The Ultimate Skull Base Maneuver Does Not Involve Removing Bone: Quantifying the Benefits of the Interfascial Dissection

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Abstract

Keywords

- ▶ anterolateral approach
- ▶ pterional
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- ▶ frontotemporal–orbitozygomatic
- ▶ orbitozygomatic
- ▶ skull base

Introduction Several adjunctive osteal skull base maneuvers have been proposed to increase surgical exposure of the anterolateral approach. However, one of the easiest methods does not involve bone: the interfascial temporalis muscle dissection.

Methods Sequential dissections were performed bilaterally on five fixed silicone-injected cadaver heads. The amount of sphenoid drilling, scalp retraction, and brain retraction was standardized in all specimens. For each approach, surgical angles were measured for four deep targets: the tip of the anterior clinoid process, the internal carotid artery terminus, the origin of the posterior communicating artery, and the anterior communicating artery. Five surgical angles were measured for each target.

Results There were increases on the order of 20% in the anteroposterior (AP)-mid, AP-lateral, and mediolateral–anterior angles for all deep targets with interfascial approach versus a myocutaneous flap. An orbitozygomatic osteotomy additionally increased almost all the angles, but incrementally less so.

Conclusion An interfascial dissection increases the surgical exposure to a larger degree than additional osteotomies for several surgically relevant working angles. The addition of an orbitozygomatic osteotomy affords a particular benefit for the suprachiasmatic region. Increased adoption of interfascial mobilization or the temporalis muscle—an easily performed and low-risk maneuver—during anterolateral craniotomies may obviate the need for more involved skull base drilling.

Introduction

The pterional approach is perhaps the most well-known approach in neurosurgery, providing access to the sylvian fissure, as well as numerous deeper structures within the basal cisterns, such as the circle of Willis, the suprasellar space, and the upper reaches of the posterior fossa. Over the

years, numerous maneuvers designed to increase illumination and surgical angles and decrease brain retraction have been described and refined. For example, drilling of the sphenoid wing and removal of the anterior and/or posterior clinoid processes increase the working area. Pellerin et al and Hakuba et al were the first to describe the addition of orbital and zygomatic osteotomies to the pterional approach,

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ushering in an era of “skull base neurosurgery.”^{1,2} Around the same time, Yasargil et al described an interfascial dissection of the temporal muscle during pterional approaches to protect the frontalis branch of the facial nerve.³ This was later applied to the frontotemporal-orbitozygomatic (FTOZ) craniotomy. Numerous morphometric studies then demonstrated that FTOZ significantly increases the working angles in the basal cisterns, compared with the standard pterional craniotomy.^{4–13} To our knowledge, however, no studies have quantified how much of this increased exposure is attributable to the treatment of the scalp and temporalis muscle.

Over the past decade, there has been a trend toward more minimally invasive approaches to skull base surgery in which the surgeon strives to achieve an adequate amount of surgical exposure required for the given pathology without excessive soft tissue and osteal dissection. This strategy results in similar surgical outcomes, with decreased operative blood loss, shorter surgical time, less postoperative pain, earlier hospital discharge, and improved cosmetic outcomes.¹⁴

This study aimed to quantify the increase in surgical exposure provided by an interfascial temporalis dissection with inferior reflection of the temporalis muscle when compared with a standard myocutaneous scalp flap. In addition, we hypothesize that much of the increased exposure provided by an FTOZ comes not from the osteotomies but from this interfascial dissection of the temporalis.

Methods

To compare the pterional approach and its extensions, sequential dissections were performed on each of 10 sides of five lightly fixed, colored silicone-injected cadaveric heads. On each side, a pterional craniotomy with a myocutaneous flap (pterional-myocutaneous) was performed followed by a pterional craniotomy with an interfascial temporalis dissection, with the temporalis muscle reflected inferiorly/posteriorly (pterional-interfascial), and finally a FTOZ (→ Fig. 1). The microsurgical instruments used included a high-speed drill (Midas Rex, Medtronic, Fort Worth, Texas, United States), and an operating microscope (Carl Zeiss, Germany). Heads were secured in a standard antrolateral approach position with a three-pin head holder.

