

# Temporalis Tendon Transfer as Part of a Comprehensive Approach to Facial Reanimation

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**Objective:** To report an approach to facial paralysis in patients for whom dynamic adjacent muscle transfer is determined to be the best treatment option.

**Methods:** Retrospective review of 7 consecutive patients who underwent orthodromic transfer of the temporalis muscle insertion for the treatment of long-standing facial paralysis. Patients underwent facial-retraining physical therapy before and shortly after the procedure. Outcomes measured included patient satisfaction, objective measurements of oral commissure elevation with smiling, and physician grading of preoperative and postoperative patient photographs. Medical records were reviewed for complications.

**Results:** Patient satisfaction was high, with a mean score of 8.5 (possible score of 10). Four patients were physi-

cian graded as excellent to superb. The other 3 patients were rated as having good postoperative results. Movement was identified in every patient and ranged from 1.6 to 8.5 mm, with mean movement of the oral commissure of 4.2 mm. One patient developed postoperative salivary fluid collection that required drainage.

**Conclusions:** Temporalis tendon transfer is a relatively easy procedure to perform that has distinct advantages compared with other forms of facial reanimation and provides very good results. This procedure results in improved form and function, may often be performed in a minimally invasive manner, and eliminates the facial asymmetry typically produced by temporalis transfer.

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THE REHABILITATION OF facial paralysis is one of the greatest challenges faced by reconstructive surgeons today. It is an unfortunate fact that there is no ideal procedure that leads to the return of fully normal facial function. Furthermore, every case of facial paralysis is different in the cause of the paralysis, the degree and location of the paralysis, and the resulting condition of the facial musculature and surrounding soft tissue envelope. Many patients initially have areas of hypofunction and hyperfunction. Central plasticity and reorganization are implicated in the etiology and recovery of facial paralysis. As a result, the surgeon treating this condition must not only be facile in the performance of multiple procedures, ranging from oculoplastic surgery to microvascular free tissue transfer, but also understand the underlying neurologic condition and have the capability of using facial retraining to optimize outcomes.

The available options for facial reanimation are determined by the duration and cause of the paralysis. There is consensus in the literature that when procedures to

reinnervate the native facial musculature are possible, these will lead to the best possible outcome. However, classic reinnervation techniques to allow movement of intrinsic facial musculature become ineffective once motor end plate fibrosis and muscle atrophy occur. In this setting, free tissue transfer with the gracilis or pectoralis minor muscle may be an option; a multistage technique is used in which cross-face grafts are performed in advance of the free flap. For some patients, such a delay and the need for multiple extensive procedures make this option untenable.

Dynamic muscle transfer remains an excellent option for facial reanimation in patients for whom the options of primary nerve repair, grafting, and nerve transfer are not possible. The mainstay of this technique is temporalis muscle transfer. We believe that this technique is measurably improved by performing the transfer in an orthodromic manner. Temporalis tendon transfer provides for improved function and elimination of the telltale signs of temporalis transfer produced by the classic technique. The technique for orthodromic temporalis insertion transfer involves release and mobilization of the

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**Figure 1.** Examples of smile patterns. A, The “Mona Lisa” smile involves primarily oral commissure elevation. B, The “canine” smile adds the contraction of the levator labii. C, The “full-mouth” smile also includes the depressor anguli oris.

temporalis at the insertion into the coronoid. The temporalis is then transferred to the oral commissure, effectively eliminating the depression in the temple and any tissue protrusion around the zygomatic arch. Dynamic muscle transfer is improved by means of activity-based therapy. Thus, facial retraining is critical to optimizing results in these patients. In this article we review a programmatic approach to a modified version of the dynamic temporalis sling, the temporalis tendon transfer procedure. This review includes a discussion of the appropriate physical therapy that should be undertaken before and immediately after surgery.

