

Intraoperative Muscle Electrical Stimulation for Accurate Positioning of the Temporalis Muscle Tendon during Dynamic, One-Stage Lengthening Temporalis Myoplasty for Facial and Lip Reanimation

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Background: Facial paralysis is a significant functional and aesthetic handicap. Facial reanimation is performed either by two-stage microsurgical methods or by regional one-stage muscle pedicle flaps. Labbé has modified and improved the regional muscle pedicle transfer flaps for facial reanimation (i.e., the lengthening temporalis myoplasty procedure). This true myoplasty technique is capable of producing a coordinated, spontaneous, and symmetrical smile. An intraoperative electrical stimulation of the temporal muscle is proposed to simulate the smile of the paralyzed side on the surgical table.

Methods: The intraoperative electrical stimulation of the temporalis muscle, employing direct percutaneous electrode needles or transcutaneous electrical stimulation electrodes, was utilized in 11 primary and four secondary cases with complete facial palsy. The duration of the facial paralysis was up to 12 years. Postoperative follow-up ranged from 3 to 12 months.

Results: The insertion points of the temporalis muscle tendon to the nasolabial fold, upper lip, and oral commissure had been changed according to the intraoperative muscle stimulation in six patients of the 11 primary cases (55 percent) and in all four secondary (revisional) cases. A coordinated, spontaneous, and symmetrical smile was achieved in all patients by 3 months after surgery by employing speech therapy and biofeedback.

Conclusion: This adjunct intraoperative refinement provides crucial feedback for the surgeon in both primary and secondary facial palsy cases regarding the vector of action of the temporalis muscle and the accuracy of the anchoring points of its tendon, thus enhancing a more coordinated and symmetrical smile. (*Plast. Reconstr. Surg.* 126: 118, 2010.)

"If thou entertainst my love, let it appear in thy smiling; thy smile becomes thee well."

Twelfth Night (Act 2, Scene 5),
William Shakespeare (1601)

Facial paralysis is considered a significant functional and aesthetic handicap. It severely hinders mastication, speech production, and eye protection, but above all it deprives one of the

essential means of mental and affective expressions: mimesis and the smile.

Dynamic facial reanimation requires the introduction of viable, innervated muscle to restore facial movement; this is performed by either a regional pedicled or a microvascular free-muscle transfer.¹⁻⁶ The latter can be done as a one-stage procedure (i.e., gracilis muscle transfer innervated by a motor branch of the masseter muscle)⁷ or as a two-stage procedure (i.e., a cross-facial free-

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Table 1. Clinical Data Summary for Primary Procedure Group*

Patient No.	Age (yr)	Sex	Etiology	Side Affected	Duration of Palsy (yr)	Was the Insertion Point Changed Due to Electrical Stimulation?
1	25	F	Bell's palsy	Right	12	Yes
2	21	F	Bell's palsy	Right	3	Yes
3	72	M	Parotid tumor	Right	2	No
4	30	M	Parotid tumor	Left	3	No
5	37	F	Congenital	Right	Congenital	No
6	31	F	Post traumatic	Left	3	No
7	7	M	Congenital	Right	Congenital	Yes
8	11	F	Otomandibular dysplasia	Left	Congenital	Yes
9	39	M	Acoustic neurinoma	Left	3	Yes
10	43	F	Bell's palsy	Left	6	No
11	11	F	Moebius syndrome	Bilateral	Congenital	Yes

*Clinical data are shown for the 11 patients who underwent a lengthening temporalis myoplasty as a primary procedure and in which an intraoperative muscle stimulation was employed. In six of 11 cases, the temporalis tendon was relocated because of the stimulation results.

nerve graft followed by the transfer of a distant muscle), which is considered the preferred method for facial reanimation.

Recently, Labbé⁸ and Labbé and Huault⁹ modified and improved the regional pedicled muscle transfer (i.e., the lengthening temporalis myoplasty procedure), thus maintaining its advantages as a one-stage dynamic facial reanimation method. Labbé and Huault⁹ have reported a true myoplasty procedure with no intermediate grafts, which has produced a coordinated, spontaneous, and symmetrical smile.

Cadaveric dissections have shown that the lengthening of the temporalis muscle by approximately 4 cm, which is necessary for the temporalis tendon to reach the oral commissure, is feasible due to the release of the temporalis muscle belly from the temporalis crest and temporal bone attachments. The temporalis tendon is anchored on the paralyzed side to preoperative points, which is a mirror image to the nonparalyzed side around the oral commissure and lips according to the Rubin smile classification.¹⁰

The technique has been practiced by Labbé for the last 15 years with satisfactory results, as well as in other specialized centers.¹¹ In some follow-up cases (up to 10 percent), however, the clinical examination revealed that the temporalis tendon

had been anchored to an inaccurate point or even detached, thus hindering the creation of a symmetrical smile.

