Technical Note

Transzygomatic approach plus mini-peeling of middle fossa for devascularization of sphenoid wing meningiomas. Technical note

Alvaro Campero[1,2], Juan F. Villalonga[2], Ramiro Lopez Elizalde[3], Pablo Ajler[4], Carolina Martins[5]

[1]Department of Neurosurgery, Hospital Padilla, Tucuman, [2]Universidad Nacional de Tucuman, Argentina, [3]Department of Neurosurgery, Hospital Civil de Guadalajara, Mexico, [4]Department of Neurosurgery, Hospital Italiano de Buenos Aires, Argentina, [5]Department of Neurosurgery, Hospital Metropolitano Oesta Pelópidas Silveira, Recife, Brasil

E-mail: Alvaro Campero - alvarocampero@yahoo.com.ar; Juan F. Villalonga - jfvillalonga@hotmail.com; Ramiro Lopez Elizalde - ramirolopezelizalde@hotmail.com; *Pablo Ajler - pablo.ajler@hospitalitaliano.org.ar; Carolina Martins - cmrecife@hotmail.com
*Corresponding author

ABSTRACT

Background: Sphenoid wing meningiomas account for 20% of supratentorial meningiomas. The main supply of these tumors is provided by branches of the middle and accessory meningeal arteries. Surgical resection of meningiomas requires early tumor devascularization. Our objective is to present the role of transzygomatic approach plus mini-peeling of the anterior third of the middle fossa in the extradural identification and coagulation of branches of middle and accessory meningeal arteries involved in tumor supply.

Methods: Ten formalin-fixed, silicone-injected cadaveric heads were used. On each side a transzygomatic approach plus mini-peeling of the anterior third of the middle fossa was performed. Between 2005 and 2017, the authors applied this technique for the resection of sphenoid wing meningiomas in 28 patients.

Results: The mean age of patients was 54 years. Thirteen tumors could be classified as medial-third type, 6 as middle-third type, and 4 tumors were lateral-third type. Five tumors represented combined types. Of these, 3 tumors involved the medial and middle-third of the sphenoid wing and 2 involved the entire wing. Surgical resection was classified as Simpson I/II in 24 patients (86%). There were no permanent deficits or postoperative mortality.

Conclusions: The transzygomatic approach combined with mini-peeling of the anterior third of the middle fossa is effective in allowing early devascularization of sphenoid wing meningiomas. These maneuvers are particularly important during resection of large tumors.

Key Words: Meningiomas, middle fossa, sphenoid wing, transzygomatic approach

INTRODUCTION

Sphenoid wing meningiomas (SWM) comprise 20% of supratentorial meningiomas.[29] These tumors are classified according to the segment of attachment to the sphenoid wing as lateral (pterional), middle, or medial (clinoidal) types.[20] Main arterial supply of SWM arise from middle and accessory meningeal arteries.[18]

One of the most important steps in surgical removal of a meningioma is its early devascularization.[13] This study describes the use of the transzygomatic approach combined with a mini-peeling of the anterior third of the middle fossa as ways to identify and control, during an early extradural stage, the arterial branches of the middle and accessory meningeal arteries supplying these tumors. Such maneuvers provide early devascularization and safer resection, particularly of large tumors.

MATERIALS AND METHODS

Ten formalin-fixed, silicone-injected cadaveric heads were used. On each side, a transzygomatic approach[6] plus mini-peeling of the anterior third of the middle fossa was performed with extradural exposure of the anterior branch of the middle meningeal and the accessory meningeal arteries.

Between 2005 and 2017, the authors applied this technique for the resection of SWM in 28 patients with SWM. No *en plaque* tumors were included in this group. Age, gender, SWM classification, preoperative symptoms, resection grade according to Simpson classification, and postoperative complications were recorded.

