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Facial Reanimation after Facial Nerve Injury

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Patients with facial paralysis are often seen in neurosurgical practice. Obtaining full facial symmetry and function after facial nerve damage presents the neurosurgeon with a difficult challenge. Various surgical techniques have been developed to deal with this problem. These include primary nerve repair, nerve to nerve anastomosis, nerve grafting, neurovascular pedicle grafts, regional muscle transposition, microvascular muscle transfers, and nerve transfers. Patient selection, timing of surgery, and details of surgical technique are discussed. The results of hypoglossal-facial anastomosis in 24 patients are described. (*Neurosurgery* 29:568–574, 1991)

Key words: Facial paralysis, Facial reinnervation, Muscle transfers, Nerve repair

INTRODUCTION

Facial paralysis, regardless of its cause, has always been a major source of concern for mankind. The causes of facial palsy are numerous and include trauma, infection, neurological, metabolic, genetic, vascular, and neoplastic disorders as well as toxic, idiopathic, and iatrogenic causes (20). Various tactics are available to a surgeon at present for facial reanimation.

There is no absolute agreement as to what constitutes the best or most appropriate treatment of a paralyzed face. Among the various techniques presently available are primary nerve repair, nerve grafting, neuromuscular pedicle grafts, regional muscle transposition, microvascular muscle transfers, and nerve transfers. These can be done alone or in combination. The best results will be obtained when the therapy is tailored to the patient's specific needs and problems.

Several procedures have been developed to improve facial tone and motor function in patients with postoperative facial nerve paralysis. The ideal treatment is intracranial end-to-end anastomosis of the facial nerve during the initial operation. Unfortunately, often the nerve has been attenuated or destroyed, making this impossible. The alternatives then are hypoglossal-facial, spinal accessory-facial, or phrenic-facial nerve anastomosis. In cases of long-standing facial paralysis (more than 2 yr), other methods must be used, which include facial dynamic or static reanimation using muscle transfers, transposition, or neuromuscular pedicle grafts.

SURGICAL TECHNIQUE

The following section will describe the techniques used at our institution for facial reanimation of injured facial nerves. Our procedure of choice is the hypoglossal-facial anastomosis, particularly for patients who are not dependent upon speech for their livelihood.

Hypoglossal-facial anastomosis

This procedure is performed under general anesthesia with the patient supine on the operating table, head turned to the contralateral side. The earlobe is stitched up anteriorly, out of the operative field. A postauricular incision is made from 0.5 inch above the tip of the mastoid down in front of the sternocleidomastoid muscle, for a length of approximately 10 cm (Fig. 1). The skin and subcutaneous tissues are opened, and the fascia and platysma muscles are then divided in a longitudinal

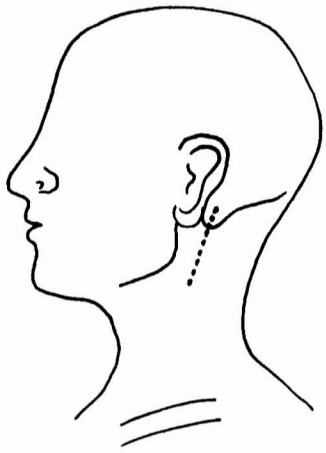

FIG. 1. Surgical incision for hypoglossal-facial nerve anastomosis.

fashion. The sternocleidomastoid muscle is identified and retracted laterally. Dissection continues superiorly and medially, and the cervical fascia is identified and opened. The posterior belly of the digastric muscle is identified, and dissection is carried around it until the anteromedial tendinous portion is identified. The hypoglossal nerve is located underneath the posterior belly of the digastric muscle. It may be identified by following the descending ansa hypoglossi up until it meets the hypoglossal nerve.

Attention is turned to the area of the mastoid tip. Using the periosteal elevator, the digastric muscle is separated partially from the periosteum of the mastoid process. The tip of the mastoid process is rongeured away, improving visualization of the area of the styloid process and the stylomastoid foramen. The authors prefer sharp dissection for the exposure of the facial nerve at its exit from the stylomastoid foramen (Fig. 2). Occasionally, it is necessary to go through the posterior portion of the parotid gland to identify this nerve. Once both the facial and hypoglossal nerves have been identified, the hypoglossal nerve is sectioned at the point where it begins to branch.

