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Case Report

Surgical management of a transosseous meningioma with invasion of torcula, superior sagittal sinus, transverse sinus, calvaria, and scalp

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Abstract

Background: Meningiomas involving both intradural and extradural structures are rare tumors. We report the complete resection of a massive complex transosseous meningioma that had invaded the torcula, superior sagittal sinus, occipital bone, and scalp.

Case Description: A 48-year-old male presented after 3 days of worsening headaches and blurry vision. Preoperative imaging demonstrated an 11 × 5-cm extra-axial mass that avidly enhanced with gadolinium in the region of the torcula. Angiography demonstrated occlusion of the involved portions of the superior sagittal sinus, torcula, and proximal left transverse sinus. Cortical drainage occurred via the veins of Labbé and deep drainage via an occipital sinus. Using image-guided stereotaxy, a wide-excision scalp resection and craniectomy with sinus exploration was planned for complete tumor removal. Parasitized cortical veins were preserved. Occluded portions of the superior sagittal sinus and left transverse sinus were resected along with the invaded parts of the falx and tentorium. The walls of the straight sinus, torcula, and right transverse sinus were repaired primarily to facilitate deep drainage. A latissimus dorsi free flap was used to reconstruct the scalp defect. Routine follow-up magnetic resonance imaging (MRI) at 18 months demonstrated no evidence of recurrence or regrowth.

Conclusions: This case illustrates the importance of identifying aberrant venous drainage pathways when considering ligation and resection of major sinuses and discusses the management of calvarial and scalp invasion.

Key Words: Dural venous sinus, meningioma, superior sagittal sinus, torcula, transosseous

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INTRODUCTION

Meningiomas arise from arachnoid cap cells in arachnoid granulations, which are particularly abundant near the dural venous sinuses and give rise to intradural tumors involving the superior sagittal sinus, torcula, and transverse sinuses.[5] Extradural meningiomas occur in locations other than the dura mater, such as the skin,

nasopharynx, neck, or bone.[9,10,14,16] Primary intradural meningiomas may grow through the bone or metastasize to extradural locations.[1,10,29,30] The majority of cases involve the skull base, convexity in the periorbital and frontoparietal regions, or cranial sutures.[7,9] We describe a case of a transosseous meningioma with extensive involvement of the occipital lobes, dural sinuses, calvaria, and scalp. We highlight the surgical strategy of ligating and resecting occluded portions of the sinuses to obtain a gross-total resection when sufficient collateral venous drainage is present, and we discuss complex repair of skull and scalp defects.

CASE REPORT

History and presentation

A 48-year-old male presented to the emergency department after experiencing 3 days of worsening headaches and blurry vision. Physical examination revealed an inferior field hemianopsia and a large firm protuberance in the posterior occiput without any overlying skin abnormality. He was a nonsmoker with no history of cancer, and a screening computed tomography (CT) scan of his chest, abdomen, and pelvis showed no evidence of malignancy. Magnetic resonance imaging and magnetic resonance angiography (MRI/MRA) of his brain demonstrated an 11 × 5-cm mass that extended both supra- and infratentorially and into the bilateral parietal and occipital lobes, the superior sagittal sinus, the torcula, and the proximal transverse sinuses [Figure 1]. There was transosseous extension through the calvaria into the posterior scalp and dermis. Cerebral angiography revealed lack of flow through portions of the superior sagittal sinus, torcula, and proximal transverse sinuses [Figure 2]. Deep venous drainage proceeded via an occipital sinus [Figure 2] and cortical venous drainage via enlarged veins of Labbé [Figure 3]. The tumor was hypervascular, with its major arterial supply from meningeal branches of the external carotid arteries (ECAs) and the posterior inferior cerebellar arteries [Figure 4]. Prior to surgery, the ECA tumor feeding vessels were embolized with coils and polyvinyl alcohol particles [Figure 4]. Our differential diagnosis included hemangiopericytoma, meningioma, sarcoma, and occult malignancy.

