Combined Subgaleal/Myocutaneous Technique for Temporalis Muscle Dissection

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Abstract

Background The frontal branch of the facial nerve (FBN) is the most susceptible neural structure to injury during frontotemporal craniotomies. The balance between adequate temporalis muscle mobilization and frontal branch protection with minimal anatomical alteration is the philosophy behind our approach to temporalis muscle dissection.

Objective To describe a combined subgaleal/myocutaneous technique for dissection and mobilization of the temporalis muscle in anterolateral cranial approaches.

Methods Interdisciplinary literature review of the anatomical course of the FBN was performed. Retrospective analysis of anterolateral craniotomies performed at our institution in which the combined subgaleal/myocutaneous (CSGMC) technique was performed.

Results A total of 71 cases of anterolateral craniotomies (excluding full variant orbitozygomatic) were performed with the successful application of a CSGMC technique (36 pterional, 31 orbitopterional, and 4 fronto-orbital). Partial frontalis weakness was transient in one case.

Conclusion The CSGMC technique provides sufficient protection for the FBN and allows for adequate mobilization for a variety of skull base exposures while minimally violating myofascial anatomy. This is the first reported technique that allows both adequate temporalis muscle mobilization with performance of the one-piece orbito-frontal and orbitopterional approaches, without disruption of the superficial/deep temporalis fascia and fat-pad complex.

Keywords

- temporalis
- interfascial
- subfascial
- frontalis palsy
- facial nerve

Introduction

The pterional craniotomy conceived by Dandy¹ and popularized by Yasargil² has evolved into the anterolateral approaches that comprise at least five subtypes: pterional, frontotemporal, orbitopterional, orbitofrontal, and frontotemporal-orbitozygomatic (FTOZ). Few key steps have been advocated to expand the virtual cone of exposure, among them is the mobilization of the temporalis muscle.^{3–6} Particular attention has been given to the frontal branch of the facial nerve (FBN) (also known as the temporal branch or the

frontotemporal branch of the facial nerve), as it is the most vulnerable neural structure to be injured during exposure with anterolateral craniotomies. The unpleasant cosmetic outcome caused by frontalis muscle palsy provoked craniofacial surgeons to thoroughly study the unique anatomy of the FBN and develop safer dissection techniques to preserve the anatomical and functional integrity of the nerve.

The balance between adequate temporalis muscle mobilization and frontal branch protection serves as the pivotal point in the anterolateral approaches. The greatest protection is obtained by the simple myocutaneous flap³ however, the

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Figure 1 Course of the frontal branch of the facial nerve (FBFN). The deep to superficial course of the FBFN is depicted from the zygoma, where it runs just deep to the parotid temporal fascia (innominate fascia) past the transition point, where it runs within the innominate fascia/temporoparietal fascia complex. This transition point overlays the superficial fat pad and is caudal to the frontozygomatic suture, where the temporalis muscle dissection begins in the combined subgaleal/myocutaneous (CSGMC) technique. Dissection in the plane of the loose connective tissue inferior to the transition has a greater risk for nerve injury.

limited muscle mobilization offered by this technique may be inadequate for deeper skull base exposures. Proposed interfascial and subfascial dissection of the deep temporal fascia has reduced the incidence of frontalis muscle palsy; however, injury to the frontal branch still occurs.^{5,7–10} The anatomical variations in the course of the FBFN above the zygoma both in direction and fascial depth steered the development of other novel approaches.^{5,11} In this article, we propose a combined subgaleal/myocutaneous (CSGMC) technique that preserves the integrity of temporal fascial planes with the ultimate goal of minimizing muscle atrophy. This technique not only provides the protection for the FBFN but also allows for adequate mobilization of the temporalis muscle comparable to the standard fascial dissection techniques.

Materials and Methods

Review of literature was performed to study the complex course of the FBFN. A body of literature in both the English and international literature has been devoted to describing the variable anatomy of the FBFN and the different techniques of dissection of the temporalis muscle and the related superficial tissue, with the ultimate goal of preserving the FBFN.^{5,7} This area of interest is interdisciplinary and expands across neurosurgical, plastics, and otolaryngology literature.

