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Authors

Uy, Benjamin R

Baisiwala, Shivani

Shih, Ryan

et al.

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Extended frontotemporal craniotomy with orbitozygomatic glenoid fossa osteotomy for resection of giant trigeminal schwannoma: illustrative case

Benjamin R. Uy, MD, PhD,[1] Shivani Baisiwala, MD,[1] Ryan Shih, BS,[1] Marcia Cornford, MD, PhD,[3] Anton Mlikotic, MD,[2] Richard G. Everson, MD,[1,2] and Duc Duong, MD[2]

[1]Department of Neurosurgery, University of California, Los Angeles; [2]Department of Neurosurgery, Harbor-UCLA Medical Center, Los Angeles; and [3]Department of Pathology, Harbor-UCLA Medical Center, Los Angeles, California

BACKGROUND Skull base lesions, including tumors of the petroclival region and brainstem, can be challenging. Surgical access to these regions is associated with significant morbidity due to their deep location and proximity to critical structures. These lesions include meningiomas, chordomas, basilar trunk aneurysms, epidermoid tumors, and schwannomas, all of which often cause mass effect with significant symptoms and thus require surgical intervention. The authors describe a corridor for safe access to maximize the preservation of essential functions while improving access without associated morbidity.

OBSERVATIONS Here, the authors describe an extended frontotemporal craniotomy combined with an orbitozygomatic glenoid fossa osteotomy to access and safely resect a giant trigeminal schwannoma. This surgical technique allowed for enhanced exposure of the lesion while reducing the surgical distance and the need for excessive subtemporal retraction, which can otherwise contribute to postoperative complications. Importantly, the procedure allowed for the long-term preservation of temporomandibular joint (TMJ) function, which is crucial for maintaining normal jaw movement and quality of life.

LESSONS The incorporation of a glenoid fossa osteotomy in the surgical approach reduced the working distance to the lesion and improved intraoperative visibility, thus minimizing retraction-related injury, allowing for safe resection and preservation of the TMJ.

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KEYWORDS extended frontotemporal craniotomy; giant trigeminal schwannoma; glenoid fossa osteotomy; case report

Petroclival and brainstem region lesions such as meningiomas, chordomas, basilar trunk aneurysms, prepontine epidermoid tumors, trigeminal schwannomas, and pontine cavernomas can be challenging pathologies to access and resect. Surgery is classically associated with significant morbidity and mortality as these lesions are deep and located near critical structures. Typical approaches to these lesions include expansions of the pterional (frontotemporal) craniotomy, including orbitozygomatic, anterior transpetrosal (Kawase), posterior transpetrosal (presigmoid), retrosigmoid, and glenoid/mandibular fossa osteotomies. The best surgical approach—or combination therein—for resection of these lesions is largely dependent on various tumor characteristics, including size, location, desire to preserve auditory function, and lesion extension beyond midline or into the middle or posterior fossa.

The pros and cons of each are as follows. Orbitozygomatic osteotomies are well suited for accessing the orbit, anterior fossa, middle cranial fossa, basilar apex, and upper clivus, enabling superior visualization. Known as the "workhorse" of skull base surgery, this approach is versatile and can be easily modified according to lesion size and extension.[1,2] These include versions mobilizing up to three separate bone flaps, permitting operative flexibility with a wide field of view while minimizing the extent of brain retraction required due to shortened working distances to key areas.[3] However, care must be taken to avoid significant retraction of the orbit and facial neuromuscular structures due to risks of visual and sensory complications,[4] and temporal lobe retraction may still be required with concomitant risk of brain injury. Extension with a glenoid fossa osteotomy can further improve visibility and reduce surgical distance, but this must be weighed carefully against the high risk of postoperative temporomandibular joint (TMJ) dysfunction. The anterior transpetrosal (Kawase) approach and its variants have been pioneered for accessing brainstem lesions and those proximal to vital neurovascular structures near the middle fossa floor.[5]

ABBREVIATIONS OZ = orbitozygomatic craniotomy; SLP = speech-language pathology; TMJ = temporomandibular joint.