This article is aimed at describing our experience with intraoperative electrical temporalis muscle stimulation for improving the accuracy of localization of the anchoring points of the temporalis tendon to the oral commissure area in primary lengthening myoplasty procedures as well as in revisional cases.

PATIENTS AND METHODS

To evaluate the muscle electro-stimulation efficacy as an intraoperative adjunct procedure to place the tendon in an accurate position, only patients with complete facial paralysis were enrolled in this study. In such a way, the smile is solely dependent on the temporalis tendon anchoring points without the interference of other functional mimetic muscles, such as in incomplete facial palsy.

Intraoperative electrical muscle stimulation was utilized in 11 primary (seven female and four male patients) and four secondary (revisional) cases (three female and one male patient) (Tables 1 and 2).

Patients' ages ranged from 7 to 72 years. All patients had complete facial paralysis. The duration of the facial palsy was up to 12 years. The etiology of the facial paralysis included acoustic neurinoma ($n = 3$), Bell's palsy ($n = 3$), parotidectomy ($n = 2$), congenital ($n = 3$), Moebius syndrome (unilateral, $n = 1$; bilateral, $n = 1$), otomandibular dysplasia ($n = 1$), cholesteatoma ($n = 1$), and posttrauma ($n = 1$). The etiologies of the secondary cases were (Table 2) mechanical dehiscence of the temporalis tendon ($n = 1$), dehiscence of the tendon following postoperative

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Table 2. Clinical Data Summary for Secondary Cases*

Patient No.	Age (yr)	Sex	Etiology	Side	Duration of Palsy (yr)	Reason for Revision	Was the Insertion Point Changed Due to Electrical Stimulation?
12	52	F	Acoustic neurinoma	Left	4	Mechanical dehiscence of the temporalis tendon from its insertion	Yes
13	9	M	Unilateral Moebius	Right	9	Dehiscence of the temporalis tendon following postoperative infection	Yes
14	35	F	Acoustic neurinoma	Right	3	Deep insertion of temporalis tendon at the nasolabial fold	Yes
15	42	F	Cholesteatoma	Right	5	Deep and tight insertion of temporalis tendon at the oral commissure	Yes

*Clinical data are shown for the four patients who underwent a revision of the primary lengthening temporalis myoplasty (secondary cases) in which an intraoperative muscle stimulation was employed. In all four patients the temporalis tendon was relocated because of the stimulation results.

infection ($n = 1$), deep insertion of the tendon at the nasolabial fold ($n = 1$), and deep and tight tendon insertion at the oral commissure ($n = 1$). The postoperative follow-up ranged from 3 to 12 months.

In all patients who were operated on, a critical subjective postoperative evaluation of the smile by the patient together with the operating surgeon was conducted, and whenever a nonsymmetrical smile was demonstrated, a revision had been proposed and executed. Therefore, no functional assessment with a standardized evaluation scale was needed. Intraoperative electrical stimulation was not employed in the primary operations of the secondary cases.

Surgical Procedure

The patient's smile was evaluated preoperatively according to the Rubin classification,¹⁰ which is based on the point of insertion and contraction vectors of the zygomatic muscles to the nasolabial fold, commissure, and orbicularis oris on the healthy side (i.e., the "Mona Lisa," "canine," and the "full teeth" smiles).

The temporalis muscle viability was ascertained before surgery by palpation of the muscle on the paralyzed side during mastication. No electromyographic examination was necessary.

These anchoring points were marked as a mirror image on the paralyzed side along the nasolabial fold and commissure. In addition, the nasolabial crease was aligned according to the healthy side. Fourteen days before surgery, the patients underwent botulinum toxin type A (Botox, Allergan, Irvine, Calif.) injections to the zygomatic, orbicularis oris, and depressor labii muscles (as needed according to the smile classification) to weaken the tensioned healthy smile muscles.

The surgical technique as described by Labbé⁸ and Labbé and Huault⁹ comprises a coronal incision, through which the exposure of the temporal aponeurosis and muscle is facilitated on the paralyzed side. The zygomatic arch is sectioned. The coronoid process, on which the temporalis muscle tendon is inserted, is osteotomized from the mandible. The whole temporalis muscle is dissected from the temporal crest and fossa, while the deep temporal nerve and vessels are identified and preserved.