RESULTS

Anatomical considerations
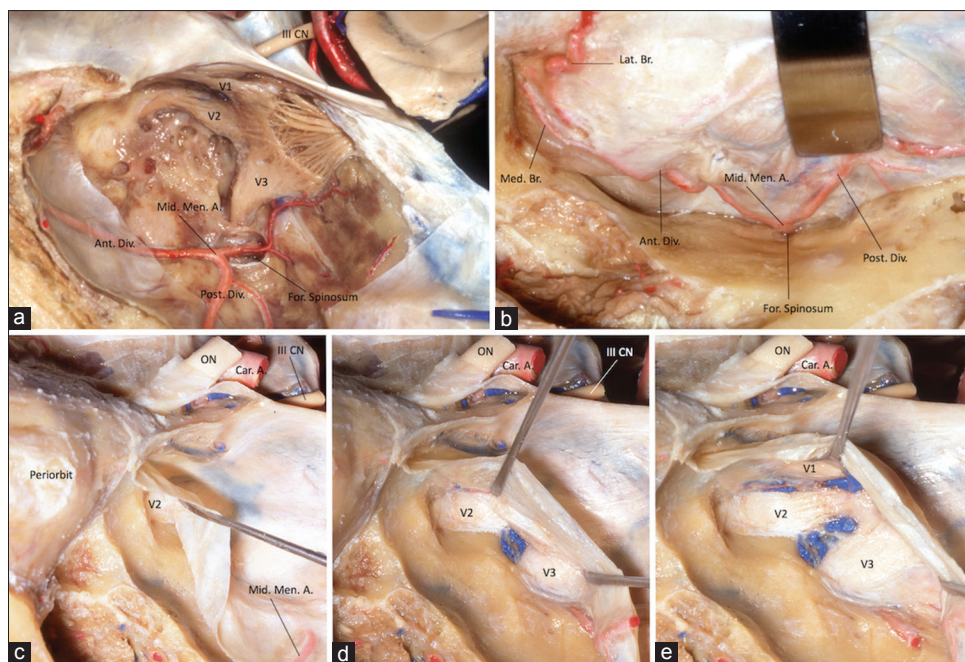*Meningeal arteries*
The maxillary artery, through its middle and accessory meningeal arteries, provides almost all the supply to the dura over the convexity and important contributions to the supply of the basal dura.[18] The middle meningeal artery normally arises from the first segment of the maxillary artery and enters the skull through the foramen spinosum [Figure 1a]. Once inside the skull, the main stem courses laterally, grooving the greater sphenoid wing, where it divides in its anterior and posterior divisions. The anterior division, for its turn, divides into lateral and medial branches [Figure 1b].

The accessory meningeal artery, also called the lesser or small meningeal artery, may arise from the maxillary or middle meningeal arteries. In 78% of the cases, the accessory meningeal artery enters the cranium through the foramen ovale. In the remaining 22% of the cases, it passes through the emissary sphenoid foramen (foramen of Vesalius). The intracranial territory of the accessory meningeal artery includes the gasserian ganglion and the adjacent middle fossa dura. The caliber of the accessory meningeal artery is approximately 1/3 to 1/2 of the middle meningeal artery.[18] Both arteries supply the dural attachment site for SWM and are, thus, the main supply for these tumors.

Middle fossa
The middle fossa of the skull extends from the posterior border of the lesser sphenoid wing and chiasmatic sulcus anteriorly to the petrous ridge of the temporal bone and dorsum sellae of the sphenoid body posteriorly.[24] To perform the mini-peeling of the middle fossa it is important to recognize the landmarks located along its endocranial surface. The endocranial surface of the middle fossa can be divided into medial and lateral parts. The medial portion of the middle fossa is the sella, whereas the most lateral portions are the temporal fossae. Between these two areas, on each side, are the parasellar regions, housing the cavernous sinuses. The medial part is formed by the sphenoid body, which presents the tuberculum sellae, hypophyseal fossa, middle and posterior clinoid processes, carotid sulcus, and dorsum sellae. The lateral part, on each side, is formed by the lesser and greater sphenoid wings, having the superior orbital fissure between them.[25] Posteriorly the lateral part of each middle fossa is completed by the squamous and petrous parts of the temporal bones. The middle fossa presents a set of foramina through which neural and vascular structures pass in and out the skull. The foramen rotundum, separated from the superior orbital fissure by the maxillary strut, is transversed by the maxillary division (V2) of the trigeminal nerve. Foramen ovale is the largest of these openings, and transmits the third division (V3) of the maxillary nerve and, most of the times, the accessory meningeal artery. Lateral to this opening is the foramen spinosum for the middle meningeal artery and a dural neural twig.[18] There may be an opening medial to foramen ovale (foramen of Vesalius) which transmits a vein connecting the pterygoid venous plexus and cavernous sinus. On occasions, it can also transmit the accessory meningeal artery.[24] The posterior trigeminal root reaches the middle fossa leaving an impression on the upper surface of the petrous bone where Meckel's cave and the semilunar ganglion sit.[24] The relationship between the floor of the middle fossa and the zygomatic arch should be known in detail as it provides the anatomical basis for choosing the transzygomatic approach. The root of the zygomatic arch is located on average +5 mm (above) the floor of the middle fossa (range: +17 mm to −4.65 mm). The midpoint of the zygomatic arch is on average +2 mm (above) the floor of the middle fossa (range: +15 mm to −9 mm). When retracting the temporal muscle over the zygomatic arch, the floor of the middle fossa is located on average −24 mm

