Case Report/Case Series

Salvage Procedures After Failed Facial Reanimation Surgery Using the Masseteric Nerve as the Motor Nerve for Free Functional Gracilis Muscle Transfer

Steffen U. Eisenhardt, MD; Nils A. Eisenhardt, MD; Jan R. Thiele, MD; G. Björn Stark, MD; Holger Bannasch, MD

IMPORTANCE Free muscle transfer innervated by a cross-facial nerve graft represents the criterion standard for smile reconstruction in facial paralysis. If primary reconstruction fails, a second muscle transfer is usually needed. Herein, we investigated the possibility of avoiding a second free muscle transfer by in situ coaptation of the gracilis muscle to the masseteric nerve.

OBSERVATIONS We report a series of 3 failed free muscle transfers for facial reanimation among 21 free flap transfers performed for facial reanimation between March 2008 and August 2013. To salvage the muscle, we performed coaptation of the neural pedicle from the cross-facial nerve graft to the masseteric nerve. This method allows for leaving the fixation sutures of the muscle at the oral commissure in place. All patients showed muscle contraction after 3 months and a smile with open mouth after 6 months. No significant difference in the range of commissure excursion was observed between the healthy and operated sides.

CONCLUSIONS AND RELEVANCE Recoaptation of the neural pedicle from the cross-facial nerve graft to the masseteric nerve, leaving the muscle transplant in place, is a suitable salvage procedure after unsuccessful reconstruction with a cross-facial nerve graft, avoiding a second free muscle transfer.

LEVEL OF EVIDENCE 4.

JAMA Facial Plast Surg. 2014;16(5):359-363. doi:10.1001/jamafacial.2014.163
Published online July 3, 2014.

Video at jamafacialplasticsurgery.com

Author Affiliations: Department of Plastic and Hand Surgery, University of Freiburg Medical Center, Freiburg, Germany (S. U. Eisenhardt, Thiele, Stark, Bannasch); Department of Anesthesiology and Intensive Care Medicine, Tübingen University Hospital, Tübingen, Germany (N. A. Eisenhardt).

Corresponding Author: Steffen U. Eisenhardt, MD, Department of Plastic and Hand Surgery, University of Freiburg Medical Center, Hugstetter Strasse 55, 79106 Freiburg, Germany (steffen.eisenhardt@uniklinik-freiburg.de).

The criterion standard in facial reanimation among patients with long-standing facial paralysis is the 2-stage approach with a cross-facial nerve graft (CFNG) initially and a subsequent free functional muscle transfer.[1,2] A single-stage alternative is the use of the motor nerve to the masseter muscle as a donor nerve,[3] which is a treatment option when the contralateral facial nerve is unavailable.[4] The use of various donor muscles has been described; however, the gracilis muscle is considered the muscle of choice by most surgeons because of its low donor site morbidity and the ideal size of its nerve and vessel pedicle and muscle excursion. The failure rate of free muscle transfer in this setting is low,[5] although the transferred muscle relies on sufficient neural input from the cross-facial nerve graft. Herein, we report 3 cases in which the neural stimulation by the CFNG was insufficient for the transferred gracilis muscle. We successfully used coaptation of the gracilis muscle to the masseteric nerve as a salvage procedure in these 3 patients.

Report of Cases

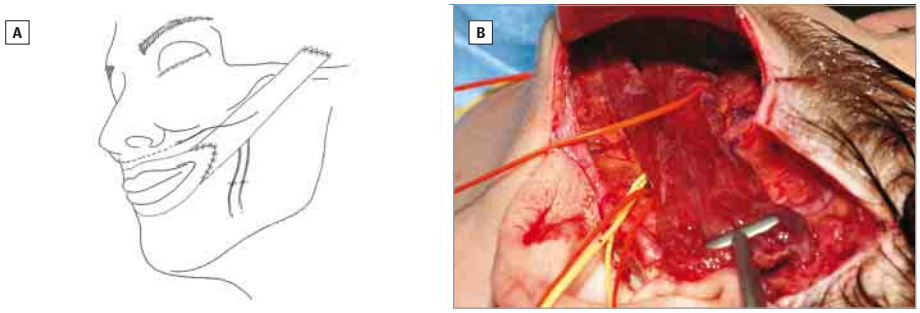
Institutional review board approval was not required because the patients were not part of a trial or study. However, written informed consent was obtained from the patients. Between March 2008 and August 2013, we performed 21 free functional gracilis muscle transfers for facial reanimation surgery. In 3 cases, we failed to achieve satisfactory results after 2-stage reconstruction for the treatment of facial paralysis. All 3 patients had long-standing complete peripheral facial paralysis after brain tumor resection for acoustic neuroma. The patient demographics are summarized in the **Table**. In all 3 patients, a CFNG was created with coaptation of the sural donor nerve to a zygomatic branch on the healthy site in an initial procedure. Before a subsequent muscle transfer, the success of the CFNG was tested clinically by a positive Tinel sign at the location of the nerve graft end. We used a short nerve graft, ending at the contralateral

