Facial Reanimation Using the Masseter-to-Facial Nerve Transfer

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Background: This article describes facial reanimation using the transfer of the trigeminal motor nerve branch of the masseter muscle (masseter nerve) to the facial nerve (masseter-to-facial nerve transfer).

Methods: A retrospective review was performed of 10 consecutive facial paralysis patients treated with a masseter-to-facial nerve transfer for reanimation of the midface and perioral region over a 7-year period. Patients were evaluated with physical examination, direct measurement of commissure excursion, and video analysis.

Results: All patients regained oral competence, good resting tone, and a smile, with a vector and strength comparable to those of the normal side. Motion developed an average of 5.6 months after masseter-to-facial nerve transfer, with 40 percent of patients developing an effortless smile by postoperative month 19.

Conclusions: The masseter-to-facial nerve transfer is an effective method for reanimation of the midface and perioral region in a select group of facial paralysis patients. The technique is advocated for its limited donor-site morbidity, avoidance of interposition nerve grafts, and potential for cerebral adaptation, producing a strong, potentially effortless smile. (*Plast. Reconstr. Surg.* 127: 1909, 2011.)

Adjacent cranial nerve transfers represent a major reconstructive option in the surgical treatment of the paralyzed face. Nerve transfers are indicated when the main trunk of the facial nerve is damaged or unavailable but the distal nerve branches and mimetic muscles remain viable. The hypoglossal (twelfth cranial nerve), facial (seventh cranial nerve) with cross-face grafts, spinal accessory (eleventh cranial nerve), and phrenic nerves have all been transferred for facial reanimation with varying degrees of success.[1–6] The traditional nerve donor sites all possess a series of strengths and weaknesses, with no single transfer possessing the full complement of desirable characteristics, including limited donor-site morbidity, strong muscle contraction, rapid recovery, and an effortless or spontaneous smile.

The trigeminal motor nerve branch to the masseter muscle has become the standard source of innervation used to power free muscle flaps in cases of bilateral congenital facial paralysis (Möbius syndrome).[7] In our reconstructive surgery institute, the role of the masseter nerve has been expanded to include direct microsurgical repair to selected buccal and zygomatic branches of the facial nerve (masseter-to-facial nerve transfer). The masseter-to facial nerve transfer has been successfully used in select cases of facial paralysis to reinnervate paralyzed mimetic muscles in the midface and perioral region, yielding a natural, symmetric smile and good resting tone.[8,9]

The masseter-to-facial nerve transfer has a series of advantages when compared with more traditional techniques.[10] The donor-site deficit produced by harvesting the motor nerve branch to the masseter is minimal. The masseter and temporalis work in concert during mastication. The absence

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Received for publication May 29, 2010; accepted October 6, 2010.

Presented at the Third Congress of the World Society for Reconstructive Microsurgery, in Buenos Aires, Argentina, October 23 through 26, 2005, and at the 21st Annual Meeting of the American Society for Reconstructive Microsurgery, in Fajardo, Puerto Rico, January 15 through 18, 2005.

DOI: 10.1097/PRS.0b013e31820e9138

Disclosure: *The author has no financial interest to declare in relation to the content of this article.*

of bite abnormalities or temporomandibular joint dysfunction noted after weakening the masseter muscle is partially accounted for by this duplication of function.

During the masseter-to-facial nerve transfer, the descending branch of the masseter nerve is divided, leaving the more proximal branches intact. This selectivity has prevented complete paralysis of the masseter muscle or atrophy, which produces a visible cosmetic deformity. In all cases, the length of the transposed descending branch of the masseter nerve has been sufficient to achieve a tension-free microsurgical nerve repair, avoiding the need for interposition nerve grafts. Recovery of function has been rapid, with muscle tone and a meaningful smile usually returning by the sixth postoperative month. The masseter nerve has a high density of motor axons, and its transfer to the facial nerve can produce forceful muscle contraction. Commissure excursion and smile vectors closely resembling the unaffected side have been routinely achieved. In addition, the physiologic connectedness of the facial and trigeminal nerves has led to trouble-free motor reeducation and the possibility for an effortless smile.

