

# Orthodromic Temporalis Tendon Transfer

## Anatomical Considerations

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**Objectives:** To define (1) at-risk structures during the orthodromic temporalis tendon transfer and (2) achievable tendon length without temporal releasing incisions or perioral lengthening materials.

**Methods:** Ten fresh cadavers provided 20 hemifaces for dissection. Measurements and photographic documentation were used to examine the parotid duct, masseteric artery, inferior alveolar nerve, internal maxillary artery, and mobilized tendon relative to adjacent landmarks.

**Results:** The parotid duct was found in a reproducible region posterior to the melolabial crease and inferior to a parotid duct reference line. The masseteric artery was found posterior to the posterior-most attachment of the tendon at its exit from the sigmoid notch (mean, 14.5 mm). The inferior alveolar nerve was found posterior to

the anterior edge of the ascending ramus (mean, 18.3 mm). The internal maxillary artery coursed superiorly from posterior to anterior along the medial mandible near the coronoidectomy site. The tendon reached beyond the melolabial crease in 17 of 20 hemifaces (85%).

**Conclusions:** The parotid duct reference line and the melolabial crease allow estimation of the parotid duct location. Anatomical relationships between the tendon, parotid duct, neurovasculature, and anatomical landmarks underscore the importance of deliberate soft-tissue retraction and subperiosteal elevation to minimize injury. The tendon alone usually provides adequate length for orthodromic suspension.

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**S**URGICAL RECONSTRUCTION for complete, unilateral facial paralysis continues to pose a formidable challenge. While a multitude of periorbital and perioral reanimation procedures exist, the general consensus holds that facial nerve reinnervation techniques are preferred. However, a number of clinical scenarios illustrate the continued role of muscular slings in the comprehensive rehabilitation of the paralyzed face. Indications include the absence of distal facial nerve branches available for grafting; multiple cranial nerve palsies with an inability to tolerate the potential oromotor dysfunction associated with a hypoglossal-nerve-facial-nerve anastomosis; disease-specific factors portending poor long-term survival; and patient-specific factors such as an unwillingness to tolerate a multistage reconstruction. Under these circumstances, surgeons may choose to avoid reinnervation techniques and instead use 1 or several independent procedures to rehabilitate the paralyzed face. For the reanimation of the lower face, dynamic muscle transfer using the temporalis muscle and its tendon can be the pre-

ferred choice for enhancing lower facial symmetry and function.

The development of temporalis muscle techniques for perioral reanimation began in 1934, when Gillies<sup>1</sup> described a procedure in which the middle third of the origin of the muscle was detached, rotated over the zygomatic arch, and sutured to the perioral musculature after being lengthened with a fascia lata graft. Although static restoration was achieved, a depression at the donor site and a protrusion of the muscle over the zygomatic arch produced additional displeasing facial asymmetry. Furthermore, there was no dynamic function. In 1953, McLaughlin<sup>2</sup> described transection of the whole temporalis muscle from its insertion on the coronoid process using an intraoral approach and attachment of the muscle to the perioral soft tissues with a fascia lata graft. This technique avoided the asymmetry of Gillies' procedure but still required a fascia lata graft for lengthening, without providing movement. Other lengthening materials, such as temporalis fascia<sup>3</sup> and pericranium,<sup>4</sup> have been described.

A more recent report, by Labbé and Huault,<sup>5</sup> showed that coronal and melo-

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labial incisions could be used to release the origin and insertion of the muscle. This technique allowed antero-inferior rotation of the entire muscle, thereby providing adequate length for suspension without using a graft and producing the ability for movement of the lower face. The direction and angle of suspension and movement being similar to the unparalyzed lower face denotes the term *orthodromic*. While orthodromic movement was finally achieved, this releasing technique used a coronal incision and an osteotomy of the zygomatic arch to gain better exposure to the coronoid process. The incision and osteotomy were later avoided by Contreras-García et al,<sup>6</sup> who described an endoscopic release of the muscle on cadaveric and human subjects, with successful results.

