Transmastoid Retrosigmoid Approach to the Cerebellopontine Angle: Surgical Technique

Mohammad Abolfotoh, MD, PhD*‡

Ian F. Dunn, MD*

Ossama Al-Mefty, MD*

*Neurosurgery Department, Brigham and Women's Hospital, Harvard Medical School, Boston Massachusetts; ‡Neurosurgery Department, Ain Shams University, Cairo, Egypt

Correspondence:
Mohamad Abolfotoh, MD,
Department of Neurosurgery,
15 Francis Street,
Boston MA, 02115.
E-mail: mabolfotoh@partners.org, m.abolfotoh@med.asu.edu.eg

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BACKGROUND: The traditional suboccipital craniotomy in the retrosigmoid approach gives limited exposure to the cerebellopontine angle (CPA) structures and necessitates cerebellar retraction, whereas the addition of drilling of the mastoid process with reflection of venous sinuses offers wider exposure of the CPA and avoids cerebellar retraction. We describe the details of the surgical technique and provide radiological measurements substantiating the advantages of this approach.

OBJECTIVE: To validate the usefulness of partial mastoidectomy in the retrosigmoid approach and to evaluate the complications of this maneuver.

METHODS: Radiological CPA measurements on computed tomography bone window films were made on the last consecutive 20 patients who underwent CPA surgery via the transmastoid retrosigmoid approach. We measured the distance and angle of work by this approach and compared the measurements with those using the traditional retrosigmoid approach if that would have been used in each case. We also reviewed 432 patients from the records of the senior author to evaluate possible complications of this approach.

RESULTS: The mean working distance for the transmastoid approach was 23.06 mm, whereas the working distance in the traditional approach was 46.44 mm. The mean increase in the angle of work after drilling of the mastoid was 25.39 degrees, and the simple average of increased distance in lateral exposure was 26.66 mm.

CONCLUSION: The transmastoid retrosigmoid approach increases the exposure and gives better access to the CPA targets. This approach alleviates cerebellar retraction, facilitates surgery in the supine position, promotes the use of the endoscope, and is associated with negligible complications.

KEY WORDS: Cerebellopontine angle, Endoscopic assisted, Retrosigmoid, Transmastoid

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Microsurgery of the cerebellopontine angle (CPA) demands meticulous dissection of its neurovascular structures with minimal retraction of the cerebellum. To avoid morbidity and to improve the trajectory and maneuverability of dissection, several modified or extended forms of the retrosigmoid approach have been used and described in the past,[1-7] including different mastoidectomy techniques that increase exposure of the CPA structures. The transmastoid retrosigmoid approach is one such modification that has been used by the senior author (O.A.) for many years.[1-3] This approach is designed to shorten the distance of work (between the margin of the craniotomy and the deep CPA targets) and improve the angle of work by mastoidectomy that totally skeletonizes the dural sinus and allows its reflection. The mastoid cortex is preserved for better cosmetic appearance.

ABBREVIATIONS: CPA, cerebellopontine angle; **IAM,** internal auditory meatus; **LSS,** lateral edge of sigmoid sulcus; **OM,** occipitomastoid; **P-IAM,** posterior wall of the internal auditory meatus

The use of the endoscope to explore the surgical field has gained a fair degree of acceptance as an adjunct to the retrosigmoid approach to CPA surgery over the past 2 decades.[8-12] The endoscope allows superior visualization of the CPA structures and extends vision to the anterior brainstem and across the midline.[13] The technique described here facilitates the use of the endoscope in CPA surgery by providing an additional lateral space for its introduction and maneuvering and also allows the surgeon to dissect easily under the endoscope.

We provide radioanatomic measurements that substantiate the benefits of this modification and describe the nuances of the transmastoid retrosigmoid approach.

MATERIAL AND METHODS

We analyzed the radiological CPA measurements from pre- and postoperative computed tomography (CT) studies done on 20 consecutive patients operated on by the senior author (O.A.) at Brigham and Women's Hospital, Harvard Medical School. Using the Centricity software (GE Healthcare, Barrington, Illinois), the distances and angles of work were measured between selected anatomic points on the bone window CT scan to compare this approach with a traditional suboccipital craniotomy. We also reviewed the records of 432 patients with a variety of lesions on whom the senior author performed CPA surgery using this approach from 1990 to 2007 to evaluate its possible complications.

Operative Technique

Patient Positioning

The patient is placed in the supine position. The trunk is moved toward the operative side to bring the head close to the edge of the table, both to shorten the distance to the microscope and reduce the surgeon's need to extend her or his arms. The ipsilateral shoulder is slightly elevated by a shoulder roll to avoid stretching the neck veins. The trunk of the table is elevated approximately 20 degrees above horizontal to keep the head higher than the heart, facilitating venous drainage. The head is then fixed to the Mayfield 3-pin head fixator and rotated to the contralateral side approximately 40 degrees; extreme head rotation should be avoided. The head is kept in mild flexion, maintaining at least a 2-finger width between the chin and sternum (Figure 1A). Anatomic points are chosen for a neuronavigation system. Sideways tilting of the surgical table can be done during surgery to improve the line of visualization and working angle whenever necessary. The table should be tilted only while multipadded straps secure the patient.