## METHODS

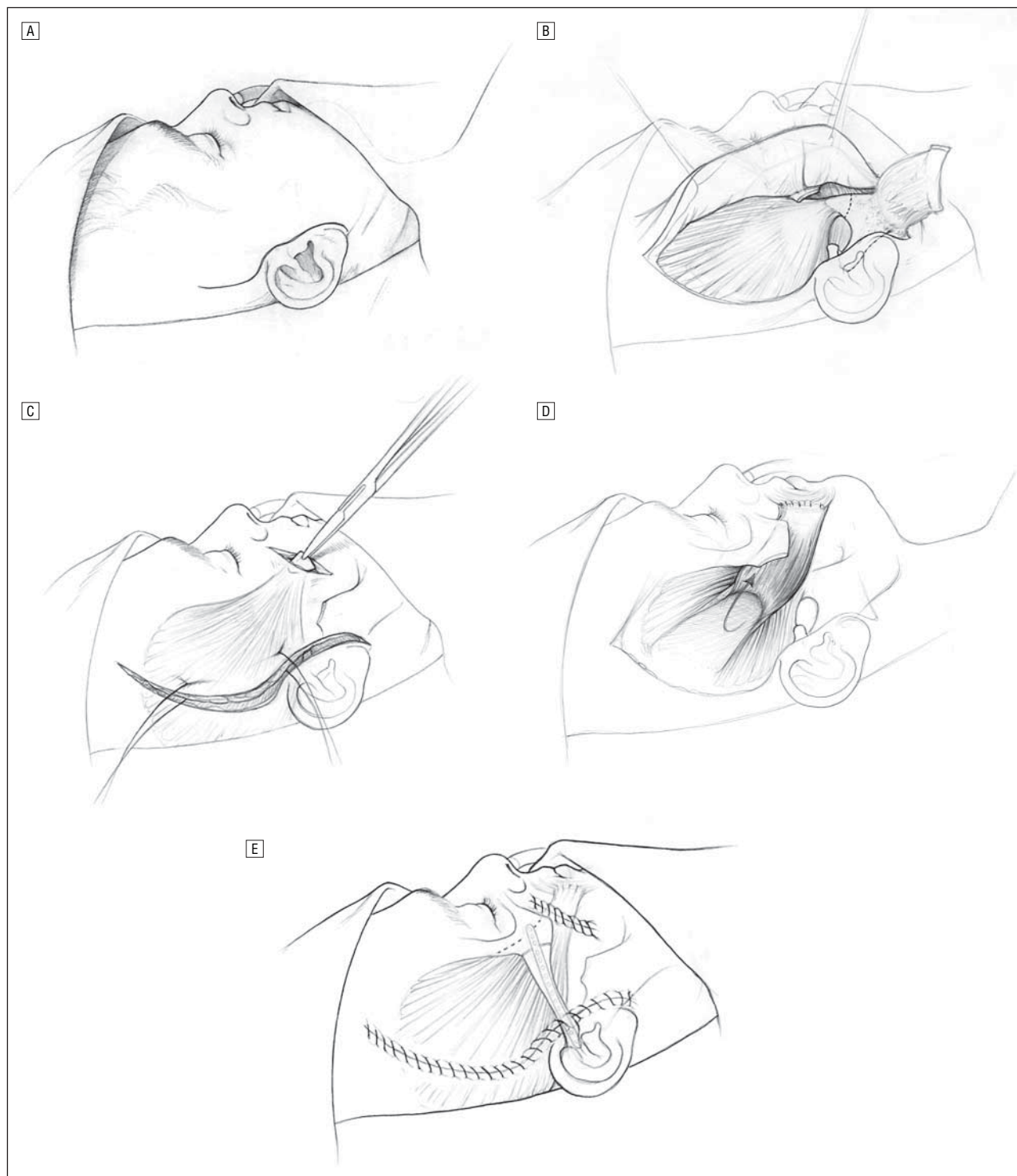
Patients selected for the orthodromic temporalis insertion transfer procedure were critically analyzed for their smile pattern.<sup>1</sup> The reinsertion site of the temporalis tendon was selected based on the pattern of dominant musculature in the patient's smile (more horizontal zygomaticus major vs more vertical levator labii superioris alaeque nasi). Comprehensive patient-directed physical therapy is then initiated. The goal of the pre-operative physical therapy is for the patient to better understand how to consciously coordinate individual muscle contraction to produce facial expression, particularly the smile. At this time, patients are educated about their smile pattern (eg, “canine” vs “Mona Lisa”) and about how they can modify this to adapt to the type of smile expected after surgery (**Figure 1**). These neuromuscular reeducation exercises are practiced before surgery and continue immediately after surgery. Patients are more facile in the performance of these exercises when initiated before surgery.

