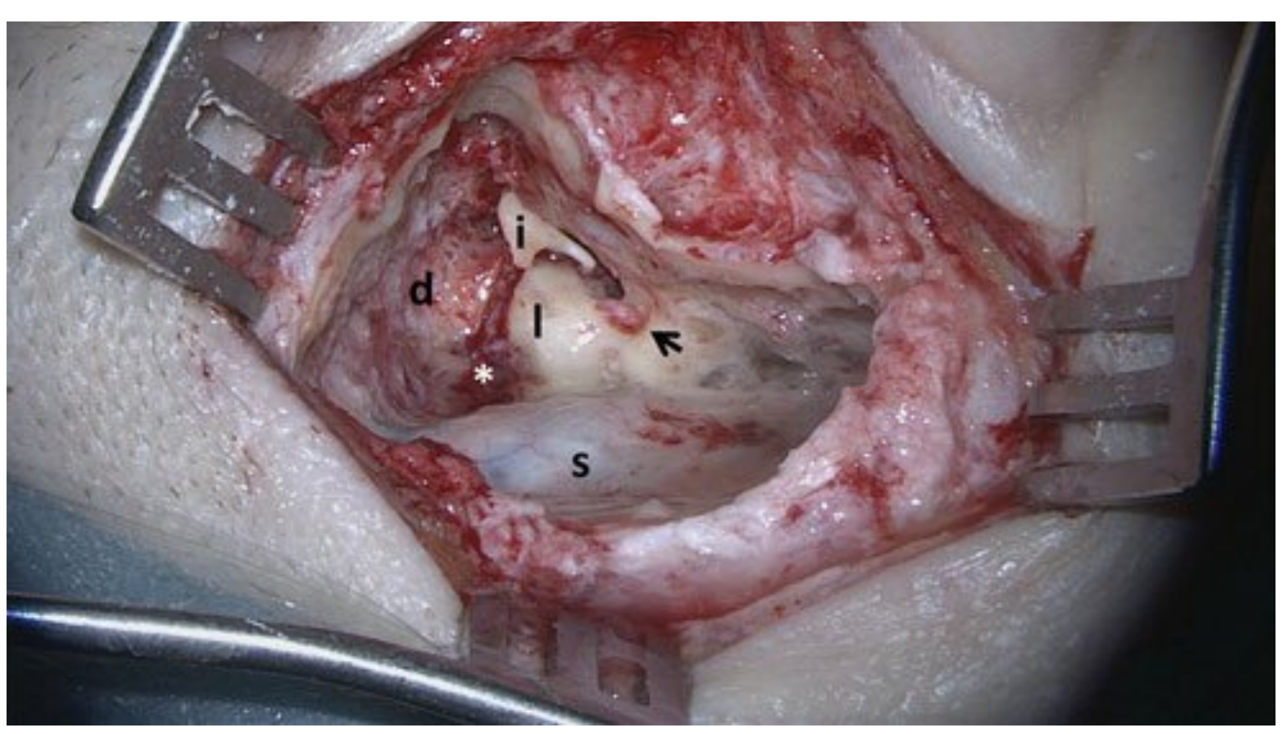


Fig. 8.4 Relation of the intratemporal course of the facial nerve to the middle ear cavity. Lateral view of right temporal bone (petrous part). Both the facial and vestibulocochlear nerves (CN VIII, not shown) pass through the internal acoustic meatus on the posterior surface of the petrous part of the temporal bone. The facial nerve courses laterally in the bone to the external genu, which contains the geniculate ganglion. At the genu, CN VII bends and descends in the facial canal. It gives off three branches between the geniculate ganglion and the stylomastoid foramen. (From Head and Neck Anatomy for Dental Medicine, © Thieme 2010, Illustration by Karl Wesker.)

nerve is rare and seen most often at its tympanic segment and associated with middle and inner ear anomalies.[6] Next, the nerve passes posterior to the cochleariform process, tensor tympani, and oval window. Distal to the pyramidal eminence, the facial nerve makes a second turn, the so-called second genu, which passes downward. Here the mastoid segment of the facial nerve begins. The tympanic segment of the facial nerve has no branches.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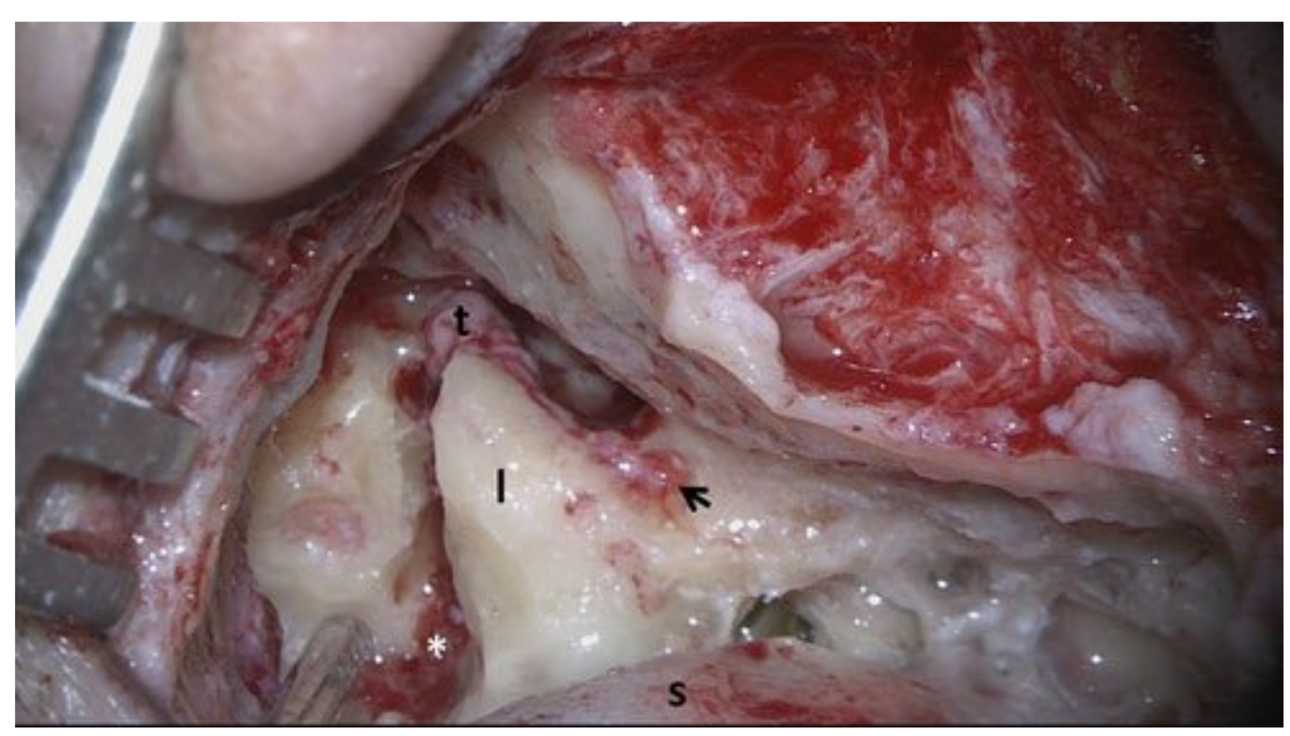
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Fig. 8.5 Intraoperative view of extended mastoidectomy in patient with right temporal bone fracture (*). Before **(a)** and after **(b)** extirpation of the incus (i) in order to explore the tympanic segment (t) of the facial nerve. The fracture has exposed and injured the facial nerve in the tympanic segment. Decompressed part of the mastoid segment of the facial nerve (arrow), dura mater of middle cranial fossa (d), lateral semicircular canal (l), and sigmoid sinus (s).