Since then, multiple authors have used their own versions of temporalis techniques either alone<sup>7,8</sup> or in conjunction with neural microsurgical techniques,<sup>9</sup> with varying results. A report on the orthodromic temporalis tendon transfer (OTTT) by Byrne et al<sup>10</sup> describes 7 patients who received muscle origin release through a preauricular incision and tendon release through a melolabial incision to restore movement to the lower face. This procedure was found to have good results in terms of facial symmetry, facial movement, and patient satisfaction. The authors followed up their original report with an updated technique that avoided the preauricular approach altogether.<sup>11</sup> Their results with 17 patients who were treated with this approach yielded symmetry at rest, oral commissure movement, lip continence, and subjective improvement in articulation in all patients.

We use a transfacial approach to the OTTT that is similar to the one described in a recent report by Boahene et al.<sup>11</sup> With this technique, the ascending ramus and coronoid process of the mandible are approached through a melolabial incision and buccal space dissection. Proximal approaches for muscle release are avoided completely. To our knowledge, an examination of the anatomical structures at risk for injury during this minimally invasive approach and the functional limitations of the mobilized tendon has not been undertaken. Therefore, our study had 2 aims: (1) to define and quantify the relationships between the field of dissection in the OTTT and adjacent salivary and neurovascular structures and (2) to evaluate the anatomical capabilities of the temporalis tendon to reanimate the lower face without temporal releasing incisions or perioral lengthening materials.

## METHODS

The OTTT dissection was performed on 20 hemifaces from 10 fresh cadaver heads. Detailed measurements and photographic documentation were used to examine the salivary and neurovascular structures relative to the field of dissection and adjacent landmarks.

Dissections began with skin and subcutaneous fat removal from each hemiface, preserving the skin of the auricle and a 2-mm strip overlying the melolabial crease. A parotid duct (PD) reference line (PDRL) was created by connecting the central point of the vermilion border of the upper lip to the most posterior point of the tragus with a silk suture. This line courses

approximately parallel and several millimeters superior to the PD.<sup>12</sup> The PD was identified as it exited the parotid gland (the lateral point) and then followed medially to its entrance into the buccinator (the medial point). **Figure 1A** shows the PD relative to the PDRL. This length of PD was measured. Vertical measurements included the distance from the PDRL to the PD at 5 points: (1) the lateral point, (2) 25% from the lateral point, (3) 50% from the lateral point, (4) 75% from the lateral point, and (5) the medial point (Figure 1B).

The surgical approach was then performed by making an incision along the melolabial crease from the nasofacial sulcus to the horizontal level of the oral commissure. This dissection was carried deep to orbicularis oris and through the buccal space to the anterior edge of the ascending ramus of the mandible. With the ramus identified, the surgical field of dissection was established horizontally and vertically. The horizontal field of dissection was defined as the space from the melolabial incision medially to where the PD crosses the most lateral aspect of the ascending ramus laterally. The vertical field of dissection was defined as the space from the inferior border of the anterior malar eminence superiorly to a horizontal line parallel to the oral commissure inferiorly. Additional measurements were made from the PD at the lateral aspect of the ascending ramus and the entrance of the PD into the buccinator to both the melolabial crease horizontally and the inferior border of the anterior malar eminence vertically.

All tissue lateral to the PD was then removed for full visualization of the temporalis muscle, the masseter muscle, and the zygoma. The masseteric artery (MA) was identified within the sigmoid notch by dissecting off the origin of the masseter muscle. The distance was measured from the MA to surrounding landmarks. The locations of the most inferior point of the sigmoid notch and the tip of the coronoid process were marked with pins. These markings were later used for measurements of the internal maxillary artery (IMA).

An oscillating bone saw was used to cut vertically across the anterior body of the mandible inferior to the space between the second premolar and the first molar. This osteotomy allowed sufficient rotation of the mandible for identification of the lingula, the inferior alveolar nerve (IAN), and the medial aspect of the intact temporalis tendon. Measurements were taken from the IAN and the intact temporalis tendon to surrounding landmarks.