On each side, a frontotemporal incision from the root of the zygoma to the hairline at the midline was made. Initially, a myocutaneous flap was raised to expose the pterion and orbital rim. A standard large frontotemporal craniotomy was performed even with the anterior fossa floor and down to the middle fossa floor. The sphenoid ridge was completely drilled down to the superior orbital fissure. An anterior clinoidectomy was not performed.

The dura was opened 1 cm from the posterior edge of the craniotomy and flapped forward. The exposed sylvian fissure was completely dissected. The supraclinoid internal carotid artery, anterior cerebral artery, anterior communicating artery (AComm), and middle cerebral artery were exposed.

Surgical angles were measured with standardized soft tissue and brain retraction (see next section). Next, to simulate a pterional with an interfascial dissection, an interfascial tempor-

Fig. 1 Photography of a cadaveric dissection: (A) Pterional with myocutaneous flap, (B) pterional with interfascial temporalis flap and (C) frontotemporal orbitozygomatic.

alis dissection was performed on the previous myocutaneous flap and the temporalis was reflected inferiorly and posteriorly. Again, surgical angles were measured. Lastly, to simulate an FTOZ approach, osteotomies of the orbit and zygoma were performed. Surgical angles were then again measured.

Standardization of Soft Tissue and Brain Retraction

During the measurement of surgical angles, the retraction of the scalp, temporalis, and brain were standardized. New Lone Star blunt retractor hooks (Cooper Surgical Incorporated, Trumbull, Connecticut, United States) were used for the scalp and temporalis retraction for each approach measurement. To standardize the tension of retraction, a length of 4 cm was marked prior to application of tension and 10 cm with tension,

Fig. 2 Photograph of a cadaveric dissection: standardization of the scalp, temporalis, and brain retraction.

and then secured. For the scalp flap, four retractor hooks were placed 3 cm apart from each other. For temporalis retraction in the interfascial and FTOZ approaches, one retractor hook was placed at the midpoint of the temporalis and was again stretched from 4 to 10 cm (►Fig. 2). The scalp and temporalis muscle retractor hooks were placed in the exact same locations for each cadaveric side dissected.

The frontal and temporal opercula were each retracted with a single 5/8 inch retractor using the Budde Halo Retractor System (Integra, Plainsboro, New Jersey, United States) (►Fig. 2). Once the retractors were placed for the measurements of the pterional with myocutaneous flap step, it was not moved, changed, or removed until all subsequent measurements on that cadaveric side were complete. To ensure no unintentional changes occurred, the retractor location on the cortical surface, the retractor angle, the retractor depth, and the length of opercular opening were noted and rechecked during the measurements of each subsequent approach.

Morphometric Analysis

On each side, surgical angles were measured for the three different approaches. Measurements were performed on four deep targets: the tip of the anterior clinoid process, the internal carotid artery terminus, the origin of the posterior communicating artery, and the middle of the AComm. For each deep target, five surgical angles were measured (►Fig. 3A). Anteroposterior (AP) angles included a medial, mid, and lateral measurement. Mediolateral (ML) angles included an anterior and mid measurement.

For each measurement, two straight probes were placed at the deep target and the angle was widened until the straight probe met resistance by either soft tissue or bone (►Fig. 3B). The angle was calculated by measuring the depth to an arbitrary set of extracranial point on one probe ($x = 7.5\text{cm}$) and the perpendicular distance from this point to the other probe (y). The angle was determined using the following tangent formula: $\text{angle} = \tan^{-1}(y/x)$.

Statistical Analysis

The surgical angles were compared using repeated measures analysis of variance followed by pairwise comparison with

Fig. 3 Photograph of a cadaveric dissection: (A) The surgical angles measured for the three approaches (white arrows= anteroposterior angles, blue arrows= mediolateral angles); (B) The technique used to measure surgical angles of a deep target using two straight probes.

Holm-Sidak correction with SPSS Statistics v 21 (International Business Machines Corporation, New York, United States). A p -value of less than 0.05 was considered significant.

Results

The median increase in each angle (expressed as percentage) with interfascial temporalis dissection and orbitozygomatic osteotomies for each target is shown in ►Table 1. Performing an interfascial temporalis dissection with reflection of the temporalis muscle inferiorly and posteriorly significantly increased the AP-mid, AP-lateral, and ML-anterior angles for all deep targets, compared with a standard myocutaneous flap for a pterional craniotomy ($p < 0.05$). There was no significant difference in the AP-medial and ML-mid angles.