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This corridor must be developed meticulously, however, as approach-related postoperative complications like facial palsy and hearing loss may still arise from damage to the facial nerve and cochlea, respectively.[6] Posterior transpetrosal (presigmoid) approaches encompass retrolabyrinthine, translabryinthine, and transcochlear subvariants in order of increasing exposure.[7] These approaches permit optimal access to the posterior fossa and cerebellopontine angle, although key neural (cranial nerve VII and VIII) and vascular (sigmoid sinus) structures assume increased risk of damage. Combined anterior and posterior transpetrosal approaches have also been demonstrated with the obvious trade-off of increased exposure concomitant to increased risk of neurovascular functional impairments.[8] Despite efforts to avoid auditory structures, both anterior and posterior transpetrosal approaches carry a risk of hearing loss. The retrosigmoid approach permits similar access to the posterior fossa and is often indicated when hearing preservation is a key operative goal. Combinations of posterior transpetrosal (presigmoid) and retrosigmoid approaches have been described.[8]

Here, we describe an extended fronto-temporal craniotomy with an orbitozygomatic glenoid fossa osteotomy to safely resect a large trigeminal schwannoma that crosses the midline and invades nearly the entire clivus, with postoperative preservation of neurological and TMJ function.

Illustrative Case

Presentation and Preoperative Workup

The patient is a 35-year-old male with no prior medical history who presented to the emergency department after a first-time seizure with loss of consciousness. At the time of arrival, he had recovered back to his neurological baseline. He described no prior symptoms, no headaches, and no focal neurological deficits. On physical examination, he was neurologically intact.

MRI of the brain with and without contrast demonstrated a well-circumscribed lobulated right petroclival mass, measuring 6.6 × 4.7 × 4.9 cm, extending into the middle and posterior fossa. The tumor extended into the right cerebellopontine angle, cavernous sinus, clivus, foramen rotundum, foramen ovale, and Meckel's cave. In addition, the lesion had crossed the midline, causing significant brainstem compression. It was T1 hypointense, T2 hyperintense, and avidly contrast enhancing, with minimal edema (Fig. 1). CT imaging demonstrated significant erosion of the petrous bone and clivus and expansion of the foramen ovale (Fig. 2). Almost the entire right side of the clivus was infiltrated with the tumor spanning nearly the entire sagittal plane and eroding past the midline with about 70% of the clivus being involved overall. Based on these imaging characteristics, our differential diagnosis at the time included trigeminal schwannoma or meningioma.

Additional workup performed during this admission included thin-cut MRI for neuronavigation and MRI of the cervical, thoracic, and lumbar spine for evaluation of syrinx or drop metastases. MRI of the spine was negative for additional lesions. After this imaging workup was completed and the patient was deemed stable, he was discharged home on levetiracetam for seizure prophylaxis, with a plan for elective resection. The surgical plan included a preoperative lumbar drain placement followed by an extended frontotemporal craniotomy with orbitozygomatic glenoid fossa osteotomy with a possible retrosigmoid craniotomy and an abdominal fat graft.