The facial nerve is sectioned at the stylomastoid foramen. The distal end of the hypoglossal nerve is swung upward posteriorly, in contact with the proximal end of the facial nerve, adjacent to the posterior belly of the digastric muscle. Using microsurgical technique, the two ends are joined (Fig. 3), using 10–0 Prolene (Ethicon, Inc., Somerville, New Jersey). Care must be taken to ensure that the nerve is not angulated or

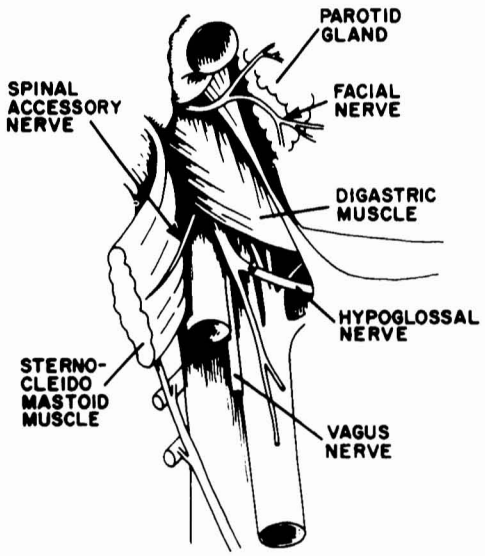

FIG. 2. Diagrammatic illustration of the anatomy and landmarks used for hypoglossal-facial and spinal accessory-facial anastomoses.

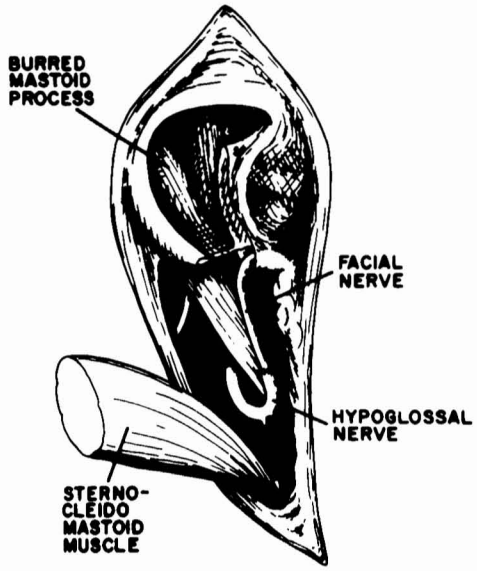

FIG. 3. Illustration of hypoglossal-facial anastomosis.

under tension. After the anastomosis has been completed, the wound is closed in standard fashion. The results of facial reanimation have been quite satisfactory, based on the patient's opinion of cosmesis and eye closure (Fig. 4, *A* and *B*).

Spinal accessory-facial anastomosis

The incision is identical to the one used for the hypoglossal-facial anastomosis. The sternocleidomastoid muscle is identified and retracted laterally and inferiorly, exposing the posterior belly of the digastric muscle. The spinal accessory nerve may be identified entering the posterior aspect of the sternocleidomastoid muscle (Fig. 2). To expose the distal end of the facial nerve, the technique described above is used. Once the facial nerve has been dissected at the stylomastoid foramen, the spinal accessory nerve is sectioned in its most distal portion, approximately where it enters the sternocleidomastoid muscle. The proximal spinal accessory nerve is swung around superiorly and posteriorly and anastomosed to the distal facial nerve (Fig. 5).

Phrenic-facial anastomosis

Two incisions are used, one similar to the one described for the hypoglossal-facial and the spinal accessory-facial anastomoses, to expose the distal facial nerve right at the stylomastoid foramen, and another that is placed approximately the width of two fingers above the clavicle in the supraclavicular fossa (Fig. 6). The sternocleidomastoid muscle is retracted medially and superiorly, and the anterior scalene muscle will then come into view. The phrenic nerve is in front of the anterior scalene muscle, underneath the fascia. Once it is identified, it is cut at the lowermost end of the anterior scalenus. The proximal end of the phrenic nerve is brought up underneath the sternocleidomastoid muscle and anastomosed to the facial nerve. It is recommended that the phrenic nerve be cut and brought up first to help judge the length of facial nerve that will be needed to perform the anastomosis without the tension. If there is trouble obtaining the needed length, it is always possible to perform a mastoidectomy and expose the facial nerve higher up at the stylomastoid foramen.

