Safe Zones for Temporal Muscle Hook Retraction: A Technical Note

Matías Baldoncini[1,2], Amparo Saenz[3], Juan F. Villalonga[3,4], Alvaro Campero[3,4], Julio Fernandez[4], Federico Sánchez-Gonzalez[5], Paulo Kadri[6], Kumar Vasudevan[2], Ossama Al-Mefty[2]

■ BACKGROUND: **The temporal muscle (TM) needs to be dissected and reflected downward in some anterolateral cranial approaches, and failing to preserve its integrity could have severe functional and cosmetic consequences. Most articles focus on techniques to prevent vascular injury during retrograde dissection or techniques to preserve the facial nerve; however, information on how to take care of the muscle during hook retraction is limited. We presented an anatomic study of vascularization of the TM, and we established safe areas for muscular hook retraction.**

■ METHODS: **We dissected 16 TMs in 8 cadaveric heads. The TM was reflected downward, and we measured the distance between the anterior branch of the posterior deep temporal artery (PDTA) and the frontozygomatic suture and the distance between the posterior branch of the PDTA and the external auditory meatus projection.**

■ RESULTS: **The average distance between the anterior branch of the PDTA and the frontozygomatic suture was 19.5 mm (range, 14—26 mm). The average distance between the posterior branch of the PDTA and the external auditory canal was 37.1 mm (range, 31—43 mm). We established 2 safe zones for hook placement: an anterior safe zone 14 mm posterior to the frontozygomatic suture and a posterior safe zone 30 mm anterior to the external auditory meatus.**

■ CONCLUSIONS: **We delimited 2 safe zones for hook placement during TM retraction aiming to avoid direct vascular damage in anterolateral cranial approaches.**

INTRODUCTION

The temporal muscle (TM) partially covers the lateral surfaces of the frontal, sphenoid, and squamous portion of the temporal bones, so it needs to be reflected downward in some anterolateral cranial approaches. The mobilization of the TM has often been associated with atrophy caused by direct damage to the muscle's fibers or by indirect injury to the neurovascular supply.[1-4] TM atrophy has severe functional consequences. Patients have presented with limitations during chewing, pain, and malocclusion. It could also have disfiguring cosmetic consequences because of the hollowing of the temporal area.[4]

Most articles focus on techniques to prevent vascular injury during retrograde dissection[2] or techniques to preserve the facial nerve during flap dissection[5-8]; however, information on how to take care of the muscle during hook retraction is limited. We believe it is essential to understand the distribution of the deep TM vascularization because it plays a critical role in sustaining muscle vitality. In this article, we presented an anatomic study of the vascularization of the TM, and we established safe areas for muscular hook retraction in anterolateral cranial approaches to avoid injury of the posterior deep temporal artery.

MATERIALS AND METHODS

Anatomic Study

We dissected 16 TMs in 8 cadaveric heads. We did 10 TM dissections at the Laboratory of Microsurgical Neuroanatomy at the University of Buenos Aires, Argentina, and 6 TM dissections at the Skull Base Laboratory in Brigham and Women's Hospital, Harvard University, Boston, Massachusetts.

Key words
- Anatomical study
- Muscular vascularization
- Surgical technique
- Temporal retraction

Abbreviations and Acronyms
PDTA: Posterior deep temporal artery
TM: Temporal muscle

From the [1]Laboratory of Microsurgical Neuroanatomy, Second Chair of Gross Anatomy, School of Medicine, University of Buenos Aires, Buenos Aires, Argentina; [2]Department of Neurosurgery, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts, USA; [3]LINT, Facultad de Medicina, Universidad Nacional de Tucumán, Tucumán, Argentina; [4]Department of Neurological Surgery, Hospital Padilla, Tucumán, Argentina; [5]Neurosurgical Division, Clinica de Cuyo, Mendoza, Argentina; and [6]Neurosurgery Department, Federal University of Mato Grosso do Sul, Campo Grande, Brazil

To whom correspondence should be addressed: Matías Baldoncini, M.D. [E-mail: drbaldoncinimatias@gmail.com]

