A modified far-lateral approach for large or giant meningiomas of the posterior fossa

Clinical article

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Object. Resecting large meningiomas along the posterior fossa convexity or cerebellopontine angle (CPA) through a suboccipital approach can be challenging. Limitations include a restricted angle of view, high venous pressures, and suboptimal brain relaxation. While a far-lateral craniotomy is a viable alternative, the risks associated with condylar resection are undesirable.

Methods. The authors retrospectively evaluated a modified far-lateral approach in a consecutive series of 12 patients with large or giant posterior fossa convexity and CPA meningiomas. This approach incorporates transverse-sigmoid sinus exposure and C-1 laminectomy, but there is no condylar resection.

Results. Between January 2006 and February 2008, 12 patients (mean age 52 years) presented with large or giant meningiomas of the posterior fossa convexity or CPA. The mean tumor volume was 72.6 cm$^3$ (range 8–131 cm$^3$). Signs and symptoms at presentation included headache (in 8 patients), cranial neuropathy (in 4), and progressive hemiparesis (in 4). There were no operative complications, and the majority of patients (9) had Simpson Grade I or II resections. There were no new permanent neurological deficits following resection, although 2 patients (17%) had transient deficits. The mean modified Rankin score decreased from 2.2 preoperatively to 0.6 postoperatively.

Conclusions. A modified far-lateral approach to the posterior fossa and CPA allows for safe, and often total, resection of large meningiomas with minimal morbidity. While avoiding the risks of condylar resection, this microsurgical strategy allows for greater field of view, minimal venous bleeding, and immediate access to the spinal subarachnoid space. (DOI: 10.3171/2009.6.JNS09120)

Key Words • far-lateral approach • meningioma • posterior fossa • cerebellopontine angle • petrous face

MENINGIOMAS within the posterior fossa present a unique operative challenge in the setting of significant mass effect and limited visualization. Even modest-sized convexity, petrous face, and CPA meningiomas can occupy a significant proportion of the posterior fossa, severely restricting surgical maneuverability, placing cranial nerves on stretch, and increasing the risk of injuring the cerebellum or its vascular supply during resection.

Traditionally, these lesions are treated through a lateral suboccipital or retrosigmoid approach (Fig. 1). While these operative corridors are sufficient in most cases, particularly when exposure is extended to its dural sinus limits, they still only provide a limited angle of view. Additionally, high venous pressures can be caused by the patient’s position, in which a substantial head turn can kink the jugular vein, while the prone position can limit venous outflow due to chest compression. Excessive venous hypertension, in turn, hinders brain relaxation and increases venous bleeding, both of which can obscure the operative field and frustrate resection. The limited bony exposure associated with these approaches can also prevent adequate brain relaxation, as the combination of mass effect and lack of direct access can restrict CSF egress from the cistern magna or the cervical subarachnoid space.

Compared with the retrosigmoid approach, the far-lateral craniotomy allows for greater visualization and operative space within the posterior fossa. It is, however, a more complex and time-consuming operation that requires drilling of the occipital condyle. Consequently, this added bone work risks injury to the veins surrounding the circular sinus and the condylar vein, which itself is highly variable in its course. Mobilization of the vertebral artery is rarely necessary during this procedure; it remains at risk for injury during condylar resection.

Here we present our single-institution experience with an alternative approach for large or giant posterior...
fossa convexity, posterior petrous face, and CPA meningiomas. This modified far-lateral approach is tailored to maximize brain exposure of these lesions, while excluding elements to improve the efficiency and risk profile of the procedure.

Methods

Patient Population and Outcome Assessment

Between January 2006 and February 2008, 12 patients with large or giant meningiomas of the posterior fossa convexity, posterior petrous face, or CPA underwent a modified far-lateral craniotomy at the University of California at San Francisco, which was performed by the senior author (M.W.M.) (Table 1). The mean age at presentation was 52 years (range 25–72 years) (Table 2). Most patients presented with signs and symptoms attributable to mass effect, including headache (in 8 patients [67%]), cranial neuropathy (in 4 [33%]), and hemiparesis (in 4 [33%]). No patients had undergone previous treatment for their meningiomas, including surgical resection, biopsy, or irradiation.