The exposure, release, and transfer of the temporalis muscle insertion may be accomplished using a variety of approaches. Most commonly, the incision for access to the temporalis muscle is made in a standard manner, extending from the preauricular crease into the temporal hair. It typically extends only a short distance (3-4 cm) into the hairline because exposure of the entirety of the muscle is necessary only if releasing incisions are made in the muscle, as will be explained later herein (**Figure 2A**). Dissection is performed deep to the periosteum of the zygomatic arch to expose the arch and to protect the fron-

tal branch of the facial nerve in cases of potential reinnervation (which is an uncommon scenario in which to apply this procedure). The entire arch is exposed. Next, the temporalis muscle is followed from the inferior surface of the arch to its insertion into the coronoid process. It may be necessary to detach the zygomatic arch to achieve adequate exposure (**Figure 2B**). The coronoid is transected at the neck and is mobilized from the surrounding tissue along with the attached temporalis tendon. A separate incision is made in the melolabial crease or the vermilion cutaneous junction. This location is determined before the procedure by examining the contralateral melolabial fold.

A tunnel is created from the subcutaneous plane of the perioral incision to the mobilized coronoid process. The coronoid with the attached tendon of the temporalis is then stretched to the perioral region (**Figure 2C**). It is important to overcorrect the lateral commissure elevation, and we find that this is often performed ideally without any extension of the temporalis. It is occasionally necessary to mobilize the temporalis muscle by performing releasing incisions around the posterior periphery of the origin. Another method of extending the reach of the temporalis is with the use of either the fascia lata or acellular dermis. This method is typically necessary if extension to allow recruitment of the orbicularis oris and lip from the contralateral innervated side is desired, as described by Sherris.<sup>2</sup>

The coronoid segment is dissected free from the temporalis tendon while preserving as much of the tendon as possible. The tendon is then spread horizontally for 3 to 4 cm and sutured to the perioral musculature and some deep dermis. The precise location of this attachment is intended to produce maximum symmetry as determined before surgery. Typically this means placement parallel to the melolabial fold and several millimeters medial to it. Several buried mattress sutures (we use a combination of resorbable and permanent sutures) are placed to fixate the tendon and muscle to the orbicularis muscle and deep dermis. Meticulous closure is performed. The result is orthodromic transfer of the insertion of the muscle as opposed to transfer of the origin of the muscle over the arch (**Figure 2D** and **Figure 2E**). The procedure may be performed in conjunction with additional techniques, such as selected nerve grafting or crossovers, midface-lift, lateral canthopexy or tarsal strip canthoplasty, face-lift, brow-lift, or other procedures as indicated by the individual patient's needs. Suction drains and a face-lift-style dressing are applied. The patient is immobilized



**Figure 2.** Essential steps of the temporalis tendon transfer procedure. A, Temporalis tendon transfer incision. B, Temporalis tendon transfer with the arch retracted. C, Temporalis tendon transferred. D, Classic temporalis sling. Note how this contrasts with the previously shown procedure. E, Temporalis tendon transfer after closure.

only until the sutures are removed, approximately 7 days after surgery. Then facial retraining is resumed with the direction of a trained therapist.

The outcome measures included subjective self-evaluation of results by the patients, subjective analysis of preoperative and postoperative photographs by head and neck surgeons and facial plastic surgeons masked to the technique used, and objective measurement of the oral commissure movement achieved. The patients

were asked to complete a questionnaire retrospectively to assess their satisfaction with the results. This was an 11-point questionnaire to assess improvement of their quality of life with respect to oral competence, nasal obstruction, articulation, and facial appearance (**Figure 3**). Preoperative and postoperative photographs were evaluated by surgeons experienced in the treatment of patients with facial paralysis. Standardized photographs were taken in the photography suite at the Facial Plastic Surgery Clinic