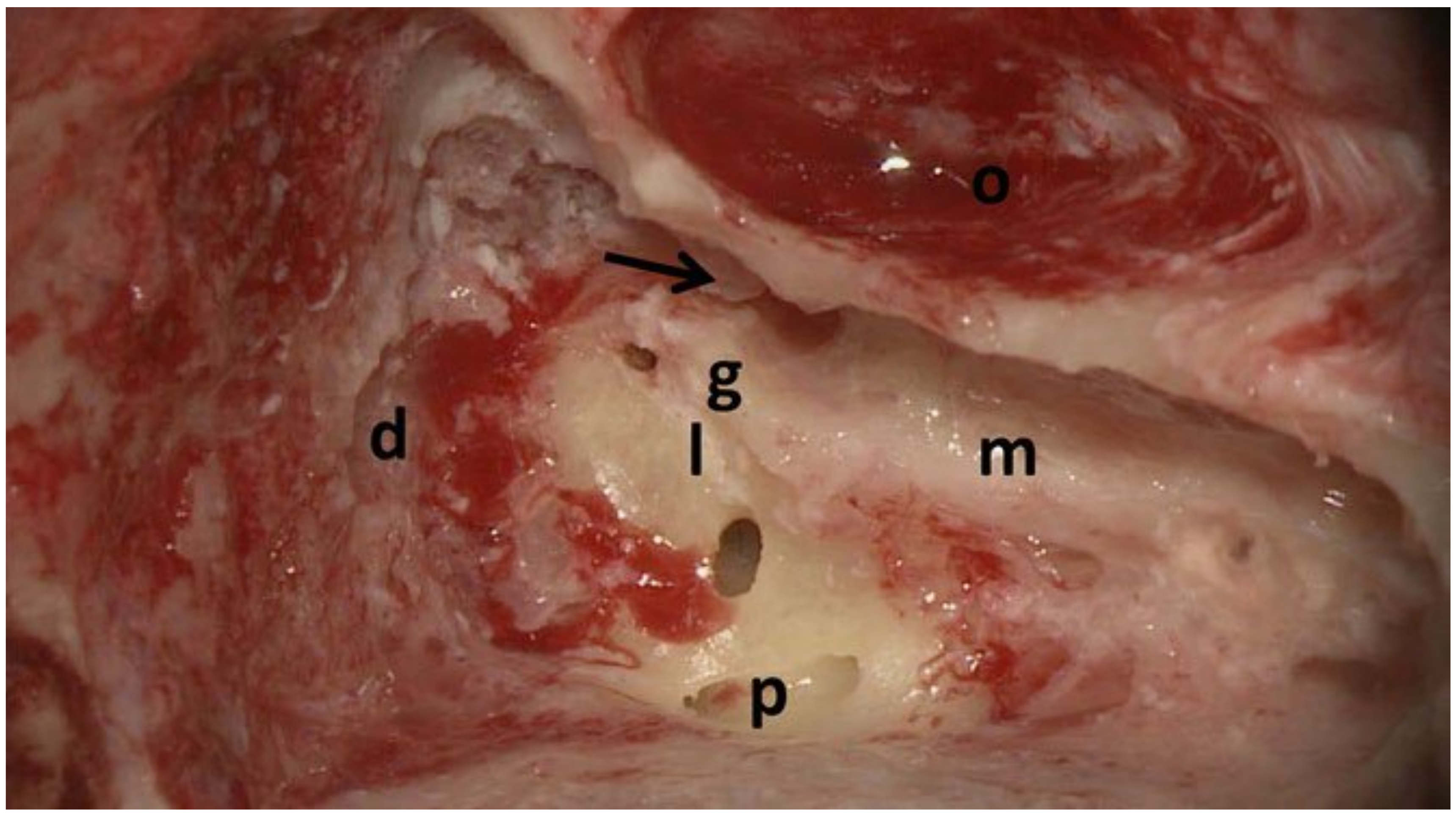

Fig. 8.6 Intraoperative view, translabyrinthine approach during vestibular schwannoma surgery of the right ear showing the relation of the second genu (g) and the mastoid segment (m) of the facial nerve to the lateral semicircular canal (l), the posterior semicircular canal (p), and the incus (arrow); dura mater of middle cranial fossa (d); external acoustic meatus (o).

Mastoid Segment

The mastoid segment begins at the second genu of the facial nerve and ends at the stylomastoid foramen (**Fig. 8.6**). Rarely, the second genu is considered separately as the pyramidal segment. The facial nerve gives off three branches from its mastoid segment. These are, from proximal to distal: the branch to the stapedius muscle, the chorda tympani, and the posterior auricular nerve. The chorda tympani passes through the tympanic cavity and the petrotympanic fissure to reach the infratemporal fossa. The chorda tympani is an important landmark when a posterior tympanotomy is being performed so as to define the level of the mastoid facial nerve and the distal limit of the tympanotomy window to the middle ear cavity. The posterior auricular nerve usually arises from the mastoid segment and leaves the temporal bone together with the facial nerve at the stylomastoid foramen. The nerve provides branches to the stylohyoid and posterior digastric muscles normally distal to the stylomastoid foramen (i.e., beyond the mastoid segment but before the extratemporal part of the facial nerve enters the parotid gland).

For facial nerve reconstruction surgery, it is sometimes necessary to access the mastoid segment of the nerve. For example, if a tumor has destroyed parts of the extratemporal facial nerve plexus, it might be that surgical exploration shows that the facial nerve is infiltrated by the tumor up to the stylomastoid foramen. In such a situation, mastoidectomy is performed and the mastoid segment of the facial nerve exposed step-by-step until tumor-free margins of the proximal facial nerve stump are achieved.

Blood Supply of the Intracranial and Intratemporal Portions

The blood supply to the intracranial and intratemporal parts of the facial nerve is provided by three main arteries. During temporal bone and middle cranial fossa surgery, these vessels should be protected to ensure optimal blood supply to the intratemporal portion of the facial nerve. A branch of the anterior inferior cerebellar artery (AICA), the labyrinthine artery, supplies the meatal segment. It may be additionally supplemented directly by small branches from the AICA. Furthermore, a branch of the middle meningeal artery, the superficial petrosal artery, runs in a retrograde fashion along the greater petrosal nerve and supplies this area. The petrosal artery is at risk of being damaged during the middle cranial fossa approach when the dura is elevated from the floor of the fossa.[7] Finally, a branch of the posterior auricular artery, the stylomastoid artery, runs retrograde into the stylomastoid foramen to supply the facial nerve. The labyrinthine segment of the facial nerve is supplied only by thin connections between the labyrinthine artery and superficial petrosal artery as end arteries. Therefore, the labyrinthine segment is the most vulnerable to ischemia, which might be why it is frequently affected in cases of idiopathic facial nerve palsy.

Radiologic Anatomy

The method of choice to depict the typical course of the facial nerve from the brainstem with its first genu (medullary segment) is by magnetic resonance imaging (MRI). With MRI, the facial nerve is also identified in the CPA anterior to the vestibulocochlear nerve within the CPA cistern. The nervus intermedius cannot always be differentiated from the facial motor nerve using standard MRI. Nowadays, 3 Tesla magnetic MRI (3T MRI) allows reliable depiction of the nervus intermedius in most cases.[8] MRI can show that both nerves and the vestibulocochlear nerve are covered by a common dural sheath.[9] Most neuroradiologists and facial nerve surgeons are familiar with computed tomography (CT) as a modality of studying the intratemporal portion of the facial nerve, especially with high-resolution CT (HRCT).[9,10] Using HRCT, the labyrinthine segment is identified on coronal and axial planes as lying between the internal acoustic meatus and the geniculate fossa. It is located between the cochlea and vestibule. Normally, this segment can always be seen when looking at the same axial plane as the lateral semicircular canal. Here the labyrinthine segment is concave on its anteromedial side as it bends around the cochlea. The tympanic segment is located between the lateral semicircular canal and

