Facial nerve disorders encompass a broad spectrum of dysfunction, ranging from subtle dynamic facial asymmetry to complete, dense paralysis. Facial nerve regeneration following injury can vary greatly and may result in hypofunction (persistent weakness or poor excursion of facial muscles), hyperfunction (hypertonicity, spasm), or aberrant regeneration (synkinesis). The impact of a facial nerve disorder can be dramatic. Disabilities encountered include corneal exposure of the affected eye, oral incompetence and articulation difficulties from orbicularis oris weakness, and functional nasal obstruction from dilator naris paralysis. None of these is perhaps as significant as the social isolation these patients often succumb to based on their perceived disfigurement and inability to convey emotion through facial expression. Because of the profound effect of this disorder on patient quality of life, a great deal of effort has been focused toward rehabilitation of the paralyzed face.

When facial nerve discontinuity is encountered, the first approach is to attempt to reestablish direct neural continuity between the facial motor nucleus and the distal facial nerve through either primary repair or autografting techniques. When this is not possible, other methods of reestablishing facial balance and movement may be considered. Facial reanimation procedures refer to interventions that restore facial symmetry, resting tone, voluntary movement, or a combination of these. Several broad categories of facial reanimation techniques exist, each appropriate to a specific set of clinical, anatomic, or outcome-related circumstances. These include reinnervation techniques, muscle transfers, and static procedures. The aim of this chapter is to describe each of these approaches, including appropriate clinical scenarios, technical aspects of the surgery, and adjunctive management strategies to optimize postoperative appearance and function.

REINNERRVATION TECHNIQUES

Reinnervation techniques, also termed nerve substitution techniques, are procedures that provide neural input to the distal facial nerve and facial musculature via motor nerves other than the native facial nerve. They are indicated in two situations. The first is when the proximal facial nerve stump is not available but the distal facial nerve and facial musculature are present and functional. This occurs following skull base tumor resections involving sacrifice of the nerve at or very close to the brainstem, where neurorrhaphy is not technically achievable. The second situation occurs following skull base surgery, intracranial injury, or traumatic facial paralysis, when the nerve is thought to be anatomically intact but there is no discernable return of function after a satisfactory waiting period of 12 months. Lack of functional recovery, electrophysiologic demonstration of lack of reinnervation potentials, and the presence of fibrillation potentials at 12 months indicate persistent complete denervation. This suggests insufficient regenerative potential from the proximal facial nerve stump and therefore mandates alternative proximal axonal input to the distal facial nerve and facial musculature.

**Hypoglossal–Facial Transfer (XII–VII Crossover)**

The nerve most often utilized to reinnervate the distal facial nerve is the hypoglossal nerve. Its proximity to the extratemporal facial nerve, its dense population of myelinated motor axons, the relative acceptability of the resultant hemitongue weakness, and the highly predictable and reliable result make it a logical choice (1–4). In the classic XII–VII transfer, the entire hypoglossal nerve is transected and reflected upward for direct neurorrhaphy to the facial nerve stump (Fig. 38.1A). Several modifications have been described (Fig. 38.1B–D), including the “split” XII–VII transfer (5), in which approximately 30% of the width of the hypoglossal nerve is divided from the main trunk of the nerve for several centimeters and secured to the lower division of the facial nerve (Fig. 38.1B). Another modification, designed to reduce tongue morbidity by avoiding the splicing away of a significant length of the partial hypoglossal trunk, is the XII–VII jump graft. This involves an end-to-side neurorrhaphy between the hypoglossal nerve and a donor cable graft (usually the great auricular nerve), which in turn is sewn to the
distal facial trunk (6) (Fig. 38.1C). This modification is based upon improved appreciation of the microanatomy of the hypoglossal nerve, which demonstrates interwoven fascicular architecture; separating a 30% segment away from the main trunk for several centimeters divides a significantly greater number of axons than if the fibers were oriented in parallel (6).

In some circumstances where the facial nerve is able to be mobilized from the second genu within the temporal bone and reflected inferiorly, removal of the mastoid tip allows for direct coaptation of the facial nerve to the hypoglossal without the need for an interposition graft (7) (Fig. 38.1D). Elimination of the cable graft provides a theoretical regenerative advantage by reducing from two neurorrhaphies to one.