An incision is made in the nasolabial crease marked preoperatively, and tunneling, via Bichat's fat pad, is facilitated to allow the free bony coronoid process to be pulled with the attached temporalis tendon into the labial commissure. The tendon is dissected from the bone and is spread and sutured to the previously marked anchoring points with nonabsorbable sutures. The temporalis muscle body is advanced downward for about 4 cm. Its superior border is sutured (maintaining the 4-cm gap) to the aponeurotic-fascial strip (of about 8 mm width), which remained on the anterior-medial border of the temporal crest. These sutures prevent further inferior and medial advancement of the muscle, which might reduce the smile amplitude.

After the temporalis muscle tendon is sutured to the perioral anchoring points, the temporalis muscle belly is stimulated electrically either directly with percutaneous sterile electrode needles (Osiris stimulator; Inomed Ltd., Teningen, Germany) or with transcutaneous electrical stimulation electrodes (Danmeter TS 6000, Odense, Denmark; NeuroTrac TENS, Verity Medical Ltd., Stockbridge, U.K.) (Figs. 1 through 3), which are placed on to the paralyzed cheek skin above the lengthened temporalis muscle belly. This creates a dynamic smile on the paralyzed side and simu-



Fig. 1. Intraoperative electrical stimulation using transcutaneous electrical stimulation electrodes (patient 2, primary case). The electrodes are located above the right temporal muscle belly. (Above) Before stimulation. (Below) During stimulation (a smile is evident).

lates, intraoperatively, the postoperative result (Figs. 1 and 2). (See Video, Supplemental Digital Content 1, which demonstrates the transcutaneous electrical stimulation of the advanced right temporal muscle to create a smile in patient 1, primary case, <http://links.lww.com/PRS/A166>). If necessary, relocation of the tendon anchoring points is facilitated to create the desired and accurate symmetrical smile.

The osteotomized zygomatic arch is fixed by mini-plates and screws, followed by stapling, draining, and dressing of the scalp coronal incision. The nasolabial incision is closed by intradermal absorbable sutures. Speech therapy and biofeedback (Myomed 932, Enraf Nonius, Delft, The Netherlands) are initiated approximately 3 weeks

postoperatively to enhance a coordinated, spontaneous, and symmetrical smile.

RESULTS

The insertion points of the temporalis muscle tendon to the nasolabial fold, upper lip, and oral commissure were changed according to the intraoperative muscle stimulation in six of the 11 primary cases (55 percent) and in all four revisional cases (Tables 1 and 2). A coordinated, spontaneous, and symmetrical smile was achieved in all patients by 3 months postoperatively by employing speech therapy and biofeedback (Figs. 2 and 3).

DISCUSSION

The intraoperative smile evident during muscle stimulation provides crucial information regarding the vector of action of the temporalis muscle and indicates whether the insertion of the tendon to the perioral area is secure, is located correctly and accurately, and is symmetrical to the healthy nonparalyzed side.

In addition, the intraoperative animation of the smile has special importance with regard to secondary revision operations. In cases of dehiscence of the tendon from the perioral area or a malposition of the attachment tendon points, which produce an asymmetrical smile, a revision employing the electrical muscle stimulation enables the surgeon to relocate the tendon position into a more precise location (Fig. 3). Care must be taken that nondepolarizing muscle relaxants are not administered as part of the anesthetic medication regimen. Such medication hinders muscle flap electrical stimulation, making intraoperative nerve stimulation futile.

The electrical muscle stimulation unit consists of a programmable electrical signal generator, a power source, and a set of electrodes. The generator can deliver trains of stimuli with variable current strengths, pulse rates, and pulse widths. In the transcutaneous electrical stimulation cases performed, the preferred waveform was biphasic, with a pulse width (duration) of 250 μ sec and a pulse rate (frequency) of 50 impulses/second (Hz), while the amplitude ranged between 20 and 50 μ A.

It was noticed that while transcutaneous electrical stimulation activates muscles of the face indiscriminately (i.e., ocular muscles as well; see Video, Supplemental Digital Content 1, <http://links.lww.com/PRS/A166>), the electrode needles penetrating the muscle operate more selectively on the temporalis muscle itself. It was also noticed that during the stimulation process, the temporalis



Fig. 2. Patient 1, primary case. A 25-year-old woman with a right Bell's palsy of 12 years' duration underwent a primary lengthening temporal myoplasty procedure. (Above, left) Preoperative smile. The black dots represent the three anchoring points of the temporal tendon according to the healthy side ("Mona Lisa" type). (Above, right) Spontaneous and symmetrical smile 3 months postoperatively. (Below, left) Intraoperative view of the right cheek in the flaccid state. Transcutaneous electrodes are placed on the skin above the muscle belly. The temporalis tendon is sutured to the three anchoring points (blue dots). (Below, right) Intraoperative electrical stimulation simulates the desired smile.

tendon forcefully retracts. Therefore, the tendon should be sutured to all anchoring points (nasolabial, oral commissure, and upper lip) before executing the stimulation to prevent the tendon from retreating backward into the deep cheek tissues, which might cause difficulty in its retrieval.