Figure 1: Middle fossa anatomy. (a and b) Meningeal arteries in the middle fossa. (c) Duramater of the middle fossa. (d and e) lateral wall of the cavernous sinus. III CN, III cranial nerve; ON: optic nerve; Car. A, carotid artery; V1: ophthalmic nerve of Willis; V2: upper maxillary nerve; V3: lower maxillary nerve; For. Spinosum, foramen spinosum; Mid. Men. A., middle meningeal artery; Ant. Div., anterior division; Post. Div., posterior division; Med. Br., medial branch; Lat. Br., lateral branch

from the muscular inner surface.[11] Therefore, freeing the zygomatic arch prior to temporal muscle reflection provides for an approach which is flush with the middle fossa floor, preventing undue temporal lobe retraction.[6]

Cavernous sinus

The cavernous sinuses are paired structures located alongside the sella, hypophysis, and sphenoid sinus. Each cavernous sinus extends from the superior orbital fissure anteriorly to the dorsum sellae posteriorly. The cavernous sinus inferior limit approximates a line passing along the upper margin of V2. Each cavernous sinus has four dural walls – lateral, medial, superior, and posterior.[32] The lateral wall has two layers (a) an external, thicker, gray-colored layer and (b) an inner, semi-transparent, shiny layer which envelopes the cranial nerves III, IV, and V1.[5] There is a loose adhesion between these layers which are easily separated.[30] Peeling the layers of the middle fossa allows visualization of the structures located along the lateral wall of the cavernous sinus, through its inner layer, without actually opening into this compartment.[12] Understanding the anatomy of the cavernous sinus is key to performing the mini-peeling of the middle fossa [Figure 1c-e].

Surgical considerations

Head positioning and incision planning

The patient lies in a supine position, head turned 30° to the contralateral side of the approach. Head is extended and lateralized, away from the shoulder. The skin incision starts at the lower margin of the zygomatic arch, 5 mm

anterior to tragus and extends, behind the hair line, to the contralateral midpupillary line [Figure 2a].

Skin incision and soft tissue dissection

Skin incision is performed using number 24 surgical blade. If needed, the preauricular segment of the skin incision may safely extend inferior to the lower margin of the zygomatic arch up to, on average, 26 mm.[8] The closer the surgeon stays from the tragus, the safer it is to extend the incision caudally up to the distance presented above [Figure 2b].

The soft skin incision starts with a subgaleal dissection, which exposes the temporalis muscle up to its anterior one-fourth where fatty tissue can be seeing through the fascial layers covering the muscle. At this level, a number 11 blade is used to deepen the incision through the external layer of the superficial temporal fascia, which is elevated with interfascial fat to protect the frontal branch of the facial nerve. In this space, one finds the small interfascial vein, perpendicular to the fascial incision, indicating that the adequate stratum has been followed. The interfascial vein should be coagulated and cut.[4] The orbital rim and the zygomatic arch are thus exposed [Figure 2c].