For cases in which the patient has a long-standing facial paralysis (usually more than 2 years), and when electrodiagnostic studies indicate the mimetic muscles of facial expression are no longer functional, methods other than reinnervation must be employed. Two categories of procedures are available, dynamic and static reanimation.

DYNAMIC TECHNIQUES

These procedures utilize regional muscle transfers in an attempt to provide both symmetry of the face at rest and voluntary dynamic movement of the paralyzed face. The muscles utilized in the dynamic reanimation procedures are the temporalis and masseter muscles supplied by the Vth cranial nerve. The techniques involve transposition of the whole or a part of the muscle, along with its nerve and blood supply. It is important to emphasize that even with the best results, none of these faces will be completely normal and that the involuntary control that occurs with emotional responses, such as laughing and crying, will not be present (Fig. 7) (13).

Temporalis muscle transposition

The temporalis muscle is easily available and has been used to reanimate the eyelids, nasolabial folds, and upper lip. Long-term results indicate that reanimation of the lower half of the face using this muscle is more successful than reanimation of the eye. For this reason, procedures described elsewhere in this text are utilized for eye reanimation and temporalis muscle transposition is used for the lower half of the face (13, 15, 16). The operation is carried out through a preauricular incision extending superiorly onto the temporal area of the scalp. The incision is carried down to the temporalis muscle fascia. The middle or central portion of the muscle is used. An incision is carried out through the fascia, muscle, and periosteum, at its superior parietal attachment, and an anterior and posterior incision to separate the central one-third of the fascia, muscle, and periosteum is carried out. The periosteum on the under surface of the inferiorly based pedicle is elevated from the lateral aspect of the skull down to the level of the zygomatic arch. A subcutaneous tunnel large enough to accommodate the muscle pedicle is next created from the temporal area to the corner of the mouth. An incision is made in the nasolabial fold or along the vermilion border of the lateral third of the upper and lower lip. The previously created tunnel is identified. The pedicle is folded over the zygoma and inserted into the tunnel, after the distal end of the pedicle has been split. The split muscle is then fixed to the lateral aspect of the subcutaneous

FIG. 4. *A*, preoperative facial paralysis; *B*, 3 months after hypoglossal-facial anastomosis; *C*, 6 months after hypoglossal-facial anastomosis; *D*, 9 months after hypoglossal-facial anastomosis.

tissue of the upper and lower lip. A Silastic implant is inserted over the zygomatic arch to prevent a depression produced by loss of bulk of the temporalis muscle. Pre- and postoperative results are demonstrated in Figure 8.

Masseter muscle

Access to the masseter muscle is obtained through an incision below the inferior border of the mandible. The anterior half of the muscle is separated from its inferior border. A tunnel is created to allow the muscle pedicle to be attached to the subcutaneous tissue of the lower lip (12, 13).

STATIC TECHNIQUES

These procedures are designed to add support and symmetry to the patient's face at rest. They provide no facial motion to the paralyzed side. Static techniques are now used more frequently as a secondary procedure to supplement results achieved by nerve grafting or dynamic techniques.

Face lift

Sagging of facial skin and loss of skin tone are exaggerated by long-standing facial paralysis. Tightening of the superficial musculoaponeurotic system under the facial skin, along with removal of excess skin, has improved long-term results (5, 17).

Fascia lata suspension

At the time of the face lift procedure, a sheet of fascia lata is suspended from the periosteum over the zygoma and attached with lateral tension to the orbicularis of the upper and lower lip and lateral commissure (Fig. 9) (18, 20).

Palmaris longus transplant

Muscle grafting is felt to improve the results of fascia lata technique. The palmaris longus muscle and its tendon have

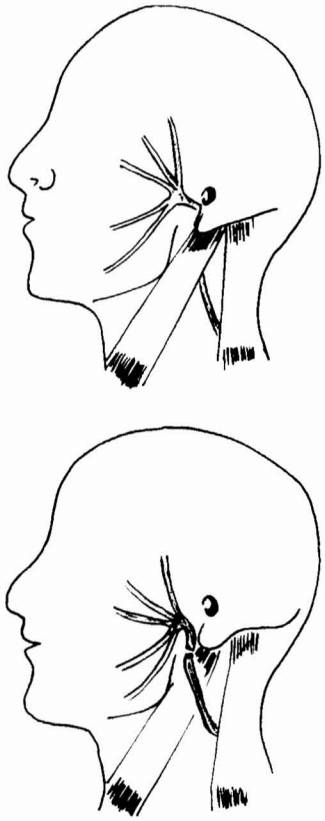

FIG. 5. Illustration of accessory-facial anastomosis.