**Surgical Technique**

The classic XII-VII procedure is performed via a modified Blair parotidectomy incision. The main trunk of the facial nerve and the pes anserinus are identified using standard facial nerve landmarks, such as the tragal pointer and the tympanomastoid suture line. The hypoglossal nerve is then located in its ascending portion, deep to the posterior belly of the digastric, along the medial surface of the internal jugular vein. The nerve is followed anteriorly and freed of fascial attachments beyond the takeoff of the descendens hypoglossi. The hypoglossal nerve is then sharply transected and reflected superiorly to meet the facial nerve. The facial nerve is transected at the stylomastoid foramen, and the entire distal trunk is reflected inferiorly and secured to the hypoglossal nerve with 5 to 7 10-0 nylon epineurial microsutures.

A modification designed to decrease mass movement of the face involves sectioning the entire facial nerve but performing a neurorrhaphy only to the inferior division of the facial nerve, or ligating the upper division distal to the pes (Fig. 38.1), and employing separate techniques for management of the upper face. The split XII-VII transfer provides many fewer axons and is therefore best utilized only for the lower segment of the face.

In the jump graft or direct XII-VII end-to-side procedure, once the exposure has been obtained the great auricular nerve graft is harvested or the proximal facial nerve is mobilized from the temporal bone, sectioned at the second genu,
and transposed into the neck by removal of the mastoid tip. The facial nerve can be further mobilized by dissecting it away from the parotid tissue beyond its bifurcation. The end-to-side neurorrhaphy is executed by removing a segment of hypoglossal epineurium, then cutting a 30% opening into the hypoglossal nerve and allowing the defect to open up. The recipient nerve is then laid into the defect, facing the proximal cut surface, and secured with microsutures.

**Results, Drawbacks, and Contraindications**

With a XII-VII transfer, good resting facial tone is achieved in more than 90% of patients. When successful, the transfer allows deliberate facial movement with intentional manipulation of the tongue. Recovery generally occurs over 6 to 24 months and in some cases has been reported to continue up to 5 years. Results are variable, with time from denervation to transfer playing a key role in outcome. There is general consensus that reinnervation must occur within 2 years following injury, otherwise neuromuscular fibrosis and atrophy progress to a point where meaningful tone and movement are not achievable (6).

The two most significant drawbacks of the procedure are the mass facial movement experienced by many patients and the variable tongue dysfunction, which has been categorized as severe in up to 25% of patients. Articulation and mastication difficulties are commonly cited. The modifications mentioned earlier are aimed at one or the other of these two problems. In addition, botulinum toxin administration in the region of the eye and physical therapy have proven useful adjuncts for patients with clinically significant mass movement.

The procedure is contraindicated in patients who are likely to develop other cranial neuropathies (e.g., neurofibromatosis type II) or who have ipsilateral tenth nerve deficits, as the combined X-XII deficit can lead to profound swallowing dysfunction.

**VII-VII Cross Facial Grafting**

Another potential source of axons for facial reinnervation is the contralateral healthy facial nerve (8). The two distinct advantages of its use are that it is the only donor source with the potential for mimetic function (the involuntary blink and
emotive smile) and that it is significantly arborized distally, so several branches may be sacrificed for use in cross facial grafting, usually without adversely affecting the healthy side. The disadvantages include many fewer motor axons than the hypoglossal, with unpredictable results; the need for a lengthy sural nerve jump graft; and the potential for facial weakness on the donor side (9). Most surgeons feel the motor power provided by the hypoglossal nerve is distinctly superior, and the use of the contralateral facial nerve strictly for reinnervation of native facial musculature has largely been replaced by cross face nerve grafting in conjunction with free muscle transfer.

Surgical Technique

The VII-VII cross facial graft technique has a great deal of surgical variability with regard to exposure of the donor and recipient nerves, the length and positioning of jump grafts, and the timing of second stage neurorrhaphy. There are insufficient data to allow specific approaches to emerge as superior to others (10–12). It is ordinarily a staged procedure, where in the first stage a sural nerve graft is harvested from the leg, tunneled subcutaneously from the ipsilateral preauricular region across the face, and sewn to the fresh cut edges of one or several buccal branches of the functioning facial nerve (Fig. 38.2), via a nasolabial fold or a preauricular incision. The growth of axons into the graft is followed clinically by tapping on the graft (Tinel’s sign); tingling indicates the presence of regenerating axons. Once regeneration has occurred across the face, a second stage is performed where the sural nerve graft is sewn to one or several branches of the affected facial nerve. Alternatively, the ipsilateral neurorrhaphy can be performed in the same operative setting.