Zygomatic arch osteotomies

Two vertically-oriented bone cuts are performed across the zygomatic arch. The first posterior most cut is located immediately anterior to the zygomatic tubercle. The second anterior most cut is located at the zygomatic angle, where the zygomatic arch meets the frontal process of the zygomatic bone [Figure 2d]. The zygomatic arch is
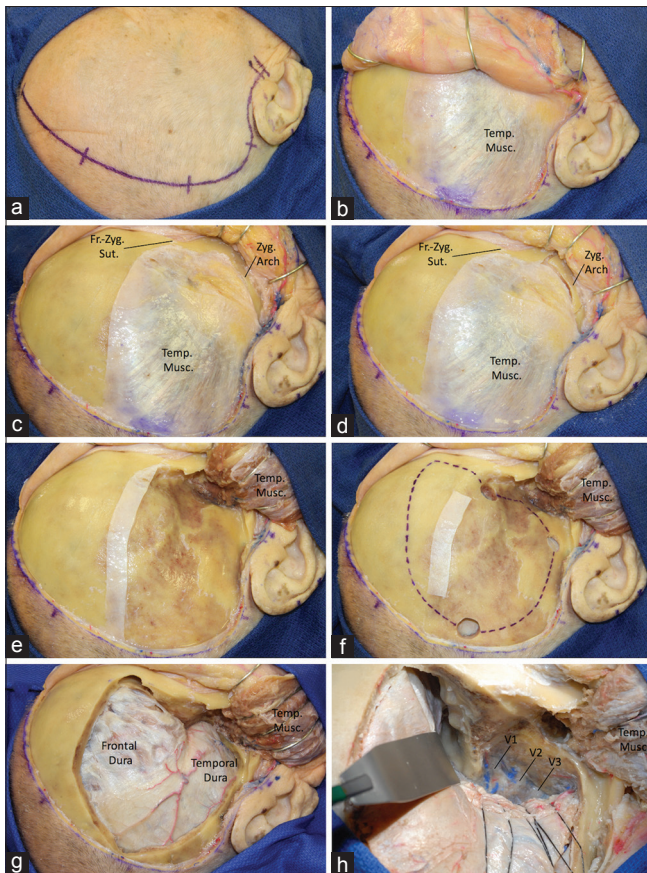
Figure 2: Middle fossa mini-peeling in a laboratory dissection. (a-h) Cadaveric dissection simulating a transzygomatic approach. Temp. Musc., temporal muscle; Fr.-Zyg. Sut., Fronto-Zygomatic suture; Zyg. Arch.: Zygomatic arch; V1: Oftalmic nerve of Willis; V2: Upper maxillary nerve; V3: Lower maxillary nerve

cut but not detached. Held by its masseteric connections it is inverted and reflected caudally with the temporalis muscle.[6] Mini plates can be used to reattach the zygomatic arch at the end of the procedure.

Temporalis muscle: Detachment and retraction
The temporal muscle is retrograde-dissected to prevent postop atrophy.[22] A small muscular cuff may be left along the superior temporal line to allow muscular reinsertion at the end of the procedure. Once free of the lateral exocranial surface of the temporal fossa, the temporalis muscle is reflected caudally through the gap provided by the zygomatic arch osteotomies. With these maneuvers the floor of the middle fossa can be exposed [Figure 2e].

Craniotomy
A fronto-temporo-sphenoidal craniotomy is performed [Figure 2f]. Thorough drilling of the greater sphenoid wing and the squamous portion of the temporal bone are accomplished to achieve complete exposure of the dura enveloping the temporal lobe and to remove all bony obstacles preventing exposure of the middle fossa floor [Figure 2g].

Mini-peeling of the anterior third of middle fossa
A number 11 blade is used to perform the initial incision at the level of the lateral most end of the superior orbital fissure. This cut is no more than a release incision that allows reaching the cleavage plane between the dural layers in this area and might be repeated at the level of foramen rotundum. Once the cleavage plane between the lateral and medial layers is found, blunt separation of the two dural layers along the middle fossa starts. This "peeling" is undertaken from anterior to posterior using a dissector. During this stage, coagulation of the dural arteries coursing along the lateral layer and comprising the anterior branch of the middle and accessory meningeal arteries is undertaken, devascularizing the tumor from its meningeal supply. The mini-peeling is carried up to the level of foramen spinosum and V3 at foramen ovale [Figure 2h].

Dural incision and tumor resection
The dural incision follows frontal and temporal extensions, allowing direct access to the tumor and complete resection. Tumor debulking becomes simpler as its vascular supply has been dealt with the mini-peeling.

Closure
Bony flap removed is replaced following dural closure. The temporal muscle is securely reattached to the superior temporal line. The zygomatic arch is restored to its anatomical location and fixed.

Patients treated

Twenty-eight patients with SWM were treated during this period. Seventeen were women. Age of the patients at surgery was on average 54 years (range: 28–82 years).

Clinical symptoms included headache (12 patients), visual deficit (5), seizures (3), intracranial hypertension (3), aphasia (1), frontal syndrome (1), hemiparesis (1), oculomotor palsy (1), and abducens palsy (1 patient).