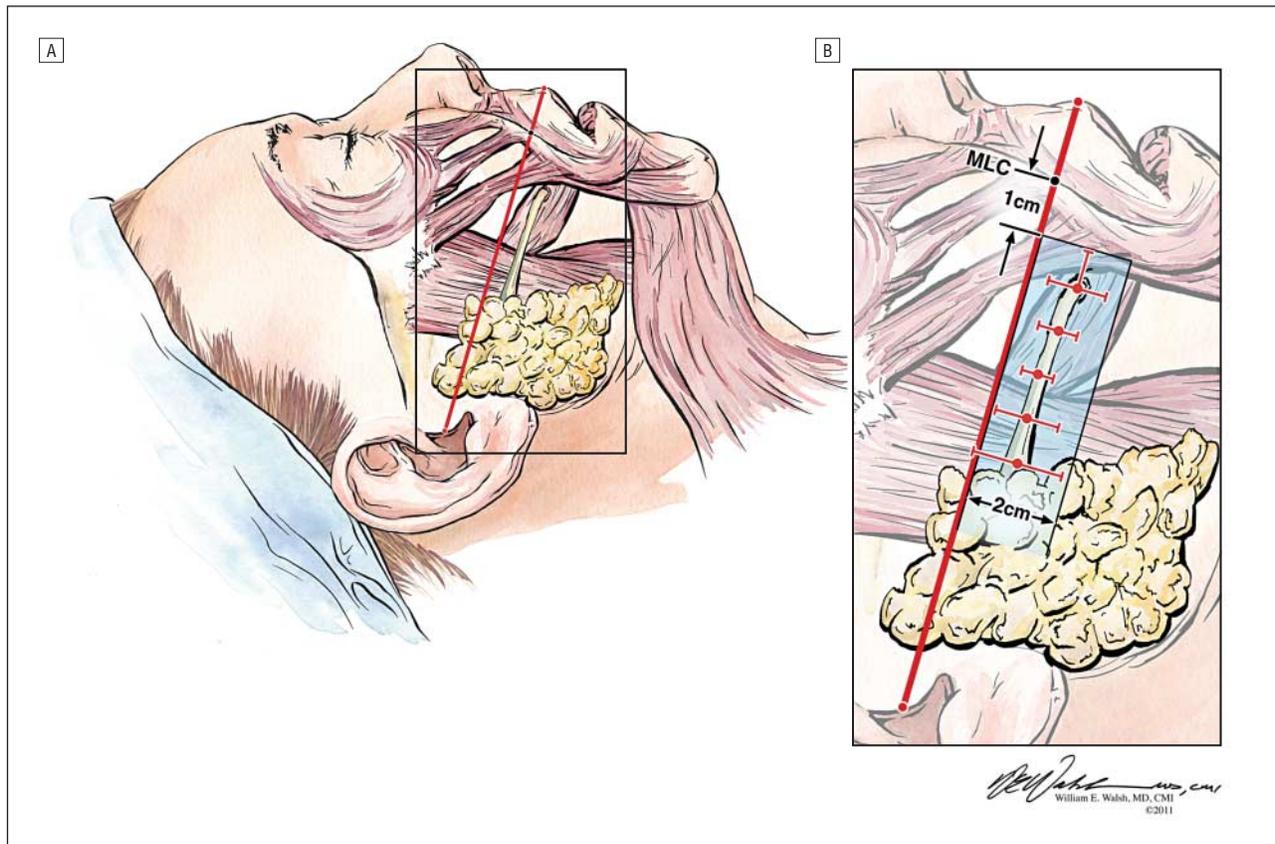
A coronoidectomy was performed with the oscillating saw, and the distal temporalis tendon was then released from its insertion. The mobilized tendon was rotated anteriorly to identify the point at which the tendon fulcrums around the anterior inferior aspect of the zygomatic process of the maxilla and the zygoma, which we termed the *zygoma flexion point* (ZFP). The tendon was rotated until the vector of the tendon was toward the oral commissure. Measurements were taken from the mobilized tendon to surrounding landmarks.

An oscillating bone saw was used to divide the mandible at the condylar neck. The hemimandible was reflected posteriorly to allow dissection of the medial soft tissues. Dissection started at the previously identified MA and continued proximally until the IMA was identified and dissected along its course medial to the ramus. Using the previously placed pins, IMA measurements were taken.

