

# The anatomical basis for surgical preservation of temporal muscle

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**Object.** Mobilizing the temporal muscle is a common neurosurgical maneuver. Unfortunately, the cosmetic and functional complications that arise from postoperative muscular atrophy can be severe. Proper function of the muscle depends on proper innervation, vascularization, muscle tension, and the integrity of muscle fibers. In this study the authors describe the anatomy of the temporal muscle and report technical nuances that can be used to prevent its postoperative atrophy.

**Methods.** This study was designed to determine the susceptibility of the temporal muscle to injury during common surgical dissection. The authors studied the anatomy of the muscle and its vascularization and innervation in seven cadavers. A zygomatic osteotomy was performed followed by downward mobilization of the temporal muscle by using subperiosteal dissection, which preserved the muscle and allowed a study of its arterial and neural components.

The temporal muscle is composed of a main portion and three muscle bundles. The muscle is innervated by the deep temporal nerves, which branch from the anterior division of the mandibular nerve. Blood is supplied through a rich anastomotic connection between the deep temporal arteries (anterior and posterior) on the medial side and the middle temporal artery (a branch of the superficial temporal artery [STA]) on the lateral side.

**Conclusions.** Based on these anatomical findings, the authors recommend the following steps to preserve the temporal muscle: 1) preserve the STA; 2) prevent injury to the facial branches by using subfascial dissection; 3) use a zygomatic osteotomy to avoid compressing the muscle, arteries, and nerves, and for greater exposure when retracting the muscle; 4) dissect the muscle in subperiosteal retrograde fashion to preserve the deep vessels and nerves; 5) deinsert the muscle to the superior temporal line without cutting the fascia; and 6) reattach the muscle directly to the bone.

**KEY WORDS** • temporal muscle • muscle atrophy • surgical technique • anatomical study

**M**OBILIZING the temporal muscle is one of the most common neurosurgical maneuvers. Such mobilization, however, is frequently associated with postoperative atrophy, and the resulting asymmetry can be severe. This asymmetry can be a consequence of malpositioning of the muscle at the end of surgery, atrophy of the entire muscle, or atrophy of the distally transected muscle.<sup>20</sup> Cosmetic and functional deficits result from this asymmetry.<sup>8,11</sup> The most remarkable cosmetic sequela is an anterior temporal hollow, which can be disfiguring and therefore psychologically detrimental to the patient.

A major problem in mobilizing the temporal muscle is a change in the position of the temporomandibular joint that generates pain, limits chewing, and causes problems of occlusion, mouth aperture, and lateral movement of the jaw.<sup>8</sup> Temporal tendonitis is also a problem and can cause temporomandibular pain, ear pressure and pain, odontalgia (especially in the mandibular teeth), zygomatic and ocular pain, anterior temporal headaches, and deep aching pain at the attachment of the temporal tendon to the coronoid process.<sup>13</sup>

Postoperative muscle atrophy stems from several factors: 1) direct injury to the muscle fibers caused by inappropriate dissection, excessive retraction, or the use of a large cuff of muscle for reattachment;<sup>11,15</sup> 2) muscle ischemia caused by

an interruption of the primary arterial supply or prolonged retraction;<sup>3,4</sup> 3) inadequate tension in the reattached muscle;<sup>20</sup> and 4) muscle denervation from direct or indirect injury to the nerve supply.<sup>10,11</sup> We describe the anatomy of the temporal muscle and technical maneuvers that can be used to achieve good functional and cosmetic results.

## Materials and Methods

We dissected the temporal muscles in seven cadaveric heads. The anterior and posterior branches of the STA were identified in the superficial fascia, then the main trunk of the STA and the origin of the MTA were dissected. The frontotemporalis branches of the facial nerve and their relationships to the zygomatic arch were observed. A zygomatic osteotomy and subperiosteal retrograde dissection were performed to mobilize the temporal muscle downward. After a temporal craniotomy and dissection of the middle cranial fossa, the mandibular nerve was followed from its intracranial portion across the foramen ovale to the infratemporal fossa. We then identified the branches that innervate the temporal muscle and noted their relationship to other muscles of the infratemporal fossa.