PATIENTS AND METHODS

Masseter-to-facial nerve transfers have been performed in 10 patients (five male and five female patients) with ages ranging from 7 to 84 years, with an average age of 40 years. The causes of facial paralysis were skull base fracture, Bell palsy, acoustic neuroma excision, neurofibromatosis type II, petrous apex cholesterol granuloma, skull base osteomyelitis, ruptured intracranial arterial venous malformation, skull base tumor, malignant schwannoma, and meningioma (one case each). Eight patients demonstrated complete hemifacial paralysis and two retained some function in the upper division of the facial nerve. The average time between the onset of facial paralysis and nerve transfer was 12 months. The earliest transfer was performed immediately after tumor excision, with the longest interval to reconstruction being 23 months.

Surgical Technique

The procedure is initiated by creating a preauricular incision and elevating a skin flap that extends to the anterior border of the parotid gland. The main trunk of the facial nerve is identified using the tragal cartilage as a guide and tested with a nerve stimulator to verify the absence of muscular contraction. The main trunk is traced into the parotid gland, and the facial nerve branches are carefully isolated. The procedure continues in a fashion similar to a superficial parotidectomy, dissecting the facial nerve branches to a point near the anterior border of the parotid gland. In cases of complete paralysis, the main trunk of the facial nerve is divided and reflected, allowing access to the underlying masseter muscle. The superficial musculoaponeurotic system and central third of the masseter muscle are released from the inferior border of the zygomatic arch. The masseter nerve arises beneath the zygomatic arch and follows a gradual, oblique course within the deep substance of the muscle. Blunt dissection and frequent probing with a nerve stimulator are used during the deep muscular dissection until the motor nerve is identified.

The motor branch to the masseter has demonstrated consistent branching during intraoperative exploration (Fig. 1). The nerve liberates a series of small proximal branches followed by a dominant descending branch. The full length of the descending branch is dissected carefully and divided at its most distal point. Adequate length is available to transpose the nerve into a more superficial plane, where an epineurial neurorrhaphy is performed to select buccal and zygomatic branches of the facial nerve with 10-0 nylon (Fig. 2). The frontal branch and dominant zygomatic branches to the orbicularis oculi are sacrificed to avoid synkinetic brow and eye motion or

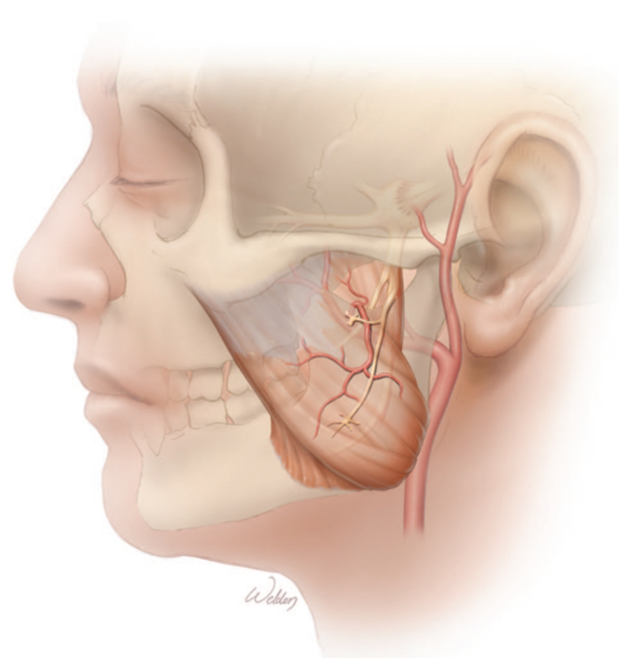

Fig. 1. Branching pattern and oblique deep muscular course of the masseter nerve.

