Facial Animation With Free-Muscle Transfer Innervated by the Masseter Motor Nerve in Unilateral Facial Paralysis

Bernardo Bianchi, MD, Chiara Copelli, MD,† Silvano Ferrari, MD,‡ Andrea Ferri, MD,§ Camille Bailleul, MD,|| and Enrico Sesenna, MD¶*

Purpose: Facial paralysis is a congenital or acquired disorder of varying severity leading to an asymmetric or absent facial expression. It represents an important debilitation from both esthetic and functional points of view. In this article we report our experience with patients treated with gracilis muscle transplantation innervated by the motor nerve to the masseter muscle. We discuss the surgical technique and the functional and esthetic results and evaluate the effectiveness of this donor nerve in providing adequate innervation to the muscle transfer for lower facial reanimation.

Materials and Methods: Fifteen patients with unilateral facial paralysis were seen and surgically treated at the Department of Maxillofacial Surgery, University of Parma, Parma, Italy, between 2003 and 2007. In this study we report on 8 cases treated with gracilis muscle transfer reinnervated by the motor nerve to the masseter muscle.

Results: In this series all free-muscle transplantations survived transfer, and no flap was lost. Facial symmetry at rest and while smiling was excellent or good in all patients, and we observed a significant improvement in speech and oral competence. With practice, the majority of patients developed the ability to smile spontaneously and without jaw movement.

Conclusions: We consider the masseter motor nerve a powerful and reliable donor nerve, allowing us to obtain a commissure and upper lip movement similar to those of the normal site for amount and direction. This is why we think that there may be a larger role for the masseter motor nerve for innervation of patients with unilateral facial paralysis who would otherwise have been considered candidates for cross-facial nerve graft innervation of the muscle transfer.

J Oral Maxillofac Surg 68:1524-1529, 2010

Facial paralysis is a congenital or acquired disorder of varying severity leading to an asymmetric or absent facial expression.[1-3] It represents an important debilitation from both esthetic and functional points of view. The totally or partially paralyzed face is in fact characterized by generalized laxity and atony, related to weakness of all muscles of facial expression; asymmetric smile and droopiness of the corner of the mouth; oral incompetence with chewing and pursing abnormalities; and impaired speech articulation. When the zygomatic branch of the nerve is involved, we can observe lower eyelid ectropion with keratitis and lagophthalmos.

The challenge of reconstruction in the paralyzed face is to provide symmetry both at rest and in active expression. The micro-neurovascular transfer of a free-muscle transplant is the procedure of choice for facial animation, and specifically, the gracilis muscle has been used as a dynamic functioning free-tissue transfer with considerable success.[2,4-7] One of the critical factors of this procedure is actually the selection of a motor nerve to innervate the transplanted muscle. The selected motor nerve must provide adequate innervation to produce strong muscle contraction and allow the patient to control the movement of

Received from the Maxillofacial Surgery, Head and Neck Department, University of Parma, Parma, Italy.

*Chief Assistant.

†Resident.

‡Associate Professor.

§Resident.

||Medical Doctor.

¶Professor and Chief.

Address correspondence and reprint requests to Dr Copelli: Maxillofacial Surgery, Head and Neck Department, Ospedale Maggiore, Via Gramsci, 14-43100 Parma, Italy; e-mail: copkids@tin.it

0278-2391/10/6807-0009$36.00/0
doi:10.1016/j.joms.2009.09.024

the muscle. To achieve synchronous and spontaneous activity, the contralateral facial nerve, used by means of a cross–facial nerve graft, is considered the first choice.[1,7-9] When there is no facial nerve available, the motor branch to the masseter muscle is used as the innervated motor nerve to the transferred gracilis muscle.[1,2,8] In this study we report on patients with facial paralysis seen and treated surgically with gracilis transplant innervated by the motor branch to the masseter muscle from 2003 to September 2007 at the Operative Unit of Maxillofacial Surgery, Head and Neck Department, University of Parma, Parma, Italy. We evaluate the effectiveness of the masseter motor nerve in providing adequate innervation to a muscle transfer for lower facial reanimation. We review the surgical technique used and the outcomes focusing on functional issues, such as oral competence, speech, and the extent of animation and its impact on these patients.

Materials and Methods

We reviewed the records of patients with facial paralysis seen between 2003 and September 2007 at the Operative Unit of Maxillofacial Surgery, University of Parma. We focused on patients treated with gracilis muscle transplantation innervated by the motor nerve to the masseter muscle.