(the Johns Hopkins Department of Otolaryngology–Head and Neck Surgery) using a digital single lens reflex camera (Fuji S1 Pro; Fujifilm USA Inc, Valhalla, New York) and imaging software (Mirror; Canfield Scientific Inc, Fairfield, New Jersey). Photographs were taken before surgery and a minimum of 4 months after surgery. A grading scale was created based on modifications to that published by Bascom et al.<sup>3</sup> Each patient was assigned a grade of I to V (I=superb, II=excellent, III=good, IV=fair, and V=poor) for improved symmetry. Each patient's photographs were analyzed using imaging software (Mirror). The motion of the oral commissure with volitional movement was quantified. An assessment of the oral commissure movement was also performed by measuring the oral commissure position at rest and during voluntary temporalis contraction. The distance of each from the midline was measured and converted similarly into actual values. The technique used to do so was modified somewhat depending on the vector sought in each patient. First, a vertical line was drawn perpendicular to the interpupillary line and colu-

mella to determine the midline. The horizontal distance to the oral commissure was measured. In patients in whom more vertical movement was achieved (mimicking levator labii), the change with and without temporalis contraction was measured in the vertical plane. In patients in whom more horizontal movement was achieved (replicating more closely the action of the zygomaticus), the change in position with and without contraction was measured in the horizontal plane (**Figure 4**). Using the intercanthal distance as a benchmark, known ratios allowed for conversions to actual measurements.

## RESULTS

Patient self-assessment results were obtained from 7 patients. Patient satisfaction was very high. Of a possible 10 points, patients reported mean satisfaction with appearance of 8.4, with feeding of 8.1, with speech of 8.7, and with smile function of 7.1.

The photographs were graded by 21 physician members of the Johns Hopkins Department of Otolaryngology–Head and Neck Surgery. Seven patients had adequate preoperative and postoperative photographs for inclusion (**Table 1**). Mean patient grades were excellent. Four of the 7 patients were graded as excellent to superb; the other 3 were rated as having good results (**Figures 5, 6, and 7**).

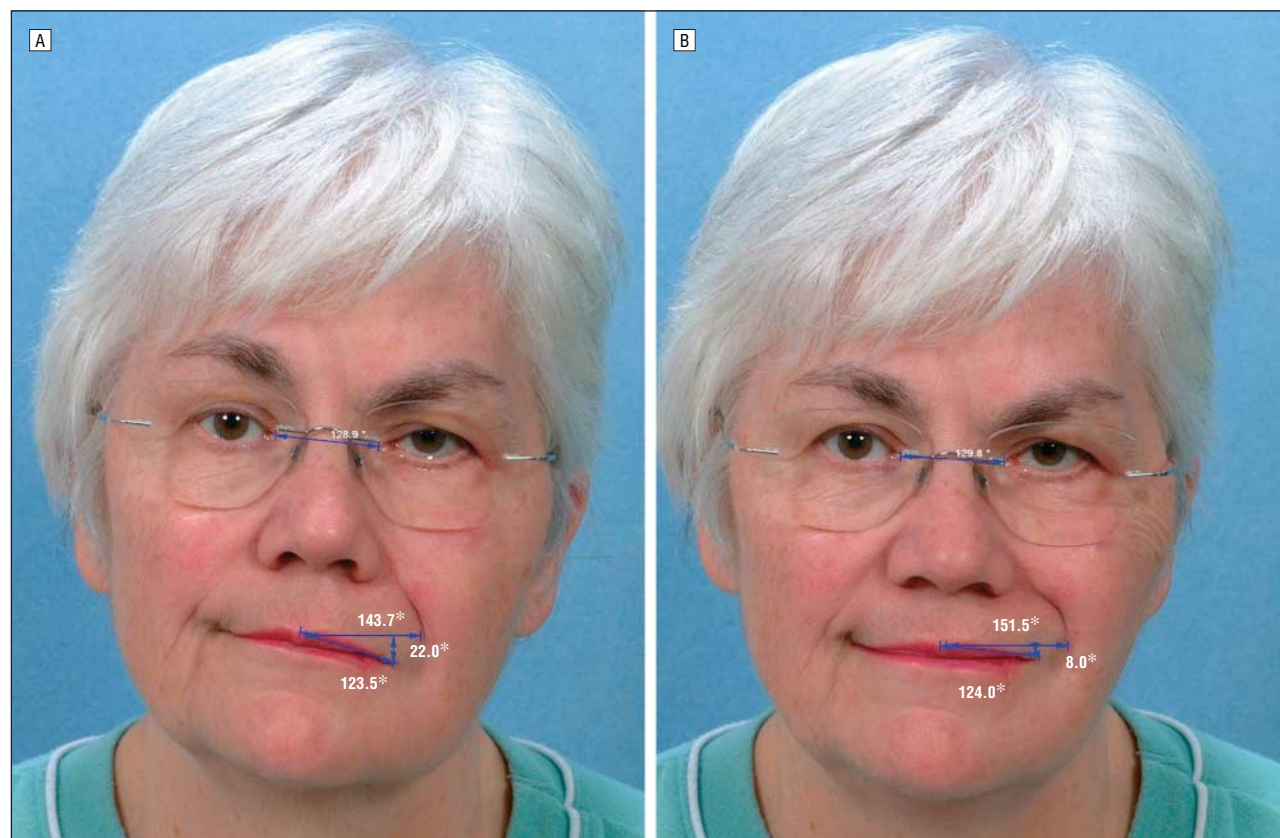
Commissure movement ranged from 1.6 to 8.5 mm in the 7 patients (**Table 2**). Mean movement was 4.2 mm. Five patients had predominantly lateral movement with slight elevation. Two patients had predominantly vertical elevation. One patient developed a salivary fistula through the nasolabial incision. This resolved with local wound care.