The blood supply on the medial side was identified, then the anterior division of the mandibular nerve was cut in the foramen ovale. The arteries that did not supply the temporal muscle were cut and separated from the main trunk of the external carotid artery and its major division into the IMA and the STA. The muscle was then removed, preserving its attachments to the coronoid process and anterior ramus of the mandible. We studied the direct arterial and nerve supply and, after their removal, separated the different bundles of the muscle.

*Abbreviations used in this paper:* DTA = deep temporal artery; IMA = internal maxillary artery; MMA = middle meningeal artery; MTA = middle temporal artery; STA = superficial temporal artery.

Anatomical Description

*Temporal Muscle*

The fan-shaped temporal muscle is composed of a main portion and three bundles (anteromedial, anterolateral, and middle lateral; Fig. 1); the main portion is further divided into anterior, middle, and posterior parts.<sup>14</sup> The anterior part of the main portion is sandwiched between the anteromedial and the anterolateral bundles and constitutes the thickest part of the temporal muscle. The main portion originates from the lateral surface of the skull (the temporal fossa) except for the part formed by the zygomatic bone, where a layer of fat is present between the muscle and the bone. Passing through the gap between the zygomatic arch and the skull, its descending fibers converge to form a thick aponeurosis in the lateral aspect. The fibers insert as two separate, tendinous heads. The superficial tendinous head inserts into the lateral surface of the coronoid process of the mandible.

The anteromedial bundle arises from the infratemporal crest of the greater wing of the sphenoid bone, and inserts into the medial aspect of the anterior ramus of the mandible. The anterolateral bundle is located superficial to the aponeurosis of the anterior region of the main portion of the temporal muscle. The middle lateral bundle is a thin muscle layer covering the aponeurosis in the middle of the main portion. When the goal is to keep the subperiosteum intact, the surgeon may not be able to recognize the separate parts of the temporal muscle when it is mobilized.

*Innervation.* The temporal muscle is innervated by the an-

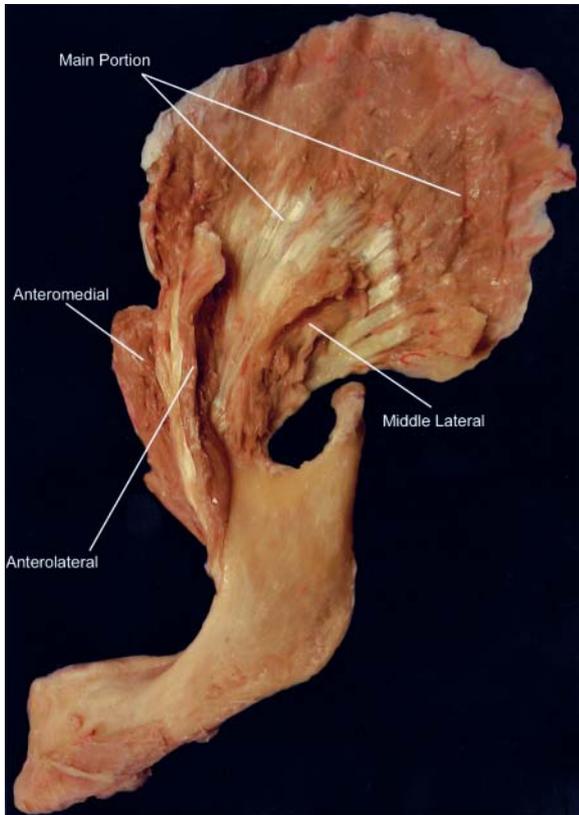


FIG. 1. Photograph of anatomical dissection (lateral view) of cadaveric temporal muscle demonstrating the four different components.