This technique was utilized in pterional, frontotemporal, and FTOZ variant craniotomies that were performed at our institution between 2008 and 2010. Patients with cranial pathology that required the full FTOZ approach were excluded. Patients were assessed in clinical follow-up at 2 weeks, 4 weeks, 6 months, and 1 year. Outcome measures of frontalis/orbicularis palsy were clinically assessed. Cosmetic outcome was clinically assessed during follow-up visits after surgery over a 1-year period. Retrospective analysis of the collected data was performed with concurrent interdisciplinary literature review.

Results

Anatomical Description (→Fig. 1)

Thorough understanding of the course of the FBFN is the key to protecting the frontalis muscle function in anterolateral craniotomies. The general course of the FBFN, as described by Pitanguy and Ramos (Pitanguy line), begins 0.5 cm below the tragus and extends to 1.5 cm above the lateral aspect of eyebrow.¹² The branches of the facial nerve and its rami, which are variable in number, cross at the middle third of the zygomatic arch and may cover up more than half the length of the arch.^{13,14} Different branching patterns have been described; however, there is controversy regarding the fascial depth of the nerve and the inconsistency of nomenclature describing the different fascial layers.¹⁵ The zygoma marks a surface transition point for separation of fascial planes of the face (infrazygomatic) and skull (suprazygomatic). At the level of the zygoma, fascial plains are strongly adherent to each other, thus complicating the interfascial course (depth) of the FBFN. The FBFN takes a deep to superficial course as it travels from its emergence from the parotid gland, over the zygoma toward the supraorbital rim.¹⁵

The most superficial suprazygomatic fascial layer encountered is the temporoparietal fascia (referred to as the *superficial musculoaponeurotic system* [SMAS], caudal to the zygoma)—also known as *superficial temporal fascia*—which is continuous with the galea superiorly and posteriorly. Deep and closely adherent to this layer is the innominate fascia, also known as the parotid temporal fascia. However, some consider the innominate fascia as part of the superficial temporal fascia, under which lays the deep temporal fascia covering the temporalis muscle¹⁶ (→Fig. 2). The deep temporal fascia becomes continuous with the periosteum at the superior temporal line (attachment of the temporalis muscle). As the deep temporal fascia approaches the supraorbital ridge, it divides into a superficial and deep layer separated by a fat

Figure 2 Anatomical representation of facial layers. The temporalis muscle is covered by the deep temporal fascia, which divides into a deep and superficial layer. Sandwiched between the deep and superficial layers of the deep temporal fascia is a fat pad. The superficial temporal fascia is contiguous with the superficial musculoaponeurotic system (SMAS) (infra-zygomatic). Just deep and closely adherent to the superficial temporal fascia is the innominate fascia. The innominate fascia is contiguous with the parotid temporal fascia (infra-zygomatic). The frontal branch of the facial nerve (FBFN) takes a deep to superficial course starting deep to the superficial temporal fascia/innominate fascia complex (at the level of the zygoma) to eventually run within this fascia complex as it proceeds cephalad.

pad. The subperiosteum is found deep to the belly of the temporalis muscle.⁴

At the inferior border of the zygoma, the course of the FBFN is deep to the temporoparietal fascia and the innominate fascia. At this level the FBFN is found just superficial to the periosteum of the arch.¹⁷ As the nerve crosses the arch the

periosteum is replaced by the deep temporal fascia. At the superior edge of the zygomatic arch the FBFN is found in close proximity to the deep temporal fascia.¹⁷ Just after crossing the zygomatic arch the FBFN travels a variable distance (1.5 to 3 cm above the superior edge of the zygoma)¹⁶ before transitioning to run within the innominate fascia¹⁶ (superficial temporal/innominate fascia complex) (►Fig. 1).

Surgical Technique

The skin incision is made in the standard fashion for a pterional craniotomy as described by Yasargil.⁹ The galea and pericranium are reflected in one layer over the frontal bone, and the skin flap is reflected forward over the deep temporal fascia up to where the fat pad appears visible through it. The fat pad is the point beyond which further anterior dissection would result in injury to the FBFN. The focus of the dissection is subsequently switched to the frontal bone around the fat pad; at this point the FBFN has transitioned to course within and be protected by the superficial temporalis fascia (galea) as it proceeds to innervate the frontalis muscle. The skin flap is mobilized anteriorly over the frontal bone until the superior edge of the orbital rim is reached. The supraorbital foramen is identified and serves as a landmark for the medialmost extent of the dissection over the orbital edge. Using Penfield # 1, further dissection is performed in a subperiosteal fashion in a lateral and downward direction over the zygomatic process of the frontal bone down to the frontozygomatic suture (►Fig. 3A). At the rim of the zygomatic process of the frontal bone, the branch of the FBFN going to the orbicularis oculi has already transitioned to course within and be protected by the superficial temporal fascia (galea). If an orbital osteotomy is planned, the peri-orbital membrane will be bluntly dissected from the orbital