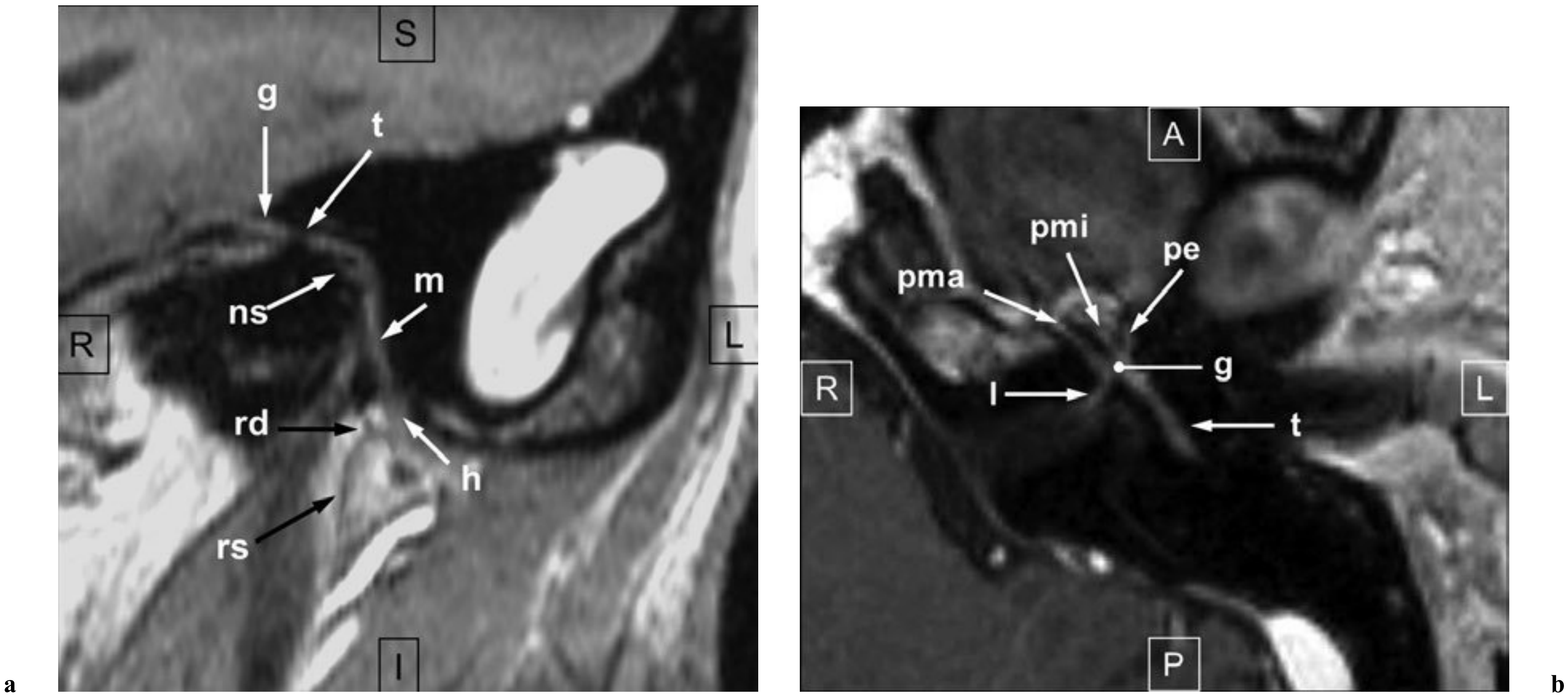

Fig. 8.7 Magnetic resonance imaging (MRI) anatomy of the normal intratemporal facial nerve. **(a)** parasagittal T1-weighted view with gadolinium contrast; **(b)** axial T1-weighter view with gadolinium contrast. A, Anterior; g, geniculate ganglion; h, main trunk at the stylomastoid foramen; I, inferior; L, left; m, mastoid segment; NS, stapedius nerve; P, posterior; pe, external petrosal nerve; pma, greater petrosal; pmi, lesser petrosal nerve; R, right; rd, digastric branch; rs, stylohyoid branch; S, superior; t , tympanic segment. (Reproduced courtesy of Dr. Hartmut Peter Burmeister, Institut für Radiologie, Klinikum Bremerhaven-Reinkenheide, Bremerhaven, Germany.)

the tympanic cavity. Its position is 1–2 mm inferior to the lateral semicircular canal. The tympanic segment is better visualized on axial CT sections. The second genu defining the beginning of the mastoid segment is identified by looking for the posterior semicircular canal. The genu normally courses about 6 mm lateral to the most inferior part of the posterior semicircular canal. Distal to the genu, the mastoid segment can be identified in the mastoid and is seen well on transaxial sections. Alternatively, this most distal intratemporal segment of the facial nerve can be found by following the canal up from the stylomastoid foramen on coronal sections.[10]

MRI, especially high-resolution 3 T MRI with contrast-enhancement, can depict the intratemporal segments of the facial nerve and even small branches like the nerve to the stapes, the posterior auricular branch, the digastric branch, and stylohyoid branch (**Fig. 8.7**).[11]

Surgical Approaches to the Intracranial and Intratemporal Portions of the Facial Nerve

The most common approaches to the facial nerve are via anterior petrosectomies (middle cranial fossa and extended middle cranial fossa approaches), posterior petrosectomies (translabyrinthine [cf. (**Fig. 7.6**)], retrolabyrinthine, and transcochlear approaches), the retrosigmoid approach, the far lateral approach, and anterior transfacial approaches (extended maxillectomy and mandibular swing approaches).[12,13] To examine the facial nerve in the CPA and meatal segment superiorly, anterior petrosal approaches offer good exposures. The posterior petrosectomies provide more direct visualization without the need for cerebellar retraction. The lateral approach exposes parts of the posterior and the entire inferior quadrants of the cisternal segment in the CPA. The retrosigmoid approach best exposes parts of the superior and inferior quadrants and the entire posterior quadrant in the CPA. Anterior and anteroinferior exposures of the facial nerve can be achieved using transfacial approaches.[13] During a middle cranial fossa approach, identification of the greater petrosal nerve is an important step. Mean distances from the arcuate eminence to the hiatus of the greater petrosal nerve in the middle cranial fossa measure about 17.5 mm. The length of this nerve within the middle cranial fossa is approximately 10 mm. From the lateral wall of the middle cranial fossa to a midpoint of the greater petrosal nerve, the mean distance is 39 mm.[14]

The facial recess approach via a posterior tympanotomy is commonly performed to facilitate cochlear implantation. The facial recess approach also allows access to the round window for insertion of middle ear implants in patients with congenital ear atresia. Even in patients with normal ears, access through the superior opening of the facial recess is limited by the presence of both the mastoid segment of the facial nerve and the chorda tympani.[15] Atresia surgery is challenging because of the altered anatomy of the facial nerve.[16] The mastoid segment of the facial nerve is more anteriorly positioned in deformed ears, on average 3 to 7 mm more anteriorly, than in ears with normal anatomy. Furthermore, most facial nerves are located above the round window in the deformed ears.[16] Hence, opening the atretic plate to obtain subfacial access to the round window is recommended in deformed ears to protect the facial nerve.

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9 Peripheral Branches of the Facial Nerve

Andrew P. Trussler

Introduction

Navigation around the facial nerve is important in any facial procedure, invasive or noninvasive. With the advent of a "less is more" trend in facial aesthetics, attention toward avoidance of the facial nerve has been falsely perpetuated. Less attention to educating medical residents on deeper-plane facelift techniques has developed an "out of sight, out of mind" attitude toward the facial nerve and its branches. Attention is gained when an inadvertent facial nerve injury happens, without the knowledge of how or where it could have occurred. It is hoped that this chapter on facial nerve anatomy will shed light on the anatomical landmarks and fascial boundaries of the nerve, as well as highlight danger zones of facial nerve injury (**Fig. 9.1**).

Facial nerve injury during facelift surgery is a relatively rare but real occurrence, with an incidence ranging between 0.5 and 2.6% This risk may be acceptably low in a primary superficial facelift, where the risk of injury to the facial nerve may be considered less, although the actual risk may be the introduction of scarring around the nerve and risk of contorting the nerve position, which makes it prone to injury in a secondary facelift procedure after a superficial facelift has failed. The more superficial facelift techniques have been subjected to longevity issues, although this topic has been subjectively debated. A 2- to 5-year longevity of a superficial lift is well documented. If the continued superficial plane is used, the risk for injury may be with superficial musculoaponeurotic system (SMAS)plication or SMASectomy, although if the deeper plane is entered, scarring may distort the facial nerve branches, making them susceptible to injury. Even injectables can cause enough irritation and scarring whereby care should be taken to maintain the fascial boundaries of the facial nerve during SMAS dissection.

A sub-SMAS dissection is safe, and the facial nerve does have a predictable location, which makes navigating around it easy for the experienced facelift surgeon. There are predictable locations that the nerve is tethered either in fascia or with a neurovascular ligamentous adhesion. These are the areas where caution is warranted when elevating the facelift flap.

Understanding of the facial nerve in three dimensions is beneficial when elevating the SMAS. Knowledge about the cutaneous landmarks, the bony landmarks, and the depth of the nerve as it traverses the face from posterior to anterior makes the ability to alter and customize the SMAS flap to meet each individual's rejuvenation goals. The thickness of the face and SMAS does vary in different patients, and a thin-faced patient will likely have a thin SMAS flap; therefore, numerical depth is less clinically applicable where anatomical boundaries with fascial planes are more relevant in facelift surgery.