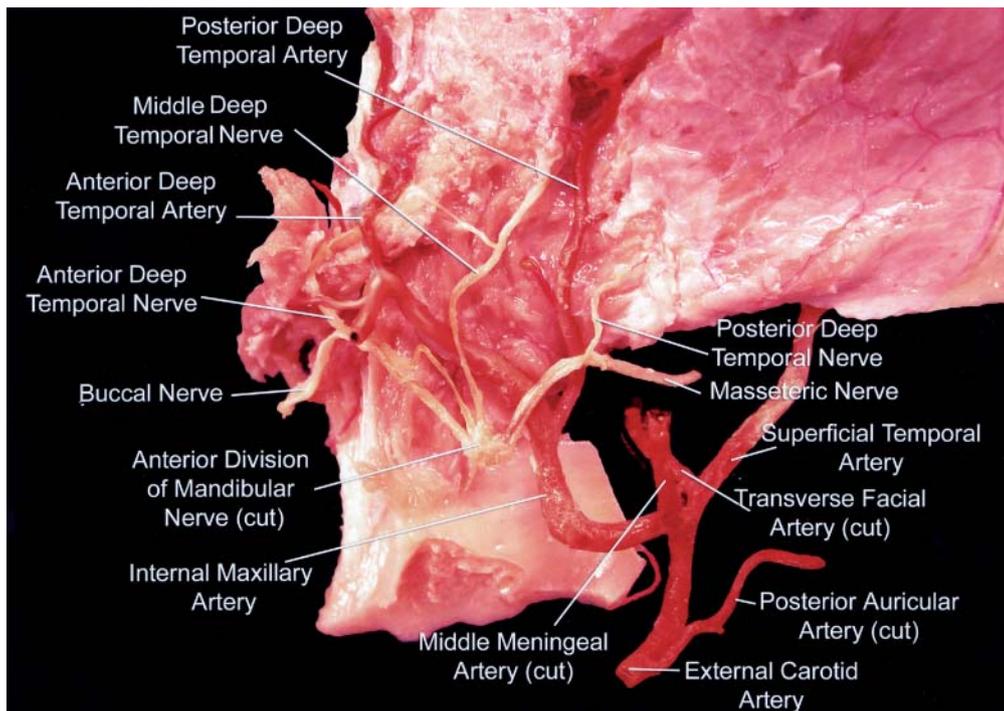


FIG. 2. Photograph of anatomical dissection showing the medial aspect of the temporal muscle and its insertion in the coronoid process of the mandible inferiorly. The blood supply by the anterior and posterior DTAs (branches of the IMA) is demonstrated, and the innervation by the anterior, middle, and posterior temporal nerves (branches of the anterior division of the mandibular nerve) is depicted.

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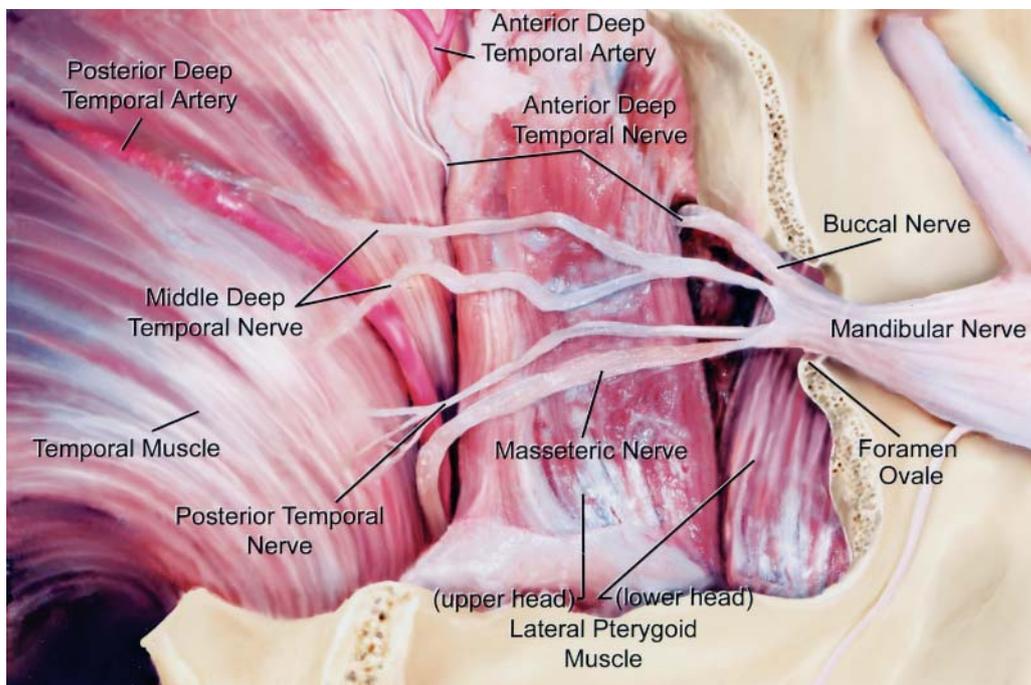