## RESULTS

### PAROTID DUCT

The **Table** shows the measurements of the PD relative to surrounding landmarks. Figure 1 illustrates the



**Figure 1.** Parotid duct (PD) location. A, The PD is shown relative to the PD reference line (PDRL) and the melolabial crease (MLC). The PDRL is drawn in red. B, The data points (red dots) represent the mean distance of the PD to the PDRL and the MLC. The error bars represent 2 SDs of the data. The blue shaded box shows a guideline for the location of the PD in relation to the PDRL and the MLC, where the PD can usually be found in a box starting 1 cm posterior to the MLC and extending 2 cm inferior to the PDRL. (Illustration by William E. Walsh, MD, CMI, ©2011 William Walsh; used with permission.)

relationship of the PD to the PDRL and the melolabial crease.

#### MASSETERIC ARTERY

The relationship between the MA, the sigmoid notch, and the tendon insertion is illustrated in **Figure 2**. The mean (SD) distance from the MA to the most inferior point of the sigmoid notch was 6.2 (3.0) mm (range, 0-11 mm). The MA exited the sigmoid notch at a mean distance of 1.8 (2.4) mm posterior to a vertical line through the most inferior point of the notch (range, 6 mm posterior to 2 mm anterior). The MA was found at a mean distance of 14.5 (5.1) mm from the most posterior point of insertion of the temporalis tendon (range, 5-23 mm).

#### INFERIOR ALVEOLAR NERVE

Figure 2 also shows the relationships between the IAN, the sigmoid notch, the mandibular ramus, and the tendon insertion. The mean distance between the IAN and the most inferior point of the sigmoid notch was 18.8 (3.4) mm (range, 11-23 mm). The mean distance between the IAN and the most anterior edge of the ascending ramus was 18.3 (3.0) mm (range, 12-24 mm). The mean distance between the IAN and the most posterior aspect of the tendon insertion was 12.1 (2.7) mm (range, 8-19 mm).

#### INTERNAL MAXILLARY ARTERY

The relationship between the IMA, the coronoid process, the sigmoid notch, and the condyle is shown in **Figure 2C**. The IMA crossed the mandible at a mean distance of 6.0 (3.6) mm (range, 2-13 mm) inferior to the most superior point of the coronoid process, 2.7 (1.8) mm (range, 0-5 mm) inferior to the most inferior point of the sigmoid notch, and 23.0 (5.0) mm (range, 15-33 mm) inferior to the most superior point of the mandibular condyle.

#### INTACT AND MOBILIZED TEMPORALIS TENDON

The mean distance between the distal end of the intact tendon insertion to the most superior point of the coronoid process was 28.9 (6.0) mm (range, 20-36 mm). Most of the substance and transferrable length of the tendon was found on the medial aspect of the coronoid process and the ascending ramus of the mandible. After coronoidectomy and mobilization of the temporalis tendon, the mean distance from the ZFP to the distal tip of the tendon was 39.2 (9.4) mm (range, 24-54 mm). The mean distance from the ZFP to the melolabial crease was 33.1 (10.1) mm (range, 20-50 mm), and between the ZFP to the oral commissure it was 43.3 (13.2) mm (range, 28-62 mm). The mobilized temporalis tendon reached beyond the melolabial crease in 17 of 20 hemifaces (85%). In the

**Table. Linear Relationships Between the Parotid Duct (PD) and Adjacent Landmarks**

Measurement Description	Mean (SD), mm	Range, mm
Length of exposed PD <sup>a</sup>	40.9 (5.2)	26-46
PD to the PD reference line		
At lateral point	8.8 (5.3)	4-22
At 25% from lateral point	7.9 (3.4)	3-16
At 50% from lateral point	7.6 (2.0)	5-10
At 75% from lateral point	9.2 (2.3)	5-14
At medial point	10.7 (3.5)	5-17
PD at medial point to melolabial crease	18.6 (3.3)	10-24
PD at ramus to melolabial crease	30.9 (7.0)	14-42
PD at medial point to malar eminence	18.6 (3.3)	10-24
PD at ramus to malar eminence	21.5 (6.0)	13-33

<sup>a</sup>Length from the lateral point (ie, the point of exit from the parotid gland) to the medial point (ie, the point of entrance into the buccinator muscle).

remaining 3 hemifaces, the tendon extended to within 3 mm of the crease.