Facial Nerve

The facial nerve is a motor nerve as it exits through the stylomastoid foramen at the skull base. The main trunk is anterior to the midportion of the earlobe and lies approximately 2 cm below the skin; it is surrounded by dense fascia. The nerve ascends from the stylomastoid foramen into the parotid gland at an approximate 45-degree angle. The main trunk branches within 1 cm of entering the parotid gland as two main trunks superior and inferior. The nerve trunks bifurcate the parotid gland's two lobes and travel superficial to the deep lobe at a depth of 1 cm (**Fig. 9.2a,b**). The two main trunks of the facial nerve split into the formal trunks of the named branches of the face as they exit the parotid gland (**Fig. 9.2c**).

Frontal Branch

The subcutaneous course of the frontal (temporal) branch was initially described in 1966 by Ramos and Pitanguy (**Fig. 9.3**).[1] Their findings of an anatomical study showed that the frontal branch coursed from 0.5 cm from the tragus to 1.5 cm lateral to the supraorbital rim. Their findings have provided a topographic map for the nerve, although its depth in three dimensions continues to be confusing. Numerous studies have described its location, but consensus has not been attained as to the depth or its fascial boundaries.

The fascial relationships of the frontal branch of the facial nerve vary remarkably within the literature. It remains ambiguous in part because of the lack of a standardized nomenclature and in part because of the considerable variation in the described depth of the nerve at various levels across the zygomatic temporal region. As shown by the works of Furnas, Gosain et al, and Stuzin et al, no consistency exists as to the exact fascial plane and safe plane of dissection in and across the zygomatic arch.[2–5] Confounding the issue further are the numerous names attributed to the various fascial layers. The temporoparietal fascia, which is a continuation of the SMAS, has multiple names and has been referred to as the superficial temporal fascia and or the galea aponeurotica. The deep temporal fascia envelops the temporalis muscle and extends down to the zygomatic arch, fusing with the periosteum anteriorly and posteriorly. This layer is often broken down into superficial and deep portions, which are separated by the temporal fat pad as described by Stuzin et al.[4,5] With regard to the superficial deep temporal fascia, several names exist in the literature and include the intermediate fascia and the innominate fascia.[4–6] Finally, there are descriptions of the loose areolar plane between the temporoparietal fascia and

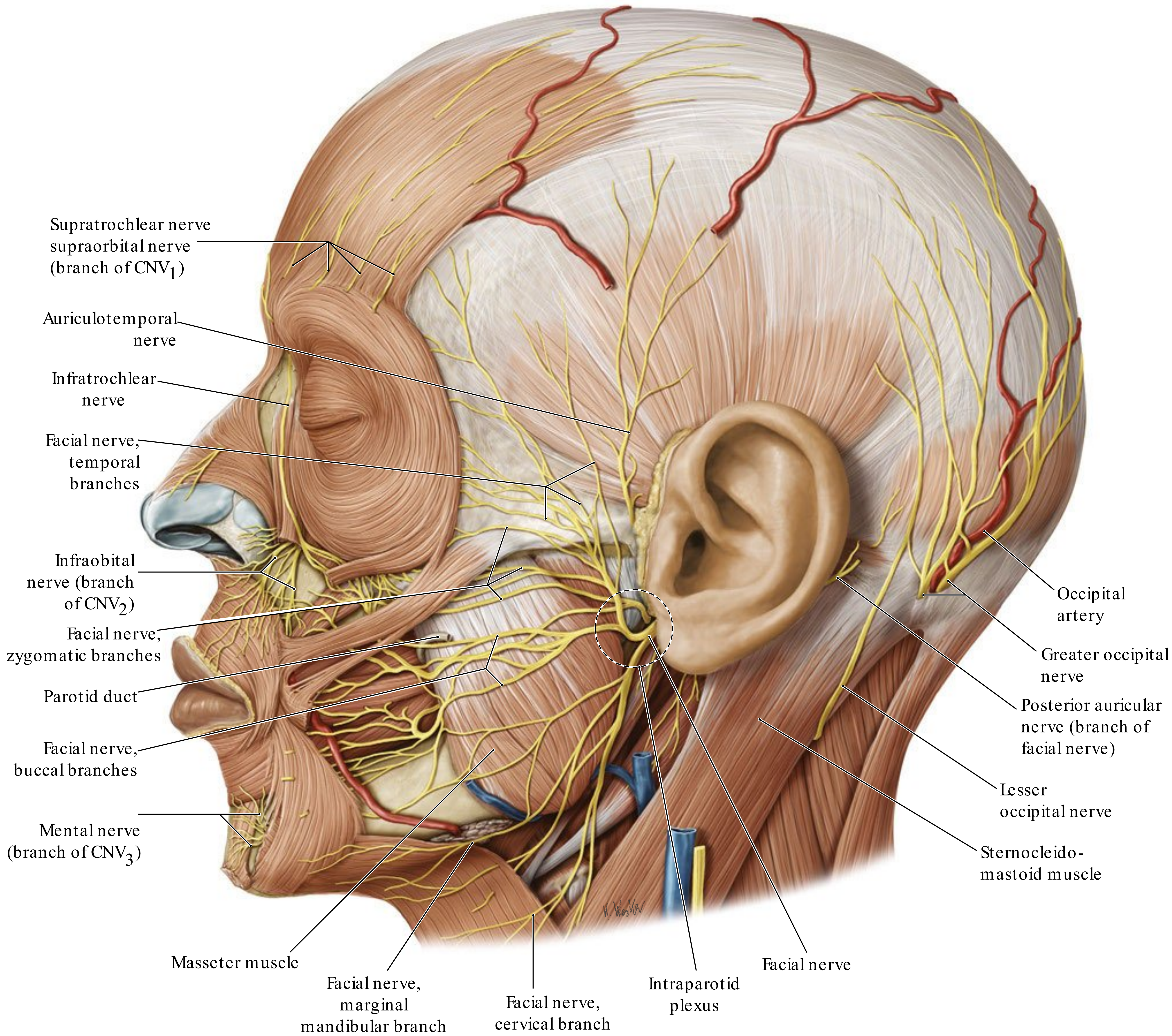
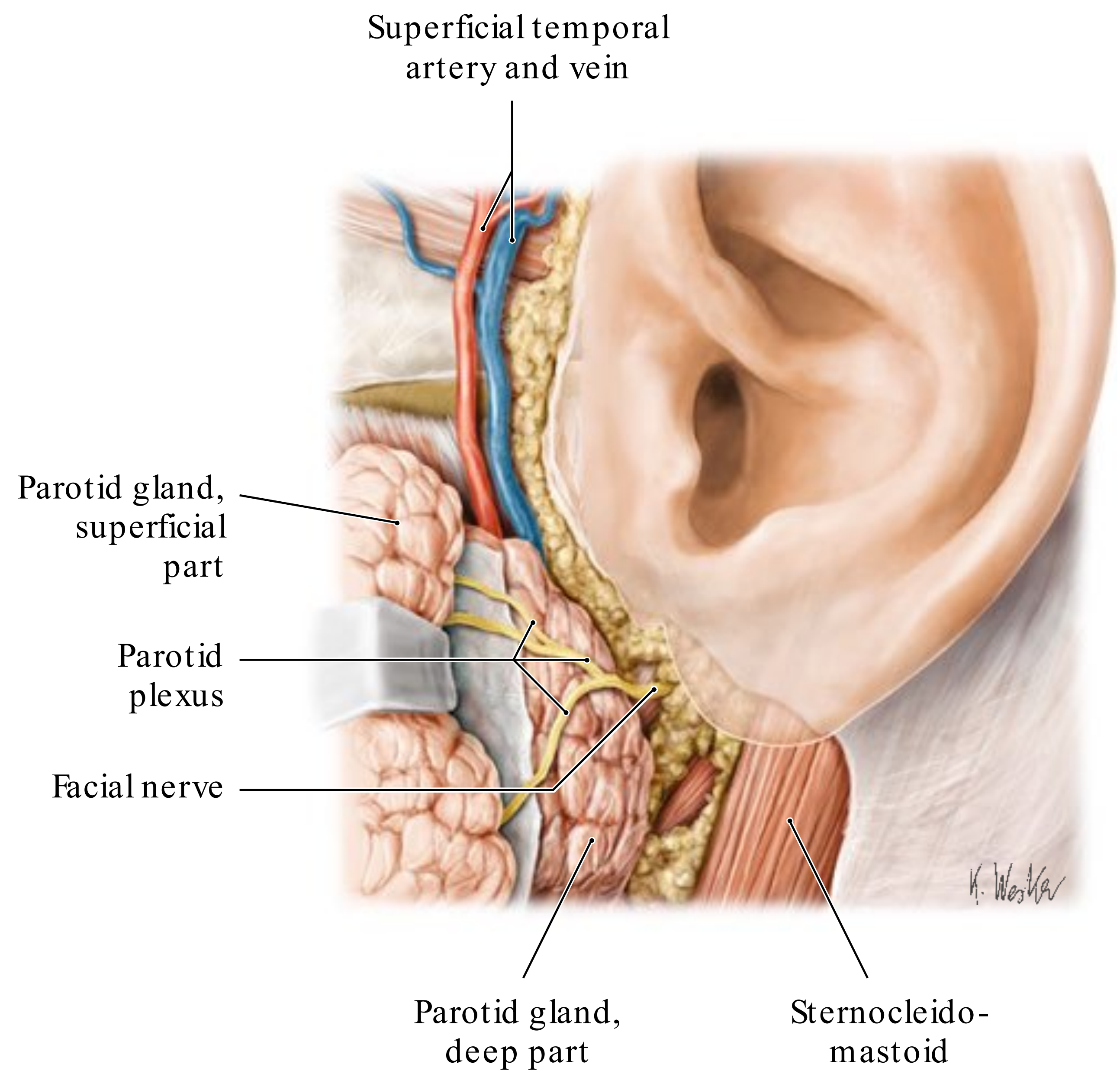