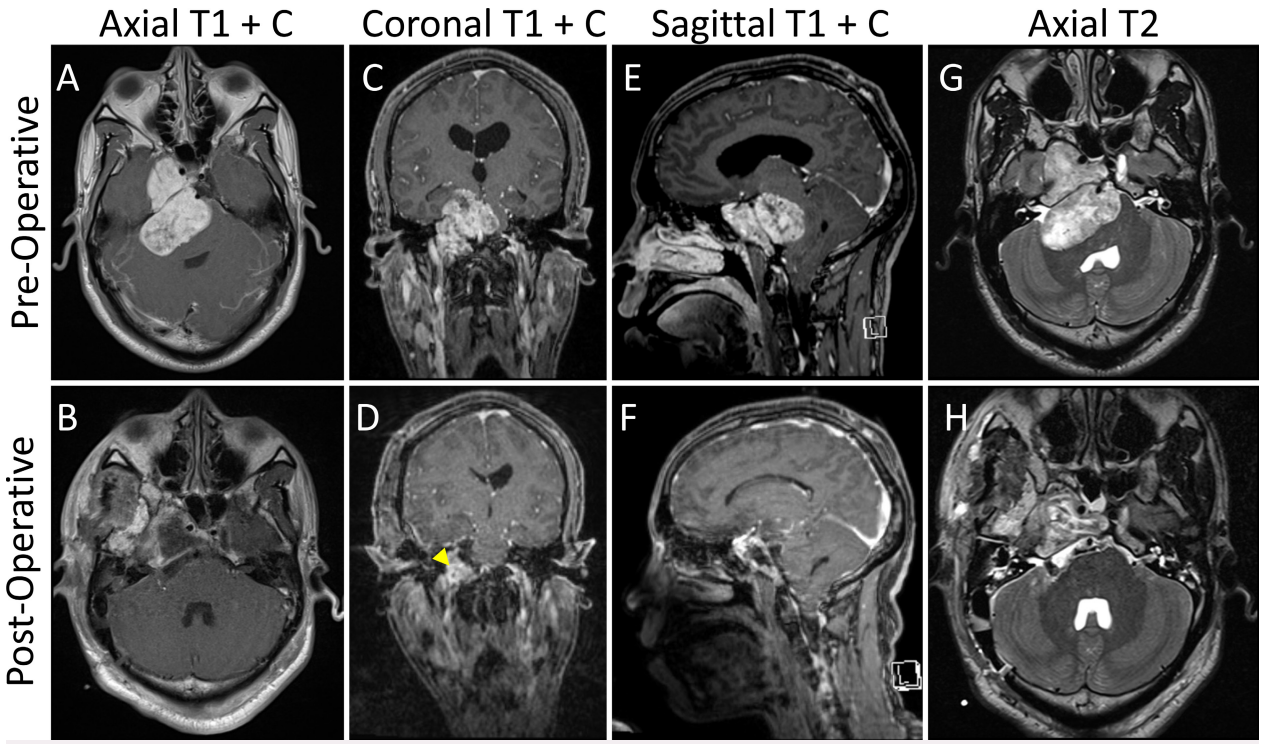


FIG. 1. Preoperative (A, C, E, G) and postoperative (B, D, F, H) MR images of the brain revealing a large multicompartmental tumor with interval near-total resection. T1-weighted axial (**A and B**), coronal (**C and D**), and sagittal (**E and F**) MR images with contrast (+ C). T2-weighted axial MR images (**G and H**). The *arrowhead* demonstrates residual tumor within the clivus and petrous bone.

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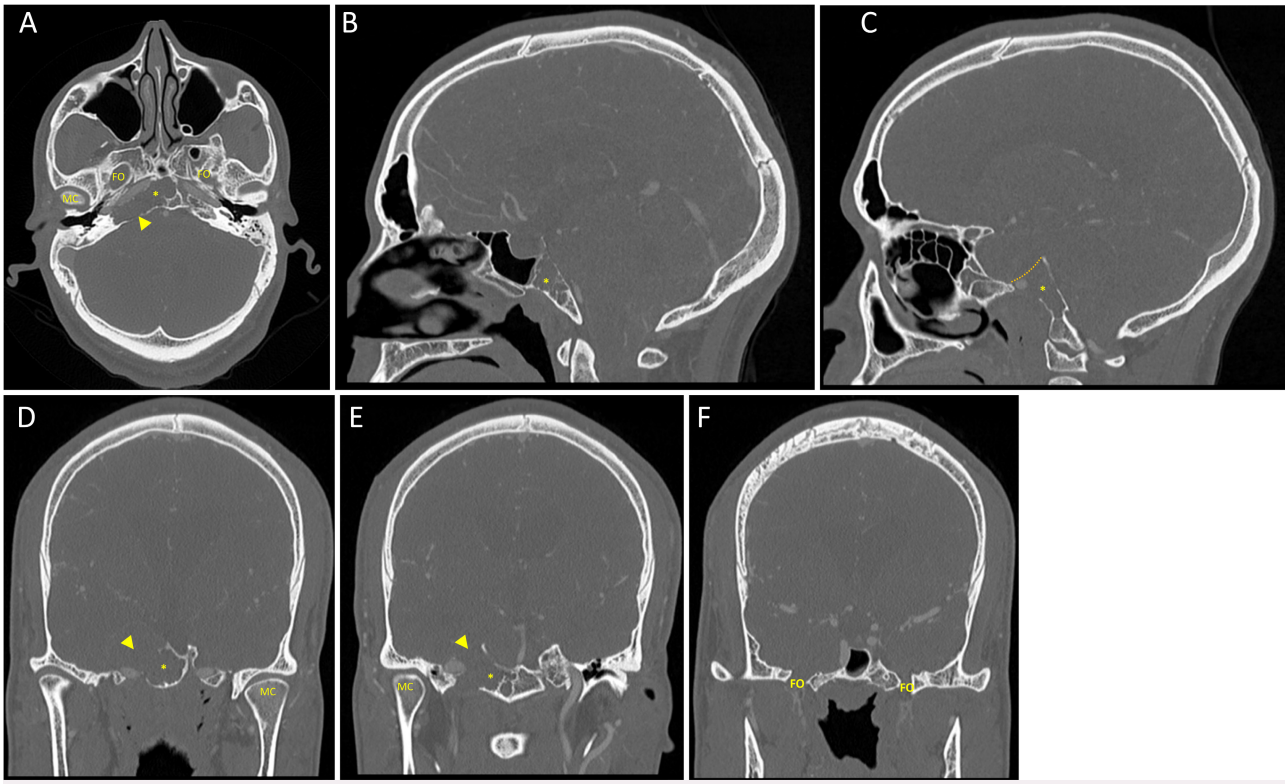