Questionnaire given to patients postoperatively.

Excellent or dramatically better	Good or moderately better	Neutral or no change	Bad or moderately worsened	Very bad or dramatically worsened						
10	9	8	7	6	5	4	3	2	1	0

1. How do you feel about the appearance of your face now (as vs before surgery)?
2. How do you feel about your ability to hold food and liquid in your mouth now (vs before surgery)?
3. How do you feel about your ability to speak clearly now (vs before surgery)?
4. How do you feel about your ability to smile now (vs before surgery)?

**Figure 3.** Patient self-assessment questionnaire.



**Figure 4.** Example of photographic measurements with (A) and without (B) temporalis contraction. \*Numbers on figure are multiplied by 0.28 to convert to millimeters.

**Table 1. Results of Physician Grading of Photographs**

Patient No./ Age, y	Physicians, No. (%)					Score, Mean
	Superb (I)	Excellent (II)	Good (III)	Fair (IV)	Poor (V)	
1/66	0	2 (9.5)	14 (66.7)	5 (23.8)	0	3.1
2/38	6 (28.6)	13 (61.9)	2 (9.5)	0	0	1.8
3/35	8 (38.1)	12 (57.1)	1 (4.8)	0	0	1.7
4/61	0	4 (19.0)	15 (71.4)	2 (9.5)	0	2.9
5/62	0	4 (19.0)	14 (66.7)	3 (14.3)	0	3.0
6/47	1 (4.8)	15 (71.4)	4 (19.0)	1 (4.8)	0	2.2
7/34	9 (42.9)	11 (52.4)	1 (4.8)	0	0	1.6
<b>Total</b>	<b>24 (16.3)</b>	<b>61 (41.5)</b>	<b>51 (34.7)</b>	<b>11 (7.5)</b>	<b>0</b>	<b>2.3</b>