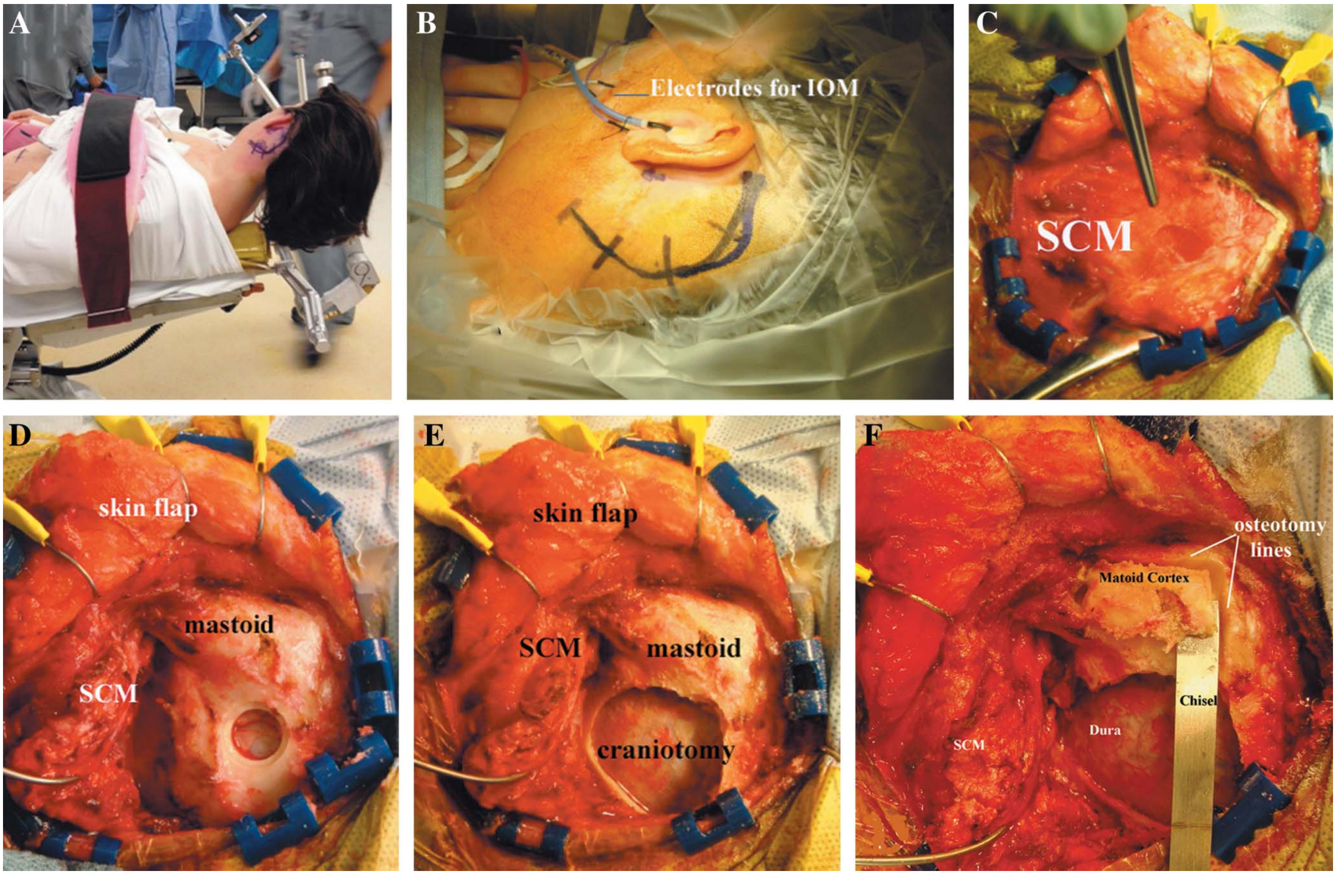

FIGURE 1. *Intraoperative pictures for surgical position and incision of left transmastoid approach.* **A**, *supine position. Patient is secured for rotation of the table. Head is rotated and fixed. Abdomen is prepared for fat harvest.* **B**, *mark for the skin incision, the electrodes were placed for fifth and eighth cranial nerve monitoring.* **C**, *skin flap reflected anteriorly. The SCM muscle was separated from the facial lines, and subperiosteal separation was started.* **D**, *the burr hole is just medial and inferior to the asterion. The mastoid process is exposed after the SCM muscle is reflected down.* **E**, *single suboccipital craniotomy was done from the burr hole.* **F**, *osteotomy was done through the cortex with drill; then the chisel is separating the undersurface of it. IOM, intraoperative monitoring; SCM, sternocleidomastoid muscle.*

Anesthesia Considerations and Intraoperative Monitoring

Neuroanesthesia is carried out without muscle relaxant for proper intraoperative neuromonitoring. Neurophysiological monitoring is routinely used, and somatosensory evoked potentials (SSEPs) and brainstem auditory evoked responses are evaluated throughout. We also monitor the relevant cranial nerves; the exact location of the lesion within the CPA determines which cranial nerve is to be monitored. However, if a large tumor occupies the whole CPA, intraoperative monitoring from the fourth through the lower cranial nerves must be maintained to preserve their anatomic integrity and physiological function (Figure 1B).

Usually there is no need to insert a lumbar drain in this kind of surgery, as opening the lateral part of the cisterna magna drains cerebrospinal fluid (CSF), and there is also no need for the use of brain-dehydrating substances such as mannitol or furosemide in this technique.

Soft Tissue

Skin Incision

An arc-shaped (wide-open C) curvilinear incision starts from the level of the upper part of the ear pinna and descends downward 2 fingerbreadths medially and behind the mastoid tip (Figure 1B) and may be extended to the upper neck skin crease 2 fingers below the mastoid tip. The skin incision is taken down to the musculofascial layer and is retracted anterolaterally over the ear pinna (Figures 1C through 1F).

Muscle Layer

The sternocleidomastoid muscle is detached from its mastoid attachment by cutting the fascial line at the base of the mastoid process. This fascial line connects the posterior temporal fascia and the upper end of the fascia, investing the sternocleidomastoid muscle (Figure 1C). The muscle is then retracted medially and inferiorly to expose the mastoid process, and the remaining suboccipital muscles are dissected in subperiosteal fashion and retracted inferiorly in 1 bloc; this subperiosteal dissection avoids injury of the occipital artery and greater occipital nerve (Figures 1D through 1F). At this point, surgeons must pay close attention to avoid injury to the vertebral artery, which may have an aberrant loop or abnormal course in the suboccipital region. The occipital artery and nerve should be kept intact while dissecting the suboccipital muscles.