#### COMMENT

Reanimation of the paralyzed face using the temporalis muscle has evolved over time to focus on the mobilization and use of the tendon insertion for suspension of the perioral soft tissues with or without proximal release of the muscle and/or use of lengthening grafts. The OTTT as described by Boahene et al<sup>11</sup> offers several advantages over other temporalis techniques. Most importantly, it is less invasive and simpler to perform than other techniques, while providing an orthodromic vector for suspension and movement. It can also be customized to patients' unique smiles. Because we use a similar technique, our study aimed to clarify the anatomical relationships encountered through this minimally invasive transfacial approach.

The most closely associated structure to the field of dissection is the PD, which crosses the field in a horizontal fashion and is most susceptible to injury from just lateral to the ascending ramus to the point where it enters the buccinator muscle. In patients with intact and functional parotid glands, injury to the PD can result in sialoceles, cutaneous fistula, or salivary duct cyst formation. The data from this study allow consistent estimation of the PD position using the PDRL and the melolabial crease, as shown in Figure 1B. We have demonstrated that the medial-most point of the PD is more than 1 cm from the melolabial incision and located in a 2-cm-wide area inferior to the PDRL. Estimating the location of the PD helps to identify that structure and then to protect the PD with careful retraction of the soft tissues.

Because the branches of the facial nerve are not of concern with long-standing, complete unilateral facial paralysis, the major neural structure that must be considered is the IAN. During the OTTT, concern for IAN injury while dissecting the tendon off the medial aspect of the ramus arises. We found that the IAN entered into the lingula more than 1 cm away from the anterior edge of the ramus in all dissections. Also, 1 cm of dissection completely mobi-

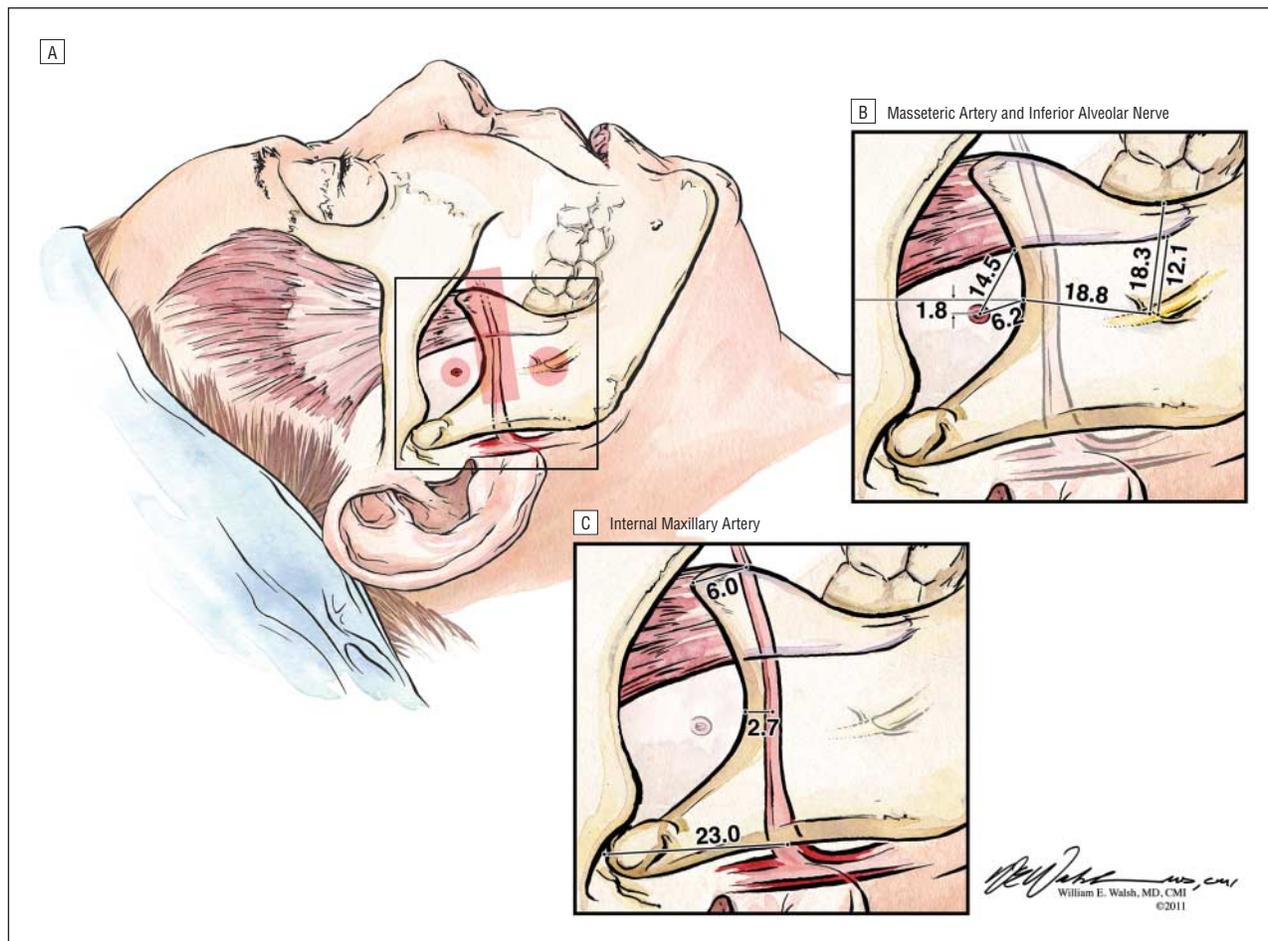
lized the entire width of the medial portion of the tendon at the level of the lingula in all dissections. Therefore, surgeons can feel reassured that 1 cm of subperiosteal dissection from the anterior edge of the ramus should mobilize the tendon, while avoiding injury to the IAN.