**COMMENT**

Procedures available for the re-creation of dynamic facial motion include reinnervation techniques, such as nerve crossovers (cross-face grafts, hypoglossal-facial nerve transfers, and trigeminal-facial transfers), adjacent muscle transfer, and free tissue transfer. The value of nerve crossovers is unquestioned. In fact, the cross-face grafting procedure is capable of providing the gold standard result in facial reanimation: bilateral, symmetrical, and spontaneous mimetic function. The limitations of nerve crossover relate to (1) the inevitable reduction in function of the contralateral side (which some consider, however, to contribute to the success of the procedure owing to the improved facial symmetry) and (2) the unpredictability of the outcome. In addition, these procedures require a prolonged period of regeneration before determining outcome. In cases of prolonged facial paralysis, the classic nerve crossover techniques (cross-face grafts and hypoglossal-facial nerve transfer) are not viable options owing to facial muscle atrophy and motor end plate fibrosis, which prevent such procedures from having any realistic chance of success beyond a certain period. The options available for dynamic reanimation in cases of long-standing facial paralysis thus become more limited. In these cases, the only techniques available to return an element of motion and symmetry to the face are free tissue transfer and redirection of adjacent innervated musculature.

The temporalis flap (and its rarely used counterpart, the masseter muscle transfer) is unique among these choices in that the effect is immediate. Note that free tissue transfer, similar to other nerve crossover procedures, requires a period of reinnervation, which invariably requires many months. We see the immediate return of dynamic movement to be a distinct advantage of the temporalis flap.

There are additional key advantages to the temporalis flap. No distant surgical sight is required; the technique limits the surgical field to the involved hemiface. The temporalis flap is easily harvested and transferred. In our experience the outcome is more predictable than dynamic free tissue transfer, such as innervated gracilis free flaps. The muscles that are candidates for use in this manner are the masseter and the temporalis. The area of the face most amenable to muscle transfer is the perioral region, where the primary goals are to restore symmetry of the smile and improve oral function.

The masseter muscle is suboptimal because rerouting of its insertion to the region of the oral commissure results in a vector of contraction that is too horizontal for optimal function. Furthermore, the defect at the angle of the mandible left by rotation of the muscle is highly visible. The temporalis muscle is a better alternative for this procedure. Orthodromic temporalis tendon transfer is indicated in cases of long-standing facial paralysis and in cases of subacute facial paralysis in patients who desire a single-stage procedure with nearly immediate dynamic function. It is possible only in patients with intact trigeminal motor function. The position of the temporalis superior and posterior to the oral commissure creates a contractile force 45° to the Frankfort plane, which can provide elevation and tightening. It can also be transferred in a manner that does not create an unsightly donor defect. First described in 1934 by Gillies,<sup>4</sup> the procedure traditionally includes the transfer of all or a portion of the origin of the muscle (Figure 6).<sup>5</sup> The muscle is transferred to the area of interest, typically the oral commissure. There are some drawbacks to the standard surgical technique, however. By removing the muscle from its fan-shaped origin on the squamous portion of the temporal bone, an unsightly defect is created in the temporal region. In addition, if the muscle is reflected in the typical manner over the arch of the zygoma, a soft tissue protrusion overlying the zygomatic arch is produced (Figure 7). Each of these can be lessened by using only the central third of the muscle belly, placing a temporal implant to fill in the depression, and even removing the zygomatic arch to lessen the protrusion. Nonetheless, the visible sequelae of the procedure remain. Thus, an important contradiction common to facial plastic surgical reconstruction emerges: the attempt to restore facial symmetry produces additional facial asymmetry. Finally, doubling the muscle on itself over the zygomatic arch alters the dynamics of contraction, which may result in ischemia and likely decreases the contractile forces that can be obtained.

To circumvent these disadvantages, multiple variations on the procedure have been created. Most important, McLaughlin<sup>6</sup> described a transoral approach that involved transecting the temporalis muscle from its insertion at the coronoid process of the mandible and attaching it to the perioral region using a fascia lata graft. Labbé and Huault<sup>7</sup> built on this concept by using a temporal approach to transfer the insertion of the muscle to the oral





**Figure 5.** Preoperative and postoperative temporalis tendon transfer procedure. A, A 28-year-old man with complete right facial paralysis after radical parotidectomy followed by radiation therapy. B, Six months after the temporalis tendon transfer procedure.



**Figure 6.** Preoperative and postoperative temporalis tendon transfer procedure. A, A 57-year-old woman with complete left facial paralysis after acoustic neuroma resection. B, Six months after the temporalis tendon transfer procedure and brow-lift.