All patients underwent preoperative and postoperative (< 72 hours) MR imaging, and they had at least 6 months of clinical follow-up. Central pathology review was performed on the basis of the WHO guidelines. Clinical data were collected from patient records and telephone interviews. All clinical assessments were performed by a neurosurgeon. In each case, the extent of resection and Simpson grade\(^{1,2}\) were determined using a combination of the surgeon’s assessment and MR imaging. Preoperative and postoperative modified Rankin Scale scores were assigned on the basis of documented clinical exams performed by a neurosurgeon. This study was approved by the University of California at San Francisco Committee on Human Research.

Surgical Procedure

In the operating room, a lumbar subarachnoid drain was placed prior to positioning. Patients were placed three-quarters prone on the operating room table, lean-
ing forward onto a foam roll. This modified park-bench position requires an axillary roll to protect the brachial plexus. The patient’s contralateral arm was padded in a dependent position and supported with a cloth sling. Hanging the arm freely improves venous return and minimizes injury to the brachial plexus during a lengthy procedure. Also, in placing the patient’s arm in the sling, the down-side shoulder drops to accommodate maximal cranial flexion and rotation.

The patient’s head, secured in a Mayfield headholder, was tilted downward 20° off horizontal and the nose was pointed 60° toward the floor (Fig. 2). In this position, the ipsilateral mastoid is at the highest point of the surgical field. The head was flexed maximally, taking care to avoid direct contact between the chin and the sternum, and was fixed in this final position by using the Mayfield attachment. Kidney rests were placed bilaterally to secure the patient’s body in anticipation of table rotation during the procedure. The ipsilateral shoulder was finally pulled toward the feet and secured with cloth tape, opening the angle between the patient’s head and shoulder.

The incision was begun at the tip of the ipsilateral mastoid and continued above the superior nuchal line, curving to the midline down to the level of C-2. Once the skin flap was elevated, a muscle cuff was preserved at the level of the superior nuchal line for muscle approxima-

<table>
<thead>
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<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>no. of patients</td>
<td>12</td>
</tr>
<tr>
<td>median age (yrs)</td>
<td>52 (range 25–72)</td>
</tr>
<tr>
<td>male/female</td>
<td>6:6</td>
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<table>
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<tr>
<th>signs/symptoms at presentation</th>
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<tbody>
<tr>
<td>headache</td>
<td>8 (67%)</td>
</tr>
<tr>
<td>cranial neuropathy</td>
<td>4 (33%)</td>
</tr>
<tr>
<td>hemiparesis</td>
<td>4 (33%)</td>
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The transverse and sigmoid sinuses were first identified using anatomical landmarks or neuronavigation and were skeletonized completely. A high-speed drill with a cutting bur was used to thin the bone overlying both sinuses. This overlying bone was reduced to an eggshell-thin layer as the sinus was exposed along its course from transverse sinus to jugular bulb, and from its anterior edge to its border posteriorly, where the dura changed in color at closure. The scalp was turned as a myocutaneous flap and pulled downward with scalp hooks. A cloth roll beneath the flap prevented an acute angle and minimized flap ischemia during long procedures. Exposure of C-2 might be necessary for adequate retraction of the scalp flap, but the muscular attachments to C-2 were left undisturbed.

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from blue to white. The cutting bur was replaced with a diamond bit, which did not cut soft tissue and allowed the remaining bone to be drilled away safely. The time needed to skeletonize the sinus was minimized by performing as much of this bony dissection as possible with the cutting bur. A generous craniotomy was then turned from the lip of the foramen magnum up to these dural sinus edges. A C-1 laminectomy with a high-speed drill completed the dural exposure, taking care to identify the sulcus arteriosus and preserve the vertebral artery, which exists as a horizontal segment in this region. As mentioned earlier, the occipital condyle was left intact (Fig. 3).

Dural opening began at the level of C-1, and CSF was drained before the posterior fossa convexity dura was opened, curving up toward the lowest end of the sigmoid sinus. A C-1 laminectomy with a high-speed drill completed the dural exposure, taking care to identify the sulcus arteriosus and preserve the vertebral artery, which exists as a horizontal segment in this region. As mentioned earlier, the occipital condyle was left intact (Fig. 3).