Vascular structures are also of concern during the OTTT. The MA courses through the sigmoid notch as it supplies the masseter muscle. During the OTTT approach, we place a right-angle clamp through the sigmoid notch to allow planning of the proper coronoidectomy location and to protect deeper structures. A right-angle clamp is inserted from the medial aspect of the mandibular dissection through the most inferior aspect of the sigmoid notch after subperiosteal elevation. Our data showed that the mean distance between the MA and the most inferior aspect of the sigmoid notch was 6.2 mm, although in 1 specimen the artery was found at the notch. Meanwhile, the IMA lies just medial to the ascending ramus and travels superiorly in a posterior to anterior direction. Our study shows that the IMA can lie just medial to the proposed location of the coronoidectomy. Therefore, careful subperiosteal dissection must be used to maintain as much tissue between (1) the bony sigmoid notch, (2) the MA as it courses through the notch, and (3) the IMA as it courses just medial to the mandible to avoid inadvertent injury while the right-angle clamp is being placed. Also, an understanding of these relationships underscores the importance of using the clamp to protect these structures during coronoidectomy with the bone saw.

Finally, we sought to better understand the reach of the mobilized temporalis tendon when it is extended to the perioral musculature for orthodromic suspension. Besides the increased length described by Contreras-García et al<sup>6</sup> using their endoscopic lengthening technique, we found no studies examining the length of usable tendon compared with the distance required to adequately suspend the tendon. In our study, the tendon was consistently inserted onto the lateral, anterior, and medial aspects of the ascending ramus. Before mobilization, the distal tip of the tendon reached anywhere from 18 to 36 mm from the most-superior point of the coronoid process. More importantly, once the tendon was mobilized, we found that 85% of the tendons had adequate length to reach beyond the melolabial crease. Three tendons (15%) did not have adequate length to reach the melolabial crease, and, in each case, the tendon tip was less than 3 mm from the crease.

The most-distal tissue was tapered in some specimens. While these specimens appeared to provide inadequate bulk for suspension, the measurements were made in relaxed, unsuspected soft tissues. We routinely overcorrect the degree of perioral suspension at surgery because of the anticipated relaxation and descent of the facial soft tissues over time. Because we overcorrect, we tend to use tendon stock proximal to the tip, which we find has adequate bulk. However, the fact that the tendon can be somewhat tapered distally after release underscores the importance of careful dissection to preserve adequate distal tendon stock.