Bone Work

Suboccipital Craniotomy

A single burr hole is made below the transverse-sigmoid junction just medial and inferior to the asterion (Figure 1D); the transverse sinus is almost always at the level of an imaginary line extending posteriorly from the zygomatic arch. A single bone flap is made with the craniotome through this burr hole (Figure 1E). Neuronavigation is helpful in confirming the exact position of the transverse-sigmoid junction. In most cases of vestibular schwannoma or upper CPA meningiomas, there is no need to open the foramen magnum.

Partial Mastoidectomy and Skeletonization of the Sinuses

After the suboccipital craniotomy flap is removed, the lateral edge of the mastoid is exposed. Then a mastoid cortex flap is fashioned for reconstruction. This flap is outlined superiorly at the asterion level by an imaginary line in posterior continuity with the zygomatic arch, anteriorly by a vertical line a few millimeters behind the external auditory meatus, and posteriorly in the mastoid tip superficial to the digastric groove. Osteotomy of the mastoid cortex along these lines is done using an oscillating saw or B1 drill, and the undersurface is detached with a chisel (Figure 1F). The honeycomb mastoid air cells are then drilled to allow exposure of the full width of the sigmoid sinus to a couple of millimeters in the presigmoid area to allow free reflection of the sinus anteriorly and to avoid obstruction of the view by overhanging sinus against the edge of the mastoid. The whole length of the sigmoid sinus has to be skeletonized from the transverse-sigmoid junction, down to the beginning of the jugular bulb (Figure 2A). The source of bleeding while drilling the mastoid is the mastoid emissary vein, which can easily be blocked with a hemostatic agent. Drilling the upper edge of the suboccipital craniotomy skeletonizes the transverse sinus.

Dural Opening and Reflection of the Sinuses

The dura is opened along the length of the exposed transverse and sigmoid sinuses, leaving a narrow cuff for a tight dural closure. In this small dural cuff, small relaxing incisions are made toward the sigmoid-transverse junction and the jugular bulb to allow sinus reflection (Figure 2B). The dural flap should be kept in place, covering and protecting the cerebellar surface. The sigmoid sinus is then reflected anteriorly and held by slinging sutures to the skin flap (Figure 2C). The transverse sinus can be reflected upward in the same way when exposure of upper areas in the CPA is needed. After opening of the dura, CSF release by opening the cisterna magna is performed to relax the cerebellum away from the exposed posterior surface of petrous bone. After the cerebellum is relaxed, it can easily be displaced down and medially by gravity.

Introducing the Endoscope

In any microscopic dissection, particularly near the end of the procedure, one can use the endoscope to explore the microscopic blind spots in the surgical field (Figure 2E). The endoscope is introduced from the lateral corridor created by removal of the mastoid.

Putting the endoscope far laterally in the field allows better visualization of the ipsilateral and contralateral brainstem sides by the 0-degree endoscope. The use of 30- and 45-degree endoscopes also provides a panoramic view of the brainstem. The additional lateral space and the trajectory allow an assistant to hold the endoscope, enabling the surgeon to dissect using both hands (Figure 3D).

Closure

If the internal auditory meatus (IAM) dura is opened as in excision of vestibular schwannoma, the meatus is plugged with fat (Figure 2C), and if the dura over the petrous bone is resected as in some cases of meningiomas, a facial graft is applied over the bone surface. The dura is then closed tightly after returning the sinuses to normal position. If necessary, a piece of pericranium is used for a graft. Any opened mastoid air cells must be drilled, their mucosa removed, and a fat graft from the abdomen used to obliterate the cavity before the mastoid cortex is reaffixed with titanium mini-plates and screws. The craniotomy flap is replaced with microplates next to the mastoid cortex. The remaining defects are filled and molded with hydroxyapatite bone substitute to ensure smooth contours of the mastoid and posterior fossa and to avoid protrusion of sharp screw heads under the skin. The sternomastoid muscle is reattached in the lower part of the posterior temporal fascia, and the skin is closed in 2 layers.