Thirteen tumors were classified as medial-third type, 6 as middle-third type, and 4 tumors were lateral-third type. Five tumors represented combined types. Of these, 3 tumors involved the medial and middle-thirds of the sphenoid wing and 2 involved the entire wing.

Resection was classified as Simpson grade I in 12 patients, II in 12, III in 3, and grade IV in 1 patient. Surgical resection was classified as Simpson I/II in 24 patients (86%). No patient required red cell transfusion. Postoperative complications included transitory aphasia (1), transitory oculomotor nerve palsy (1), transitory abducens nerve palsy (1), CSF fistula that required transitory lumbar drainage (1), and wound dehiscence (1 patient). No permanent pain or masticatory disfunction were registered. There were no deaths related to treatment. We include a case example in Figure 3a-l.
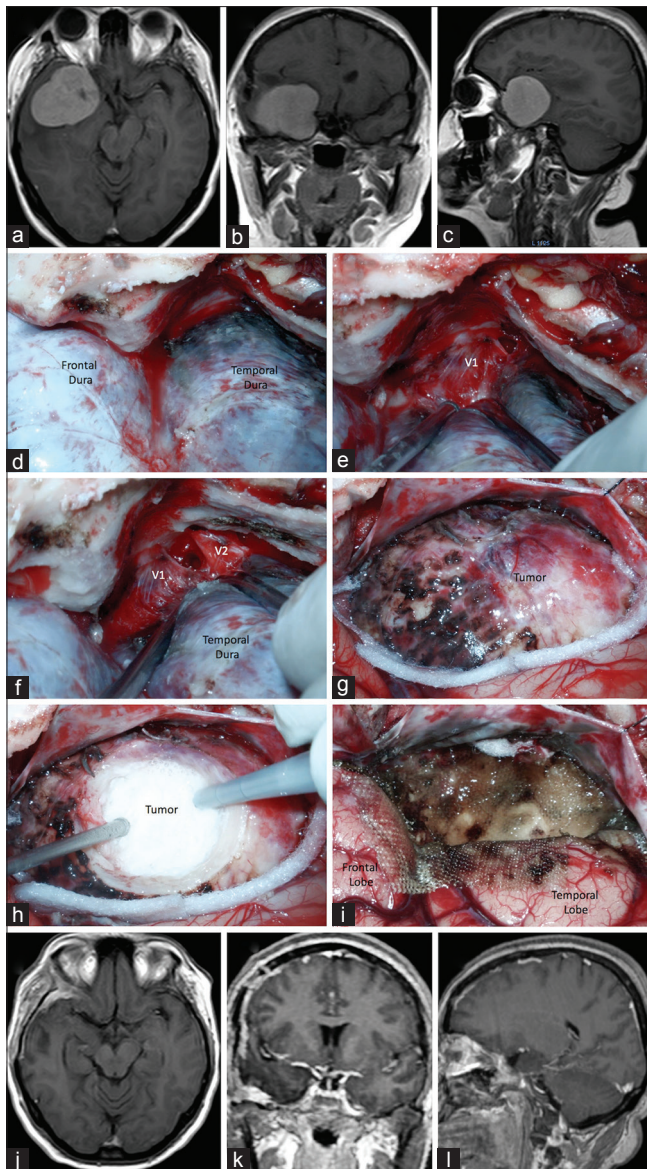
Figure 3: Mini-peeling of the middle fossa in real surgery. (a-c) Preoperative MRI gadolinium sequence. (d-g) Extradural time; (h-i) intradural time. V1: Ophthalmic nerve of Willis; V2: Upper maxillary nerve. (j-l) postoperative MRI gadolinium sequence

DISCUSSION

The traditional approach to SWM has been pterional.[28,31] A problem during cytoreduction using pterional approach – particularly with large tumors – is excessive bleeding. Excessive bleeding hinders surgery and translates into risks for patients.[15] Recently, reports have been made using the orbito-zygomatic approach plus peeling of the middle fossa, and through a combination of extradural and intradural techniques, devascularization and SWM resection are accomplished.[1,14,19] Although such concepts are not yet neurosurgical common sense, it constitutes our view that these latter skull base techniques are fundamental to surgically resect most of SWM.

Although they require anatomical expertise and present technical features to master, as a group, such approaches provide clear advantages over more traditional choices.[7] In this scenario, our experience has proved that, when adequate exposure of the middle fossa floor is needed, it depends solely on reflecting the temporalis muscle further caudally, to which end, planned osteotomies of the zygomatic arch without its complete detachment are the safest, most important, means to accomplish.