Figure 3 The combined subgaleal/myocutaneous technique. The standard pterional skin incision is made (A). The skin and attached superficial temporal fascia/innominate fascia complex is reflected as shown. The reflection is halted at the beginning of the fat pad. The frontal branch of the facial nerve (FBFN) overlays the fat pad within the fascial complex distal to the transition point and deep to the innominate fascia proximally (as shown in ►Fig. 1). Attention is given to the zygomatic process of the frontal bone, where the dissection is taken to the edge of the frontozygomatic suture (B). Incision is made in the temporalis muscle, leaving a muscular cuff. The temporalis muscle is then reflected downward and over the skin/fascial complex protecting the FBFN.

roof and lateral wall by using Penfield #1. Using monopolar electrocoagulation, the temporalis muscle is divided near its insertion at the superior temporal line, leaving a myofascial cuff. The myofascial cuff starts at the frontozygomatic suture and extends posteriorly parallel to the superior temporal line. This cut is then turned and extended inferiorly to run parallel to the vertical limb of the skin incision (►Fig. 3B).

The muscle is elevated from the bone in a caudal-to-rostral fashion using periosteal elevator or Penfield #1 to preserve the subperiosteum and the underlying muscular blood supply. Avoiding electrocoagulation during muscle separation preserves muscular blood supply and minimizes muscle atrophy. Unlike the myocutaneous flap technique in which the muscle is retracted forward with the skin flap, in the CSGMC technique the muscle is freed from the skin/galea complex to the beginning of the fat pad. The muscle is then separated from the frontal process of the zygomatic bone and sphenoid bone (►Fig. 3B). Muscle dissection from the zygomatic bone is performed in a subperiosteal fashion while the frontal branch is protected within the preserved fascial planes and cushioned by the underlying temporalis muscle from the dissecting instrument (►Fig. 3B). The additional dissection over the frontosphenoid suture and the zygomatic process made it possible to place the McCarty burr hole and perform the orbital osteotomy. Additionally, it allows muscle retraction downward and laterally, thus avoiding obstruction of the line of sight by the muscle bulk in an anterolateral approach.

Patients

During the period between 2008 and 2010, the CSGMC technique for temporalis muscle dissection was applied in 71 cases. The surgical approaches were as follows: pterional approach in 36 cases (50.7%), orbitopterional approach in 31 cases (43.7%), and fronto-orbital approach in 4 cases (5.6%). The pathology treated comprised aneurysms, arteriovenous malformations, sphenocavernous meningiomas, and pituitary adenomas.

Cosmetic Outcome

Postoperative clinical evaluation of cosmetic outcome performed during follow-up clinic visits did not reveal any noticeable difference between the operative and the normal side in all patients. This was evident at the subjective and objective levels by the end of the first year after surgery.

Frontalis Palsy

There was no incidence of anatomical damage to the FBFN in the 71 surgeries. One case of transient postoperative partial frontalis palsy (1.4%) was noted in a pterional craniotomy. Progressive improvement was noted at the 2-week follow up. Complete resolution was noted 6 weeks after surgery. The return of function suggests that the etiology of palsy was retraction injury rather than direct transection.

Discussion

A novel CSGMC technique for temporalis muscle dissection preserves the temporal fascial layers and minimally violates

the anatomical integrity of the temporalis muscle. An orbital osteotomy can be performed without the need for temporal fascial mobilization. This technique provided not only protection for the FBFN but allowed for adequate mobilization of the temporalis muscle comparable to the standard fascial dissection techniques.