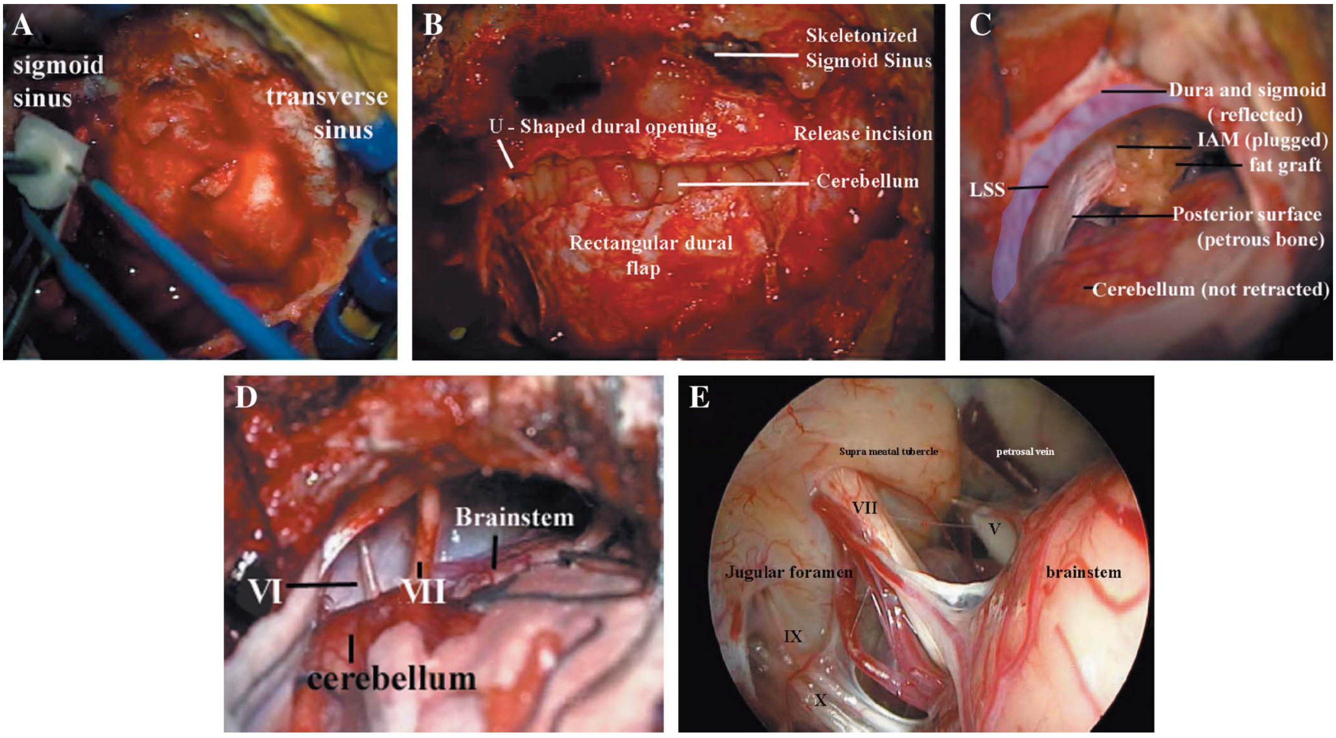

FIGURE 2. *Microscopic photographs (**A-D**) and endoscopic photograph (**E**) of the dural and intradural exposure of left transmastoid approach. **A**, full skeletonization of the sigmoid and transverse sinuses. **B**, opening of the dura shows the release incision at the angles of the dural incision. **C**, the sigmoid sinus was reflected anteriorly and its dural cuff was hitched to the skin flap. The cerebellum is displaced down and medially with gravity (no retractors). Note: the sigmoid sinus was artistically enhanced. **D**, microscopic exposure for the transmastoid approach. The ipsilateral brainstem is well exposed. The cerebellum is covered without retraction. **E**, endoscopic view for 0-degree endoscope showing view of all compartments of the cerebellopontine angle. The endoscope is used to explore the microscopic blind spots. LSS, lateral edge of sigmoid sulcus; IAM, internal auditory meatus; V, VI, VII, IX, X, cranial nerves shown in the figure.*

Measurements

The asterion and the occipitomastoid (OM) sutures are considered the lateral limits of the traditional retrosigmoid craniotomy. Although the lateral limit after the transmastoid modification is the lateral point of the sigmoid sulcus (LSS), the posterior wall of the IAM (P-IAM) is considered a central target point. To measure and compare distances of work between the 2 approaches, 3 distance lines are identified between these landmarks: line A from the LSS to P-IAM, line B from the OM to P-IAM, and line C from the OM to LSS. Line A represents the distance of work in the transmastoid approach, line B represents the distance of work in the traditional retrosigmoid approach, and line C represents the lateral distance gained after removal of the mastoid (Figure 4A). To measure and compare angles of work between the 2 approaches, 3 angles were also identified between bony landmarks where the point of all angles considered the P-IAM. Angle 1 is the angle between the medial edge of the traditional craniotomy and LSS, angle 2 is the angle between the medial edge of the traditional craniotomy and OM, and angle 3 is the angle between OM and LSS. Whereas angle 1 represents the surgical envelope for the transmastoid approach, angle 2 represents the surgical envelope for the traditional retrosigmoid approach, and angle 3 is the lateral angle added by removal of the mastoid (Figure 4B).

RESULTS

The mean distance of work in the transmastoid retrosigmoid approach (line A) is 23.06 mm but ranges from 18 to 27.21 mm, whereas the mean distance of work in the traditional retrosigmoid (line B) equals 46.44 mm and ranges from 37.38 to 54.72 mm, and the mean lateral distance gained after removal of the mastoid (line C) equals 26.66 mm, ranging from 19.86 to 36.21 mm. The mean angle of work with the transmastoid approach (angle 1) is 64.21 degrees, ranging from 51.3 to 86.4 degrees, whereas the mean angle of work in the traditional retrosigmoid approach (angle 2) is 38.82 degrees, ranging from 27.3 to 66.9 degrees, and the lateral angle of work gained after removal of the mastoid (angle 3) is 25.39 degrees, ranging from 16.4 to 36.3 degrees.

After comparing distances and angles of work between both approaches, it is obvious that the distance of work in the transmastoid approach (line A) is much shorter than in the traditional retrosigmoid approach (line B) because line B is more than double the length of line A, whereas the angle of work