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The 8 heads were fixed in a 10% formalin solution, and the arteries and veins were injected with colored red and blue latex, respectively. We carried out the dissection in a stepwise manner, performing a pterional approach initially and then a transzygomatic approach. We mobilized the TM with retrograde dissection and then carefully dissected the deep fascia to expose the deep temporal arteries. We also had to expose the frontozygomatic suture anteriorly and the projection of the external auditory meatus posteriorly to measure the safe zones. The TM was reflected inferiorly simulating a real-life scenario, and we measured the distance between the anterior branch of the posterior deep temporal artery (PDTA) and the frontozygomatic suture and the distance between the posterior branch of the PDTA and the external auditory meatus projection. We calculated the average distances and the range between these 2 points to determine the safe zones for muscle retraction.

All dissections were performed under the microscope using an electronic digital caliper ruler to measure the distances. During each dissection, we took multiple photographs to control the measurements and to illustrate the anatomy of the vessels. We used a Nikon D7200 (Nikon Corporation, Tokyo, Japan) camera with a Micro-NIKKOR 40mm f/2.8 (Nikon Corporation) objective and annular flash. All photographs were taken using a tripod, and the camera was equally configured for all images, using a 20 diaphragm, 100 shutter speed, 250 ISO, and 1/128 annular flash.

RESULTS

After we reflected the TM in the 8 cadaveric specimens, we found the deep arteries colored in red. In the middle of the muscle, we found a common arterial trunk located in the deep temporal fascia (**Figure 1**). This trunk was the PDTA, and it was the primary vascular supply for the TM. In all specimens, the PDTA was a lateral branch of the maxillary artery and had an anterior and posterior division (**Figure 2**). We had also located a smaller, more anterior branch, the anterior deep temporal artery, but it was dismissed from our measurements because of its size and inconsistency in our specimens.

The average distance between the anterior branch of the PDTA and the frontozygomatic suture was 19.5 mm (range, 14—26 mm). The average linear distance between the posterior branch of the PDTA and the external auditory meatus was 37.1 mm (range, 31—43 mm). We therefore established 2 safe zones for hook placement according to the measurements we had made in the laboratory: an anterior safe zone that is 14 mm posterior to the frontozygomatic suture and a posterior safe zone that is 30 mm anterior to the external auditory canal (**Figure 2**). In placing the retractions in these safe zones, none of the cadaveric specimens had compression of the PDTA.

DISCUSSION

The TM needs to be dissected and reflected downward in some anterolateral cranial approaches, and failing to preserve its integrity could have severe consequences. Some patients may experience cosmetic and functional abnormalities secondary to muscle atrophy, such as limitation during chewing, pain, disc displacement, joint sounds, masticatory abnormalities, and facial asymmetry.[4]

Several authors have reported techniques to prevent TM atrophy during pterional,[3,7,9-11] orbitopterional,[12,13] zygomatic,[14-16] and pretemporal[17] approaches. These authors highlighted the importance of doing a correct subperiosteal muscular dissection to avoid injuries to the deep temporal arteries. They also strongly discouraged the use of monopolar cautery, especially against the muscle, and recommended an osteotomy in the zygoma in cases where excessive retraction is needed to expose the temporal fossa. Spetzler and Lee[3] suggested to preserve a small cuff of the muscle attached to the skull to maintain muscle tension and prevent atrophy. Zager et al.[10] proposed microfixation of the TM using microscrews, eliminating the incision across the muscle's fibers. Horimoto et al.[6] described a subfascial temporal dissection, in which the TM was reflected inferoposteriorly without the need of incision of muscle. Most of these