In dealing with meningiomas, an essential maneuver, prior to dural opening, is maximal devascularization of the lesion. This can be accomplished by microsurgical coagulation or preoperative embolization of meningeal branches.[26]

Preoperative embolization can be an attractive adjunct to resection. However, it must be total to decrease operative blood loss; and an aggressive embolization can generate permanent postprocedural neurological deficits.[3,21,27]

Agreement exists that, whenever possible, this should be accomplished single-time, during surgery, avoiding complications.[9,16]

This paper provides the description of a straightforward surgical option to deal with SWM, namely the transzygomatic approach plus mini-peeling of the middle fossa. This choice of approach provides for a simpler bony work, which can be accomplished by neurosurgeons working in all kinds of neurosurgical scenarios without straining the technological arsenal available. It also offers the possibility of early tumor devascularization, which enables safer and expedient resection. To adequately perform the transzygomatic approach plus mini-peeling of the middle fossa two maneuvers are key – (a) the zygomatic osteotomy,[6,10] offering the possibility to work flush with the middle fossa floor and (b) partial (mini) peeling of the anterior third of the middle fossa, allowing for anatomical devascularization of the tumor. As a whole, these maneuvers provide for (1) a intradural surgical field which is free of major bleeding, (2) enhanced surgical effectiveness by cutting short dealing with multiple bleeding spots, (3) shorter time of intradural resection and possibly, by allowing improved visualization, and (4) lesser risk of postoperative morbidity.

Other potential advantages of this approach, not directly evaluated in this study might involve the findings of Ouyang et al.,[23] which demonstrated that no blood transfusion during treatment of SWM can be associated with enhanced quality of life in the postoperative period. Our results are comparable to other neurosurgical series.[2,17,20,23,28,29]

We recommend the transzygomatic approach plus mini-peeling of the middle fossa to become a part of the surgical armamentarium of neurosurgeons dealing with SWM.

CONCLUSIONS

The transzygomatic approach plus mini-peeling of the middle fossa are two surgical maneuvers that allow for effective devascularization and dealing with SWM. They are particularly important when large tumors are considered.