Fig. 9.1 Overview of the facial nerve (left lateral view). (Reproduced from THIEME Atlas of Anatomy, Head and Neuroanatomy, © Thieme 2010, Illustration by Karl Wesker.)

the deep temporal fascia, and some authors refer to this area as a separate fascial plane and have referred to it as the innominate fascia or subaponeurotic plane. These variations and discrepancies are partly to blame for the lack of consistency with respect to the depth and location of the frontal branch of the facial nerve across the zygomatic temporal region.

The thought that the nerve branch travels within the SMAS has clinically correlated with the alteration of facelift technique. Stuzin et al. describe a lateral low SMAS fasciotomy to protect the frontal branch with a superior extension to the lateral canthus.[7] In the high SAMS technique, the SMAS is incised transversely at a level above the zygomatic arch. The advantage of this technique would be to provide a vertical vector to the facelift with a composite flap containing SMAS and subcutaneous cheek tissue.[8,9] Based on previous studies, one might expect a 100% incidence of frontal branch injury, but in reality the author has not had any permanent nerve injury. The technique to prevent nerve injury in this technique includes a subcutaneous temporal dissection superficial to the frontal branch 2 cm above the arch at the level of the lateral canthus. The nerve is isolated on a temporal mesentery with deep dissection on the deep temporal fascia. After the SMAS has been elevated, the level of SMAS transection is then incised with a push cut across the arch to the orbicularis oculi while maintaining the temporal mesentery.

The high SMAS facelift uses a multiplanar sub-SMAS and subcutaneous dissection to mobilize the cheek and then a transverse SMAS fasciotomy above the zygomatic arch to allow for a vertical vector of repositioning. This direction of facelift replaces the facial soft tissue as a composite unit to a youthful and natural position. The transverse SMAS incision has been one point of



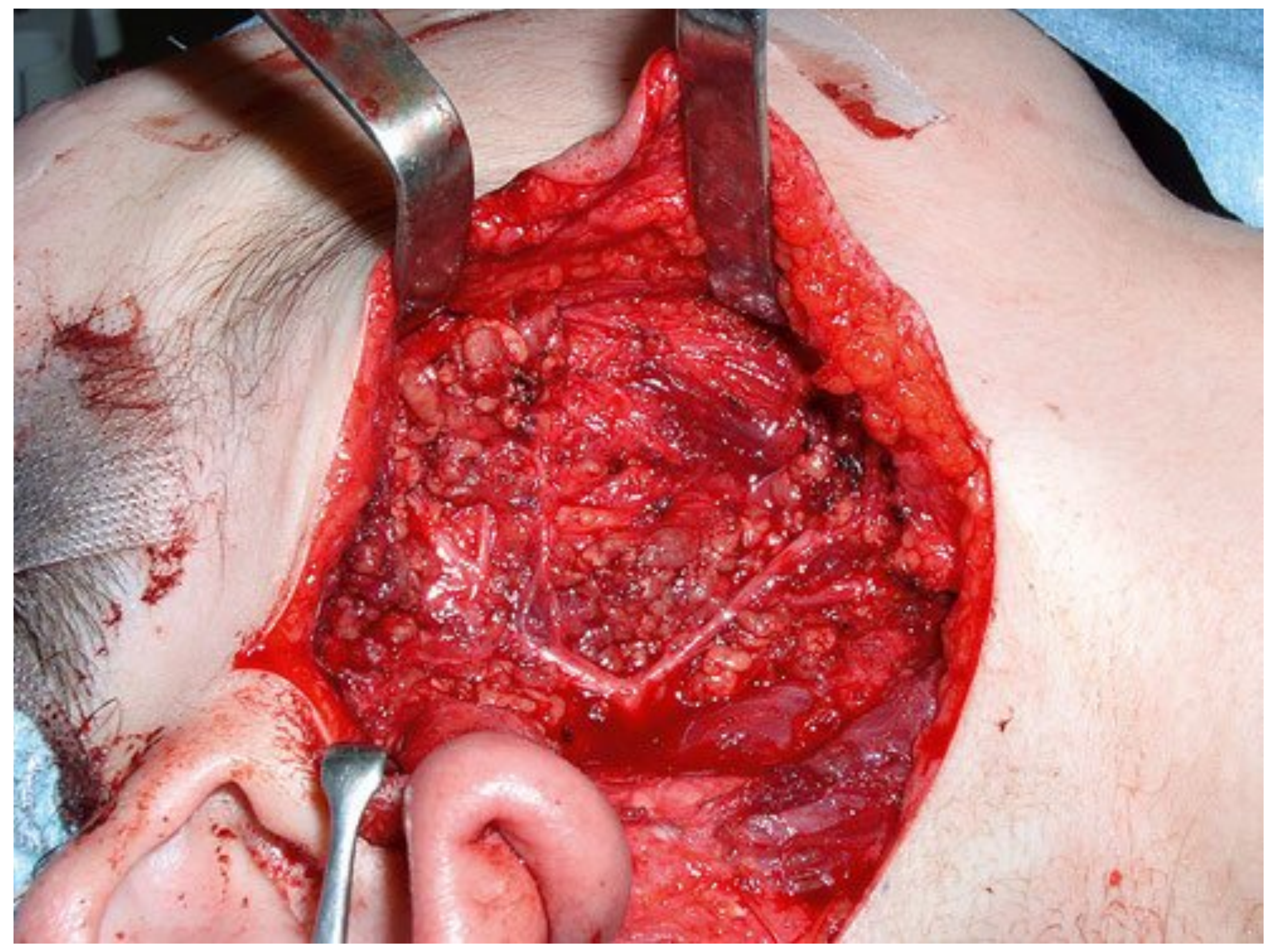


Fig. 9.2 The facial nerve in the parotid gland **(a)** Main trunk of the facial nerve and parotid plexus (left lateral view). The nerve ascends from the stylomastoid foramen into the parotid gland and bifurcates into two main trunks: superior and inferior. (From THIEME Atlas of Anatomy, Head and Neuroanatomy, Thieme 2010, Illustration by Karl Wesker.) **(b)** Operation findings of a right parotid tumor. The superficial layer of the right parotid gland was resected and parotid plexus of the facial nerve was exposed.