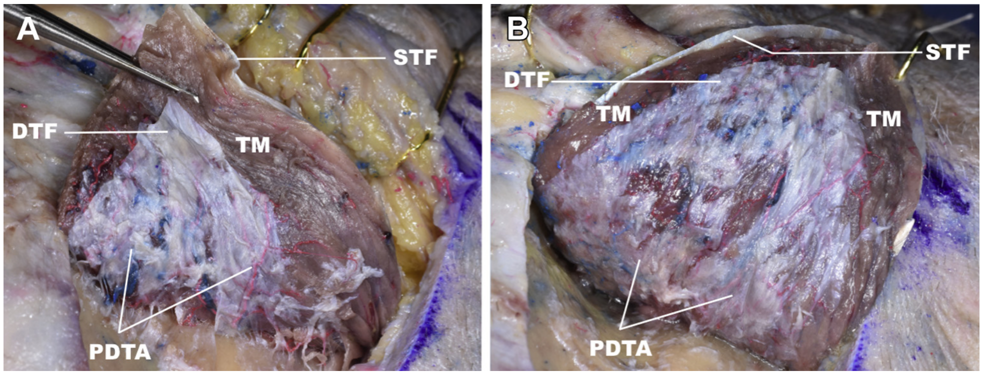

Figure 1. Progressive dissection of a right temporal muscle illustrating the vascular anatomy. (**A**) Lateral view of a right pterional approach with subperiosteal dissection of the temporal muscle to protect the deep temporal fascia. (**B**) Note the relationship between the deep temporal vessels and the fibers of the temporal muscle. DTF, deep temporal fascia; TM, temporal muscle; STF, superficial temporal fascia; PDTA, posterior deep temporal artery.

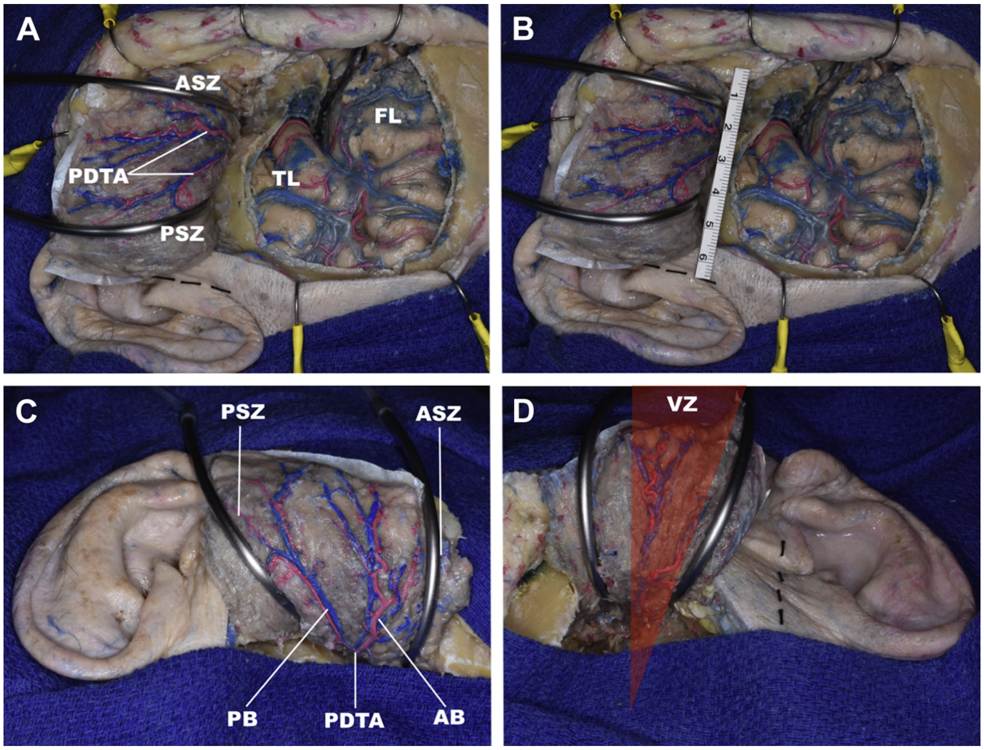

Figure 2. Progressive dissection of a left temporal muscle illustrating the safe zones for hook position. (**A**) Lateral view of a left pterional approach. The muscle has been reflected downward to expose the location of the anterior and posterior branches of the posterior deep temporal artery. (**B**) The 2 safe zones have been exposed, and the hook retractors were placed within the safe margins of 14 mm posterior to the frontozygomatic suture and 30 mm anterior to the external auditory canal projection. (**C**) Progressive dissection reveals the relationship between the anterior and posterior branches of the deep temporal artery and the hook retractors located within the safe zones. (**D**) The vascular zone is demarcated with a red triangle. This zone should be avoided when placing the hook retractors. PDTA, posterior deep temporal artery; ASZ, anterior safe zone; PSZ, posterior safe zone; TL, temporal lobe; FL, frontal lobe; AB, anterior branch; PB, posterior branch; VZ, vascular zone.