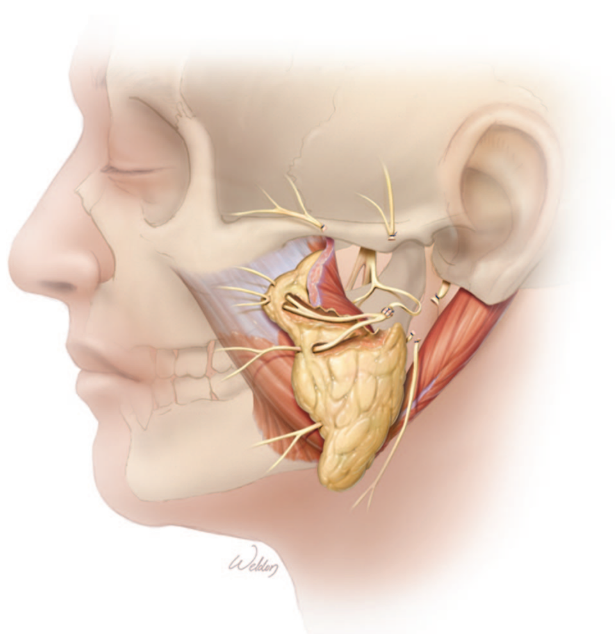

Fig. 2. Drawing depicting surgical anatomy. Microsurgical anastomosis of the descending branch of the masseter nerve to selected buccal branches of the facial nerve is shown.

connected to cross-face nerve grafts. The parotid fascia is repaired and the operative site is treated with fibrin glue before closure. The patients are maintained on a soft diet for 4 weeks, and a home therapy program is initiated once facial tone develops.

The surgical approach is altered when facial paralysis is incomplete. If brow and eye function are present, the main trunk of the facial nerve cannot be divided. The masseter nerve is explored using the narrow interval between the functioning zygomatic branches, and care must be taken to avoid traction injury. The mobilized masseter nerve is then anastomosed to the lower division of the facial nerve and select zygomatic branches, and the integrity of the temporofacial division of the facial nerve is preserved.

RESULTS

Follow-up ranged from 7 to 84 months, with an average of 30 months. All patients regained oral competence, good resting tone, and a nearly symmetric smile, with only mild asymmetry of the nasolabial fold. Resting facial tone returned an average of 3.6 months after surgery. The earliest recovery of facial motion was seen during the third postoperative month. The patient with the slowest recovery did not develop significant motion for 8 months. On average, facial motion comparable to the unaffected side developed 5.6 months after the masseter-to-facial nerve transfer. The vector of the reconstructed smile and degree of motion resembled that of the normal side. The commissure excursion of the reconstructed side ranged from 1 to 1.7 cm, with an average movement of 1.2 cm. The slowest recoveries were seen in the most elderly patients; however, the degree of motion eventually regained was not age dependent.

An effortless smile produced without teeth clenching developed in four of the 10 patients by postoperative month 19 and was present in 75 percent of patients who were followed for 2 or more years (Table 1). No visible wasting of the masseter muscle or temporomandibular joint dysfunction was identified, and no significant synkinesis or socially disturbing facial motion with eating was encountered. One patient developed a sialocele that responded to aspiration and glycopyrrolate. An additional patient developed otitis externa that resolved with topical antibiotics. A third patient experienced tumor metastasis requiring additional chemotherapy and irradiation.

CASE REPORTS

Case 1

The patient in case 1 was a 13-year-old boy (patient 1 in Table 1) who sustained a skull base fracture and closed head injury in a motor vehicle accident resulting in a complete left hemifacial paralysis and lateral rectus palsy. He presented 11 months after injury with oral incompetence and conjunctivitis. Magnetic resonance imaging confirmed a transverse temporal bone fracture with associated facial nerve injury, and electromyography demonstrated no evidence of recovery. That same month, the patient underwent surgical reconstruction. The masseter nerve was transferred to selected buccal and zygomatic branches of the facial nerve for smile restoration (Fig. 3). The eye was addressed with a cross-face nerve graft and temporary gold weight.

The patient required a 48-hour hospitalization and followed an unremarkable postoperative course. Resting facial tone was noted at the 4-month follow-up, and a smile approximating the unaffected side developed during the fifth postoperative month. Jaw clenching was initially required to produce facial motion; however, a smile independent of biting down had evolved by postoperative month 19.