contention in gaining acceptance of this procedure secondary to the lack of consensus of the course of the frontal branch and the inherent risk of frontal branch injury. The study by Trussler et al has demonstrated that if the procedure is performed appropriately, the frontal branch is deep to the SMAS above the zygomatic arch and has an additional layer of fascia, the parotid temporal fascia, covering it.[10] This fascia was first described in 1965 by Furnas as a laminated areolar tissue continuous with the galea.[3] Additional descriptions have included a superficial temporal fascia, temporoparietal fascia, and innominate fascia. I propose that the fascia be named by its origin and insertion, like that of the parotid masseteric fascia and temporaparietal fascia, so that the terminology is uniform in this region. The parotid temporal fascia is not a novel fascia, as demonstrated by previous descriptions, although this term is a plea for consistency so that the course of the frontal branch can be easily related to the fascial boundaries over the zygomatic arch. This study employs both gross dissections under loop magnification as well as histologic evaluation of 1 cm intervals over the arch. The frontal branch of the fascial nerve can be easily identified by its sub-

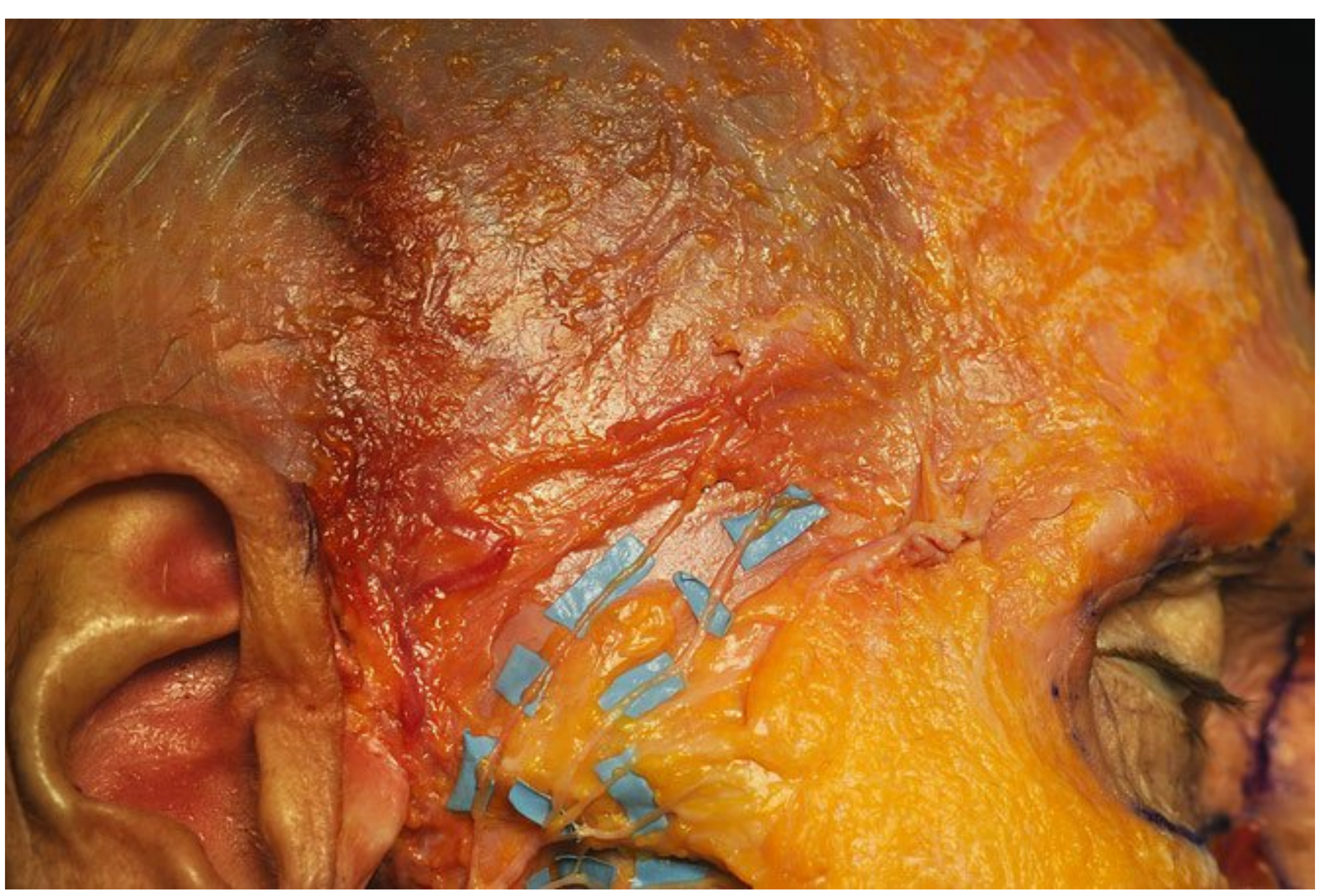


Fig. 9.3 Dissection of the right temporal branch of the facial nerve.

cutaneous course over from the tragus to the lateral brow. The cutaneous landmarks defined by Pitanguy were confirmed to be accurate in this study,[1] although this was not the focus of the study. The frontal branch was identified in all cadaver dissections via a pretragal incision and a sub-SMAS dissection with elevation of the parotid and identification of the zygomaticofrontal trunk of the facial nerve. This trunk was uniformly covered by the investing fascia of the parotid, which then extended superiorly as the parotid temporal fascia where the nerve traveled in a heterogeneous fat pad. The SMAS was easily elevated off this fascia as there was an areolar plane between them. This plane was easily elevated to above the arch, with the SMAS maintaining its integrity; the parotid temporal fascia can be elevated off of the nerve to above the zygomatic arch as demonstrated in the dissection video accompanying this chapter.

The histologic evaluation reinforces the dissection findings and demonstrates that there are two independent fascial planes below the arch; these planes are maintained to approximately 2 cm above the arch when the frontal branch penetrates the temporal-parietal fascia and travels with the anterior branch of the superficial temporal artery.

The findings of the study by Trussler et al showed that the frontal branch has a defined anatomical course and uniform fascial plane within which it travels (**Fig. 9.4**).[10] The nerve does not travel within the SMAS, which is the thought and teaching that have been passed on in the anatomical teaching in this area. This inaccurate description imposes a false sense of security when approaching the arch and midface from a superior and deep plane and is echoed in past descriptions of the subperiosteal facelift having a high number of frontal branch palsies. In evaluating the histologic specimens, the nerve closely abuts the periosteum of the arch, and if the arch is to be accessed, it should be done so by bilaminating the deep temporal fascia, elevating the periosteum off of the arch, or both. Additionally, the SMAS can be elevated above the arch and exists as a layer on histologic evaluation, which contradicts a previous study demonstrating that the SMAS does not cross the arch.

All these findings are clinically supported by the fact that I have performed more than 1,000 high SMAS facelifts without any permanent nerve injuries. This clinical finding demonstrates that the high SMAS facelift is safe and the frontal branch of the facial nerve is protected by the parotid temporal fascia at the zygomatic arch.