Results, Drawbacks, and Contraindications

The major disadvantage with cross facial nerve grafting is that results are inconsistent. Some authors report excellent recovery, whereas many others find it entirely unsatisfactory. It appears that it is most useful in association with other reanimation modalities, to address a single territory within the face rather than to reinnervate the entire contralateral facial nerve. Recent studies employing the cross facial graft for isolated marginal mandibular paralysis demonstrate its utility (13).

OTHER REINNERVATION TECHNIQUES

Several other cranial nerves have been employed for reinnervation of the distal facial nerve stump. The spinal accessory nerve (14), glossopharyngeal nerve, and trigeminal nerve have all been described as potential donors, though none has gained great popularity. The donor morbidity and difficulty with surgical exposure far exceed that found with XII-VII and cross facial grafting. Experimentation with uti-
lizing isolated branches, such as the sternocleidomastoid branch of the spinal accessory nerve (15,16), would decrease donor morbidity, potentially increasing the utility of this technique.

**MUSCLE TRANSPosition TECHNIQUES**

When the distal facial nerve or facial musculature has undergone degeneration to a point of significant atrophy or fibrosis, even the delivery of viable motor axons will not provide adequate excursion to create appreciable facial expression. Occasionally, resection of extensive disease involves removal of facial musculature for adequate tumor extirpation. In these situations, the transfer of functional innervated musculature into the face offers the only possibility of meaningful facial movement. A segment of innervated muscle can be transposed into the appropriate segment of the face from the temporalis, masseter, digastric, or other regional muscles or transferred from a distant site (gracilis, pectoralis minor, serratus anterior, latissimus dorsi) and reinnervated locally.

Effective rehabilitation requires training and physical therapy to achieve optimal function. The literature does support the concept of neural plasticity whereby, after a certain training period, patients with trigeminally driven muscle transfers into the face are able to achieve movement without initiating a clenching of teeth. Whether this is a central nervous system phenomenon or a peripheral phenomenon is not known (17).

**Temporalis Muscle Transposition**

When intact, the temporalis muscle is the first choice for reanimation of the smile in the chronically paralyzed face. It is also useful as an interim therapy, when the regenerative potential of the facial nerve is in question (e.g., following skull base surgery), during the waiting period for regeneration (18), as it does not interfere with any potential facial nerve regeneration. Further, it may be utilized to manage the upper face in conjunction with a XII-VII transfer to the lower division of the nerve. It serves as a static support to the oral commissure and provides trigeminally controlled dynamic movement.

Before proceeding, it is imperative to establish that the muscle and its nerve and vascular supply are intact, as many neurotologic procedures damage these structures, and several congenital facial palsy syndromes are associated with other cranial nerve abnormalities that may affect temporalis muscle function. Severe atrophy of the musculature, such as in an edentulous patient, would also be a contraindication to this approach.

**Surgical Technique (19)**

The procedure is performed through an incision from the superior temporal line down to the attachment of the lobule, and sometimes extending postauricularly as with a rhytidectomy. Flaps are then raised both anteriorly and posteriorly in the subdermal plane, just under the hair follicles. Care is taken to preserve the superficial temporal artery and veins, so that the temporoparietal fascial flap can be utilized to obliterate the donor site defect. The temporoparietal fascial flap is then reflected from the true temporalis muscular fascia, working superiorly to inferiorly, leaving the temporoparietal fascial flap pedicled on its vessels. A flap is then raised in the subdermal plane from the zygomatic arch to the oral commissure. The skin flap extends medi ally all the way to the lateral border of the orbicularis oris muscle to achieve adequate coaptation to the transferred muscle. A 1.5-cm wide strip of temporoparietal muscle with its underlying pericranium is then elevated from the calvarium. The segment is chosen so that reflection over the zygomatic arch will pull the commissure in a vector appropriate to the patient’s smile pattern (20). A double staple line of gastrointestinal anastomosis staples is placed along the superior muscle edge, to provide a firm purchase for the insetting sutures (Fig. 38.3A). Once this is accomplished, the muscle is reflected into the midface and secured with vicryl sutures to the orbicularis oris, with good muscle-to-muscle contact to promote potential neurotization of the orbicularis fibers. The commissure is deliberately overcorrected, so that with relaxation, appropriate position is achieved (Fig. 38.3B). The temporoparietal fascial flap is then placed into the temporals strip defect (Fig. 38.3C), and the incision is closed over a drain. A mastoid-type dressing is placed for the first postoperative night. The incision is closed with 5-0 nylon interrupted sutures. Physical therapy is vital to achieving satisfactory muscle function and is instituted within weeks after the transfer to develop appropriate control and excursion of the transferred muscle.