Case 2

A 66-year-old woman (patient 4 in Table 1) presented with a 16-month history of complete right hemifacial paralysis after undergoing resection of a petrous apex cholesterol granuloma (Fig. 4). Her medical history was significant for non–insulin-dependent diabetes mellitus and hypertension. Preoperative magnetic resonance imaging and electromyography failed to demonstrate a tumor or evidence of facial nerve recovery and she underwent a masseter-to-facial nerve transfer and implantation of a gold eyelid weight. The patient was hospitalized overnight and had an unremarkable postoperative course. She demonstrated recovery of facial tone by the fourth postoperative month and oral competence was reestablished the following month. A smile comparable to the unaffected side developed during the seventh postoperative month and became effortless during the second postoperative year.

Table 1. Summary of Patient Data

Patient	Age (yr)	Sex	Cause and Degree of Paralysis	Time Interval before Surgery (mo)	Onset Tone (mo)	Onset Motion (mo)	Commissure Excursion (cm)	Effort to Smile (Bite)	Follow-Up (mo)
1	13	M	Skull base fracture (complete)	11	4	5	1.4	No	84
2	18	M	Acoustic neuroma excision; neurofibromatosis type II (incomplete)	23	4	7	1.0	Yes	8
3	61	F	Bell palsy (incomplete)	19	Always present	6	1.2	No	11
4	66	F	Petrous apex; cholesterol granuloma (complete)	16	4	7	1.4	No	68
5	84	M	Chronic mastoiditis skull base osteomyelitis (complete)	5	6	8	1.7	Yes	19
6	7	F	Ruptured intracranial AVM (complete)	12	3	4	1.1	No	55
7	69	M	Skull base tumor (complete)	0	3	4	1.1	Yes	9
8	49	F	Cerebellopontine angle meningioma (complete)	2.5	3.5	4.5	1.3	Yes	27
9	25	F	Acoustic neuroma (complete)	15	3	4	1.2	Yes	9
10	7	M	Malignant schwannoma (complete)	17	2.5	3	1.0	Yes	7

M, male; F, female; AVM, arteriovenous malformation.

DISCUSSION

In our reconstructive institute, the masseter-to-facial nerve transfer as initially described by Spira has evolved into the technique of choice for reanimating and "babysitting" paralyzed mimetic muscles in the midface and perioral region.[10] It has been used as part of a regional approach to rehabilitation of the paralyzed face and has demonstrated a series of advantages, including minimal donor-site morbidity; strong muscle contraction, producing a symmetric, natural-appearing smile; avoidance of interposition nerve grafts; rapid recovery of tone and facial motion; constant nerve anatomy; and potential for cerebral adaptation and an effortless smile.

The masseter-to-facial nerve transfer produces a minimal donor-site deficit when compared with more traditional options. This is a result of functional overlap of the masticatory muscles along with preservation of the proximal motor branches of the masseter nerve that prevents complete denervation.

The masseter nerve has demonstrated a constant anatomical branching pattern and sufficient length to achieve a primary anastomosis to the facial nerve without the need for interposition nerve grafts.[11,12] The lack of functional impairment with the masseter-to-facial nerve transfer stands in contrast to other cranial nerve donors.

The complete hypoglossal-to-facial nerve crossover is capable of producing strong facial motion but is associated with a series of drawbacks.[13,14] In his review of 122 hypoglossal-to-facial nerve transfers, Conley describes a series of complications, including tongue atrophy (27 percent), difficulty eating (45 percent), impaired speech (27 percent), and mass motion (80 percent).[15] Although these complication rates have been reduced by performing a "partial" hypoglossal-to-facial nerve transfer using an interposition nerve graft, they have not been ameliorated.[1,16] In addition, the therapeutic window for the partial hypoglossal transfer is narrow, as the best results are achieved when the surgery is performed within the first 3 months after facial nerve injury.[3] In contrast to the masseter-to-facial nerve transfer, the hypoglossal crossover is contraindicated in individuals with neurofibromatosis (type II) and adenoid cystic carcinoma, who are susceptible to the development of multiple cranial nerve deficits. Hypoglossal transfers combined with a tenth cranial nerve deficit can result in profound swallowing dysfunction. Transferring the spinal accessory or phrenic nerve can also be associated with significant functional impairment, including shoulder weakness and hemidiaphragmatic paralysis.[5,6,17,18] Donor-site morbidity using the contralateral facial nerve is characteristically low; however, the prospect of damaging the normal facial nerve during operative exploration remains an inherent risk.