FIG. 3. Artist-enhanced photograph of anatomical dissection showing the course of the deep temporal nerves in the infratemporal fossa.

terior division of the mandibular nerve (Figs. 2 and 3). This nerve usually gives rise to three branches: the masseteric (most posterior), the middle deep temporal, and the buccal (most anterior). The anterior deep temporal nerve is a branch of the buccal nerve, and can originate as one or more branches. The buccal and anterior temporal nerves pass through the lateral pterygoid muscle, between the upper and lower heads of the muscle at its anterior aspect. After it separates from the buccal nerve, the anterior deep temporal nerve divides into many tiny branches that supply the anteromedial bundle, the anterior part of the main portion of the temporal muscle, and the anterolateral bundle.

The middle and posterior deep temporal nerves run on the superior surface of the upper head of the lateral pterygoid muscle. The middle deep temporal nerve can originate separately or share a trunk with the masseteric nerve, which separates soon after leaving the foramen ovale. It innervates the middle part of the main portion of the temporal muscle and the middle lateral bundle. The posterior deep temporal nerve originates from the masseteric nerve as one or many tiny branches before it reaches the superior border of the upper head of the lateral pterygoid muscle and turns downward to innervate the masseter muscle. The posterior deep temporal nerve supplies the posterior part of the main portion of the temporal muscle. The masseteric and the deep temporal nerves are related to the posterior root of the zygoma.

**Vascular Supply.** The temporal muscle derives its blood supply from the MTA, a branch of the STA, and from the anterior and posterior DTAs, which are branches of the IMA (Fig. 3). The anterior DTA supplies the anterior portion of the muscle, the posterior DTA supplies the midportion, and the MTA supplies the posterior portion. The ante-

rior DTA can then anastomose with arteries perforating the zygomatic bone and the lateral aspects of the greater wing of the sphenoid bone. The MTA usually arises at the point where the STA crosses over the zygomatic arch, perforating the fascia, and enters the muscle from its lateroposteroinferior aspect. One anterior and one posterior branch can be identified. An arterial anastomosis through the temporal bone can be seen when the muscle is elevated, mostly in the anterior and mid-inferior portions. These are connections of the MMA with the DTAs in the temporal bone and a common source of bleeding during deinsertion of the muscle.

### *Surgical Procedure*

The anatomical findings described earlier are the basis for the constellation of technical maneuvers we routinely use to preserve the temporal muscle.

**Skin Incision.** A curvilinear incision made behind the hairline prevents a scar on the patient's forehead. This incision is begun 1 cm anterior to the tragus and is continued as needed to the opposite superior temporal line. The STA courses posterior and the frontotemporalis branches of the facial nerve run anterior to the incision.

**Preservation of the STA.** When the skin incision starts higher in the temporal area and advances downward, the STA can be identified and separated from the skin by dissection in the subcutaneous plane. Its attachment to the muscle is preserved and it is not raised with the skin flap as is commonly practiced. After sharp dissection against the galea, the scalp flap is reflected anteriorly, leaving thick areolar tissue with a pericranial layer adhering to the calvaria. The anterior branch of the STA can be cut distally and reflected with the scalp flap.

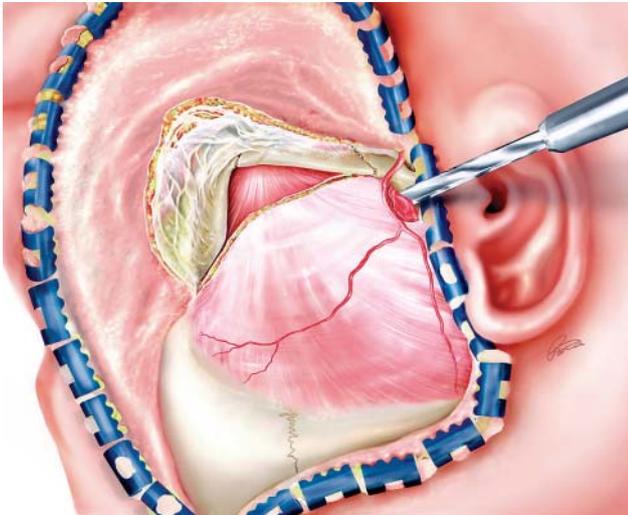


FIG. 4. Artist's illustration demonstrating preservation of the STA, preservation of the facial branches in the fat pad by subfascial dissection, and the initial dissection of the subperiosteum on the zygomatic root.