Further addition of orbitozygomatic osteotomies resulted in only modest additional increases in all of the angles for each deep target ($p < 0.05$), except for the ML-mid angle, which was not increased, and the AP-medial angle, which was dramatically increased with the orbitozygomatic approach. The AP-medial angle corresponds to a subfrontal working corridor, and was increased by an average of 18.7% with the FTOZ approach.

The AP-mid, AP-lateral, and ML-anterior angles were increased to a greater degree with the interfascial dissection

Table 1 Median increase in exposure of myocutaneous flap versus interfascial temporalis dissection per angle

Exposed feature	Angle	MC→IF	IF→FTOZ
Anterior clinoid process	AP-medial	0.0%	10.3%
	AP-mid	6.4%	3.9%
	AP-lateral	14.2%	3.5%
	ML-anterior	9.5%	4.5%
	ML-mid	0.0%	0.0%
Internal carotid artery terminus	AP-medial	0.0%	13.6%
	AP-mid	17.4%	5.3%
	AP-lateral	35.1%	4.7%
	ML-anterior	14.8%	6.0%
	ML-mid	0.0%	0.0%
Posterior communicating artery	AP-medial	0.0%	20.5%
	AP-mid	15.3%	5.9%
	AP-lateral	27.4%	7.4%
	ML-anterior	23.2%	5.7%
	ML-mid	0.0%	0.0%
Anterior communicating artery	AP-medial	0.0%	30.5%
	AP-mid	23.0%	5.7%
	AP-lateral	27.8%	7.5%
	ML-anterior	20.4%	10.3%
	ML-mid	0.0%	0.0%

Abbreviations: AP, anteroposterior; IF→FTOZ, interfascial temporalis dissection with additional frontotemporal orbitozygomatic osteotomy; MC→IF, myocutaneous flap with additional interfascial temporalis dissection; ML, mediolateral.

For each deep target, the median percent increase in each angle with subsequent interfascial temporalis dissection and orbitozygomatic osteotomies.

(15.5, 26.1, and 17.0%, respectively) than with the orbitozygomatic osteotomies (5.2, 5.8, and 6.6%, respectively) for all deep targets. For the posterior communicating artery, these angles were increased by 15.3, 27.4, and 23.2% with the interfascial temporalis dissection, and only further increased by 5.9, 7.4, and 5.7% with the addition of orbitozygomatic osteotomies. For the anterior communicating artery, these angles were increased by 23.0, 27.8, and 20.4% with the interfascial temporalis dissection, and further increased by 5.7, 7.5, and 10.3% with the addition of orbitozygomatic osteotomies. However, the FTOZ did increase the AP-medial angle of exposure to the anterior communicating artery by a significant 30.5%, compared with interfascial dissection alone. This increase in the AP-medial angle was less pronounced for the posterior communicating artery (20.5%).

Discussion

The pterional craniotomy is a workhorse approach for many tumor and vascular pathologies. To increase the surgical angles and decrease the amount of brain retraction, numerous adjuvant maneuvers can be performed, including orbital

and/or zygomatic osteotomies, sphenoid ridge drilling, and anterior or posterior clinoidectomies. Yet, these additional osteal maneuvers can result in increases in blood loss and operative time, more postoperative pain, longer hospital stays, and worse cosmetic outcomes.

Our study demonstrated that the lion's share of the increase in surgical angles provided by an FTOZ approach, especially in the paraclinoid region, is actually due to the inferior and posterior reflection of the temporalis muscle. The addition of this maneuver alone to the standard pterional craniotomy can provide the necessary increases in surgical angles and illumination needed for many pathologies while avoiding the pitfalls of additional osteotomies. It does not completely obviate the benefits of orbitozygomatic osteotomies mainly for the suprachiasmatic area and for larger and deeper pathologies.