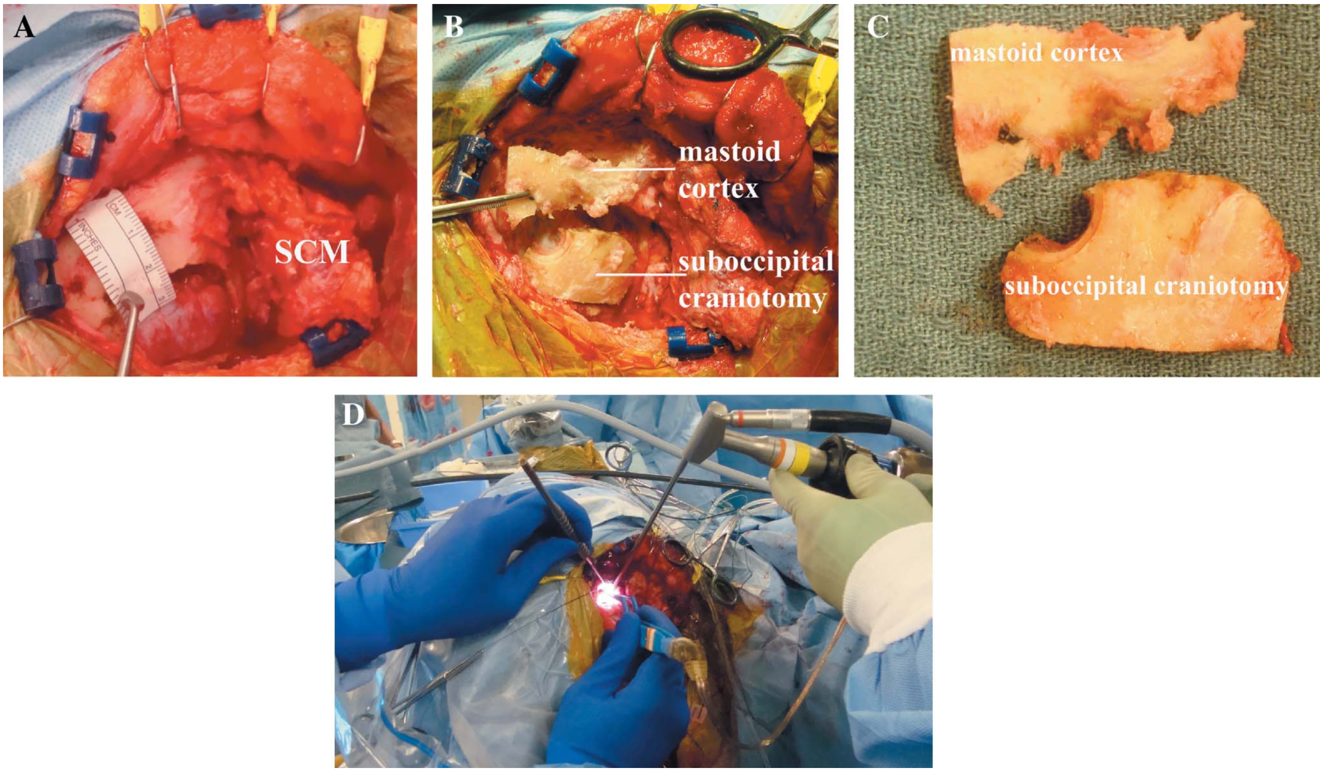

FIGURE 3. *Intraoperative photographs show some benefits of removing the mastoid via a right transmastoid retrosigmoid approach.* **A**, *removal of the mastoid adds an approximately 2-cm corridor anteriorly to the approach instead of retracting the cerebellum backward.* **B**, *2-piece craniotomy flaps of the approach, begins with the suboccipital craniotomy, which is left in place only for demonstration.* **C**, *the mastoid cortex is preserved for reconstruction along with the suboccipital craniotomy.* **D**, *the endoscope is introduced far laterally in the surgical corridor at the site of drilled mastoid, the surgeon is dissecting freely under the endoscopic view.*

in the transmastoid approach (angle 1) is much more than the angle of work in the traditional retrosigmoid approach (angle 2).

Reviewing the complications for 432 patients treated using this approach revealed that 29 patients had a CSF leak: 8 required repair, 3 had suspected aseptic meningitis after the CSF leak, 12 had temporary suboccipital headache, and 3 had postoperative radiological sinus thrombosis (asymptomatic).

DISCUSSION

Skin and Muscle Flap

During reflection of the skin flap, care should be taken to avoid injury to the lesser occipital and greater auricular nerves, which curve around the posterior border and ascend on the sternocleidomastoid muscle to supply the skin behind the ear.[2,14,15] Preserving these sensory nerves might help alleviate postoperative occipital headache, neuralgia, and dysesthesia.[2,14,15] The greater auricular nerve may become an important nerve graft conduit if a cranial nerve is injured.[2]

Benefits of Mastoidectomy in the Retrosigmoid Approach

Although partial mastoidectomy is not routinely performed by most neurosurgeons when performing microsurgery on the CPA via the retrosigmoid approach, removal of the mastoid is in line with the principle of cranial base surgery that exposure should be increased by removal of bone rather than retraction of the neural tissues. It has several advantages, including avoiding retraction on the cerebellum, giving space for sinus reflection, shortening the distance to the porus acousticus and tumors, increasing the angle of work, improving surgical maneuverability, increasing the exposure to the brainstem (Figure 2D), and allowing room for better and freer maneuverability of the endoscope.

The medial aspect of the mastoid process is grooved with the sigmoid sinus. Inferiorly, the sigmoid sinus curves medially and forward, crossing the occipital bone to enter the jugular foramen.[16,17] Some authors have described limited drilling of the mastoid and skeletonization of sinuses in the retrosigmoid approach.[4-7] However, to get the full advantage of this maneuver requires a greater degree of partial mastoidectomy to reflect the