**Other Regional Muscle Transfers**

The masseter muscle transfer, popularized by Rubin (20) and by Baker and Conley (21), can also provide excursion at the oral commissure. The entire muscle is ordinarily freed from its mandibular attachments and secured to the lateral aspect of the orbicularis oris, much the same way as the temporalis muscle. However, given its more lateral vector pull and the contour defect it creates at the commissure, it remains a far second choice to the temporalis muscle transposition. Modifications which address this and simplify the procedure have been reported in a few patients (22), though no substantial improvement has been clearly established.

The digastric muscle transfer is useful in isolated marginal mandibular nerve injuries, but compromises oral competence in the total facial paralysis patient. In the appropriately selected patient with isolated marginal mandibular nerve injury, the procedure can be effective at restoring depressor function to the lower lip. It involves sectioning the digastric muscle at the junction of the posterior belly and its tendon, then freeing the anterior belly and tendon from sur-
Transposed Temporalis Muscle

Orbicularis Oris Muscle

Bone Surface

Temporoparietal Fascia

Temporalsis Muscle

FIG. 38.3 Temporalis muscle transposition. A: Securing the transposed muscle to the orbicularis oris. Note the double staple line and mattress sutures from temporalis muscle to modiolus. B: Note the overcorrection of the commissure so that the first molar is visible. C: After muscle inset, the temporoparietal fascial flap is placed into the donor site defect.
rounding structures and securing it to the orbicularis oris along the ipsilateral inferior border (Fig. 38.4). Mylohyoid nerve innervation to the anterior belly can be maintained (23) or the muscle can be driven by a cross face nerve graft as shown (13).

Other local muscle flaps have been suggested—for example, the innervated platysma musculocutaneous flap (24)—but insufficient numbers of treated patients leave their ultimate utility in question.

Free Muscle Transfer

With the advent of microvascular free tissue transfer, the opportunity to bring functional muscle from a distant site into the face became possible. In a number of clinical scenarios, this approach is preferred. First, if the proximal facial nerve stump is available but the facial musculature has been resected, a free muscle graft can be transferred and driven by the ipsilateral proximal facial nerve. This has the potential of providing involuntary, mimetic movement in the face. Patients with long-standing facial paralysis in whom the temporalis transposition is not an option may achieve superior results from free muscle transfer powered by either the ipsilateral trigeminal nerve or a cross facial nerve graft rather than through an alternative regional muscle transfer.

Congenital facial palsy patients are also good candidates for the procedure because they lack adequate muscles of facial expression or facial nerve trunks for neurorrhaphy and may have other cranial neuropathies (25). The procedure is most commonly performed as a two-stage procedure for

**FIG. 38.4** Transfer of the anterior belly of the digastric. The tendon is divided and filleted into separate slips and secured to the orbicularis oris. Note that native innervation can be maintained or replaced by a cross face nerve graft.
unilateral paralysis and a single-stage procedure for bilateral paralysis (i.e., Moebius syndrome). This is because for unilateral paralysis, the muscle is powered by a cross facial graft from a buccal branch of the healthy facial nerve, requiring a 9- to 12-month waiting period for axonal extension through the cable graft before muscle transplantation. For bilateral paralysis, the muscle is driven by the ipsilateral trigeminal or hypoglossal nerve, which eliminates the need for a regeneration phase and second operative procedure.

The gracilis muscle was the first muscle utilized in successful facial reanimation (26), and remains the most popular choice for this purpose. Modifications involving use of subsegments of the muscle and alternative neural sources for the graft have been described (27, 28). The muscle implantation procedure is described next.

**Surgical Technique**

Preoperatively, the vector of the smile on the healthy side (if present) is noted so that it can be emulated on the affected side. The procedure is begun by harvest of the gracilis muscle from the medial aspect of the thigh. An incision is made 1.5 cm posterior and parallel to a line connecting the pubic tubercle to the medial condyle of the tibia. The soft tissues are divided until the belly of the gracilis muscle is identified. The vascular pedicle is located entering the deep surface of the muscle, 8 to 10 cm distal to the pubic tubercle, and followed proximally for a length of 6 cm. The obturator nerve is then identified 2 to 3 cm proximal to the vascular pedicle and similarly traced. The muscle is marked at 1-cm increments so that when it is surgically removed and contracted, the resting length can be estimated. The pedicle, nerve, and muscle belly are then divided, using the gastrointestinal anastomosis stapler for the muscle division, and removed from the surgical bed (29).