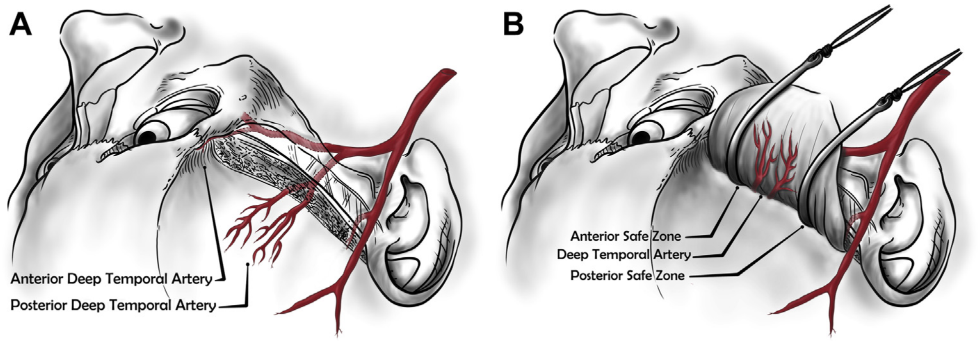

Figure 3. Artist's illustration of the vascular anatomy of the temporal muscle and the safe zones. (**A**) Lateral view of the anatomy of the anterior and posterior deep temporal arteries and their relationship with the temporal muscle. The 2 branches of the posterior deep temporal artery are also depicted. (**B**) Representation of the reflected temporal muscle with the anterior and posterior deep temporal arteries and the hooks placed in the safe zones.

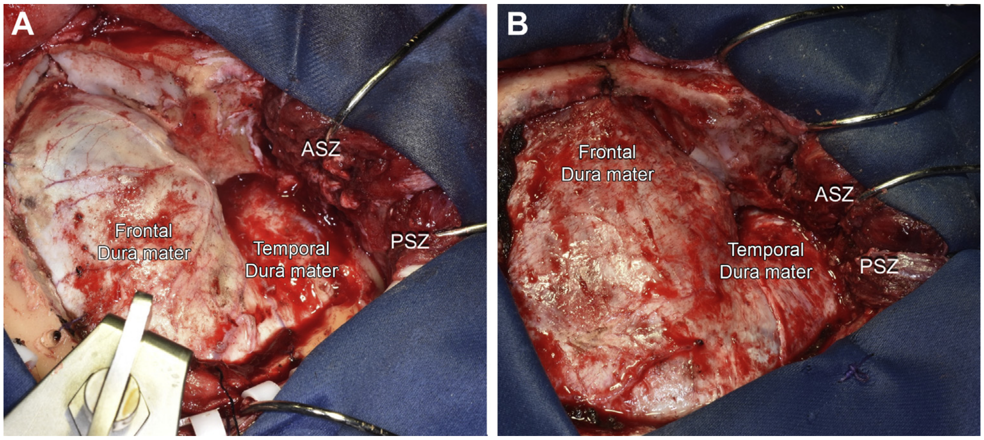

Figure 4. Surgical photographs showing the use of the safe zones in a patient. In both approaches, 2 hooks were sufficient to obtain an adequate exposure of the temporal fossa. (**A**) Pterional approach. (**B**) Pretemporal approach. ASZ, anterior safe zone; PSZ, posterior safe zone.

recommendations focus on avoiding a direct lesion of the deep temporal vessels or preserving the muscle's fibers and the facial nerve.