FIG. 2. Preoperative axial (**A**), sagittal (**B and C**), and coronal (**D–F**) CT angiograms of the head demonstrating bony remodeling. The *arrowhead* shows remodeling of the petrous temporal bone, the *asterisk* indicates bony invasion of the clivus, and the *dotted line* represents projected petrous temporal bone edge based on contralateral side imaging. FO = foramen ovale; MC = mandibular condyle.

Surgical Case Description

The patient was readmitted 1 day prior to his scheduled surgery. A cerebral angiogram was obtained to assess the vascular anatomy and potential vascular feeders for embolization; however, the tumor had no embolizable targets. A preoperative lumbar drain was placed for intraoperative and postoperative CSF diversion.

The patient was brought to the operating room and positioned supine with a bump in a Mayfield head clamp. Intraoperative Stealth neuronavigation (Medtronic) was registered and utilized throughout the case. A right-sided curvilinear pterional scalp incision was made behind the hairline, with the medial aspect extending beyond the midline. An additional perpendicular incision was performed to provide adequate access to the remainder of the craniotomy and transverse-sigmoid junction. Temporalis interfacial dissection was carried out to eventually expose the orbital rim and zygoma. A modified two-piece extended frontotemporal craniotomy with orbitozygomatic glenoid fossa osteotomy was carried out.[9–11] First, the frontotemporal craniotomy was performed in the standard manner. Burr holes were placed at MacCarty's keyhole, above the transverse sinus, and above the posterior zygoma (glenoid keyhole). An additional burr hole was placed at the asterion, allowing for visualization of the transverse-sigmoid junction, and a small retrosigmoid craniotomy was performed. The remainder of the orbitozygomatic glenoid fossa osteotomy was carried out by disarticulating the TMJ through a glenoid fossa osteotomy, as described by Froelich et al.[11] A Penfield no. 1 was used to preserve the joint while subperiosteally removing the cartilage to maintain the capsule and ligaments of the TMJ to safely disarticulate the joint.

Using a reciprocating saw, we performed the first cut of the extended OZ as far posterior as possible on the zygoma from the glenoid keyhole with a slight posterior-to-anterior slant while protecting the joint from injury to the capsule (Fig. 3 lower). The remainder of the OZ was performed in the standard manner with the reciprocating saw and osteotomes to complete the osteotomies dividing the zygomatic bone near the malar eminence, superior orbital rim from the roof of the orbit, and, finally, the lateral orbital wall (Video 1).[10]

VIDEO 1. Three-dimensional rotational rendering of the right-sided extended frontotemporal craniotomy combined with an orbitozygomatic glenoid fossa osteotomy and retrosigmoid craniectomy. Click here to view.

Following extradural development of the middle fossa, a C-shaped dural opening was performed with a low temporal opening. Transsylvian and subtemporal approaches were used for resection in this case. Based on the prior CT scans, the tumor had eroded through the petrous temporal bone, and thus minimal bony removal was required to provide adequate exposure (Fig. 2). At this time, the lumbar drain was opened for CSF relaxation and subtemporal retraction was performed with eventual static retraction. The tentorium was easily visualized and subsequently opened to reveal the tumor. To allow for more anterior and medial exposure, the sylvian fissure was split. Using both the subtemporal transtentorial and transsylvian corridors, we carried out tumor resection with a combination of bipolar electrocautery, ultrasonic aspiration, and blunt microdissection.