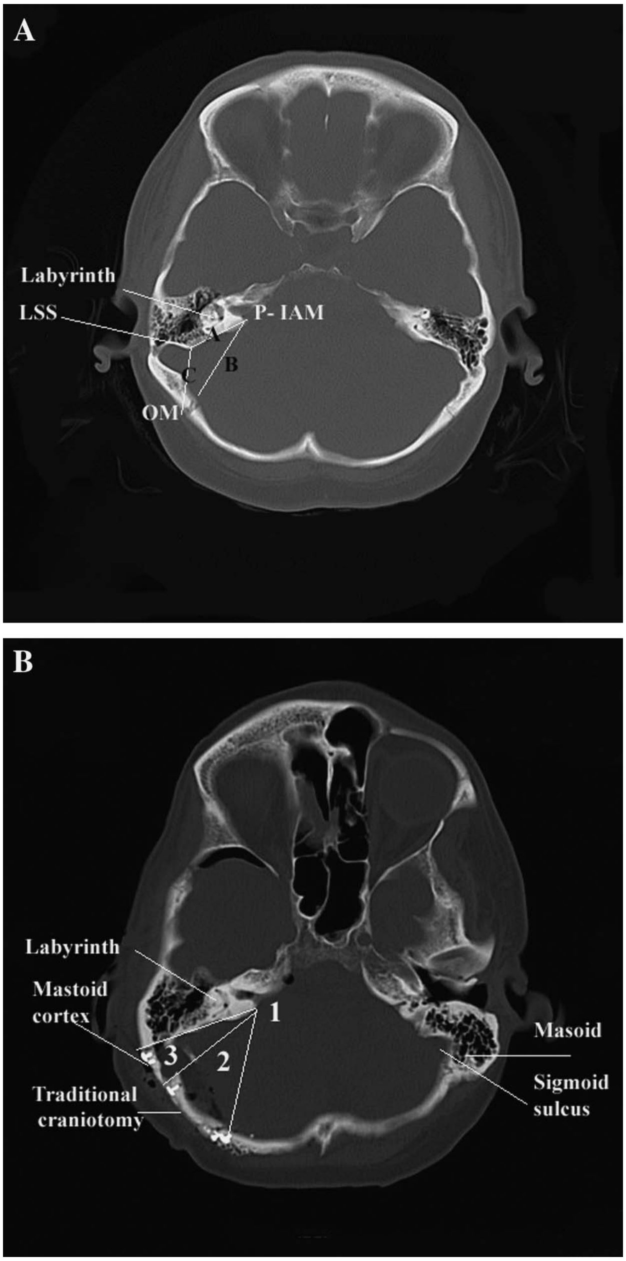

FIGURE 4. *Computed tomography bone window shows the radiological measurements of the angle and distance of work in the right retrosigmoid approach. **A**, preoperative study shows comparison between the distance of work in the transmastoid approach (line A) and the traditional retrosigmoid approach (line B), whereas (line C) is the lateral distance gained after removal of the mastoid process. **B**, postoperative study shows comparison of the angles of work for the transmastoid and traditional craniotomies (angle 1); the total angle of work of the transmastoid approach (angle 2); the angle of work for the traditional craniotomy only (angle 3); the angle of work gained after removal of the mastoid. LSS, lateral edge of the sigmoid sulcus; OM, occipitomastoid suture; P-IAM, posterior wall of the internal auditory meatus.*

whole width of the sigmoid sinus anteriorly out of field and avoid the obstruction from overhanging sinus over the medial edge of the remaining mastoid (Figures 2A and 2C).

In the past, cerebellar retraction was a necessary and frequent step when performing microsurgery on the CPA via the retrosigmoid approach. However, many complications were reported due to this retraction, including postoperative posterior fossa edema, cerebellar contusions, injury of the stretched cranial nerves, and ischemic injuries of the cerebellum and perhaps even the brainstem.[18,19] It is likely that avoiding retraction of the cerebellum decreases the risk of these surgical morbidities, improves the functional status of the patient, and helps prevent postoperative transient ataxia and headache.[4,18,19] The addition of a lateral angle by removal of the mastoid along with displacement of the cerebellum by gravity away from the surgical corridor eliminates the need for any cerebellar retraction and avoids postoperative complications (Figures 2C and 2D).

Varieties of positioning for the retrosigmoid approach have been described, including supine, prone, lateral decubitus, park bench, and sitting position.[20,21] However, the supine position remains the simplest, easiest, and safest for CPA approaches,[20,22] as many complications are still associated with all other positions.[23-25] The traditional suboccipital craniotomy can be performed with the patient in the supine position, but additional retraction of the cerebellum from lateral to medial will be required. Such retraction is injurious to cranial nerves, especially the cochlear and facial nerves[1-3,16,26] in the sitting position, and the retraction might be less, as gentle lifting of the cerebellum upward and medially is required; however, the sitting position has well-known difficulties and complications.[24,27,28] Removal of the mastoid makes CPA surgery with the patient in the supine position more effective and avoids the complications of other surgical positions.

Endoscopic-assisted Transmastoid Retrosigmoid Approach

Endoscope-assisted CPA surgery has many advantages; it has been reported in vascular decompression surgeries, and in tumor surgeries, it may increase the extent of resection.[8-12] The endoscope allows the surgeon to explore microscopic "blind spots" around the fifth or seventh nerves, the opening of Meckel's cave, the porus acousticus, the inferior cerebellum, the jugular foramen, and the ventral aspect and contralateral side of the brainstem.[13] Introducing the endoscope in the transmastoid approach from this far lateral trajectory improves the angle of visualization and gives a panoramic view of the anterior and contralateral brainstem. Removal of the mastoid allows the assistant surgeon to introduce, hold, and direct the endoscope without hindering the movement of the main surgeon, who can dissect using 2 hands.

Precautions and Limitations

A CSF leak can be encountered in intradural approaches plus mastoidectomy.[5] In 432 cases performed by the senior author, there were 29 CSF leaks, 8 of which were re-explored and repaired. However, a CSF leak is easily avoidable by tight closure of the dura and proper sealing of any opened mastoid air cells, which can be improved by removal of mucosa and drilling of small cavities within the mastoid, then packing the drilled mastoid cavity with an autologous free fat graft. Fat is effective in decreasing the incidence of CSF leak and infection and is a very safe material.[29] Complications are very rare; fat necrosis, lipid meningitis, or fatty exudate from the ear occurred in only 10 patients from among 1581 cranial base cases after packing with autologous fat graft.[29] We avoid closing the mastoid air cells with bone wax, as it is not very helpful in preventing CSF leak and may increase the risk of infection and foreign-body granuloma.[30-32] Preservation and refixation of the mastoid cortex provide better cosmetic appearance, avoid complications of the defect after mastoidectomy, and also help in holding the fat inside the drilled mastoid cavity.

Postoperative infection after this approach is very rare. In the literature, meningitis was found to be a complication in 1 case of modified retrosigmoid approach after CSF leak in a small series.[5] In the 432 cases reviewed herein, septic meningitis was suspected in only 3 patients after CSF leak, and no other forms of intracranial infection were found. Theoretically, one would not perform the intradural work in the presence of mastoiditis; such surgery should be deferred until the infection is properly managed.

It has been reported that anterior mobilization of the sigmoid sinus may be responsible for slightly higher rates of sinus thrombosis.[33] Among 432 patients, only 3 showed asymptomatic sinus thrombosis on the postoperative magnetic resonance imaging. In addition, we noted no intra- or postoperative venous congestion resulting from this maneuver. Although only gentle reflection (not true mobilization) of the sinus is required to gain better visualization of the CPA, one should be careful not to twist the sinuses and occlude them completely. Noninvasive CT venography is routinely performed before the surgery; we do this to exclude venous sinuses variations or anomalies before surgical manipulation of the sinuses. Caution is required for cases with dominant sinuses on the side of the approach. In addition, we avoid manipulating the single sinus if present on the side of the operation (Figure 5).