Standardized neurologic examination was performed in all cases. Facial expression, oral motor function, and speech were evaluated clinically, and the majority of patients underwent electromyographic examinations during their first office visit. All patients were videotaped and photographed with particular attention to facial expression, oral motor function, and speech.

The movements of the oral commissure and upper lip on the normal side were studied carefully preoperatively. According to Zuker et al,[10,11] the location of the nasolabial fold was noted, as was the extent of excursion and direction of movement of the commissure and upper lip.

SURGICAL TECHNIQUE

The procedure begins with 2 teams operating simultaneously to elevate the muscle and prepare the face. The ipsilateral gracilis is usually used for transfer. The gracilis is approached through a short medial thigh incision, posterior to the line joining the adductor tubercle to the medial condyle. The vascular pedicle is identified on the anterior border of the gracilis at the junction of the upper quarter and lower three quarters. The nerve to the gracilis from the anterior branch of the obturator nerve is traced to the obturator foramen. Only a segment of the muscle is needed. In fact, the use of the entire muscle leads to excess bulk. We have found that approximately one third to one half of the muscle is needed to produce the appropriate amount of movement and to avoid excess bulk. The anterior third of the muscle is usually selected, and the fascicle that innervates this segment is identified and labeled.

Facial dissection is performed simultaneously while harvesting the gracilis. The facial incision is begun in the scalp near the upper pole of the ear, courses downward through the preauricular area, and then, after a small posterior curve, courses anteriorly in the neck with submandibular extension. The cheek flap is elevated below the fat but above the parotid fascia. The plane of the dissection is carried anteriorly to the anterior border of the masseter muscle. Superiorly, the dissection extends up onto the body of the zygoma and the temple. The facial vessels are identified at the level of the anterior border of the masseter. Once the vessels are identified, the dissection continues anteriorly just above the vessels to the commissure and upper lip. Three to 5 sutures are placed for secure anchorage and careful positioning of the muscle. The first suture is placed in the oral commissure, the second is placed in the lower lip, and the third, fourth, and fifth are placed in the upper lip. They are positioned so that they do not produce eversion or inversion. With traction, they should produce a nasolabial crease that looks as natural as possible. The motor nerve to the masseter is identified on the undersurface of the masseter muscle. It is usually found coursing vertically downward at the posterior margin of the muscle, just below the zygomatic arch. Occa-

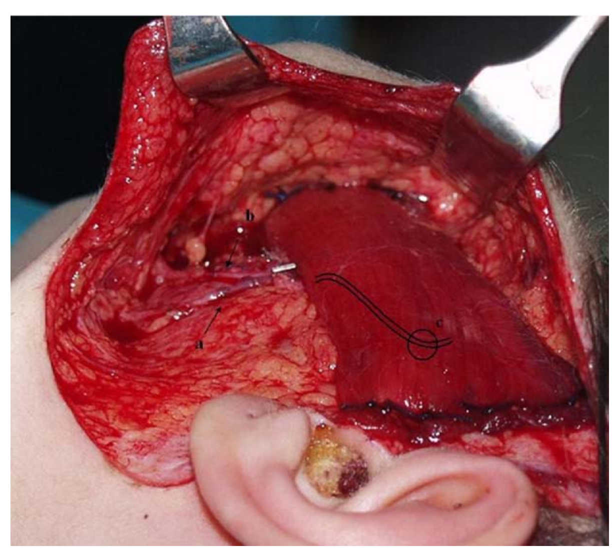

FIGURE 1. Muscle position in subcutaneous pocket with venous (*a*) and arterial (*b*) repair; design of site of nervous anastomosis with masseteric nerve (*c*).

Bianchi et al. Facial Animation With Free-Muscle Transfer. J Oral Maxillofac Surg 2010.

FIGURE 2. *A*, *B*, Preoperative view at rest and smiling. *C*, *D*, Postoperative view 1 year later at rest and smiling.

Bianchi et al. Facial Animation With Free-Muscle Transfer. J Oral Maxillofac Surg 2010.

sionally, however, it may be seen coursing obliquely downward and anteriorly or even transversely parallel to the arch. A nerve stimulator is extremely helpful in identifying the motor nerve to the masseter. Once the nerve is identified, it is cleared of its fibrous connections and traced inferiorly, superficially, and anteriorly into the muscle. The gracilis muscle is transferred to the face with the neurovascular pedicle on the deep surface, enabling subsequent debulking if necessary. Figure 1 shows the position of the muscle in the pocket and the neurovascular anastomoses. The distal end of the muscle is fixed to the lips and oral commissure through the previously positioned sutures. Anastomoses are carried out between the facial vessels and the artery and larger of the paired venae comitantes of the gracilis. In 20% to 25% of patients, the facial vein cannot be found; in these cases we must isolate the transverse facial vein. Once vascularization is ensured, a fascicular nerve repair unites the recipient nerve in the face to the selected fascicle of the motor nerve in the gracilis. After the neurovascular repairs, the muscle origin is secure. It is sutured with a slight degree of tension at the corner of the mouth and anchored to the temporal fascia and preauricular fascia. Tension at the insertion may be relieved by a prefabricated hook.