**Figure 7.** Preoperative and postoperative temporalis tendon transfer procedure. A, A 36-year-old woman with complete right facial paralysis after acoustic neuroma resection. Gold weight implant had been placed several years previously at a different institution. B, One year after the temporalis tendon transfer procedure and removal of the gold weight implant.

**Table 2. Results of Photographic Analysis: Commissure Movement**

Patient No.	Lateral Movement, mm	Vertical Elevation, mm
4	0	4.0
3	2.2	3.9
1	8.5	0
2	4.6	0
5	2.3	0
7	1.6	0
6	4.5	0

commissure without an extension graft, which they did by releasing the origin of the muscle and allowing the entire muscle to slide through the buccal region. Contreras-Garcia and Braga-Silva<sup>8</sup> reported the use of an endoscopic transtemporal approach for this procedure in 2 patients, but further reports on this technique are lacking. Croxson et al<sup>9</sup> described a modified approach to the temporalis tendon through a nasolabial incision.

We have found the procedure to be relatively easy to perform. It provides symmetrical oral commissure elevation. The vector of pull is essentially ideal. There is no soft tissue depression produced in the temple and no tissue protrusion overlying the zygomatic arch. Similar to all procedures performed for unilateral facial paralysis, there may be the need to revise the procedure in the future. We believe that this likelihood should be dis-

cussed with the patient in advance. The paralyzed hemiface is more prone to the effects of gravity and aging than the nonparalyzed side. Therefore, in many patients optimal results require revision procedures every several years.

In some patients the muscle has been resected or the innervation compromised. A common cause of facial paralysis is the resection of benign or malignant tumors involving the temporal region, the infratemporal fossa, or the superior aspect of the parotid gland. In these instances, resection of the temporalis muscle may be necessary for tumor extirpation, and another method for restoration of facial function must be chosen.

We believe that facial retraining is essential to optimize results in most patients undergoing facial reanimation. Although the benefit of facial retraining is not proven, several studies have suggested a positive effect on outcomes.<sup>10-15</sup> We recommend the coordinated care of a physical therapist with expertise in facial retraining. Modalities typically used with facial motor rehabilitation include use of motor conduction velocity testing, electromyography, and mirror feedback.<sup>16</sup> We have found value in combining mirror feedback with electromyography.

Rehabilitation specific to patients who have undergone a temporalis muscle sling at the Johns Hopkins Facial Plastic Surgery Clinic in the Department of Otolaryngology–Head and Neck Surgery has included the strategies already established by researchers in the



field of facial motor rehabilitation for nonsurgical facial motor patients. Treatment includes teaching a patient how to exercise the transferred temporalis muscle while monitoring for synkinetic movement. Initially, exercises include individualized contractions of the muscles of the contralateral part of the face only, then with the transferred temporalis contracting. Use of electromyographic biofeedback is helpful for a patient to learn the difference between the 2 types of contractions and for facilitation of desired movement. Electromyographic biofeedback is used for facilitation rather than inhibition of muscle tone. It is important for the postoperative patient to be trained to identify the presence of synkinetic movement and then in the techniques to minimize it.

Physical therapy for patients undergoing temporalis sling reconstruction begins before surgery to instruct the patient in the basic principles of facial motor rehabilitation. Postoperative physical therapy may begin 1 week after surgery. Treatment frequency is 1 time per week until the patient has established the ability to dissociate the 2 types of facial motions, with and without use of the sling, plus the ability to avoid synkinetic movement. Once the patient is independent with a home exercise program, treatment frequency decreases to 1 time per month for reassessment and progression of the home program. Rehabilitation may last for 12 months and beyond, depending on patient progress.

In conclusion, the effective treatment of facial paralysis requires a comprehensive approach based on a thorough and thoughtful evaluation of the individual patient's history, physical examination findings, and goals. We believe that in patients in whom reinnervation of the muscles of facial expression is not an option, orthodromic temporalis tendon transfer is an effective, safe, and simple procedure. It eliminates the stigmata of the more classic technique of temporalis transfer, in which the transfer of the origin of the muscle produces asymmetry. The procedure is best performed in conjunction with intensive physical therapy.

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