CONCLUSION

The transmastoid modification is considered an extended retrosigmoid approach. Extensive partial mastoidectomy with full skeletonization and reflection of the dural venous sinuses are the major steps used in this approach to improve the surgical corridor to the CPA. This modification is safe and significantly increases the exposure to CPA targets by decreasing the working distance, widening the surgical envelope, and avoiding cerebellar retraction. It also facilitates the use of the endoscope, eliminating the need for the patient to be in a sitting position and making the supine position more effective.

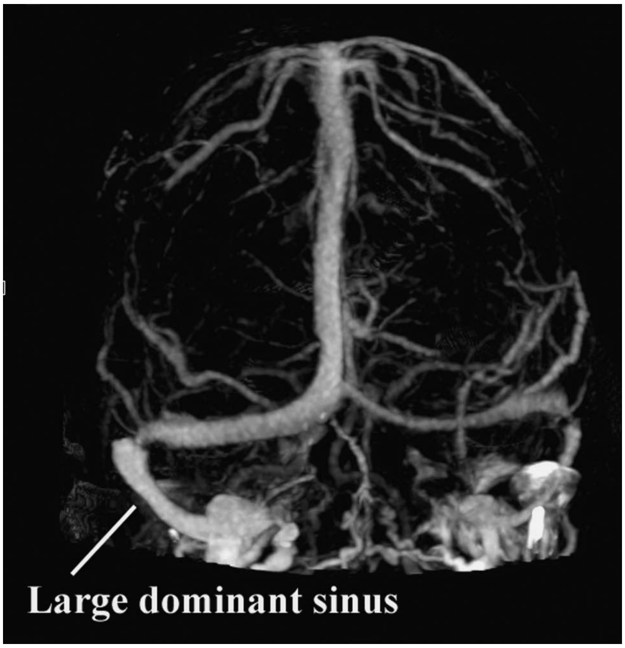

FIGURE 5. *Computed tomography angiography (venous phase) shows dominant right venous sinuses; caution is required in cases in which manipulation of the sinuses during the retrosigmoid approach is necessary.*

Disclosure

The authors have no personal financial or institutional interest in any of the drugs, materials, or devices described in this article.

REFERENCES

1. Al-Mefty O. Surgery of the posterior cranial base. In: Al-Mefty O, ed. *Surgery of the Cranial Base*. Boston, MA: Kluwer Academic Publisher; 1989:259-274.
2. Al-Mefty O. Meningiomas of the posterior cranial base. In: Al-Mefty O, ed. *Operative Atlas of Meningiomas*. Philadelphia, PA: Lippincott Williams & Wilkins; 1998:323-330.
3. Haddad GF, Al-Mefty O. The road less traveled: transtemporal access to the CPA. *Clin Neurosurg*. 1994;41:150-167.
4. Silverstein H, Nichols ML, Rosenberg S, Hoffer M, Norrell H. Combined retrolabarynthine- retrosigmoid approach for improved exposure of the posterior fossa without cerebellar retraction. *Skull Base Surg*. 1995;5(3):177-180.
5. Shelton C, Alavi S, Li JC, Histelberger WE. Modified retrosigmoid approach: use for selected acoustic tumor removal. *Am J Otol*. 1995;16(5):664-668.
6. Quinones-Hinojosa A, Chang EF, Lawton MT. The extended retrosigmoid approach: an alternative to radical cranial base approaches for posterior fossa lesions. *Neurosurgery*. 2006;58(ONS Suppl 2):ons208-ons214.
7. Raza SM, Quinones-Hinojosa A. The extended retrosigmoid approach for neoplastic lesions in the posterior fossa: technique modification. *Neurosurg Rev*. 2011;34(1):123-129.
8. Schroeder HWS, Oertel J, Gaab MR. Endoscope-assisted microsurgical resection of epidermoid tumors of the cerebellopontine angle. *J Neurosurg*. 2004;101(2):227-232.
9. Miyazaki H, Deveze A, Magnan J. Neuro-otologic surgery through minimally invasive retrosigmoid approach: endoscope assisted microvascular decompression, vestibular neurotomy, and tumor removal. *Laryngoscope*. 2005;115(9):1612-1617.
10. Jarrahy R, Berci G, Hrayr K, Shahinian HK. Endoscope-assisted microvascular decompression of the trigeminal nerve. *Otolaryngol Head Neck Surg*. 2000;123(3): 218-223.