In the case of bilateral Moebius syndrome, the intraoperative muscle stimulation enabled the surgeon to anchor the tendons in precise points to

create a bilateral symmetrical smile, which was confirmed immediately on the operating table. Although the patient is in the supine position during surgery, which causes the cheek skin and soft tissue to drift in a posterior direction due to gravitation, the vector of the stimulated and contracted temporalis muscle and the created smile is not affected.

Since the complete duration of facial paralysis consists of years, the paralyzed side could not op-



Fig. 3. Patient 14, secondary/revisonal case. A 35-year-old woman presented with a right facial palsy due to excision of an acoustic neurinoma. A primary lengthening temporal myoplasty procedure was executed. (*Below, left*) The postoperative result demonstrated that the temporal tendon had been inserted too deeply at the nasolabial fold, which has caused a reduced retraction of the right oral commissure and upper lip and a nonsymmetrical smile. (*Below, right*) Coordinated, spontaneous, and symmetrical smile ("Mona Lisa" type) 4 months after the revision surgery. The detached portion of the temporal tendon was identified and reattached to the accurate anchoring point, causing a correct retraction of the right oral commissure and elevation of the right upper lip. (*Above, left*) Intraoperative view of the right cheek in the flaccid state. Intramuscular electroneedles are placed into the proximal temporal muscle belly. (*Above, right*) Intraoperative electrical stimulation simulates the desired smile on the operating table.

pose the contracting force and tension of the healthy side's smile. Therefore, mild to severe displacement of the paralyzed oral side beyond the midline toward the healthy side was evident during smiling in all patients.

Thus, Botox injections are used to weaken the pulling force of the healthy side and enable the following advantages:

1. The paralyzed oral area returns in some manner to its natural position, which creates better facial symmetry, enabling more precise preoperative planning.
2. It enables the lengthened temporalis muscle tendon to easily reach the paralyzed nasolabial and oral commissural area without the risk of tearing the delicate tendon fibers.



Video Available Online

Video. Supplemental Digital Content 1 demonstrates transcutaneous electrical stimulation of the advanced right temporal muscle to create a smile in patient 1 (primary case), <http://links.lww.com/PRS/A166>.

3. It reduces the tension on the lengthened temporalis muscle tendon sutures at the paralyzed nasolabial area, thus enhancing the healing process and reducing the risk of postoperative partial or complete dehiscence of the tendon.
4. It assists the physiotherapist/speech therapist in educating the patient during the postoperative period (Botox injections might be continued for up to 1 year after surgery) to produce a coordinated and symmetrical smile.

Biofeedback (activating the mastication muscle as a smile muscle with immediate feedback) is begun 3 weeks postoperatively and facilitates cerebral adaptation due to brain plasticity. It enables eventually a spontaneous smile, which has been demonstrated in all of our cases, and has been shown to occur with other forms of smile reanimation.¹²

Although sophisticated aids to assess the preoperative and postoperative mimic movements deficits have been published,^{13,14} the intraoperative muscle stimulation method provides a real-time dynamic assessment of the smile. Thus, it enables immediate surgical correction.

To recall the smile of the normal side during surgery, it is proposed that patients be presented in the operating room with preoperative photographs with and without a smile. In addition, a preoperative video taken for each patient and evaluated during the preoperative planning could be played during the muscle stimulation process as well. Some intraoperative feedback during secondary facial reanimation has been reported by

percutaneous stimulation of the cross-facial nerve to validate the functionality of the reinnervated transferred free muscle flap.¹⁵

This study introduces a technical addendum to facilitate accurate placement of the temporalis tendon insertions during a dynamic one-stage facial reanimation and might be employed in other regional muscle transfers (regardless of which muscle transfer technique is used). In addition, this intraoperative refinement overcomes the drawback of temporalis tendon malposition as has appeared in a few cases; thus, fewer revisional procedures will be needed.

Further studies of intraoperative electrostimulation in incomplete facial palsy patients in whom the temporalis myoplasty is employed are advocated. In conclusion, this proposed intraoperative muscle stimulation during dynamic one-stage facial reanimation might be considered as an important adjunct for the surgeon to achieve an accurate and symmetrical smile.

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PATIENT CONSENT

Patients provided written consent for use of their images.

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