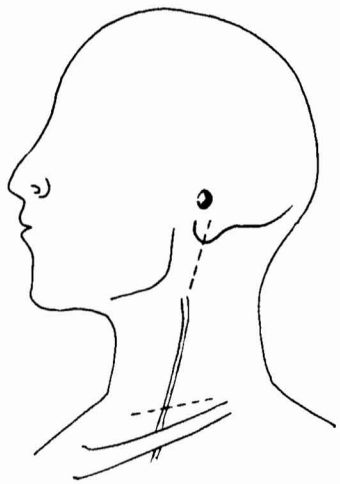

FIG. 6. Illustration of incisions for phrenic-facial anastomosis.

been used with good results. The improvements from this technique appear to be better than that from the use of fascia lata (13). The flat muscle of the palmaris longus is divided along its fascial tendinous envelope, creating an upper and lower slip. These slips are inserted into subcutaneous tunnels in the upper and lower lip to encircle the mouth. The muscle is then fixed to the mucocutaneous border of the corner of the mouth, as well as to the upper and lower lip. The tendon is passed around the zygomatic arch and attached with tension to the upper aspect of the lip-cheek crease. The tendon, therefore, serves as a pulley to draw the corner of the mouth laterally upward. The muscle has been demonstrated to survive as a free graft. It receives new innervation from the orbicularis oris of the normal side of the face (10).

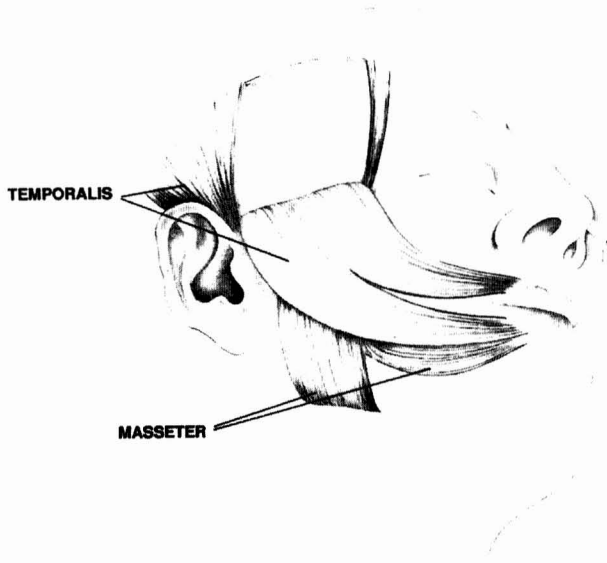

FIG. 7. Central portion of temporal muscle and/or interior half of the masseter muscle is used to provide dynamic reanimation to the lower half of the face.

Brow lift

Drooping of the brow secondary to facial paralysis not only produces a cosmetic defect, but can also impinge on the upper lid and limit upward gaze. If the brow is elevated, the eye will be more opened. This is the cosmetic effect desired, but it also exposes the cornea to more damage if steps have not been taken to protect it (gold weight or spring) (Fig. 10).

Direct brow lift

With the patient upright, the paralyzed brow is elevated to match the normal side. The amount of skin to be removed is marked above the brow. Incisions are made along the markings and at the upper border of the brow hair. Skin, subcutaneous tissue, and muscle are removed. The brow is now fixed into its new position with permanent sutures, attaching the orbicularis muscle below to the periosteum above. The skin is then carefully closed. The scar, particularly in a person with adequate eyebrow hair, is inconspicuous.

Temporal lift

If brow hair is sparse or missing, the scar from a direct brow lift will be more visible. In these cases, a temporal lift may be elected. The approach is indirect and therefore results are less predictable. A preauricular incision is carried up and slightly forward into the temporal area. Dissection is carried forward to and below the orbital rim. Upper and lateral tension on the flap raises the brow. Excess skin and subcutaneous tissue is removed in the temporal area and the wound is closed (21). With a temporal lift, the scar is located within the hair-bearing scalp and therefore is not visible in most cases.