Table. Patients With Failed Free Muscle Transfer for Facial Reanimation After Paralysis Caused by Brain Tumor Resection for Acoustic Neuroma

Patient No./ Sex/Age, y	Paralysis Duration, y	Time Since Gracilis Muscle Transfer, mo	Complication and Additional Procedure	Spontaneous Smile[a]
1/F/21	6	6	Flap thinning, canthoplasty	No
2/F/48	1	7	Not applicable	No
3/F/48	2	7	Flap thinning, fascia lata sling for upper lip	Yes

[a] After 6 months, all 3 patients were able to smile voluntarily with an open mouth (so-called social smile) without clenching the teeth.

Figure 1. Revision Surgery Overview



A, The gracilis muscle is sutured to the orbicularis oris muscle and the temporal fascia and lies over the masseteric fascia. The neural pedicle lies under the muscle belly and is coapted to the cross-facial nerve graft short graft (interrupted line) at the level of the upper lip on the paralyzed side. B, Shown is the intraoperative exposure on reexploration at 6 months.

upper lip in all patients as described by Fattah et al.[6] The end of the nerve was clipped to allow for easier identification for the second procedure. In a second procedure 6 to 9 months after the creation of the CFNG, we transferred the gracilis muscle with its neural pedicle, a branch of the obturator nerve. The facial artery and vein were used as recipient vessels (**Figure 1**A), and patency of the anastomosis was monitored after microanastomosis by an implantable Doppler probe attached to the draining vein.[7,8] Doppler signal was normal in all patients, and the implantable Doppler probe was removed on the seventh postoperative day without complications. Six months after this second complication-free procedure, no muscle excursion was observed, or the resulting muscle contraction was too weak to generate a symmetrical smile. Because we had used a short CFNG, the length of the neural pedicle of the gracilis muscle averaged only 6 cm. In patients with a successful CFNG and gracilis muscle procedure, we usually see muscle contraction after 3 to 4 months; therefore, we did not expect major improvement at this time and performed revision surgery to avoid further muscle atrophy. Postoperative electromyography was not performed because its outcome would not have influenced the indication for revision surgery because muscle contraction was insufficient.

We performed a salvage procedure to prevent atrophy of the muscle. We used the modified face-lift incision scar of the previous procedure and identified the gracilis muscle. The muscle was well perfused and showed no macroscopic signs of tissue necrosis but had lost most of its volume (Figure 1B).

We released the temporal fixation sutures and lifted the muscle to expose the neurovascular pedicle (**Figure 2**A and B). Coaptation of the CFNG to the nerve pedicle of the muscle was accessed by an enoral incision (Figure 2C). The nerve was carefully dissected from the neurovascular hilus of the muscle to the coaptation site to the CFNG. The coaptation showed no sign of hypertrophic scarring or major neuroma formation. The coaptation was excised and sent for histopathological examination. After freeing the nerve from the surrounding tissue, the masseteric nerve was prepared. The masseteric nerve can be reliably found a mean (SD) of 3.16 (0.30) cm anterior to the tragus at a level 1.08 (0.18) cm inferior to the zygomatic arch.[9] The masseter muscle was carefully dissected until the masseteric nerve could be exposed and dissected at its distal end (**Figure 3**A and B). Epineural coaptation was performed (Figure 3C), and the muscle flap was sutured to the temporal fascia under light tension. Silicon drains were left in place for 2 days, and the sutures were removed after 1 week.