The CSF at this point relaxed the posterior fossa without the usual struggle of trying to find the cistern magna from a standard retrosigmoid approach. Once CSF was drained, the convexity dura above the foramen could easily be opened without fear of herniation of normal cerebellum, and the 2 dural openings were connected working from superior to inferior. In this way, any bleeding from the circular sinus was easily controlled. The medial flap was subdivided twice more, with one cut heading toward the transverse-sigmoid junction and the other cut heading toward the sigmoid sinus. Prior to tumor resection, the cistern magna and cervical CSF spaces were thoroughly fenestrated and decompressed.

A watertight dural closure, either primarily or with duraplasty, prevented CSF leaks and pseudomeningocele formation. The presence of a CSF drain for 48 hours postoperatively allowed for maintenance of low intracranial pressure postoperatively, facilitating dural healing. The craniotomy flap was reapproximated with titanium plates and mesh. The C-1 lamina can be replaced, although this
Modified far-lateral approach for posterior fossa meningiomas

### TABLE 3: Extent of resection by Simpson grade

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<th>Simpson Grade</th>
<th>No. of Patients (%)</th>
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<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>I</td>
<td>8 (67)</td>
</tr>
<tr>
<td>II</td>
<td>1 (8)</td>
</tr>
<tr>
<td>III</td>
<td>3 (25)</td>
</tr>
<tr>
<td>IV</td>
<td>0</td>
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### TABLE 4: Postoperative neurological morbidity and deficit resolution profile

<table>
<thead>
<tr>
<th>Condition</th>
<th>No. of Patients (%)</th>
<th>Postop Interval (wks)</th>
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<tbody>
<tr>
<td>cranial neuropathy</td>
<td>4 (33)</td>
<td>&lt;4  2  &gt;4</td>
</tr>
<tr>
<td>hemiparesis</td>
<td>4 (33)</td>
<td>0  0</td>
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is not our usual practice. As mentioned earlier, the nuchal line muscle cuff allows for a tight muscle closure and decreases the incidence of postoperative pseudomeningocele. The galea and skin were each closed separately with running suture.

### Results

**Patient and Tumor Demographics**

Eight tumors (67%) were right-sided and 4 (33%) were left-sided. The most common location was along the posterior fossa convexity (in 5 patients [42%]), followed by the CPA (in 4 [33%]) and the petrous face (in 3 [25%]). The mean tumor volume was 72.6 cm³ (range 8–131 cm³), and the median maximal tumor diameter was 4.9 cm.

**Microsurgical and Clinical Outcome**

Three patients (25%) underwent preoperative embolization, and the mean estimated blood loss was 477 ml. According to the Simpson grading system, Grade I, II, and III resections were achieved in 8 (67%), 1 (8%), and 3 (25%) patients, respectively. In the patient with a Simpson Grade II resection, a portion of the tumor’s dural attachment involved a dural sinus wall. Consequently, an intrasinus resection was not pursued in favor of dural leaflet coagulation. For the 3 patients with Simpson Grade III resections, however, dural coagulation was not possible because of the proximity and involvement of adjacent cranial nerves (Table 3). Eleven tumors (92%) were diagnosed as WHO Grade I lesions, and 1 tumor (8%) was designated WHO Grade II.

No patient died, and there was no incidence of intraoperative complications in this cohort. Surgical complications, including CSF leakage, epidural hematoma requiring evacuation, and wound infections requiring antibiotics, did not occur in any patient. Similarly, there were no medical morbidities reported during the hospital course, including pulmonary embolus or deep vein thrombosis requiring anticoagulation. While there were also no new, permanent neurosurgical morbidities, 2 patients had new, transient postoperative cranial neuropathies, amounting to a 17% rate of transient neurological morbidity (Table 4). Among all patients, there was no incidence of postoperative myocardial infarction, meningitis, or hydrocephalus. The patients’ overall clinical improvement following resection was evaluated using a modified Rankin Scale score. Preoperatively, the mean score was 2.2, but it improved to 0.6 postoperatively.

### Discussion

The modified far-lateral approach we describe here has not been studied for the resection of large or giant posterior fossa meningiomas. Its advantages include immediate access to the cervical subarachnoid space, no venous kinking due to patient positioning, expanded bony decompression, and a large field of view allowing a better line of site. While the approach involves more bone work than a simple retrosigmoid approach, the lack of condylar resection saves time compared with a standard far-lateral approach. Nevertheless, we do not use this surgical strategy for all posterior fossa meningiomas, and it is evident that for many of these lesions more than one operative approach can be effective. However, for comparatively larger posterior fossa convexity, posterior petrous face, and CPA meningiomas, the tailored exposure allows for maximal resection with minimal morbidity.