CLINICAL MATERIAL

At our institution, between 1984 and 1990, 24 patients who underwent resection of large acoustic neurinomas suffered complete loss of ipsilateral facial nerve function. All of the patients were treated with hypoglossal-facial nerve transfer and anastomosis. The time between loss of function and surgery ranged from 2 weeks to 1.5 years. Follow-up ranged from 6 months to 4.6 years.

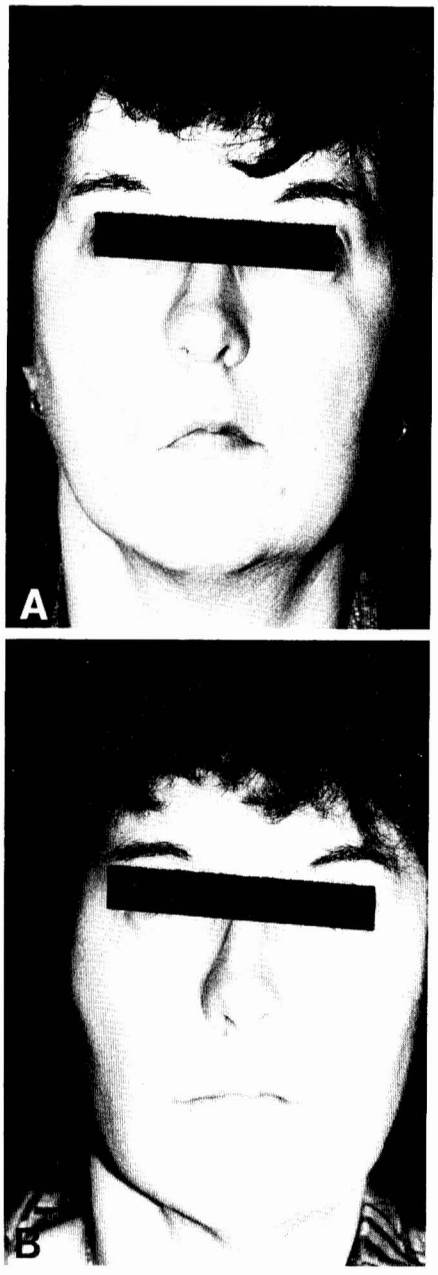

FIG. 8. A 38-year-old patient with total right VIIth nerve paralysis, 3 years after removal of right-sided acoustic neurinoma. *A*, preoperative; *B*, 6 months after temporalis muscle transposition.

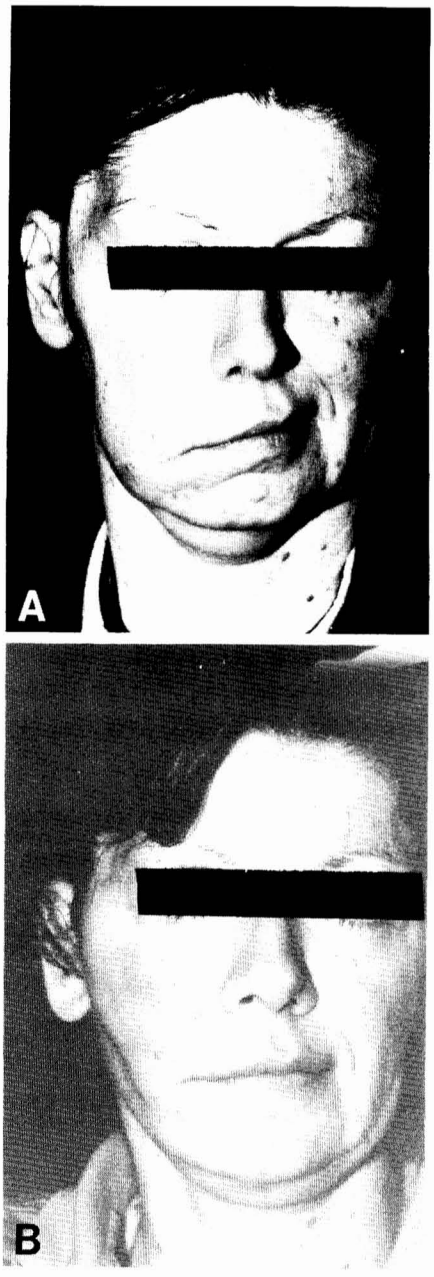

FIG. 9. A 41-year-old patient with a history of bilateral acoustic neurinoma removal (von Recklinghausen's disease), total right Vth and VIIth nerve paralysis 3 years after right acoustic neurinoma removal. *A*, preoperative; *B*, 6 months after right face lift with fascia lata suspension.