In this article, we have focused on vascular preservation during hook retraction. Excessive downward retraction of the TM jeopardizes blood flow through the deep temporal arteries causing ischemic damage. Kadri and AlMefty[4] reported pathologic reactions of ischemia in microvascular occlusion after 15 minutes and irreversible ischemic damage after 6–8 hours.[18] During dissection of the TM, we usually disconnect the anastomosis between the middle meningeal artery and the deep temporal artery, leaving the deep temporal artery as the sole blood supply to the TM. If we position the hooks over the anterior or posterior branches of the PDTA during muscle retraction, we could jeopardize the blood supply to the entire muscle.

To define the optimal areas to place the hook retractors, we did an anatomic study of the vascularization of 16 cadaveric TMs. Although an anterior and a posterior deep temporal artery have been described as the primary source of vascular supply,[4] we found a predominant PDTA as the main vessel in the inner surface of the muscle. The anterior deep temporal artery was small and inconsistent in most cadaveric specimens. Once we had reflected the muscle downward, we established 2 safe areas where the hook would not damage the anterior and posterior branches of the PDTA (**Figure 3**). The anterior hook should be placed 14 mm posterior to the frontozygomatic suture, and the posterior hook should be placed 30 mm anterior to the external auditory canal projection. We chose the frontozygomatic suture and the external auditory canal as anatomic landmarks because they are constant in most patients and easy to identify even when the TM is retracted. We used a ruler to measure the distance from the anatomic landmarks, and once the safe zones were identified, it was easy to place the hooks in the desired location (**Figure 4**). In all of the cadaveric specimens where the hooks were placed in these 2 locations, the PDTA branches remained intact. We also recommend the use of large hooks with a round tip and no sharp edges because they allow traction without damage of TM muscle fibers and prevent compression of the muscle over the zygomatic process (**Figure 5**).

We believe it is important to establish these safe zones to preserve the integrity of the TM, as its damage carries cosmetic and functional deficits that could be devastating for the patient. Furthermore, it makes no sense to perform a careful dissection of the deep temporal fascia to protect the muscle's vascularization if afterward we place the hooks over the vessels, causing postoperative edema, ischemia, and subsequent muscle atrophy.

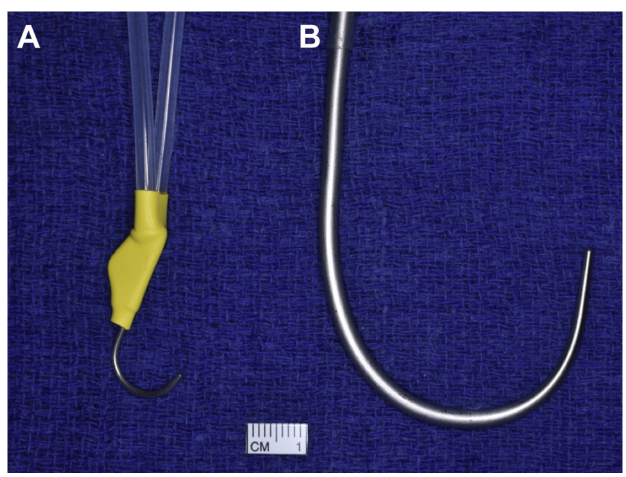

Figure 5. Photographs of 2 different models of hook retractors. (**A**) A small hook recommended for skin retraction. (**B**) A large hook recommended for temporal muscle retraction because the round tip produces less damage to the muscle's fibers.

Our study has its limitations, such as the high variability between the different measurements and a small sample size. However, we believe this work provides the necessary evidence to be a stepping-stone for new studies in patients.

CONCLUSIONS

We have delimited 2 safe zones for hook placement during TM retraction with the aim to avoid direct vascular damage in anterolateral cranial approaches.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Matías Baldoncini: Investigation, Validation, Writing - original draft, Project administration. **Amparo Saenz:** Writing - original draft, Formal analysis, Methodology. **Juan F. Villalonga:** Investigation, Formal analysis. **Alvaro Campero:** Investigation, Writing - review & editing. **Julio Fernandez:** Formal analysis, Software. **Federico Sánchez-Gonzalez:** Writing - review & editing, Conceptualization, Formal analysis. **Paulo Kadri:** Writing - original draft, Validation. **Kumar Vasudevan:** Conceptualization, Writing - original draft, Writing - review & editing. **Ossama Al-Mefty:** Writing - review & editing, Project administration.