Results

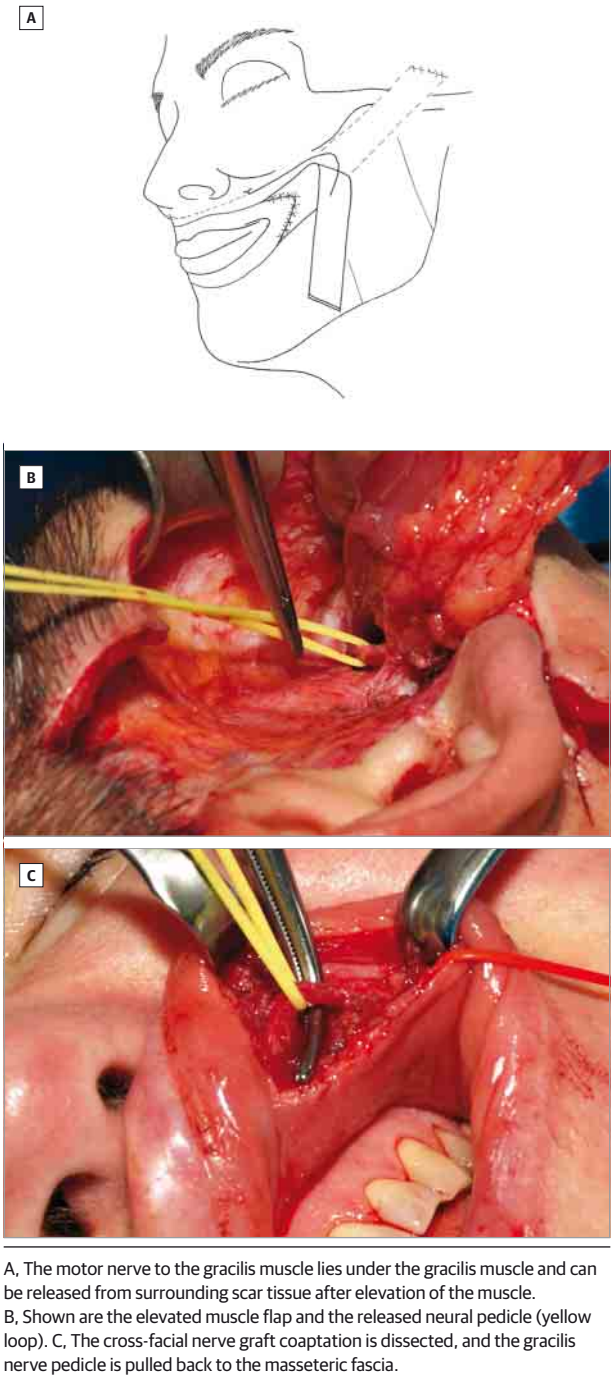
The postoperative course was uneventful in 2 patients. A postoperative hematoma in the third patient had to be drained in the operating room.

In all 3 patients, contraction of the muscle when clenching the teeth was notable after 3 months, which reached a maximum at 6 months. After 6 months, all patients were able to smile voluntarily with an open mouth (so-called social smile). A spontaneous smile could not be achieved by any of the patients. The postoperative excursion of the oral commissure was symmetrical to that of the healthy side as shown in **Figure 4** and in **Video 1** and **Video 2**.

In an attempt to quantify the outcome, the distance between the tragus and the commissure when smiling before and after surgery was measured (**Figure 5**). After surgery, we found a significant reduction in the distance when smiling, which was not significantly different from that of the healthy side, suggesting a symmetrical range of excursion.