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Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Attia M, Umansky F, Paldor I, Dotan S, Shoshan Y, Spektor S. Giant anterior clinoidal meningiomas: Surgical technique and outcomes. J Neurosurg 2012;117:654-65.
2. Behari S, Giri PJ, Shukla D, Jain VK, Banerji D. Surgical strategies for giant medial sphenoid wing meningiomas: A new scoring system for predicting extent of resection. Acta Neurochir 2008;150:865-9.
3. Bendszus M, Rao G, Burger R, Schaller C, Scheinemann K, Warmuth-Metz M, *et al*. Is there a benefit of preoperative meningioma embolization? Neurosurgery 2000;47:1306-12.
4. 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 2017;13:622-6.
5. Campero A, Campero AA, Martins C, Yasuda A, Rhoton AL. Surgical anatomy of the dural walls of the cavernous sinus. J Clin Neurosci 2010;17:746-50.
6. Campero A, Campero AA, Socolovsky M, Martins C, Yasuda A, Basso A, *et al*. The transzygomatic approach. J Clin Neurosci 2010;17:1428-33.
7. Campero A, Martins C, Socolovsky M, Torino R, Yasuda A, Domitrovic L, *et al*. Three-piece orbitozygomatic approach. Oper Neurosurg 2010;66:ons-E119.
8. Campero A, Socolovsky M, Martins C, Yasuda A, Torino R, Rhoton AL. Facial-zygomatic triangle: A relationship between the extracranial portion of facial nerve and the zygomatic arch. Acta Neurochir 2008;150:273-8.
9. Carli DF, Sluzewski M, Beute GN, Van Rooij WJ. Complications of particle embolization of meningiomas: Frequency, risk factors, and outcome. Am J Neuroradiol 2010;31:152-4.
10. Cheng CM, Chang CF, Ma HI, Chiang YH, McMenomey SO, Delashaw JB. Modified orbitozygomatic craniotomy for large medial sphenoid wing meningiomas. J Clin Neurosci 2009;16:1157-60.
11. Dayoub H, Schueler WB, Shakir H, Kimmell KT, Sincoff, EH. The relationship between the zygomatic arch and the floor of the middle cranial fossa: A radiographic study. Neurosurgery 2010;66:363-9.
12. Dolenc VV. Transcranial epidural approach to pituitary tumors extending beyond the sella. Neurosurgery 1997;41:542-52.
13. González Darder JM, Quilis Quesada V, Botella Macia L. Abordaje pterional transcigomático. Parte 2: Experiencia quirúrgica en la patología de base de cráneo. Neurocirugía 2012;23:96-103.
14. Hakuba A, Liu SS, Shuro N. The orbitozygomatic infratemporal approach: A new surgical technique. Surg Neurol 1986;26:271-6.
15. Hsu SY, Ou CY, Ho YN, Huang YH. Application of surgical Apgar Score in intracranial meningioma surgery. PloS one 2017;12:e0174328.
16. Kallmes DF, Evans AJ, Kaptain GJ, Mathis JM, Jensen ME, Jane JA, *et al*. Hemorrhagic complications in embolization of a meningioma: Case report and review of the literature. Neuroradiology 1997;39:877-80.
17. Langevin CJ, Hanasono MM, Riina HA, Stieg PE, Spinelli HM. Lateral transzygomatic approach to sphenoid wing meningiomas. Oper Neurosurg 2010;67:377-84.
18. Martins C, Yasuda A, Campero A, Ulm AJ, Tanriover N, Rhoton Jr A. Microsurgical anatomy of the dural arteries. Operative Neurosurgery 2005;56:211-7.
19. McDermott MW, Durity FA, Rootman J, Woodhurst WB. Combined frontotemporal-orbitozygomatic approach for tumors of the sphenoid wing and orbit. Neurosurgery 1990;26:107-16.
20. Nakamura M, Roser F, Jacobs C, Vorkapic P, Samii M. Medial sphenoid wing meningiomas: Clinical outcome and recurrence rate. Neurosurgery 2006;58:626-39.
21. Nam Y, Shah A, Couldwell WT, Yashar M, Kalani S, Park MS. Preoperative embolization of skull base meningiomas: Current indications, techniques, and pearls for complication avoidance. Neurosurg Focus 2018;44:E5.
22. Oikawa S, Mizuno M, Muraoka S, Kobayashi S. Retrograde dissection of the temporalis muscle preventing muscle atrophy for pterional craniotomy. J Neurosurg 1996;84:297-99.
23. Ouyang T, Zhang N, Wang L, Jiao J, Wang Y, Zhao Y, *et al*. Sphenoid wing meningiomas: Surgical strategies and evaluation of prognostic factors influencing clinical outcomes. J Cytol Histol 2014;5:1.
24. Rhoton AL. The anterior and middle cranial base. Neurosurgery 2002;51:273-302.
25. Rhoton AL. The middle cranial base and cavernous sinus. In: Dolenc, VV, Rogers L, Eds. Cavernous Sinus. Vienna: Springer; 2009. p. 3-26.
26. Richter HP, Schachenmayr W. Preoperative embolization of intracranial meningiomas. Neurosurgery 1983;13:261-8.
27. Rosen CL, Ammerman JM, Sekhar LN, Bank WO. Outcome analysis of preoperative embolization in cranial base surgery. Acta Neurochir (Wien) 2002;144:1157-64.
28. Russell SM, Benjamin V. Medial sphenoid ridge meningiomas: Classification, microsurgical anatomy, operative nuances and long-term surgical outcome in 35 consecutive patients. Oper Neurosurg 2008;62:38-50.
29. Sughrue ME, Rutkowski MJ, Chen CJ, Shangari G, Kane AJ, Parsa AT, *et al*. Modern surgical outcomes following surgery for sphenoid wing meningiomas. J Neurosurg 2013;119:86-93.
30. Umansky F, Nathan H. The lateral wall of the cavernous sinus: With special reference to the nerves related to it. J Neurosurg 1982;56:228-34.
31. Wen HT, de Oliveira E, Tedeschi H, Andrade FC, Rhoton AL. The pterional approach: Surgical anatomy, operative technique and rationale. Operative Techniques in Neurosurgery 2001;4:60-72.
32. Yasuda A, Campero A, Martins C, Rhoton Jr AL, de Oliveira E, Ribas GC. Microsurgical anatomy and approaches to the cavernous sinus. Oper Neurosurg 2005;56:4-27.