The concept of omitting the condylar resection during a far-lateral craniotomy was first introduced by Nanda et al., who conducted a cadaveric study demonstrating that a 50% resection of the condyle equated to a 19.9° increase in the angle of visibility. Their accompanying clinical experience used this approach to treat lesions of the foramen magnum, including meningiomas, aneurysms, dermoid cysts, and rheumatological manifestations. In our experience, lesions at the foramen magnum, as well as those that are more ventrally placed, are best treated with condylar resection. This approach allows more lateral visualization, although it can be avoided in certain circumstances, as exemplified by their report.

For lesions located more cranially, such as those described in the current series, the condylar resection contributes little to expanding the operative field. In our experience, maximal resection is instead facilitated by aggressive CSF decompression and a wide dural opening. Accordingly, our modified far-lateral approach combines lumbar drainage with direct access to the cervical subarachnoid space to attain immediate decompression. Skeletonization of the transverse and sigmoid sinuses also allows for their retraction with dura, widening the opening into the CPA and creating a trajectory flush with the petrous bone (Fig. 3). In contrast, the traditional retrosigmoid or suboccipital craniotomies leave a ledge of bone over the sigmoid sinus that closes these surgical corridors and necessitates cerebellar retraction. Compared with the standard supine position for a retrosigmoid craniotomy with head rotation, which allows the surgeon to view the tumor interfaces from behind and below, this position...
and the approach allow the surgeon to view the interfaces from either side of the patient, below and above, with a more direct and less tangential view.

Petrous face meningiomas and CPA meningiomas are the most common meningiomas of the posterior fossa and are typically treated with a retrosigmoid craniotomy. While this approach has been used with success, its utility declines with large-diameter tumors, which can exert extreme mass effect that, in turn, precipitates the cerebellum to herniate beyond the dural edges and can place adjacent cranial nerves, already on stretch, at risk during tumor manipulation. Greater exposure not only decompresses the posterior fossa contents, but also reduces the risk of venous bleeding and vascular injury.

Although partial condylar resection is a central component of the standard far-lateral approach, its utility is only evident when lateral exposure and lateralized line of sight is needed at the level of the foramen magnum. However, resection of the condyle is not without risk. Partial occipital condylectomies can lead to occiput–C1 instability with as little as 50% removal. Additionally, while the modified far-lateral approach does not eliminate the risk of encountering bleeding from a robust circular sinus, eliminating the need for condylar resection lessens the chance of disrupting engorged veins that are sometimes associated with this venous complex. Furthermore, the variable course of the condylar vein can lead to unnecessary and inconvenient blood loss. For the lesions we describe, foregoing condylar resection did not appreciably change our ability to maximize tumor resection, but it simplified the each operation considerably.

Conclusions

In the modern neurosurgical era, in which posterior fossa meningiomas are often managed conservatively and radiosurgical treatment is an established alternative, large or giant posterior fossa convexity, cerebellopontine, and posterior petrous face meningiomas represent an increasingly greater proportion of the meningioma surgeon’s operative experience. The modified far-lateral craniotomy we have described is an efficient technique to maximize resection while minimizing operative morbidity. Our data suggest that the current morbidity profile with this approach includes a 17% rate of transient neurological morbidity, but a 0% incidence of permanent deficit, while achieving a Simpson Grade I or II resection in 75% of patients.

N. Sanai and M. W. McDermott

Disclaimer

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

Acknowledgment

The authors would like to thank the departmental illustrator, Kenneth X. Probst, for all manuscript artwork.

References


Manuscript submitted January 24, 2009. Accepted June 29, 2009. Please include this information when citing this paper: published online October 30, 2009; DOI: 10.3171/2009.6.JNS09120. Address correspondence to: Michael W. McDermott, M.D., Department of Neurological Surgery, University of California at San Francisco, 505 Parnassus Avenue, Box 0112, San Francisco, California 94143. email: mcdermottm@neurosurg.ucsf.edu.