To evaluate the functional and esthetic results of microsurgical reconstruction, we only considered patients with a minimum follow-up of 12 months. The results were analyzed by use of patient response, clinical examination, and preoperative and postoperative videotaping of patients filmed at rest and performing several standard facial movements to show muscle action, spontaneity, independence, and fine facial movements during speech.

CASE 1

Case 1 is a female patient who came to our center at age 51 years and presented as having a monolateral Möbius-like form on the right side (Fig 2).

CASE 2

Case 2 is a female patient who presented at age 60 years with an iatrogenic right facial paralysis due

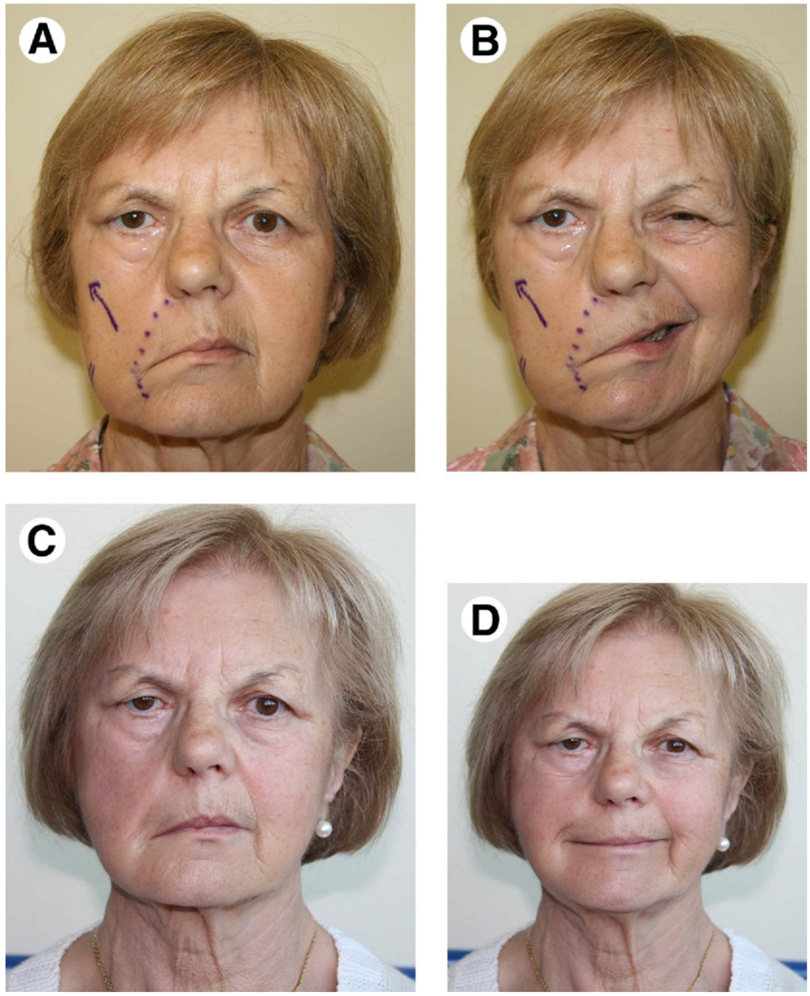

FIGURE 3. *A*, *B*, Preoperative view at rest and smiling with lines corresponding to nasolabial crease and to vector of smile from oral commissure toward tragus. *C*, *D*, Postoperative view 8 months later at rest and smiling. An upper eyelid weight was positioned on the right side to improve eye closure.

Bianchi et al. Facial Animation With Free-Muscle Transfer. J Oral Maxillofac Surg 2010.

to previous resection of an acoustic neuroma (Fig 3).