A preauricular incision is then made and extended to just below the mandible to identify the facial vessels for microvascular anastomosis. An anterior flap is raised, exposing the zygomatic arch and malar eminence, extending medially to expose the orbicularis oris. The stump of the cross face nerve graft is identified for the neurorrhaphy, in the case of a cross face nerve graft, and the masseteric nerve is identified immediately under the zygomatic arch if it is a one-stage procedure. Some surgeons place a temporary static sling from the zygomatic arch to the corner of the mouth so that the newly transferred muscle will not bear the weight of the face for the initial postoperative period (30). The gracilis muscle is then secured to the modiolus, stretched to its resting tension length as determined by the incremental markings, trimmed to the appropriate length, and secured to the zygomatic arch or temporalis fascia to create the appropriate vector pull (Fig. 38.5). The microvascular anastomoses and

![Figure 38.5](image-url)
the neurorrhaphy are performed, and the incisions are closed over suction drainage. Chewing is avoided for the first 5 postoperative days.

Alternative free muscle grafts for facial reanimation have been described, including the pectoralis minor, latissimus dorsi, serratus anterior, and abductor hallucis (31–36). The current thrust is to achieve a one-stage reconstruction powered by the contralateral facial nerve (37). This requires a muscle whose nerve supply can be harvested to a length of 15 cm, eliminating the need for a separate cross facial graft. Several pioneers of the initial gracilis transfer now prefer one-stage reconstruction with the latissimus dorsi and its long neural pedicle (30,37). Subjective and objective comparisons of free muscle transfer versus temporalis transfer demonstrate superior excursion in the former but overall poorer aesthetic results based on increased bulk and overlying skin tethering (38). These methods are in a period of rapid evolution, and time will reveal which free muscle transfers yield most optimal long-term facial reanimation results.

STATIC FACIAL REANIMATION PROCEDURES

Some facial paralysis patients are best rehabilitated through static techniques. These include patients who are poor candidates for prolonged general anesthesia for medical reasons, patients with a poor prognosis in whom reanimation over a long time is not appropriate, and dynamic reanimation failures.

Patients with partial recovery following Bell’s palsy, Ramsay Hunt syndrome, or other conditions leading to aberrant regeneration are also suitable candidates for static reanimation procedures. Often there is adequate facial movement, and the unsightly facial asymmetry is attributable to hypertonicity, contracture, synkinesis, and subtle cervical and brow positioning abnormalities. These can be addressed via an asymmetric rhytidectomy with unilateral or asymmetric superficial muscular aponeurotic system with possible intraoperative intentional sacrifice of selected branches on the pathologic side to relax an area of hypertonicity. Unilateral brow lift often complements the procedure.

Static procedures can be directed at specific functional and cosmetic issues (19,39) (Figs. 38.6–38.9). For example, nasal obstruction due to nasal valve collapse from dilator nares paralysis can be addressed with standard nasal valve

FIG. 38.6 Static technique for facial reanimation. A patient with long-standing left facial paralysis is depicted. Note the brow ptosis, midfacial asymmetry, external nasal valve collapse, and commissure malposition.
repair (Fig. 38.7). If oral incompetence is a significant complaint, lateral lower lip resection (Fig. 38.8) or selective myomectomy may be of benefit; fascia lata slings have been described to improve cosmesis and competence in this area (40). Creation of a nasolabial fold via a two-stitch prolene suture technique, a modification of the Keller facelift (41), has proven effective as well. Management options for the eye are discussed in detail in a subsequent chapter, though unilateral brow lifting is commonly utilized (Fig. 38.9). Static procedures are also used in conjunction with dynamic re-
animation techniques as touch-ups or to refine a satisfactory result even further.

SUMMARY

Facial paralysis is a disfiguring and debilitating condition whose management is determined by a large set of clinical variables. A systematic approach to the problem is presented here, employing reinnervation techniques as a first line and muscle transfer for dynamic reanimation as a second line when feasible, reserving static rehabilitation procedures for otherwise poor surgical candidates and those with modest or specific deficits.

Efforts are ongoing to improve or preserve neural function, to evoke better native facial nerve regeneration with nerve grafting techniques, and to optimize static and dynamic transfer for facial expression. The quantification of facial muscle function is another ongoing area of study, so that distinct, measurable changes in function can be recorded following different interventions. Observer-based scales, computer-based image analysis programs, and patient-based outcome surveys will serve as valuable tools in the future to clarify the expected benefit from each of the described interventions.

REFERENCES