11. Grotenhuis AJ. The use of the endoscope in microvascular decompression surgery. *Oper Tech Neurosurg.* 2001;4(3):162-165.
12. Rak R, Sekhar LN, Stimac D, Hechl P. Endoscope-assisted microsurgery for microvascular compression syndromes. *Neurosurgery*. 2004;54(4):876-883.
13. Abolfotoh M, Yi L, Tavanaiepour D, Dunn I, Al-Mefty O. Endoscopic assisted CPA surgery. Abstract presented at: New England Neurosurgical Society, annual meeting; June 21-23, 2012; Brewster, MA.
14. Fujimaki T, Son JH, Takanashi S, et al. Preservation of the lesser occipital nerve during microvascular decompression for hemifacial spasm. Technical note. *J Neurosurg.* 2007;107(6):1235-1237.
15. Ducic I, Moriarty M, Al-Attar A. Anatomical variations of the occipital nerves: implications for the treatment of chronic headaches. *Plast Reconstr Surg.* 2009;123 (3):859-863; discussion 864.
16. Rhoton AL Jr. Overview of temporal bone. Anatomy and surgical approaches of the temporal bone and adjacent areas. *Neurosurgery*. 2007;61(4 suppl):S153-S168.
17. Rhoton AL Jr. The cerebral veins. *Neurosurgery*. 2002;51(4 suppl):S159-S205.
18. Kane AJ, Sughrue ME, Rutkowski MJ, Berger MS, McDermott MW, Parsa AT. Clinical and surgical considerations for cerebellopontine angle meningiomas. *J Clin Neurosci.* 2011;18(6):755-759.
19. Charalampakis S, Koutsimpelas D, Gouveris H, Mann W. Post-operative complications after removal of sporadic vestibular schwannoma via retrosigmoid-suboccipital approach: current diagnosis and management. *Eur Arch Otorhinolaryngol.* 2011;268(5):653-660.
20. Wait SD, Gazzeri R, Teo C. Simple, effective, supine positioning for the retrosigmoid approach. *Minim Invas Neurosurg.* 2011;54(4):196-198.
21. Kaye AH, Leslie K. The sitting position for neurosurgery: yet another case series confirming safety. *World Neurosurg.* 2012;77(1):42-43.
22. Erdogan E, Civelec E, Onal MB, Solmaz I, Kural C, Yakupoglu H. A new method of patient's head positioning in suboccipital retrosigmoid approach. *Neurol India.* 2009;57(6):777-779.
23. Fathi AR, Eshtehardi P, Meier B. Patent foramen ovale and neurosurgery in sitting position: a systematic review. *Br J Anaesth.* 2009;102(5):588-596.
24. Lindross AC, Niiya T, Randell T, Romani R, Nernesniemi J, Niemi T. Sitting position for removal of pineal region lesions: the Helsinki experience. *World Neurosurg.* 2010;74(4-5):505-513.
25. Rath GP, Bithal PK, Chaturvedi A, Dash HH. Complications related to positioning in posterior fossa craniectomy. *J Clin Neurosci.* 2007;14(6):520-525.
26. Rhoton AL Jr. The cerebellopontine angle and posterior fossa cranial nerves by the retrosigmoid approach. *Neurosurgery*. 2000;47(3 Suppl):S93-S129.
27. Gale T, Leslie K. Anaesthesia for neurosurgery in the sitting position. *J Clin Neurosci.* 2004;11(7):693-696.
28. Porter JM, Pidgeon C, Cunningham AJ. The sitting position in neurosurgery: a critical appraisal. *Br J Anaeasth.* 1999;82(1):117-128.
29. Taha AN, Almefty R, Pravdenkova S, Al-Mefty O. Sequelae of autologous fat graft used for reconstruction in skull base surgery. *World Neurosurg.* 2011;75(5-6):692-695.
30. Leprovost N, Taupin A, Soubeyrand E, Labbé D, Compère JF, Bénateau H. [Foreign body granuloma due to Horsley wax®]. *Rev Stomatol Chir Maxillofac.* 2011;112(2):117-120.
31. Low WK, Sim CS. Bone wax foreign body granuloma in the mastoid. *ORL J Otorhinolaryngol Relat Spec.* 2002;64(1):38-40.
32. Bolger WE, Tadros M, Ellenbogen RG, Judy K, Grady MS. Endoscopic management of cerebrospinal fluid leak associated with the use of bone wax in skull-base surgery. *Otolaryngol Head Neck Surg.* 2005;132(3):418-420.
33. Mattei TA, Ramani R. Critical remarks on the proposed "extended retrosigmoid approach." *Neurosurg Rev.* 2011;34(4):527-530.

COMMENTS

The authors have prepared a manuscript on the Transmastoid Retrosigmoid Approach to the Cerebellopontine Angle. In the era of minimally invasive neurosurgery with the use of endoscopes this represents an evolution of the classically retrosigmoid approach but yet is not the maximally invasive various transpetrous approaches required to use the presigmoid corridor. As the authors state the traditional suboccipital craniotomy and the retrosigmoid approach gives less exposure to the cerebellopontine angle and may necessitates cerebellar retraction. The additional drilling of the mastoid process with reflection of venous sinuses offers wider exposure of the CPA. The authors demonstrated with post operative CT, that the mean working distance for the transmastoid approach is 23.06 mm vs 46.44 mm for the traditional retrosigmoid approach. Although this is an interesting addition to surgery to the CPA angle, it is important to remember that more is not always better and for skull base surgery this is the same. I believe that most pathology at the CPA angle can be approached with a simple retrosigmoid approach and more extensive approaches are only needed for pathology that extends closer to the midline. This said skull base approaches are important for the surgeon to master and have available but common sense must rule as the more extensive approaches do have higher complication rates.

Gavin W. Britz
Durham, North Carolina

The authors performed a thoroughly illustrated surgical study which shows the advantages of partial removal of the mastoid process during surgery of the cerebello-pontine angle. The restricted surgical corridor provided by the retrosigmoid approach necessitates significant cerebellar retraction particularly when dealing with medium and large lesions, or when attempting to access lesions located anterior to the VII-VIII nerve complex. I agree with the authors that partial removal of the mastoid process provides better visualization when using the microscope and facilitates use of an endoscope. However, this is not used routinely and only when the particular situation mandates the increased working angle. Skeletonization of the sigmoid sinus and, very importantly, exposure of a few millimeters of pre-sigmoid dura allows for reflection of the sinus anteriorly, thus minimizing the need for cerebellar retraction and shortening the distance of the surgical targets form the edge of the craniotomy. More importantly, this surgical maneuver improves visualization of the area around the porus acousticus which, in most cases, is hidden by the anterior edge of the craniotomy. In most cases, however, I don't find it necessary to expose the sigmoid sinus entirely up to jugular bulb, as suggested by the authors, unless the lesion also involves the lower cranial nerves.

Use of the endoscope during surgery of the cerebello-pontine angle contributes to minimizing cerebellar retraction, provides valuable assistance in tumor removal and microvascular decompression, and allows the surgeon to obtain a better view of the medial structures. I agree with the authors that anterior reflection of the sigmoid sinus provides an improved corridor for insertion and manipulation of the endoscope.

Antonio Bernardo
New York, New York