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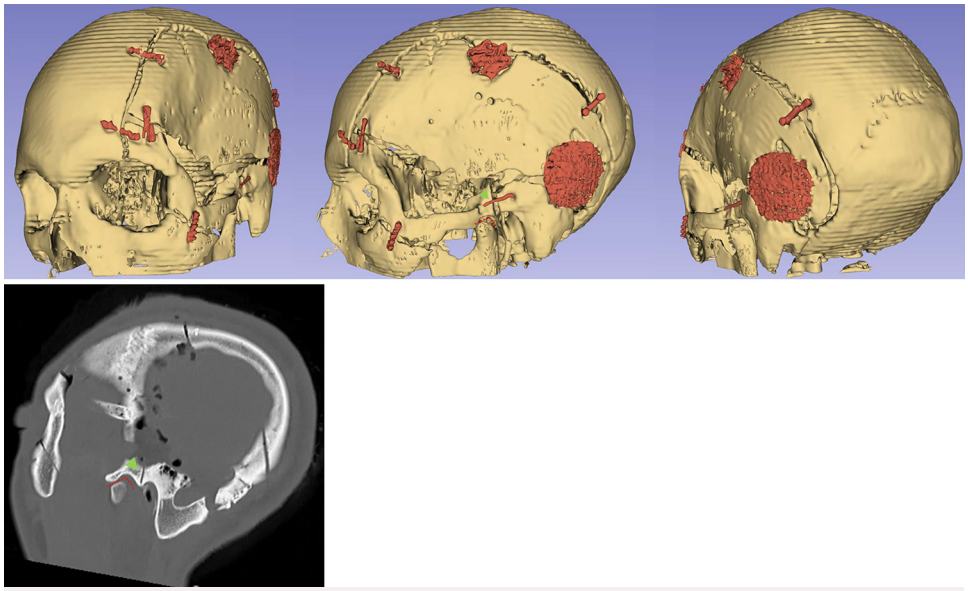


FIG. 3. Extended frontotemporal craniotomy combined with an orbitozygomatic glenoid fossa osteotomy and retrosigmoid craniectomy. **Upper:** Three-dimensional reconstruction of the craniotomy. Bone plates overlying the craniotomy and osteotomies are shown in *orange*. The center sagittal rendering demonstrates the posterior cut along the zygoma (*arrowhead*) and TMJ and the site of disarticulation for the glenoid fossa osteotomy (*dotted line*). **Lower:** Sagittal postoperative CT scan of the head showing the corresponding posterior cut along the zygoma (*arrowhead*) and TMJ (*dotted line*).

For closure, a dural substitute was sewed in and abdominal fat was placed in the epidural space and covered with collagen glue. The bone flap was reapproximated and plated with attention to the glenoid fossa, ensuring that the joint remained intact and the condyle was resting within the articular fossa. A Jackson-Pratt drain was placed for 24 hours. Postoperative motor evoked and somatosensory evoked potentials along with cranial nerves VII–XI were stable.

Postoperative Course

The total duration of the case was approximately 20 hours. Postoperatively, the patient was admitted in stable condition to the intensive care unit. He was kept intubated given the prolonged case duration and the concern for possible postoperative cranial nerve deficits. Lumbar drain output was maintained at 10 ml/hr, systolic blood pressure was maintained at 90–140 mm Hg, and serum sodium levels were carefully regulated to be between 140 and 150 mEq.

The patient was weaned from sedation on postoperative day 1 and was able to move all extremities and respond to questions. He was successfully extubated on postoperative day 2 and had a formal speech-language pathology (SLP) evaluation, which showed no immediate swallowing function concerns but did show some jaw stiffness. A bite-sized soft diet was recommended. The ear, nose, and throat service was consulted for jaw stiffness, and stretch therapy with tongue depressors was recommended, which led to gradual improvement. After 1 week, the lumbar drain was clamped for 24 hours and subsequently removed, and goals were adjusted to normal parameters (sodium 135–145 mEq, systolic blood pressure 90–160 mm Hg). On postoperative day 10, a follow-up SLP evaluation showed that the patient could safely start a mechanical soft diet with plans to transition slowly to a regular diet by 6 weeks postoperatively. The patient's condition was downgraded, and he was discharged to rehabilitation in stable condition approximately 2 weeks following surgery.