REFERENCES

1. Thompson N. Transplantation of skeletal muscle. In: Converse JM, ed. *Reconstructive Plastic Surgery*. Philadelphia, PA: Saunders; 1997:293-300.
2. Oikawa S, Mizuno M, Muraoka S, et al. Retrograde dissection of the temporalis muscle preventing muscle atrophy for pterional craniotomy. Technical note. *J Neurosurg*. 1996;84:297-299.
3. Spetzler RF, Lee KS. Reconstruction of the temporalis muscle for the pterional craniotomy. Technical note. *J Neurosurg*. 1990;73:636-637.
4. Kadri P, AlMefty O. The anatomical basis for surgical preservation of temporal muscle. *J Neurosurg*. 2004;100:517-522.
5. Campero A, Ajler P, Paíz M, Elizalde RL. Microsurgical anatomy of the interfascial vein. Its significance in the interfascial dissection of the pterional approach. *Oper Neurosurg (Hagerstown)*. 2017;13:622-626.
6. Horimoto C, Toba T, Yamaga S, Tsujimura M. Subfascial temporalis dissection preserving the facial nerve in pterional craniotomy—technical note. *Neurol Med Chir (Tokyo)*. 1992;32:36-37.
7. Yasargil MG, Reichmen MV, Kubik S. Preserving the frontotemporal branch of the facial nerve using the interfascial temporalis flap for pterional craniotomy. Technical note. *J Neurosurg*. 1987;67:463-466.
8. Youssef AS, Ahmadian A, Ramos E, Vale F, van Loveren HR. Combined subgaleal/myocutaneous technique for temporalis muscle dissection. *J Neurol Surg B Skull Base*. 2012;73:387-393.
9. Park JH, Lee YS, Suh SJ, Lee JH, Ryu KY, Kang DG. A simple method for reconstruction of the temporalis muscle using contourable strut plate after pterional craniotomy: introduction of the surgical techniques and analysis of its efficacy. *J Cerebrovasc Endovasc Neurosurg*. 2015;17:93-100.
10. Zager EL, Del Vecchio DA, Bartlett SP. Temporal muscle microfixation in pterional craniotomies. Technical note. *J Neurosurg*. 1993;79:946-947.
11. Rodriguez Rubio R, Chae R, Vigo V, et al. Immersive surgical anatomy of the pterional approach. *Cureus*. 2019;11:1-25.
12. Al-Mefty O. Supraorbital-pterional approach to skull base lesions. *Neurosurgery*. 1987;21:474-477.
13. Andaluz N, van Loveren HR, Keller JT, Zuccarello M. The one-piece orbitopterional approach. Technical note. *Skull Base*. 2003;6:241-245.
14. Campero A, Campero AA, Socolosky M, et al. The transzygomatic approach. *J Clin Neurosci*. 2010;17:1428-1433.
15. Al-Mefty O, Anand VK. Zygomatic approach to skull base lesions. *J Neurosurg*. 1990;73:668-673.
16. Spallone A, Rizzo A, Konovalov AN, Giuffre R. Fronto-orbito zygomatic approach: a technical modification. *Skull Base Surg*. 1996;6:125-128.
17. Chaddad-Neto F, Dória-Netto HL, Campos-Filho JM, Reghin-Neto M, Oliveira E. Pretemporal craniotomy. *Arq Neuropsiquiatr*. 2014;72:145-151.
18. Appell HJ, Glöser S, Duarte JA, Zellner A, Soares JM. Skeletal muscle damage during tourniquet-induced ischemia. The initial step towards atrophy after orthopaedic surgery. *Eur J Appl Physiol Occup Physiol*. 1993;67:342-347.

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