Microsurgery adopted the philosophy of expanding the virtual cone of exposure in return for minimal manipulation of the delicate neurovascular structures. Without adequate exposure, further brain retraction becomes necessary, thereby increasing the risk of retraction injury. A variety of anterolateral approaches have been described, with particular attention to mobilization of the temporalis muscle that tends to obstruct the surgical trajectory. Classically, surgeons have relied on interfascial and subfascial dissections of the deep temporal fascia for mobilization of the temporalis muscle in anterolateral approaches in general and orbitozygomatic variants in particular. Mobilization of the fascia protects the frontal branch of the fascial nerve and allows muscle retraction downward and away from the anterolateral surgical trajectory. However, violating the fascial planes may be an added factor that contributes to temporalis muscle atrophy in addition to the risk of injuring the FBFN.

Anatomical Considerations

As mentioned in the anatomy section, the exact course of the FBFN and its rami can be variable and/or controversial.^{15,18} Knowledge of the anatomy of the frontotemporal region is imperative to avoid injuring vital neurovascular structures. Aberrant anatomy of the FBFN has been described, including the variable course and depth within the interfascial fat pad.⁵ Many investigators have studied the relationship of the FBFN to the superficial temporal artery (STA) as a landmark to determine a safe zone; however, this is controversial, complicated further by the variability of the level at which the STA bifurcates. In our CSGMC technique, subgaleal dissection (below the plane of the STA and FBFN) is safely performed until the edge of the interfascial fat pad is identified. As illustrated in ►Fig. 1, the FBFN takes a deeper course close to the periosteum of the zygomatic arch (deep to the superficial temporal fascia) and hence makes it more susceptible to injury. Agarwal et al determined a transition zone, as described above, (1.5 to 3 cm above the zygoma and 0.9 to 1.4 cm posterior to the lateral orbital rim), which is anterior to the frontal branch of the STA and over the superficial fat pad. Hence, dissection over the superficial fat pad should be restricted distal to this transition zone and maintained in a plain deep to the superficial temporal fascia as in the CSGMC technique.

Standard Techniques (►Fig. 4)

Traditionally, three different approaches for dissection of the temporalis muscle have been described; these include the myocutaneous,³ subfascial⁷ and interfascial⁹ techniques. Spetzler described a myocutaneous technique for the pterional approach by simply reflecting the skin in combination with the attached fascial layers and the underlying temporalis muscle in one piece.³ It provides quick access to the temporal

Figure 4 Temporalis muscle dissection. Interfascial technique (A): The superficial layer of the deep temporal fascia is dissected to gain access to the superficial fat pad. This layer is then reflected over on the superficial temporal fascia/innominate fascia complex. Subfascial technique (B): the deep temporal fascia is dissected from the belly of the temporalis muscle and reflected as one piece to protect the frontal branch of the facial nerve (FBFN). Combined subgaleal/myocutaneous technique (C): the superficial dissection is stopped at the beginning of the fat pad, then the zygomatic process is exposed to the edge of the frontozygomatic suture, at which point the muscular cuff is initiated. This technique allows for the downward retraction of the temporalis muscle (as shown) while still providing protection of the FBFN.

bone and hence is useful in cases of trauma in addition to better temporalis muscle reconstruction. However, the muscle bulk partially obstructs the surgical trajectory, thus limiting surgical exposure in the orbitozygomatic variants. The interfascial and subfascial techniques have been applied to gain better surgical access to deep-seated neurovascular structures and pathologies in the parasellar region while protecting the FBFN. The interfascial technique, as described by Yasargil,⁹ involves identifying the superficial fat pad, making an incision in the superficial layer of the deep temporal fascia behind the visible fat pad and reflecting it anteriorly with the FBFN to provide protection for the nerve (► Fig. 4A). The temporalis muscle and the remaining fascia is subsequently divided and reflected in a downward and lateral direction. The subfascial technique described by Coscarella et al⁷ involves reflecting the temporalis muscle fascia as one layer to protect FBFN (► Fig. 4B). The muscle is then reflected separately in a downward and lateral direction.

The key feature of both techniques is that they separate the temporalis muscle from the overlying subcutaneous structures, hence allowing the bulky muscle belly to be separately retracted out of the line of sight. Also, they provide access to the lateral orbital wall for full variant FTOZ craniotomy. The interfascial and subfascial techniques have expanded the base of the anterolateral corridor with an acceptable low risk of injuring the FBFN. The extensive dissection of the temporalis muscle, particularly with the interfascial approach, may increase the degree of temporalis muscle atrophy with a negative impact on postoperative cosmesis and pain. However, the subfascial and interfascial techniques are still required for the full FTOZ variant.