Approximately 1 month following his procedure, the patient was readmitted for concern for fluid drainage from his ear and a subgaleal fluid collection. The patient was evaluated and found to have intact tympanic membranes and no active leakage. The fluid was sent for laboratory testing for beta-2 transferrin and found to be negative. The patient was treated with 1 week of ciprofloxacin ear drops, which fully resolved the symptoms. During this admission, the patient had an additional SLP evaluation and was advanced to a regular diet, with no TMJ concerns noted. He continued to recover well and followed up in the outpatient clinic at 3 months following his surgery with no acute concerns. He was neurologically intact at the time of follow-up. Final pathology came back as a grade I schwannoma with classic appearing Verocay bodies and Antoni A and B regions. In addition, the sample was Sox10 and S100 positive with a low proliferation index (Fig. 4).

Informed Consent

The necessary informed consent was obtained in this study.

Discussion

Observations

Resections of giant trigeminal schwannomas with good neurological outcomes have previously been reported utilizing a variety of approaches. Common surgical approaches include the frontotemporal, subtemporal, fronto-orbital, and retrosigmoid approaches as well as the expanded endonasal endoscopic approach.[12] Radiographic features that hinted at the diagnosis of a trigeminal schwannoma include its homogeneously enhancing nature on MRI with the associated T2 hyperintensity and T1 hypointensity. Trigeminal schwannomas tend to have well-circumscribed, smooth borders and may contain a cystic component. They may have the traditional "dumbbell" appearance, as with other schwannomas, with narrowing at the porus trigeminus

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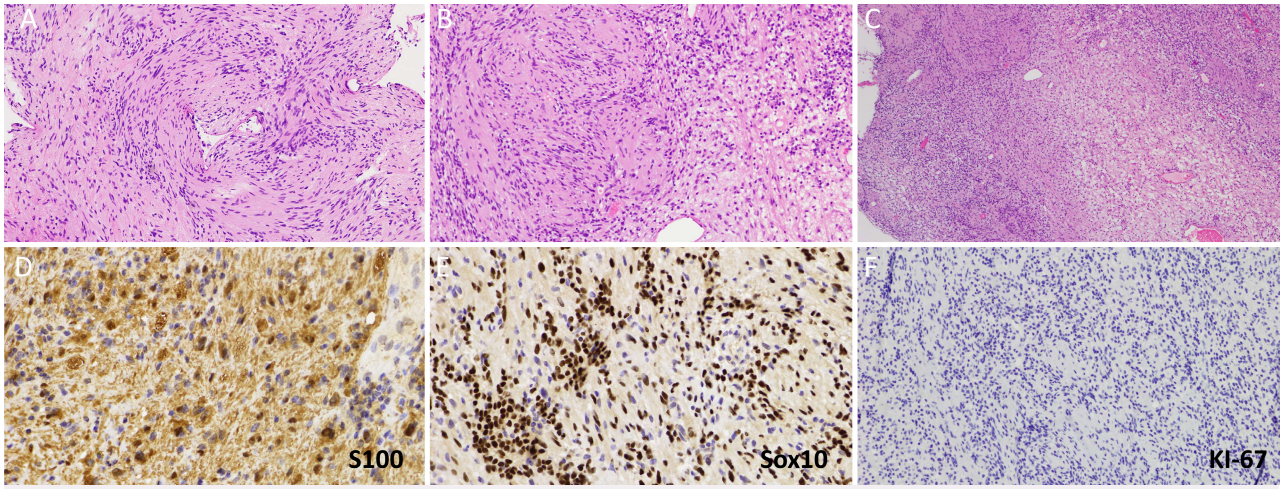


FIG. 4. Pathology was consistent with a grade I schwannoma. **A–C:** Hematoxylin and eosin stains revealing Antoni A and B cells along with Verocay bodies. **D:** The tumor demonstrated strong S100 positivity. **E:** The tumor demonstrated Sox10 positivity. **F:** The Ki-67 proliferation index was low. Original magnification ×100 (A, B, and F), ×50 (C), ×200 (D and E).

and extension into Meckel's cave and nearby cisterns. Furthermore, trigeminal schwannomas may demonstrate smooth erosion or expansion of bony landmarks along the trigeminal nerve, including the foramen ovale, foramen rotundum, or superior orbital fissure. Our patient's tumor exhibited many of these features. Although large, the tumor appears lobulated and smooth with extension into Meckel's cave, the preprontine cistern, and the cerebellopontine angle. On CT imaging, the tumor demonstrated expansion of the foramen ovale and erosion of the clivus and petrous aspect of the temporal bone.