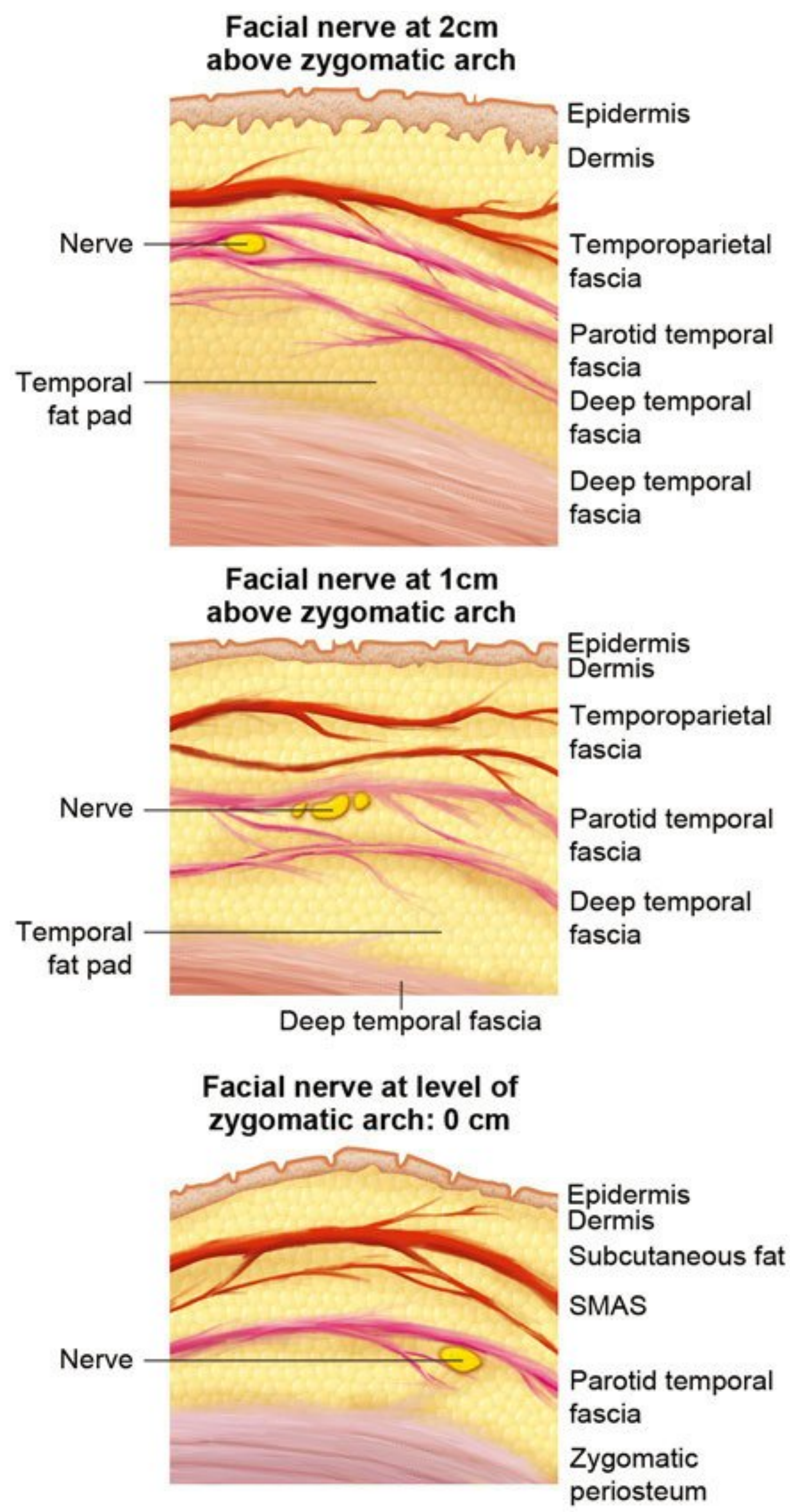


Fig. 9.4 The fascia plane where the temporal branch travels.

Zygomatic Branch

The zygomatic branch of the facial nerve has clinical implications in lower eyelid function and midface movement. It is at risk as it exits the parotid gland, although it travels within similar bounds as the frontal branch. Its terminal branches can be injured in lower eyelid and midface procedures. This type of injury is clinically less severe secondary to its multiple rami. The zygomatic branch of the facial nerve travels within the superior portion of the parotid gland. The nerve branches from the superior trunk in the parotid gland and lies deep to the parotid masseteric temporal fascia. It runs with the transverse facial artery in line with the parotid duct as it travels anteriorly into the buccal space. The nerve travels beneath the zygomatic as major muscle but may give a branch superficial to the muscle, which innervates the orbicularis oculi laterally. The zygomatic branch of the facial nerve gives off rami to innervate the deep surface of the levator and orbicularis oculi. There is medial cross-innervation of the buccal and zygomatic medial branches, which has significance in the blink response, lower eyelid position, and tone. Injury to these rami during open lower eyelid procedures may result in an ectropion, which can correct as these small branches reinnervate the muscle (**Fig. 9.5**).

In the cheek, the zygomatic branch is covered by the parotid gland. The area of vulnerability exists at the origin of the zygomaticus muscle or McGregor's patch, where there is a dense ligamentous adhesion with the neurovascular bundle, which indicates the transition from deep to superficial planes of the nerve.[11] Scissor spreading in the superficial plane, as well as pressure instead of cautery for hemostasis, can help eliminate injury to the branch. The perforator vessels from the transverse facial artery are typically encountered as well as the zygomatico-orbital sensory branch.

Fig. 9.5 Dissection of the right facial nerve. B, buccal branch; C, cervical branch; M, marginal mandibular branch; T, temporal branch; Z, zygomatic branch.

Buccal Branch

The buccal branch rami travel within the midportion of the parotid gland. The rami exit the nerve more posteriorly than the superior trunk rami because the parotid gland is narrower as it descends into the tail. The buccal rami travel anteriorly on the masseter muscle and below the parotid masseteric fascia. At the anterior border of the masseter, the nerve branches traverse from the deep fascia to perforate into the more superficial buccal fat compartment. The end point is the undersurface of the facial levator muscles (**Fig. 9.6**).

Elevation of the SMAS flap off of the parotid is relatively easy as the dissection progresses anteriorly. The dissection off of the parotid and onto the parotid masseteric fascia is a landmark to prevent damage to the buccal branches, which are seen below the transparent fascia in an avascular plane. Dissection into the masseter muscle is indicative of too deep of a dissection and possible injury to the buccal branches. Vertical scissor spreading is all that is needed to elevate the SMAS off the parotid masseteric fascia. Previous surgery and injections may make this plane adherent and difficult to elevate.

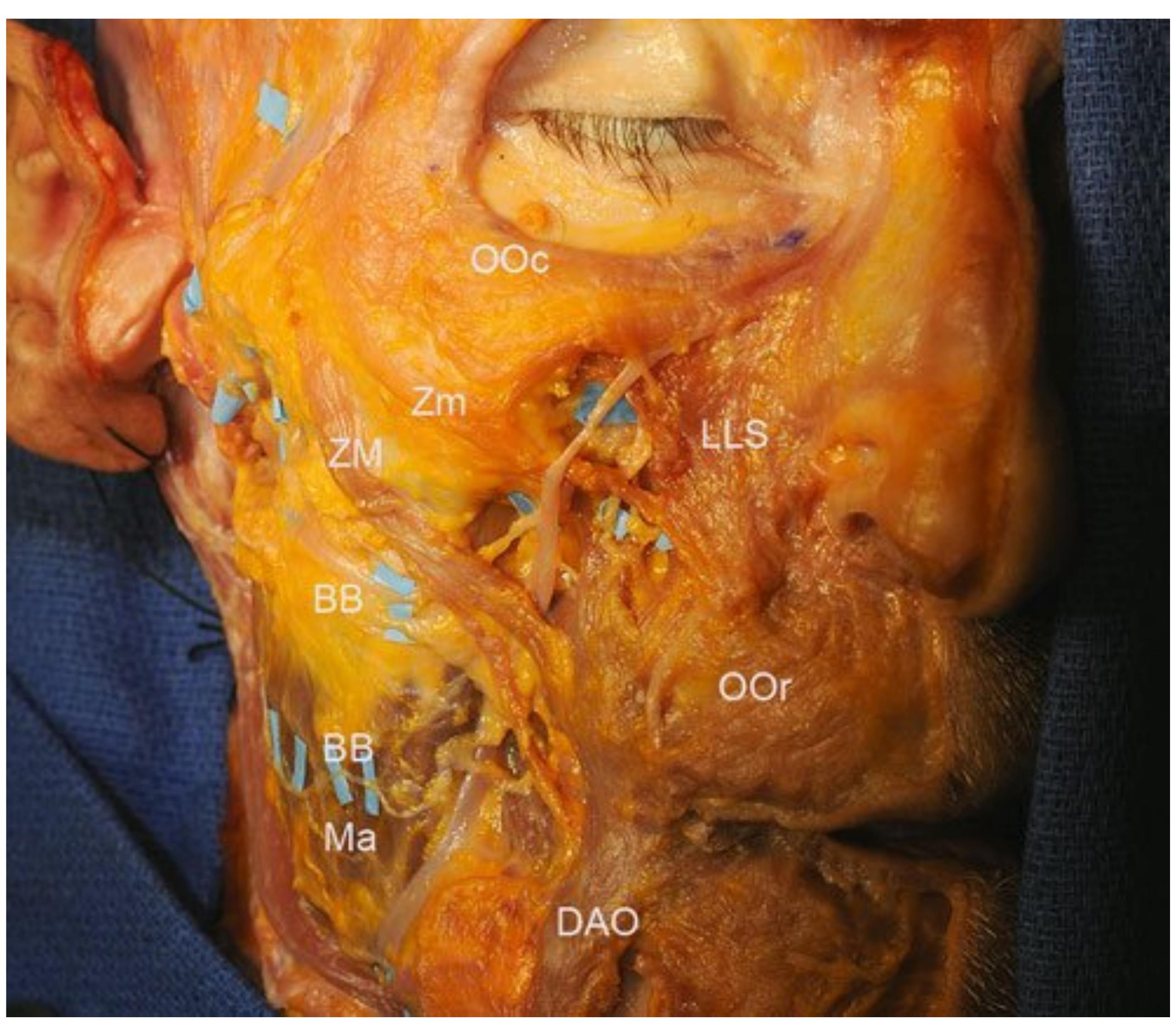


Fig. 9.6 Dissection of the right buccal branch. BB, buccal branch of the facial nerve; DAO, depressor anguli oris; LLS, levator labii superioris; Ma, masseter; OOc, orbicularis occuli; OOr, orbicularis oris; ZM, zygomatic major; Zm, zygomatic minor.