**Subfascial Dissection of the Frontotemporal Branch of the Facial Nerve.** The technique we use to dissect the frontotemporal branch of the facial nerve differs from the standard interfascial dissection of this branch.<sup>19</sup> We aim to lift and reflect with the skin flap both the superficial and deep fascia, protecting the fat pad that contains the frontotemporal branches of the facial nerve. The superficial and deep fascia of the temporal muscle are incised until muscle fibers are visualized through the incision. This incision is made 1 cm posterior and parallel to the course of the frontotemporal branches of the facial nerve, along the zygomatic arch. The deep fascia, the superficial fascia, and the fat pad between these structures containing the frontotemporal branches of

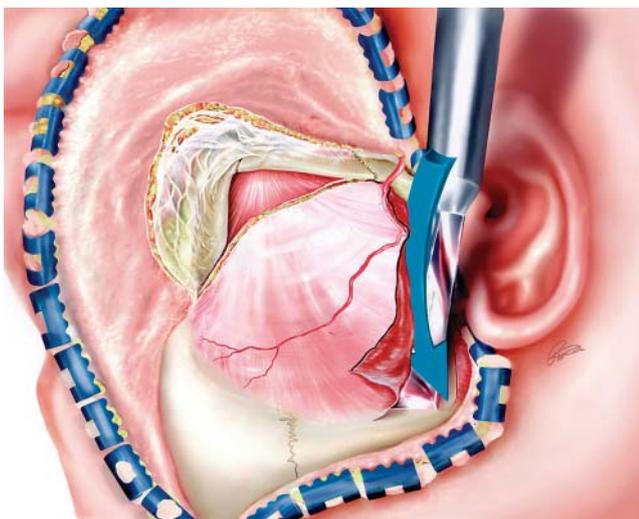


FIG. 5. Artist's illustration showing the retrograde dissection of the temporal muscle, preserving the subperiosteum and detachment of the muscle from the superior temporal line, preserving the integrity of the muscle fibers.

the facial nerve are then reflected with the skin flap. The subfascial dissection assures that the branches of the facial nerve are preserved.

**Zygomatic Osteotomy.** If access to the lower temporal fossa is needed, the temporal muscle must be further retracted downward. An osteotomy of the zygoma not only alleviates brain retraction but also allows a better view without excessive retraction of the muscle, which could injure the muscle fibers, vascularization, or innervation. The osteotomy is performed with oblique cuts anteriorly through the malar eminence, and posteriorly through the root of the zygoma. Because of its shape, the zygomatic arch is easily reattached.<sup>12</sup> The posterior deep temporal and masseteric nerves are related to the posterior root of the zygoma. To prevent injury to these nerves, the temporal muscle is protected from the cutting tool by a spatula applied between the muscle and the zygoma while making the posterior cut.

**Subperiosteal Dissection.** The temporal muscle itself is incised posterior to the preserved STA. To avoid injury to the MTA at the point where it relates to the posterior root of the zygoma, subperiosteal dissection is started at the root of the zygoma and moves directly forward (Fig. 4). At this point, a periosteal elevator is introduced into the lower part of the incision of the temporalis muscle. The surgeon must ensure that the elevator is positioned under the subperiosteum, and the dissection is made in an inferior-to-superior and posterior-to-anterior manner (Fig. 5). This first step in the subperiosteal dissection of the muscle is crucial if its innervation is to be preserved.