Yasargil described the exposure obtained from a pterional approach as a pyramid, whose base is formed by the sphenoid wing, posterolateral orbital roof, and sylvian fissure.¹⁵ The pterional corridor funnels down toward the basal cisterns, which lie at the apex of the exposure. Enlarging the base of the pyramid requires drilling the lateral sphenoid wing and the posterolateral extension of the orbital roof, and splitting the sylvian fissure.¹⁵

Mediolateral Angles

In our study, the ML anterior angle roughly corresponded to the "pterional pyramid's" base. A posterior and inferior retraction of the temporalis muscle through the interfascial dissection further exposed the sphenoid wing, and significantly augmented the anterior view. The orbitozygomatic approach slightly increased this angle from both sphenoidal and—more so—orbital perspectives. The ML-mid angle is rather related to a corridor through the sylvian fissure at the posterior aspect of the pyramid's base. Widening this angle is more dependent on sylvian fissure dissection instead of superficial osteotomies or muscular retractions. This angle thus did not increase after the interfascial or orbitozygomatic steps of our study.

Anteroposterior Angles

The AP-lateral angle showed the most dramatic increase with interfascial dissection for all targets. The inferior and posterior retraction of the temporalis increased the lateral and temporal aspect of the pterional exposure. Similarly, the AP-mid angle was augmented with interfascial (and to a lesser extent with orbitozygomatic) dissection as the temporal and sphenoidal sides of the exposure were enlarged. The pretemporal approach capitalizes on the benefits of the anterolateral angles of attack to reach deeper targets, such as the cavernous sinus and the basilar artery.¹⁶ A key step of this approach is to maximize posterior and inferior temporal muscle retraction to further expose the temporal pole and sphenoid wing, obviating the need for a full orbitozygomatic osteotomy.¹⁷ In our study, exposure to the clinoid process was mostly gained through the anterolateral angles (►Table 1), which corroborates the rationale behind pretemporal transclinoid transcavernous approaches.

The AP-medial angle did not increase with interfascial dissection because retracting the temporalis inferiorly and posteriorly would rather affect the lateral/temporal, more than the fronto-orbital aspects of the pyramid's base. The orbitozygomatic approach added an orbital osteotomy to the exposure, which augmented the subfrontal corridor. This increase in the AP-medial angle is the most notable advantage compared with interfascial dissection, and this advantage was most obvious for the target of the anterior communicating artery. This is in line with the surgical literature that recommends an orbital osteotomy to widen the exposure to anterior communicating artery aneurysms.⁷ The FTOZ approach offers a low angle of attack to targets involving the suprachiasmatic cistern and third ventricle.^{4,8} In our experience, we routinely employ an orbital osteotomy to address pathologies in the regions of the chiasmatic cistern (optic chiasm, pituitary stalk) and lamina terminalis cistern (anterior communicating artery). Examples include proximal anterior cerebral artery (including anterior communicating artery segment) aneurysms, craniopharyngiomas, and tuberculum sellae meningiomas.

When the maximum amount of surgical exposure is absolutely necessary, the orbital and zygomatic osteotomies of the FTOZ approach provided a more modest additional increase in surgical angles. Along with adding an inferior angle to higher targets (anterior communicating artery segment aneurysms, high riding basilar apex aneurysms, lesions involving the third ventricle), the FTOZ approach significantly enlarges the superficial working area, increases surgical freedom, and shortens the distance to deeper regions (interpeduncular fossa).^{7,8} Such additional exposure may be indicated for larger skull base tumors or posterior circulation aneurysms being approached via a transsylvian corridor.

For anterolateral approaches to the skull base, one must tailor the approach to match the given pathology, imaging, and surgical plan. While additional osteal maneuvers provide increased working angles, increased illumination, and decreased brain retraction, they come at a cost. For many pathologies, performing an interfascial temporalis dissection with only inferior and posterior reflection of the muscle provides the additional surgical exposure needed to increase illumination and broaden instrument working angles.

Limitations

Our study was performed on fixed cadaveric specimens that do not replicate the physiological conditions of surgery in vivo (e.g., brain consistency, cerebrospinal fluid release, and effects of anesthesia). Also, only five surgical angles of attack were studied for four anatomical targets. Although such selection was made for standardization, it does not necessarily reflect a complete three-dimensional evaluation of the approaches in question.

Conclusion

When performing a pterional craniotomy, an interfascial temporalis muscle dissection—as opposed to elevation of a

myocutaneous flap, even without additional osteotomies—provides a significant increase in surgical angles and should be considered when additional exposure is needed. Further osteotomies should be tailored to the location of the targeted pathology.

Conflict of Interest

No financial or material support was accepted as part of this study. None of the authors have any financial relationships to disclose.

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