Mandibular Branch

The mandibular gland exits the parotid at the angle of the mandible. It is covered with the transitional fascia of the parotid masseteric and deep cervical fasciae. The nerve travels anteriorly above the mandibular border in most patients (**Fig. 9.7**). In 19%of cases, the nerve is located below the border of the mandible and can be found 1 to 3 cm below the border before it crosses the anterior to the facial vessels.[12] In cases in which the nerve is below the mandible, it runs anteriorly and crosses the surface of the posterior digastric muscle and then the capsule of the submandibular gland, lying deep to the investing cervical fascia and curving a variable distance below the mandible. The nerve perforates through the deep cervical fascia at the inferior border of the midmandible near the anterior margin of the masseter muscle, where it then crosses superficial to the facial artery to enter the buccal space lying beneath the platysma, ultimately innervating the major lip depressors and mentalis muscle.

The marginal mandibular nerve can be injured in the cheek and in the neck. Inadvertent injury can occur with subcutaneous dissection along the mid-mandibular border with push-cut scissor dissection, blunt injury with liposuction or injection, as well as electrocautery after bleeding occurs in this area after blind dissection. Injury to the nerve in the neck can occur if the dissection traverses the platysma and enters the deep cervical fascia. Dissection of the neck platysma should start several centimeters below the angle of the mandible in a relatively loose,

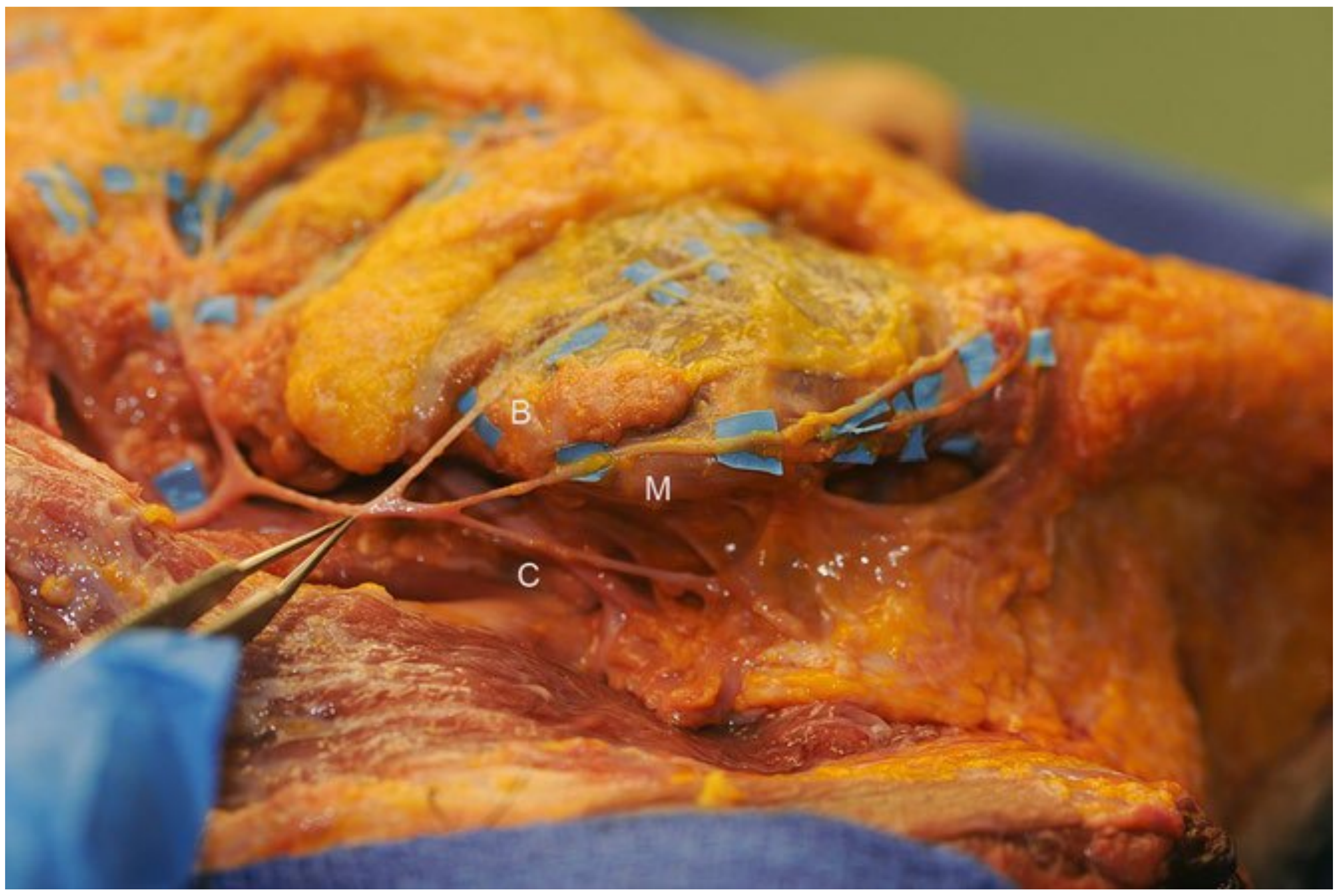


Fig. 9.7 Dissection of the right buccal, mandibular and cervical branches. B, buccal branch; C, cervical branch; M, marginal mandibular branch.

avascular areolar plane. In a revision neck-lift procedure, adherence of the platysma to the skin may direct the dissection through the platysma and inadvertent injury to the nerve if this dissection plane is continued.

In a sub-SMAS cheek dissection, the greatest risk of injury for the marginal mandibular nerve is in the lower anterior cheek as the buccal space is approached. Vertical spreading and blunt dissection over the parotid masseteric fascia adequately elevate the SMAS flap, with care taken to avoid the lower anterior border of the mandible where the nerve crosses the facial vessels. Hemostasis under the extended SMAS flap in the lower cheek should be attained with pressure and not electrocautery.

Cervical Branch

The cervical branch exits the parotid gland at its caudal border below the angle of the mandible. It immediately perforates through fibrous adhesions at the tail of the parotid and travels above the deep cervical fascia. The nerve travels within the fibroareolar connective tissue to the undersurface of the platysma, where it divides and sends rami anteriorly and inferiorly.

Dissection beneath the SMAS and platysma can risk injuring the cervical branch anterior to the angle of the mandible, where it emerges from the parotid gland. Dissection in front of the angle at a level deep to the platysma should be performed with blunt dissection to elevate the SMAS flap. This dissection can be difficult secondary to the dense fascial adhesions over this area; freeing the SMAS and platysma enough for movement should be the goal rather than an extensive dissection.

The danger zones for the cervical branch and the mandibular branch are adjacent to each other and can be treated as a single zone during a SMAS-platysma facelift, 1 cm above the border of the mandible to 2 cm below the mandible from the angle to the oral commissure (**Fig. 9.7**). Adequate mobilization of the SMAS-platysma flap may entail the release of the fascial attachments in this area. A dissection plane above this danger zone in the cheek and below in the neck can be connected with blunt dissection and spreading, which can create a mobile mesentery of soft tissue to help protect the path of the mandibular and cervical nerve branches.

Conclusions

- Know the variations of the nerve branches.
- Understand the fascial boundaries of the nerve branches.
- Use safe dissection techniques in the areas of fascial adherence.
- Hold pressure rather than cauterize bleeding in the anterior cheek.

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