Although the facial nerve is the only donor capable of producing true spontaneous, emotionally mediated motion, the muscle excursion achieved with cross-face nerve grafts is usually limited. The tendency to produce weak motion with significant residual asymmetry remains the tech-

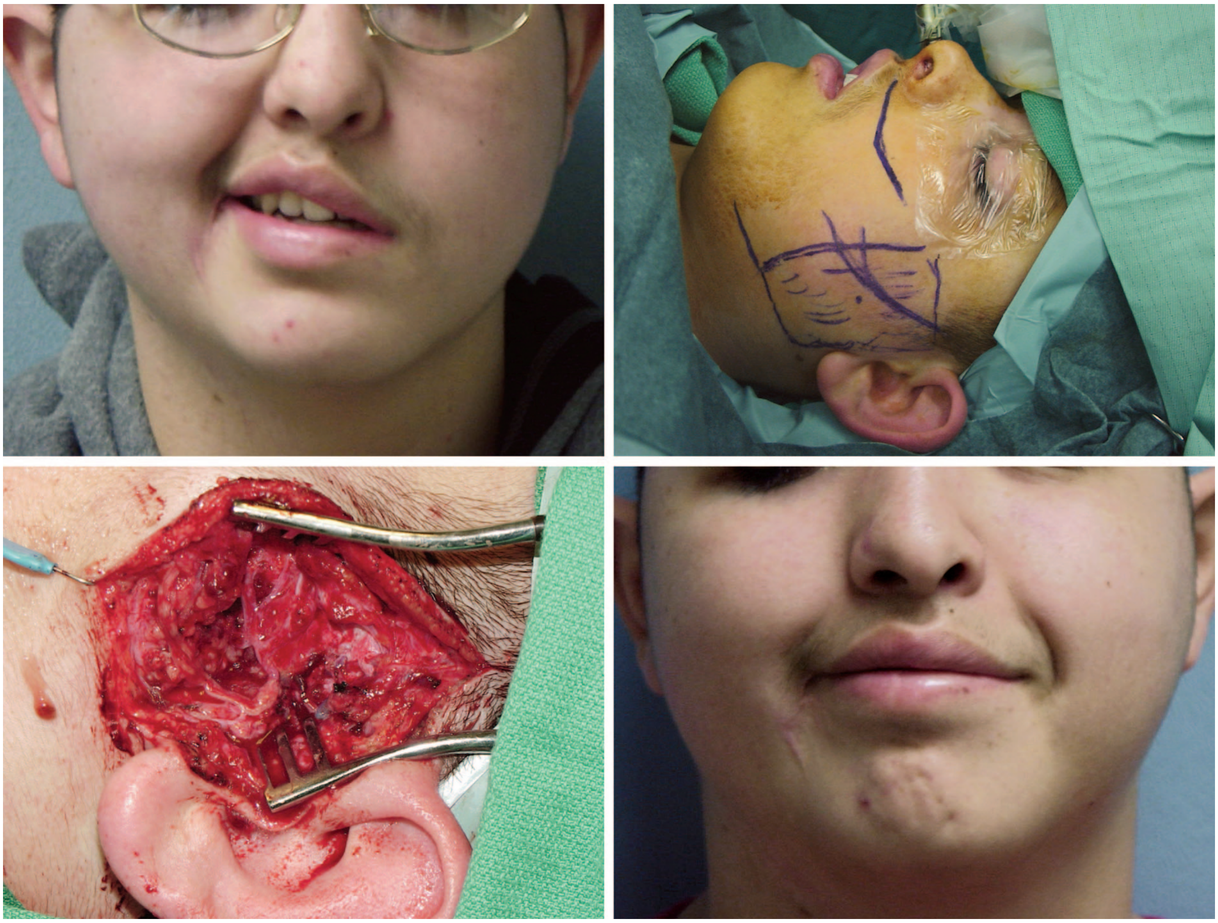

Fig. 3. Case 1. (*Above, left*) Left facial nerve paralysis 11 months after a skull base fracture. (*Above, right*) Preoperative markings for masseter-to-facial nerve transfer and combined cross-face nerve graft for reestablishment of eye closure are shown. (*Below, left*) Microsurgical anastomosis of the descending branch of the masseter nerve to selected buccal branches and cross-face nerve grafting to the zygomatic facial nerve branches were performed. (*Below, right*) Facial motion during the eighth postoperative month.

nique's principal drawback.[3] The ability of the masseter and facial nerves to produce muscle contraction was directly compared in a study by Bae et al.[19] In a review of 122 free gracilis muscle flap facial reanimations, the excursion produced by flaps innervated with cross-face nerve grafts was significantly less then those neurotized by the masseter nerve.