The posterior deep temporal nerve is located at the level of the posterior root of the zygoma, and even the masseteric nerve can be injured during the zygomatic osteotomy. These nerves arise from a common trunk. As dissection progresses anteriorly, the middle and anterior deep temporal nerves are preserved by maintaining subperiosteal dissection. The anterior deep temporal nerve is better protected by tissue and fascia because it enters the lower part as a branch of the buccal nerve. Because the origin of both the anterior and posterior DTAs is lateral to the lateral pterygoid muscle, these arteries usually run in a more protected plane in the inferior portion.

During dissection, the anastomosis between the DTA and the MMA can be a source of bleeding through the bone. Monopolar cautery, especially against the muscle, is not used to control this bleeding because it can damage the nerves and arteries. Deinsertion of the muscle is performed in the superior temporal line so that no piece of muscle without innervation or vascularization is left attached to the bone. The entire muscle is reflected downward without excessive retraction so as not to compromise the blood supply or stretch the muscle and nerves.

**Reattachment of the Muscle.** When the muscle is repositioned at the end of surgery, a series of holes is made in the bone within the superior temporal line and the superior part of the muscle is reattached (Fig. 6). The posterior part of the muscle flap is reattached to the incised muscle.

We retrospectively reviewed the records of 10 patients in whom the procedure we describe was applied. Comparing the bulk of the temporal muscle on both sides, no asymmetry was encountered in the representative follow-up magnetic resonance image (Fig. 7). Good cosmetic results with no disfiguring temporal hollow were noted. No complaints

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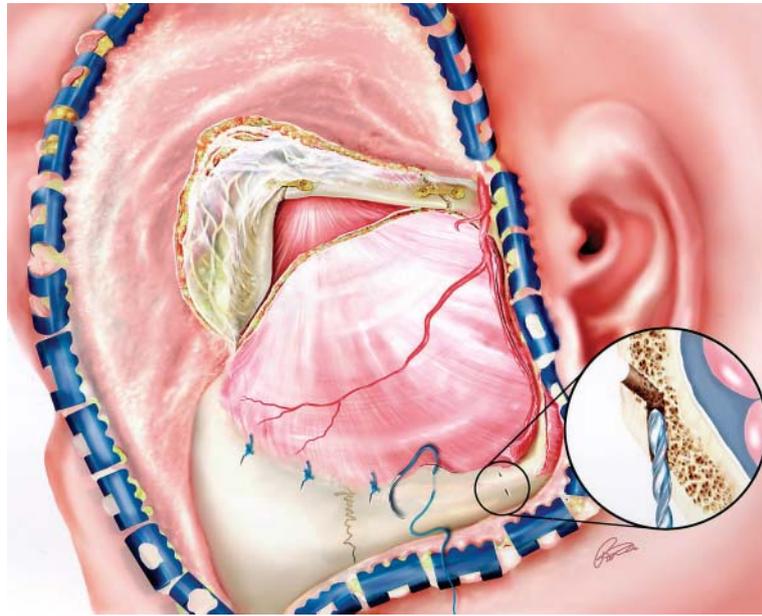


FIG. 6. Artist's illustration of reattachment of the temporal muscle to the superior temporal line, preserving muscle tension. *Inset* shows hole making at the superior temporal line in the bone flap for muscle reattachment.

about pain or dysfunction of the temporomandibular joint were noted in this small cohort.

### Discussion

The temporal muscle is one of the structures that can be mobilized during the most common neurosurgical procedures. As indicated by its nerve supply, the muscle is derived from the first branchial arch and has a complex anatomy:<sup>1,9,16,18</sup> a main portion that is divided into anterior, middle, and posterior parts, and three muscle bundles (anteromedial, anterolateral, and middle lateral).<sup>13,14</sup> Although some authors believe that this muscle consists of separate bundles,<sup>14</sup> we consider the main portion and the bundles to be a unit. The intraoperative view does not allow the recognition of parts or different bundles when the goal is to keep the subperiosteum intact and the whole muscle is superficial to it. Oikawa, et al.,<sup>11</sup> have used retrograde dissection of the temporal muscle, preserving the subperiosteum to prevent muscle atrophy.

The functional integrity of the muscle depends on its innervation, the vascular supply, the integrity of the fibers, and muscle tension.