RESULTS

Because of the complex functions of the facial nerve, a number of defects are associated with facial nerve injury. Several grading systems to classify recovery from facial nerve lesions have been proposed. Botman and Jongkees (3), May (14), Pietersen (19), and House and co-workers (7, 8) have all contributed classifications. The classification system of House has become widely accepted and used; however, after nerve repair or hypoglossal-facial nerve anastomosis, the results will not be comparable to those of an intact nerve. Thus, May has put forth a classification that specifically takes into account nerve trunk interruption. The grades and descriptions are as follow (see Table 1): Grade I, mild dysfunction; Grade II, mild to moderate dysfunction; Grade III, moderate dysfunction; Grade IV, moderately severe dysfunction; Grade V, severe dysfunction; Grade VI, total paralysis.

Using the aforementioned classification, the patients were graded as follow: Grade I, 18 patients; Grade II, no patient; Grade III, no patient; Grade IV, 6 patients; Grade V, no patients; Grade VI, no patient. All of the patients who were Grade IV had their surgery more than 1 year after the loss of function. There were no complications such as wound infections or problems with deglutition from loss of one hypoglossal nerve. None of the patients has demonstrated any significant problems with speech. All patients developed paralysis and atrophy of the ipsilateral tongue. Seventy-five percent of the

TABLE 1
Facial Nerve Dysfunction Grading System (May)

Grade	Description	Results	Definition and Recovery Results
I	Mild dysfunction	Superb	Some mimetic (spontaneous) movement: individual movement: complete eyelid closure and smile but asymmetrical with maximal effort
II	Mild to moderate dysfunction	Excellent	Mimetic movement absent: otherwise same as I
III	Moderate dysfunction	Good	Mass movement: otherwise same as I
IV	Moderately severe dysfunction	Fair	Incomplete eyelid closure and/or very weak mouth movement
V	Severe dysfunction	Poor	Symmetry only, tone intact, no movement
VI	Total paralysis	Failure	Flaccid, tone lost

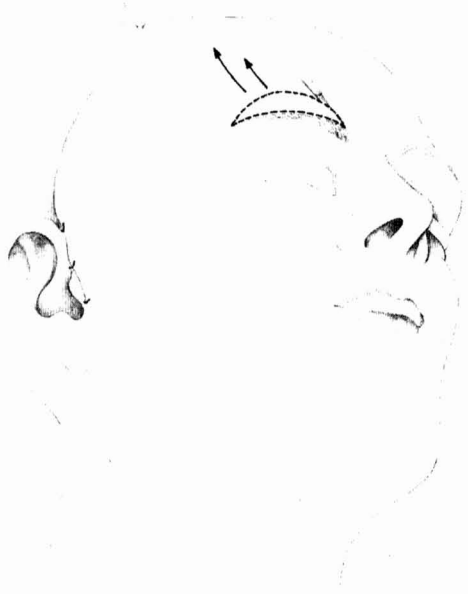

FIG. 10. Brow lift. The brow is elevated with direct lift (*dotted lines*) or temporal lift (*solid line incision*).

patients have been extremely satisfied with the subsequent cosmetic improvement.

DISCUSSION

Sir Charles Bell (2) (1774–1842) authored the first book on nerves and nerve disorders, and in 1821 established that the facial nerve was responsible for the motor control of the facial musculature. In 1879, Drobnick (6) performed the first nerve transfer by anastomosing the facial and spinal accessory nerves. A few years later, in 1900, Manasse (11) and Ballance (1) anastomosed the spinal accessory, hypoglossal, and glossopharyngeal nerves. The first hypoglossal-facial transfer was done by Korte in 1903 (9). At present, every case of facial paralysis can be improved by one or a combination of surgical procedures. For the neurosurgeon, the most commonly encountered cause of facial paralysis will be secondary to posterior fossa surgery, most notably for acoustic neurinomas.