Results

Between 2003 and September 2007, 15 patients with unilateral facial paralysis were seen and surgically treated at the Department of Maxillofacial Surgery, University of Parma. They comprised 7 female patients and 8 male patients with a mean age, when treated, of 20.5 years (range, 7-60 years). Fourteen patients had unilateral Möbius syndrome, and the other patient had an acquired iatrogenic facial paralysis. One patient had a previous treatment at a different hospital through a cross–facial nerve graft, without signs of reinnervation. All patients underwent microsurgical reconstruction for restoration of facial movement with gracilis muscle transplantation. The motor nerve to the masseter was used in 8 patients. In the remaining 7 patients the transplant was reinnervated by means of a cross–facial nerve graft with the contralateral facial nerve. In this series all free-muscle transplantations survived transfer, and no flap was lost. In 1 patient a hypertrophic scar developed at the site of the neck incision. Reinnervation of the gracilis muscle took about 3.5 months. Postoperatively, all patients had smile training by the speech-language pathologist using mirror exercises and biofeedback. Through direct questioning regarding functional problems, all patients with preoperative difficulties regarding oral competence reported a significant improvement with no spontaneous drooling and with adequate capability to control oral fluid. Facial symmetry at rest and while smiling was excellent or good in all patients in whom innervation was provided by the masseter motor nerve. They were happy with the esthetic and functional results and reported that their facial movement was a good representation of a smile.

In the group of patients who underwent a cross-facial nerve graft, we observed involuntary movements and dyskinesia in one case, and another patient did not have muscular contraction because of the lack of reinnervation of the transplant. Nevertheless, in the remaining patients a symmetric, synchronous, and spontaneous smile was obtained, even with only a minor strength of contraction provided by the reinnervation with the contralateral facial nerve in some cases.

Discussion

The lack of facial animation in patients with facial paralysis poses a major barrier to interpersonal communication and creates severe esthetic and functional problems.[1,3] The micro-neurovascular transfer of a free-muscle transplant is the procedure of choice for facial animation.[4-7] Specifically, the gracilis muscle has been used as a dynamic functioning free-tissue transfer with considerable success.[2,5] One of the critical factors of this procedure is the selection of a motor nerve to innervate the transplanted muscle. Not only must sufficient innervation be present to power the muscle, this innervation must be specific to the desired activity to achieve spontaneity, synchronicity, and symmetry.

Many different donor motor nerves have been used with varying success. For those patients who have sufficiently strong contralateral facial nerves, a cross-facial nerve graft is considered the ideal choice.[1,7-10] For the remainder of patients, the hypoglossal nerve, the nerve to the masseter, and the accessory nerve are available options. For the patients with unilateral facial paralysis who were not candidates for cross-facial nerve grafting, the main choice is represented by the nerve to the masseter.[1,2,6] Previous experience using the hypoglossal nerve as the donor motor nerve has indicated that even if tongue function is present postoperatively, uncontrolled contraction of the free-muscle transfer developed with tongue movement in those patients. Because tongue movement is constant and often involuntary, the hypoglossal nerve is used as a donor only as a last resort.[4] Criticisms of the spinal accessory nerve as the donor nerve are reported in multiple series because of the distance from the face and the lack of synergy of the sternocleidomastoid and trapezius muscles with smiling.[1,4,5]

Surgery using the masseteric nerve for facial animation is actually considered a very reliable and reproducible technique when the contralateral VII nerve is not adequate and in patients who underwent a previous failed cross-facial nerve graft.[1,2,6,8] It may also be particularly suitable for the older patient in whom cross-facial nerve graft reinnervation is difficult, for the patient has a heavy face or a lot of rest asymmetry, for the patient who does not wish to undergo 2 operations, in case of failure of a previous cross-facial nerve graft, or for the patient who has a very powerful smile on his or her normal side. As in earlier reports, using the masseteric nerve, we observed the production of an amount of movement that is in the normal range, with a consistently good movement that allows us to obtain symmetry.[8,9] On the contrary, the cross-facial nerve graft procedure provides less movement than on the normal side of the face. However, it provides a spontaneous movement that we are not sure can be provided by the motor nerve to the masseter nerve.[7,8] This spontaneity is crucial in producing a normal-appearing smile.