The glenoid fossa osteotomy was previously described in cadavers to improve exposure to the posterior portion of the infratemporal fossa, the vertical segment of the petrous internal carotid artery, and the temporal fossa floor. It was also described to allow for superior visualization and a reduction in the surgical working distance.[11] This reduction in working distance allowed for improved manipulation of the tumor for resection, especially when dissecting along the brainstem and the clivus. Given that tumor invasion was seen throughout the entire right side of the clivus and a large portion of the petrous temporal bone, we planned to perform an extended frontotemporal craniotomy combined with an orbitozygomatic glenoid fossa osteotomy and retrosigmoid craniectomy. The upper third (zone 1, dorsum sellae to internal auditory canal) of the clivus can be reached with a frontotemporal orbitozygomatic craniotomy (OZ) with an anterior petrosectomy. The middle zone (zone 2, internal auditory canal to jugular tubercle, along with midbrain and pons) can be accessed with the addition of posterior petrosal approaches (presigmoid retrolabyrinthine or translabyrinthine transmastoidectomy). Finally, the remainder of the clivus (zone 3) can be accessed via a retrosigmoid approach combined with a far lateral or extreme lateral transcondylar approach.[13,14]

Tumor destruction of the anterior petrous bone permitted visualization of the upper clivus and Meckel's cave, allowing for visualization (Fig. 2C–E). Given the extensive erosion of the petrous bone and the addition of the glenoid fossa osteotomy, we were able to visualize and access the inferior portions of the tumor within the clivus from above without approaching the tumor from the retrosigmoid craniotomy. However, small postoperative residual was seen within the inferior petrous temporal bone medial to the petrous segment of the carotid and at the lateral inferior clivus. Although the tumor extensively remodeled the petrous bone, eliminating the need for an anterior petrosectomy, many of the landmarks of Kawase's rhomboid were not able to be clearly identified. Notably, additional bony exposure may have improved the extent of resection. Furthermore, the petrosal segment of the carotid serves as a barrier that may have impeded lateral inferior access and visualization of the tumor.

Functional removal of the glenoid fossa without violation of the superior articular cartilage allowed for preservation of the joint capsule and long-term maintenance of the joint integrity with full recovery of jaw function by 6 weeks postoperatively. Postoperatively, the patient experienced stiffness of the jaw and soreness, which resolved with time and jaw exercises. He was placed on a soft diet postoperatively to aid in his recovery, but ultimately by his 6-week postoperative visit he was able to chew solids without restrictions and pain. This highlights the importance of maintaining subperiosteal dissection of the cartilage during exposure to avoid associated TMJ morbidity. This case illustrates the use of an extended frontotemporal craniotomy combined with an orbitozygomatic glenoid fossa osteotomy as a feasible technique for resection of a giant trigeminal schwannoma with good neurological and functional outcomes. This technique for improved visualization without significant associated morbidity can be added to the surgical arsenal of approaches to optimize resection of skull base lesions.

Lessons

Giant trigeminal schwannomas should be high on the differential for tumors that are homogeneously enhancing, smoothly remodel nearby bone and foramina, or have a dumbbell-like appearance across the porus trigeminus. Extended frontotemporal craniotomy combined with an orbitozygomatic glenoid fossa osteotomy decreases the surgical working distance to optimize tumor resection while reducing subtemporal retraction without significant associated TMJ-related morbidity if the joint capsule is maintained.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Duong, Uy, Baisiwala, Everson. Acquisition of data: Uy, Cornford, Mlikotic, Everson. Analysis and interpretation of data: Duong, Uy, Shih, Cornford. Drafting the article: Uy, Baisiwala, Shih, Mlikotic. Critically revising the article: Duong, Uy, Baisiwala, Shih, Everson. Reviewed submitted version of manuscript: Uy, Baisiwala, Shih, Cornford, Mlikotic, Everson. Approved the final version of the manuscript on behalf of all authors: Duong. Administrative/technical/material support: Everson. Study supervision: Duong, Everson.

Supplemental Information

Videos

Video 1. https://vimeo.com/1087129177.

Correspondence

Duc Duong: Harbor-UCLA Medical Center, Los Angeles, CA. dduong@dhs.lacounty.gov.

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