### Effects of Denervation

After denervation, the muscle undergoes a series of morphological, physiological, biochemical, functional, and metabolic changes.<sup>17</sup> There is a 30% decrease in muscle weight 1 month after denervation; that percentage increases to between 50 and 60% after 2 months. With prolonged denervation, the blood supply deteriorates and fibrosis progresses with ultimate replacement of muscle by fat cells.<sup>10,17</sup> All three deep temporal nerves are located superficial to the subperiosteum and can be damaged by dissection or cauterization of soft tissue. Thus, subperiosteal dissection, particularly in the zygomatic and lower temporal fossa, is of

paramount importance in preserving the nerves and avoiding the use of monopolar cauterization in the area of their crossing.

### Effects of Devascularization

A rich anastomotic vascularity feeds the temporal muscle from the MTA, the anterior and posterior DTAs, and their connections.<sup>6,16,18</sup> Extensive vertical and horizontal anastomotic channels can be identified. The MTA and DTAs form a dense vascular plexus 1.8 cm from the superior temporal line that also anastomoses with the STA.<sup>5</sup> The anterior DTA communicates with small branches of the lacrimal artery, which perforate the zygomatic bone and the greater wing of the sphenoid bone.<sup>5,6</sup> The MMA forms an anastomosis with the DTAs in the temporal bone. The MMA also connects with the STA through the temporal muscle, and the MTA is also connected to the anterior and posterior DTAs.<sup>2,7</sup>

In the muscle, pathological reactions to ischemia can be



FIG. 7. Coronal magnetic resonance image obtained 7 years after craniotomy for resection of trigeminal schwannoma; fat is observed in the tumor bed in the cavernous sinus. Notice the symmetry and the healthy temporal muscle on both sides.

observed within 15 minutes,<sup>3</sup> and 6 to 8 hours of ischemia produces irreversible damage after microvascular occlusion caused by the propagation of thrombus.<sup>4</sup> When the temporal muscle is mobilized, the connection through the bone with the MMA and the anastomosis through the pericranium from the opposite side are compromised. The vascular supply then depends on the DTAs and the STA, which means that these vessels should be preserved. Excessive downward retraction of the temporal muscle that compromises the flow through the temporal arteries yields an ischemic period. Keeping dissection in the subperiosteal plane prevents direct injury of the DTAs. If excessive retraction is necessary to increase the exposure of the lower part of the temporal fossae, an osteotomy of the zygoma reduces the tourniquet effect of the retraction.

#### *Integrity of the Fibers*

Muscle fibers are traumatized by cutting, dissection, and retraction.<sup>11,15</sup> Using the subperiosteal plane in retrograde fashion,<sup>11</sup> from the side of the acute angle of the muscle's attachment to the skull (for example, with an inferior-to-superior incision), the surgeon can easily maintain the integrity of the fibers. Even the strong insertion of the muscle in the superior temporal line can be dissected.

#### *Muscle Tension*

Muscle tension is also critical in maintaining functionality and preventing atrophy from disuse.<sup>10,20</sup> To maintain the contraction of the muscle, its insertions must be preserved. Some authors keep a bundle of muscle to which they reattach it.<sup>15</sup> The injured fibers, however, develop fibrosis and scars and the vascular and nerve supply to the distal part of the flap is compromised, which contributes to the degree of atrophy and asymmetry after surgery.<sup>10,20</sup> The use of screws to reattach the muscle has also been described, but this method costs more and introduces foreign material into the surgical field.<sup>20</sup> Reattaching the muscle directly to the bone is a simple way to keep the tension of the muscle without creating dead tissue or introducing foreign materials.

Preserving the frontotemporal branch of the facial nerve, which is at risk during mobilization of the muscle, is of paramount importance for good cosmetic results. Any of the three branches of this nerve (anterior, middle, or posterior) can be injured during dissection.<sup>19</sup> When the incision is continued to the level of the tragus, usually the posterior branch of the tragus nerve, which innervates the anterior and superior auricular muscles, is transected. This maneuver, however, does not incur any apparent deficit. Subfascial dissection allows us to preserve the anterior and middle branches of the frontotemporal division, which innervate the orbicularis oculi and corrugator (anterior) and frontalis (middle) muscles.<sup>19</sup> These nerves are more related to cosmetic problems.

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