The timing of surgery depends on the state of integrity of the facial nerve. If it is anatomically severed and cannot be repaired intracranially, it is the authors' practice to wait 3 to 4 weeks, then readmit the patient for hypoglossal-facial anastomosis. If the nerve is anatomically and physiologically preserved during surgery, but is without postoperative function, the anastomosis is generally not performed for at least 2 years, as 90% of the patients on the authors' service seem to have adequate, although delayed, functional facial nerve recovery. The results that may be achieved with the facial nerve anastomosis are a normal resting tone of the facial musculature and less than perfect voluntary symmetrical facial motion.

We have described several procedures that may be used in an attempt to provide facial symmetry and recovery of facial function in patients who have sustained permanent facial nerve damage. The method used depends on the surgeon's choice and knowledge. The treatment of choice among surgeons treating this condition is nerve grafting, with the hypoglossal-facial anastomosis being the most favored. With this procedure, facial musculature tone generally shows signs of recovery between 4 and 6 months, with symmetry of the face at rest being restored. Movement of the ipsilateral side usually appears first about the oral commissure, then gradually progresses to the cheek, lips, and orbits over the ensuing 18 months. Good results are usually obtained if surgery is done within 1 or 2 years, but have been obtained in some patients as late as 10 years after the loss of facial movement, when not associated with severe muscular atrophy (4). The major contraindication for nerve grafting is the anatomical or functional absence of facial musculature. In patients for whom nerve grafting is no longer possible, static as well as dynamic techniques for facial reanimation have been described. Dynamic reanimation procedures utilizing temporalis and/or masseter muscles give symmetry as well as active voluntary movement of the patient's face. Static techniques provide no facial movement, but do add support and symmetry to the patient's face at rest.

We have included surgical methods for facial reanimation that do not necessarily fall in the neurosurgeon's surgical realm. For the neurosurgeon dealing with facial nerve injuries, however, a familiarity with these procedures will afford a more comprehensive and complete view of the surgical management of this common condition.

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COMMENT

The authors describe several surgical approaches for the reanimation of the permanently paralyzed face. They discuss their experience with hypoglossal-facial anastomosis in 23 patients. The results would suggest that this method is a reliable means of providing some movement and function. Their experience with this procedure is consistent with the reported results of others in terms of overall reliability. As was the case in their series, it is very unusual for any nerve grafting procedures to result in adequate movement of the forehead. Although the authors discuss several other approaches to reanimating the face, there is little rationale for when and under what circumstances these other procedures should be utilized. In general, the use of phrenic and accessory nerve grafting have not resulted in satisfactory facial reanimation and have been abandoned by most surgeons.

Management of the paralyzed face is a complex problem. It is best managed by a team of specialists including neurosurgeons, oculoplastic surgeons, and facial reconstructive surgeons. Of fundamental importance is management of the eye, which the authors do not address. The use of tarsorrhaphies and more recently gold weights and ocular springs are essential to the maintenance of a healthy cornea and a prevention of a visual loss and incapacitating pain. Which oculoplastic procedure is best suited for a particular patient depends upon the patient's age, skin laxity, and the presence or absence of corneal anesthesia. All of these procedures have the advantage of being reversible. One of the major disadvantages of hypoglossal facial anastomosis as described by the authors is the resultant facial synkinesis that results from anastomosing the entire hypoglossal nerve to the main trunk of the facial nerve. A proven alternative to this technique is to split the hypoglossal nerve and anastomose half of the nerve to the lower branch of the facial nerve. This results in little or no problem with movement of the tongue and provides excellent movement in the corner of the mouth. It allows for the patient to smile without closing an eye simultaneously. Under these circumstances the eye can be managed with either a gold weight or a spring, allowing the patient to exhibit more natural facial movement.

The use of the temporalis transposition flap is the mainstay for most surgeons now engaging in facial reanimation surgery. It can be done in conjunction with a facial hypoglossal anastomosis or in a patient who has sustained injury to the facial nerve but the outcome of which is uncertain. In most cases, it allows for excellent movement in the corner of the mouth as well as improved static symmetry. If facial nerve recovery does occur, this procedure has no adverse effects on the regeneration process. It allows for early rehabilitation in patients who might otherwise have to wait 2 to 3 years. In many cases the cosmetic result of a temporalis transposition in combination with an upper lid gold weight or ocular spring is superior to that obtained with hypoglossal facial anastomosis.

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