Historically, the use of non-facial motor nerve donors has in fact been believed to preclude spontaneous facial expression. Moreover, the patient is not considered to be able to move the facial muscles independently of the original muscle of the donor nerve. As in previous reports, we are unable to comment on emotional expression in our series. Nevertheless, as reported by Manktelow et al,[12] we observed that some patients are able to move their transferred muscles independently of their jaws. Moreover, they report not having to think longer about activating their facial muscles while laughing, suggesting that, to some extent, they have developed an involuntary facial expression of emotion. According to Manktelow et al, the ability to smile without biting and thinking about it brings up the issue of cerebral plasticity, or cerebral cortical reorganization. This is the ability of the human brain to reorganize, adapt, and compensate for injury or changes in the environment. Actually, cortical plasticity has been demonstrated in multiple instances of sensory and motor reinnervation and in many clinical situations, including Braille reading, after nerve injuries, limb amputations, or nerve transfers in patients with brachial plexus injuries.[12,13] It is likely that there is a similar process, with the facial nerve center taking over control by activating connections to the fifth nerve center and, through this center, activating the motor axons of the masseter branch of the trigeminal nerve, causing gracilis muscle contractions and a smile.[12-14] In the future, functional magnetic resonance imaging may be used to study this process in facial paralysis and to determine whether the cortical area activated during smiling in patients who have undergone facial reanimation innervated by the nerve to the masseter is different from the cortical area activated in control patients when contracting the masseter muscle.[12,13] To achieve a spontaneous and symmetric smile, an important role is played by postoperative smile training by a speech-language pathologist using mirror exercises and biofeedback. When reinnervation of the muscle appears 3 to 6 months after transfer, an active exercise program must be started; in this way, progress in strength, excursion, and most importantly, symmetry can be achieved. The age of the patient when operated on did not influence the results from an esthetic or functional point of view. In adults we observed a longer time of reinnervation (5-6 months) than in children (3.5 months).

As reported by other authors, we consider the masseter motor nerve a powerful and reliable donor nerve, allowing us to obtain a commissure and upper lip movement similar to those of the normal site for amount and direction.[6,8,9] Moreover, our clinical experience, in accord with different studies, has shown that independent smile and jaw closure are attainable in these patients, refuting previous speculation.[10-13] This is why we think that there may be a larger role for the masseter motor nerve for innervation of patients with unilateral facial paralysis who would otherwise have been considered candidates for cross-facial nerve graft innervation of the muscle transfer.

References

1. Hoffman WY: Reanimation of the paralyzed face. Otolaryngol Clin North Am 25:649, 1992
2. O'Brien BM, Pederson WC, Khazanchi RK, et al: Results of management of facial palsy with microvascular free-muscle transfer. Plast Reconstr Surg 86:12, 1990
3. Westin LM, Zuker R: A new classification system for facial paralysis in the clinical setting. J Craniofac Surg 14:672, 2003
4. Terzis JK, Noah EM: Dynamic restoration in Möbius and Möbius-like patients. Plast Reconstr Surg 111:40, 2003
5. Johnson PJ, Bajaj-Luthra A, Llull R, et al: Quantitative facial motion analysis after functional free muscle reanimation procedures. Plast Reconstr Surg 100:1710, 1997
6. Terzis JK, Noah ME: Analysis of 100 cases of free-muscle transplantation for facial paralysis. Plast Reconstr Surg 99:1905, 1997
7. Ueda K, Harii K, Asato H, et al: Neurovascular free muscle transfer combined with cross-face nerve grafting for the treatment of facial paralysis in children. Plast Reconstr Surg 101: 1765, 1998
8. Bae YC, Zuker RM, Manktelow RT, et al: A comparison of commissure excursion following gracilis muscle transplantation for facial paralysis using a cross-face nerve graft versus the motor nerve to the masseter nerve. Plast Reconstr Surg 117: 2407, 2006
9. Lee EI, Hurvitz KA, Evans GR, et al: Cross-facial nerve graft: Past and present. J Plast Reconstr Aesthet Surg 61:250, 2008
10. Zuker RM: Facial paralysis in children. Clin Plast Surg 17:95, 1990
11. Zuker RM, Goldberg CS, Manktelow RT: Facial animation in children with Möbius syndrome after segmental gracilis muscle transplant. Plast Reconstr Surg 106:1, 2000
12. Manktelow RT, Tomat LR, Zuker RM, et al: Smile reconstruction in adults with free muscle transfer innervated by the masseter motor nerve: Effectiveness and cerebral adaptation. Plast Reconstr Surg 118:885, 2006
13. Lifchez SD, Matloub HS, Gosain AK: Cortical adaptation to restoration of smiling after free muscle transfer innervated by the nerve to the masseter. Plast Reconstr Surg 115:1472, 2005
14. Gosain AK, Birn RM, Hyde JS: Localization of the cortical response to smiling using new imaging paradigms with functional magnetic resonance imaging. Plast Reconstr Surg 108: 1136, 2001