The strong muscle contraction produced by the masseter nerve transfer is comparable to that achieved with the hypoglossal nerve transfer.[20] This clinical finding has also been confirmed in an animal model. Frydman et al. have compared standard hypoglossal-to-facial nerve transfer to masseter-to-facial nerve transfers in rabbits.[21] Histologic and electromyographic evaluation demonstrated similar mean muscle fiber diameters and atrophy scores, indicating that both techniques provide sufficient axonal input for facial reanimation. The spinal accessory and phrenic nerves also provide adequate axonal input but lack the "physiologic dynamism" needed to create a natural appearing smile.[4]

A significant shortcoming of nerve transfers has been the development of unwanted mass facial motion. Facial spasm is frequently produced with eating (hypoglossal-to-facial nerve transfers), shoulder movement (spinal accessory-to-facial nerve transfers), and inspiration (phrenic nerve transfers).[6,13,15]

In addition, an extensive period of motor reeducation is typically required to achieve a proficient, effortless smile. Several large trials have reported good to excellent results in 22 to 65 percent of patients with hypoglossal-to-facial nerve transfers; however, Baker cautioned that a behavioral response closely simulating a normal smile develops in approximately 10 percent of highly motivated patients.[13,14] The initial experience with masseter-to-facial nerve transfers has demon-