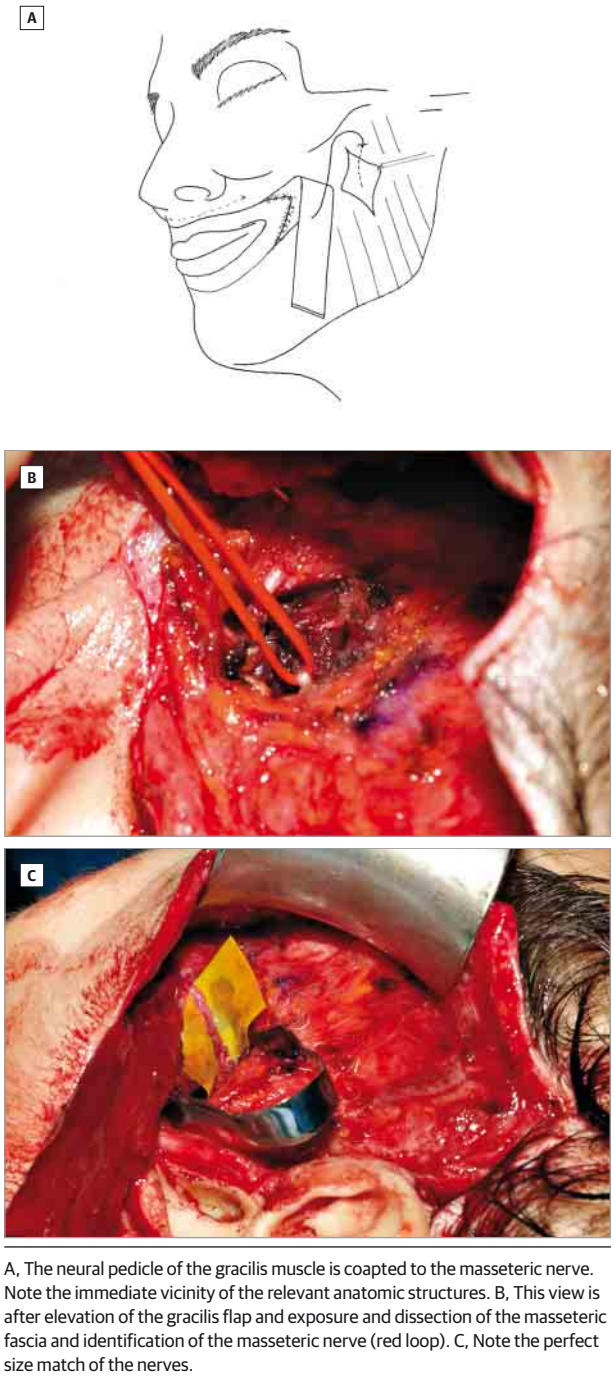
All patients reported a high level of satisfaction with the functional result. Two patients requested thinning of the flap

Figure 2. Intraoperative Views of Patient 3 in the Table



A, The motor nerve to the gracilis muscle lies under the gracilis muscle and can be released from surrounding scar tissue after elevation of the muscle. B, Shown are the elevated muscle flap and the released neural pedicle (yellow loop). C, The cross-facial nerve graft coaptation is dissected, and the gracilis nerve pedicle is pulled back to the masseteric fascia.

Figure 3. Intraoperative Views of Patient 3 in the Table



A, The neural pedicle of the gracilis muscle is coapted to the masseteric nerve. Note the immediate vicinity of the relevant anatomic structures. B, This view is after elevation of the gracilis flap and exposure and dissection of the masseteric fascia and identification of the masseteric nerve (red loop). C, Note the perfect size match of the nerves.

at 9 months after the procedure, which was combined with resection of the depressor labii inferioris muscle and canthopexy of the lower eyelid in one patient and with placement of a fascial sling to the upper lip in the other patient.

Histopathological examination of the nerve coaptation site revealed Schwann cell proliferation typical of neuroma formation. However, nerve fascicles crossing the coaptation site were identified, indicating that the nerve coaptation was sufficient.

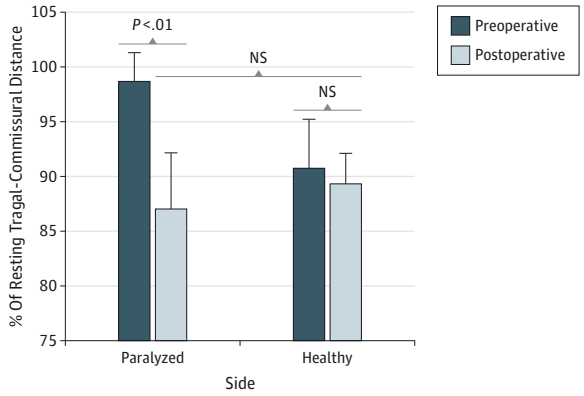
Discussion

Facial reanimation surgery is a complex and challenging field. A 2-stage reanimation of the smile by a preliminary CFNG, followed by free functional muscle transfer with coaptation of the motor nerve to the CFNG, is the criterion standard technique. This complex procedure usually has a good success rate, with complication rates as low as 2%.[5]

Figure 4. Preoperative and Postoperative Views of Patient 1 in the Table

Coaptation of the gracilis muscle to the masseteric nerve was successfully used as a salvage procedure at 6 months after the gracilis muscle transfer. A symmetrical voluntary smile was achieved.