Our superolateral suspension usually exceeds 3 mm; therefore, our results indicate that proximal muscle re-



**Figure 2.** Neurovascular structures at risk. A, Approximate locations of the masseteric artery (MA) (superior red circle), internal maxillary artery (IMA) (red rectangle), and inferior alveolar nerve (IAN) (inferior red circle). B, Mean distances in millimeters between the MA, tendon insertion, and sigmoid notch, as well as the IAN, ramus, tendon insertion, and sigmoid notch. C, Mean distances in millimeters between the IMA, coronoid, sigmoid notch, and condyle. (Illustration by William E. Walsh, MD, CMI, ©2011 William Walsh; used with permission.)

lease and lengthening grafts are not necessary if the entire distal end of the tendon is used. However, grafting techniques may be needed if the quality of the distal tendon is inadequate to securely hold the resuspended perioral musculature. Also, lengthening grafts would likely be needed if suspension were required beyond the melolabial crease, such as to the midline of the upper or lower lip, as described by Sherris.<sup>13</sup>

It was interesting to note that during our dissections, tendon from the medial pterygoid and mylohyoid muscles seemed to blend with the medial insertion of the temporalis tendon. During prior cases using the OTTT technique, we attempted to raise the distal temporalis tendon as far as possible to gain maximum length. We observed that the harvested distal temporalis tendon is at times of poor quality after this extensive dissection. According to our study, one explanation for this observation is that the true temporalis tendon may be shorter than initially expected and that the additional “poor-quality tendon” may represent medial pterygoid or mylohyoid tendon harvested along with the true temporalis tendon.

The main limitation of this study is that all measurements were made on cadavers, in which soft-tissue quality can only approximate that found in live human sub-

jects. These measurements should be verified in patients undergoing the OTTT.

In conclusion, during OTTT for complete, unilateral facial paralysis, injury to the PD, IAN, MA, and IMA can be avoided with anatomical understanding, deliberate retraction of soft tissues, careful subperiosteal elevation, and protection of vascular structures. Also, mobilized temporalis tendon, if carefully elevated, can provide adequate length to suspend the perioral soft tissues without the need for releasing incisions on the muscle origin or perioral lengthening materials.

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## REFERENCES

1. Gillies H. Experiences with fascia lata grafts in the operative treatment of facial paralysis. *Proc R Soc Med.* 1934;27(10):1372-1382.
2. McLaughlin CR. Surgical support in permanent facial paralysis. *Plast Reconstr Surg (1946).* 1953;11(4):302-314.
3. Andersen JG. Surgical treatment of lagophthalmos in leprosy by the Gillies temporalis transfer. *Br J Plast Surg.* 1961;14:339-345.
4. McLaughlin CR. Permanent facial paralysis: the role of surgical support. *Lancet.* 1952;2(6736):647-651.
5. Labbé D, Huault M. Lengthening temporalis myoplasty and lip reanimation. *Plast Reconstr Surg.* 2000;105(4):1289-1298.
6. Contreras-García R, Martins PD, Braga-Silva J. Endoscopic approach for lengthening the temporalis muscle. *Plast Reconstr Surg.* 2003;112(1):192-198.
7. Breidahl AF, Morrison WA, Donato RR, Riccio M, Theile DR. A modified surgical technique for temporalis transfer. *Br J Plast Surg.* 1996;49(1):46-51.
8. Croxson GR, Quinn MJ, Coulson SE. Temporalis muscle transfer for facial paralysis: a further refinement. *Facial Plast Surg.* 2000;16(4):351-356.
9. Terzis JK, Olivares FS. Mini-temporalis transfer as an adjunct procedure for smile restoration. *Plast Reconstr Surg.* 2009;123(2):533-542.
10. Byrne PJ, Kim M, Boahene K, Millar J, Moe K. Temporalis tendon transfer as part of a comprehensive approach to facial reanimation. *Arch Facial Plast Surg.* 2007;9(4):234-241.
11. Boahene KD, Farrag TY, Ishii LE, Byrne PJ. Minimally invasive temporalis tendon transposition. *Arch Facial Plast Surg.* 2011;13(1):8-13.
12. Barton NW, Miller SH, Graham WP III. Managing lacerations of the parotid gland, duct and facial nerve. *Am Fam Physician.* 1976;13(4):130-134.
13. Sherris DA. Refinement in reanimation of the lower face. *Arch Facial Plast Surg.* 2004;6(1):49-53.