The Combined Subgaleal/Myocutaneous Technique

Inspired by the modern minimally invasive movement, we ventured a different way of dissecting and mobilizing the temporalis muscle. The proposed technique is a balanced compromise between the myocutaneous and fascial dissection techniques; it combines a subgaleal dissection with the myocutaneous (“no dissection”) and thus is called the *combined subgaleal/myocutaneous technique*. We do not perform fascial dissection during temporalis muscle mobilization to preserve the anatomical integrity of the muscle and the FBFN. We start the dissection in a subgaleal fashion until the fat pad is reached, then the muscle is mobilized as a myocutaneous flap in a downward and lateral direction. With this technique, the subgaleal dissection at the lateral rim of the orbit to the zygomatic arch is minimized (► Fig. 3A). The temporalis muscle incision is started at the supraorbital rim and behind the root of the zygomatic process of the frontal bone, where the FBFN is most superficial and already within the superficial temporal fascia. Further dissection and mobilization of the temporalis muscle from the zygomatic process and over the frontosphenoid junction is performed in a submuscular fashion, thereby protecting the FBFN. Freeing the temporalis muscle from the overlying galea and underlying bone permits its downward retraction away from the line of sight in anterolateral approaches (► Fig. 3B).

Clinical Applications (► Fig. 5)

Anterolateral approaches include pterional, frontotemporal, and the FTOZ approach with its variants (fronto-orbital, temporal, orbitopterional, and full). The full FTOZ craniotomy requires the exposure and splitting of the body and arch of

Figure 5 Intraoperative stepwise dissection of the temporalis muscle. Curvilinear incision is made and subgaleal dissection is performed to expose deep temporal fascia (superficial temporalis fascia); the dissection is halted when the edge of interfascial fat pad is visualized (a). Penfield #4 showing the frontozygomatic suture (b). The temporalis muscle is incised starting from the frontozygomatic suture and extended posteriorly, leaving a muscular cuff. The muscle incision is then continued inferiorly, in line with the curvilinear flap (c). Subperiosteal dissection is performed with Penfield #1 to expose the frontozygomatic suture (d). The temporalis muscle belly is then retracted inferiorly with hooks giving access to keyhole site at the frontozygomatic suture (e).

zygomatic bone and hence is not attainable via the CSGMC technique. We applied the CSGMC technique in all our anterolateral craniotomies, including orbitozygomatic approaches except the full FTOZ approach. In 71 cases the pathology treated comprised anterior circulation aneurysms and a variety of tumors. There was no limitation of the surgical exposure posed by the temporalis muscle. There was only one incident of transient postoperative partial frontalis palsy, which occurred in a pterional craniotomy and was attributed to retraction injury to the FBFN. The cosmetic and functional outcomes were clinically evaluated during postoperative visits. There was minimal temporalis muscle atrophy on the operative side as compared with the contralateral normal side. However, all patients were highly satisfied with the cosmetic outcome. Frontalis muscle function was intact in all patients at the end of the follow-up period. We consider the CSGMC technique a valuable addition to a surgeon's armamentarium of techniques for anterolateral approaches. It offers maximum protection of the FBFN, adequate trajectory for visualization of a variety of skull base pathologies, and relatively minimal violation of the temporalis muscle anatomy and vascularity. Its application could be safely extended to include the one-piece orbitofrontal and orbitopterional approaches.

Our judgment of the success of the CSGMC technique is not based on prospective evaluation or morphometric studies. However, our clinical series of diverse pathology successfully treated with satisfactory cosmetic and functional outcomes strongly support the usefulness of this technique.

Conclusion

The CSGMC technique is a valid technique that can be added to the current techniques of temporalis muscle dissection. It has the following advantages: it is simple, it offers maximum protection to the FBFN, and it poses minimal violation of the temporalis muscle anatomy and vascularity with positive impact on the degree of postoperative muscle atrophy.

This is a comprehensive report of a technique that allows both adequate temporalis muscle mobilization and performance of the one-piece orbitofrontal and orbitopterional approaches without disruption of the superficial/deep temporalis fascia and fat-pad complex.

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