Figure 5. Analysis of the Distance Between the Tragus and the Commissure When Smiling Before and After Surgery



Values are given as percentages of the resting distance between the tragus and the commissure. After surgery, the distance was significantly reduced on the paralyzed side, and no significant difference compared with the healthy nonoperated side was noted, indicating a symmetrical range of excursion. NS indicates nonsignificant.

However, the success depends not only on whether the free tissue transfer survives but also on whether coaptation to the CFNG and the consecutive muscle reinervation are sufficient to generate a smile that is symmetrical to the healthy nonparalyzed side. In our hands and according to the literature,[4] the CFNG delivers less neural input than the masseteric nerve as a donor nerve, resulting in less muscle excursion. This procedure can lead to unsatisfactory results because of insufficient muscle excursion, especially in patients who have high excursion of the oral commissure on the healthy side when smiling.

If the neural input to the gracilis muscle is insufficient to generate a symmetrical smile, the surgical options are limited and usually require the creation of another CFNG and muscle transfer if the patient is unwilling to accept the limitations of local muscle transfers. However, because the 2-stage reconstruction usually requires 18 months before the final result is obtained, patients are understandably hesitant to embark on an additional major reconstructive procedure with another free tissue transfer once the first attempt has proven to be unsuccessful.

Following coaptation to the masseteric nerve, the first muscle contractions will occur 2 to 3 months after surgery so that another long waiting period is avoided. The involved structures are in the immediate anatomic vicinity, so another nerve graft is unnecessary, but the motor nerve to the masseter nerve can be reached with the obturator nerve branch to the gracilis muscle, which needs to be dissected from its primary coaptation site to the CFNG. When the procedure is not delayed, the gracilis muscle can be left in place, obviating another muscle transfer and preventing additional donor site morbidity. The approach chosen by us is intriguing because a second major operation can be avoided. Our technique is superior to other previously described salvage procedures in which a second muscle transfer and nerve coaptation to the masseter nerve were performed.[10,11] If the primary reconstructive procedure has occurred more than 12 months previously, we advise the performance of a new muscle transfer. To date, no conclusive data exist on how long after denervation of a muscle can a reinervation be possible. However, because donor site morbidity of the gracilis

muscle is low,[12] we would advocate not risking a secondary failure and wasting the valuable option of coaptation to the masseteric nerve.

A potential pitfall is a nonfunctional masseteric nerve. Especially in patients with a brain tumor or after a stroke, neurological examination with evaluation of the trigeminal function is necessary. Needle electromyography and electrical muscle testing can be helpful in analyzing the progress of regeneration.[13] In our patients, these methods were not used because we did not expect additional information that would have changed the operative salvage approach.

Disadvantages of the use of the motor nerve to the masseter nerve compared with the use of a CFNG are well known. In a substantial number of patients, a spontaneous smile cannot be achieved, and smiling movement remains dependent on clenching the teeth in some patients.[14] In all our patients in whom masseter nerve coaptation served as a salvage procedure, only a social smile could be achieved. However, larger series of patients are necessary to demonstrate whether the rate of nonspontaneous results is higher among this patient group; social smile rates of 59% following reconstruction are described in the literature.[14] As an alternative to achieving a spontaneous smile, the CFNG could be left in place, and an end-to-side coaptation could be performed with the masseter nerve, assuming that the CFNG is functional but too weak to lead to sufficient excursion. A similar approach has recently been described by Biglioli and coworkers.[15] In addition to coaptation to the masseteric nerve, they performed an end-to-side CFNG and obtained spontaneous smiles in all of their patients. However, leaving the CFNG in place in our protocol would require another nerve graft to bridge the gap between the masseter nerve and the gracilis nerve because the obturator branch can be mobilized only when the CFNG coaptation site is dissected.

Before freeing the nerve and dissecting the primary coaptation to the CFNG, the coaptation site should be examined and evaluated as to whether neuroma excision and new coaptation seem feasible. In all our patients, we examined the nerves for neuroma formation and in one case performed a novel coaptation after neuroma resection that was ineffective. Histopathological evaluation showed nerve fibers distal to the coaptation side, suggesting that coaptation to the CFNG was successful, but most likely the quantity of nerves crossing both coaptation sites (the zygomatic branch to the CFNG and the CFNG to the obturator branch of the gracilis muscle) was too low to lead to sufficient excursion of the muscle. However, at this stage we can only speculate why the primary procedure was unsuccessful.