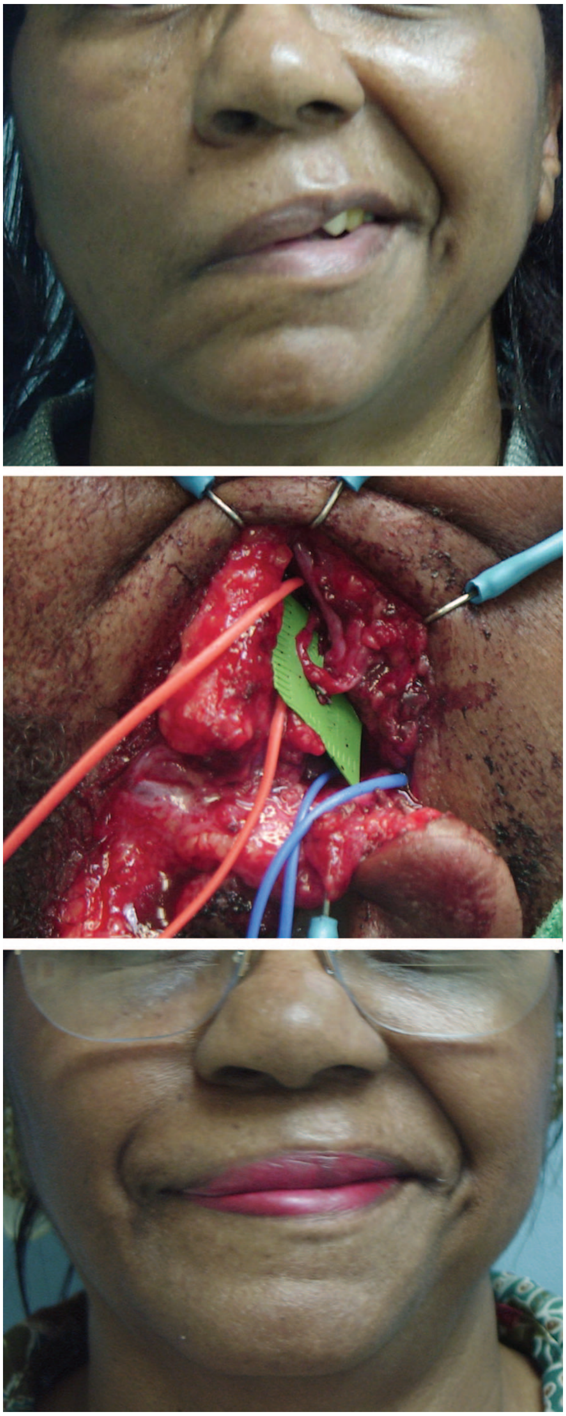

Fig. 4. Case 2. (*Above*) Right facial paralysis 14 months after excision of a petrous apex cholesterol granuloma. (*Center*) Transfer of the descending branch of the masseter nerve to selected buccal branches of the facial nerve. (*Below*) Facial motion during the ninth postoperative month.

strated rapid reinnervation, with the onset of facial motion occurring an average of 5.6 months after surgery. Uncomplicated motor reeducation has also been observed with the masseter-to-facial nerve transfer. All the patients in the study group could produce a naturally appearing smile by the eighth postoperative month, and 40 percent of the patients reported the development of an "effortless" smile by postoperative month 19. Seventy-five percent of patients followed for 2 or more years could produce a smile without biting down. Efficient cerebral adaptation with the masseter nerve has also been described by Manktelow et al.[22]

These investigators reviewed their experience with 41 functional free muscle flaps innervated by the motor nerve branch to the masseter nerve. In long-term follow-up, 82 percent of patients could animate without biting and 53 percent smiled without conscious effort. The ability of the masseter nerve to produce an effortless smile has also been confirmed by Lifchez and associates, who investigated the influence of cortical adaptation on smile restoration after free muscle flap reconstruction.[23]

The motor division of the trigeminal nerve appears advantageous with regard to motor reeducation. Reviewing a 30-year experience with masseter and temporalis muscles transfers, Rubin et al. noted that 66 percent of patients could smile without clenching their teeth and an additional 30 percent required minimal volitional input.[24] Evolution of an effortless smile was attributed to the neuroplastic potential of the brain and development of new neurocranial pathways between the masseter nerve and the facial nerve. This concept is further supported by the close proximity of the facial and trigeminal nerve nuclei in the pons. Scattered reports also exist describing spontaneous redevelopment of facial motion after sacrifice of the facial nerve during total parotidectomy.[25,26] Electroneurographic evidence has suggested that the transected facial nerve branches are neurotized by the adjacent trigeminal nerve fibers. Alternate explanations for spontaneous recovery include the presence of aberrant pathways between the fifth and seventh cranial nerves. Embryologic evidence is available demonstrating the presence of trigeminal nerve fibers within facial nerve branches.[27,28] Developmental models have also identified facial nerve fibers coursing within the motor pathway of the trigeminal nerve that ultimately reunite with the facial nerve branches by means of masseter-to-facial nerve communicating rami.[29] The details of the anatomical relationship between the masseter nerve and the facial nerve require additional clarification. However, it is highly probable that the "connectedness" of these nerves and the neuroplasticity of the central nervous system contribute to the ease of adaptation witnessed clinically when the masseter nerve is used for facial reanimation.

CONCLUSIONS

The masseter-to-facial nerve transfer is an effective method for selective reanimation of the midface and perioral region. The technique is reserved for facial paralysis patients fow whom the proximal nerve stump is unavailable but the facial nerve branches and mimetic muscles remain viable. The masseter-to-facial nerve transfer is advocated for its ability to produce a strong, potentially effortless smile with minimal donor-site morbidity.

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ACKNOWLEDGMENT

The author thanks Dr. Melvin Spira for pioneering work with masseter nerve transfers and for endless enthusiasm and support.

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