Conclusions

Direct recoaptation of the neural pedicle from the CFNG to the masseteric nerve, leaving the free muscle transplant in place, is a suitable salvage procedure after unsuccessful 2-stage reconstruction with the CFNG if the muscle tissue is viable. Symmetrical excursions of the oral commissure and a satisfactory social smile can be achieved; however, a spontaneous smile could not be obtained in our patients.

ARTICLE INFORMATION

Accepted for Publication: February 21, 2014.

Published Online: July 3, 2014. doi:10.1001/jamafacial.2014.163.

Author Contributions: Drs S. U. Eisenhardt and Bannasch had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: N. A. Eisenhardt, Bannasch.
Acquisition, analysis, or interpretation of data: S. U. Eisenhardt, N. A. Eisenhardt, Stark, Bannasch.
Drafting of the manuscript: N. A. Eisenhardt.
Critical revision of the manuscript for important intellectual content: S. U. Eisenhardt, N. A. Eisenhardt, Stark, Bannasch.
Administrative, technical, or material support: All authors.
Study supervision: S. U. Eisenhardt, Stark, Bannasch.

Conflict of Interest Disclosures: None reported.

REFERENCES

1. O'Brien BM, Pederson WC, Khazanchi RK, Morrison WA, MacLeod AM, Kumar V. Results of management of facial palsy with microvascular free-muscle transfer. *Plast Reconstr Surg*. 1990;86(1):12-24.

2. Terzis JK, Olivares FS. Long-term outcomes of free-muscle transfer for smile restoration in adults. *Plast Reconstr Surg*. 2009;123(3):877-888.

3. Momeni A, Eisenhardt S, Stark GB, Bannasch H. Single-stage microsurgical reconstruction for facial palsy utilising the motor nerve to the masseter [in German]. *Handchir Mikrochir Plast Chir*. 2010;42(2):95-101.

4. Bae YC, Zuker RM, Manktelow RT, Wade S. 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*. 2006;117(7):2407-2413.

5. Gousheh J, Arasteh E. Treatment of facial paralysis. *Plast Reconstr Surg*. 2011;128(6):693e-703e.

6. Fattah A, Borschel GH, Manktelow RT, Bezuhly M, Zuker RM. Facial palsy and reconstruction. *Plast Reconstr Surg*. 2012;129(2):340e-352e.

7. Bannasch H, Iblher N, Penna V, et al. A critical evaluation of the concomitant use of the implantable Doppler probe and the vacuum assisted closure system in free tissue transfer. *Microsurgery*. 2008;28(6):412-416.

8. Eisenhardt SU, Momeni A, Iblher N, et al. The use of the vacuum-assisted closure in microsurgical reconstruction revisited. *J Reconstr Microsurg*. 2010;26(9):615-622.

9. Borschel GH, Kawamura DH, Kasukurthi R, Hunter DA, Zuker RM, Woo AS. The motor nerve to the masseter muscle. *J Plast Reconstr Aesthet Surg*. 2012;65(3):363-366.

10. Horta R, Silva P, Silva A, et al. Facial reanimation with gracilis muscle transplantation and obturator nerve coaptation to the motor nerve of masseter muscle as a salvage procedure in an unreliable cross-face nerve graft. *Microsurgery*. 2011;31(2):164-166.

11. Bianchi B, Copelli C, Ferrari S, Ferri A, Sesenna E. Successful salvage surgery after treatment failures with cross graft and free muscle transplant in facial reanimation. *J Craniomaxillofac Surg*. 2012;40(2):185-189.

12. Carr MM, Manktelow RT, Zuker RM. Gracilis donor site morbidity. *Microsurgery*. 1995;16(9):598-600.

13. Michaelidou M, Herceg M, Schuhfried O, et al. Correlation of functional recovery with the course of electrophysiological parameters after free muscle transfer for reconstruction of the smile in irreversible facial palsy. *Muscle Nerve*. 2011;44(5):741-748.

14. Manktelow RT, Tomat LR, Zuker RM, Chang M. Smile reconstruction in adults with free muscle transfer innervated by the masseter motor nerve. *Plast Reconstr Surg*. 2006;118(4):885-899.

15. Biglioli F, Colombo V, Tarabbia F, et al. Double innervation in free-flap surgery for long-standing facial paralysis. *J Plast Reconstr Aesthet Surg*. 2012;65(10):1343-1349.