Surgery

A small open biopsy of the abnormal scalp and involved occipital bone was performed as an initial procedure to obtain a tissue diagnosis. Pathological analysis revealed meningioma, World Health Organization (WHO) Grade I. For definitive treatment, the patient was positioned prone using a Mayfield 3-pin head holder. Using image-guided stereotaxy, we planned a wide-excision scalp resection and craniectomy with sinus exploration to allow for complete tumor removal. The scalp was excised en bloc in a circular fashion with a wide margin, and intraoperative frozen pathological diagnosis confirmed that the scalp margins were free of tumor. The underlying calvaria was grossly abnormal—alternately hyperostotic with areas of soft tumor infiltration. The superior sagittal sinus, torcula, and transverse sinuses were outlined stereotactically, and multiple burr holes were placed along the sinuses and the periphery of the planned bone flap, which encompassed portions of both the supra- and infratentorial compartments. Craniectomy was performed using a high-speed drill with burrs and footplate.

The dura was opened over the bilateral parietal and occipital lobes. The tumor was dissected from the underlying brain using standard microsurgical technique [Figure 5]. Clear brain invasion was noted throughout with parasitized dilated cortical vessels, which were preserved since they drained into veins of

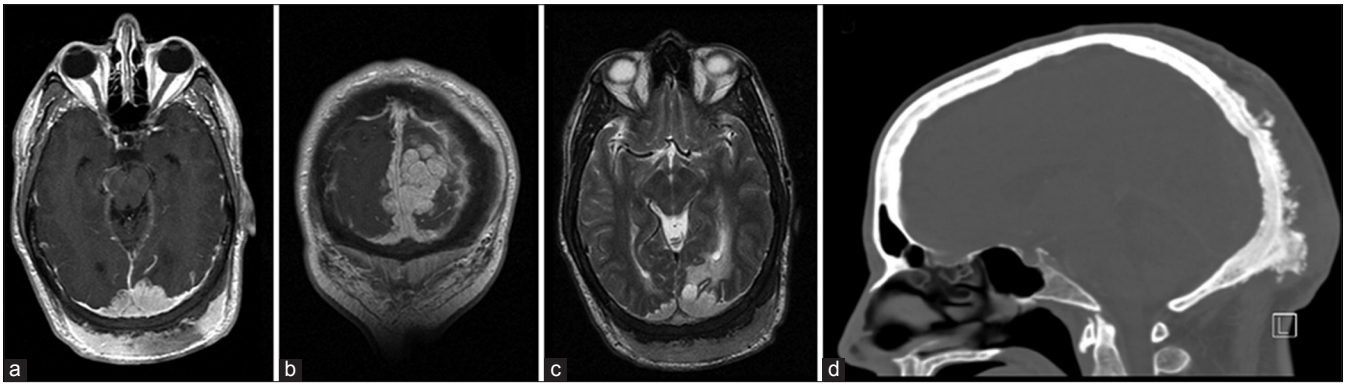

Figure 1: Axial (a) and coronal (b) contrast-enhanced T1-weighted MRI demonstrates tumor encasing the posterior portion of the superior sagittal sinus extending into the torcula. Abnormal thickening of the posterior scalp is seen. (c) Axial T2-weighted MRI sequence demonstrates abnormal hyperintensity in the white matter of the occipital lobe consistent with vasogenic edema from parenchymal tumor invasion. (d) Sagittal view of contrast-enhanced CT scan, bone window, shows that the occipital bone is both hyperostotic and thickened from tumor infiltration

Figure 2: Lateral view cerebral angiogram after left internal carotid artery injection. The posterior skull/extra-axial tumor invades and occludes 7 cm of the posterior superior sagittal sinus, torcula, and proximal transverse sinus (black arrows). There is reconstitution at the distal transverse sinuses. Deep venous drainage occurs via an occipital sinus that connects the straight sinus to the left jugular bulb (white arrow)

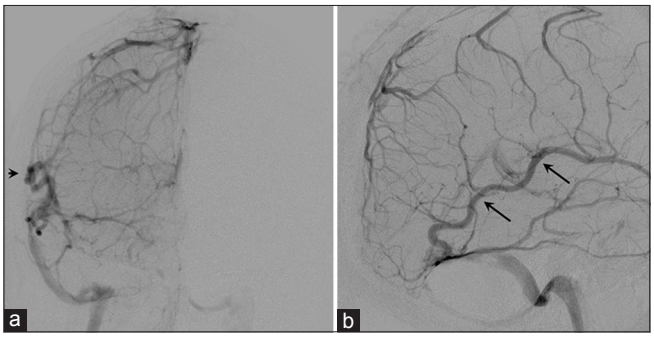

Figure 3: Anteroposterior (a) and lateral projection (b) cerebral angiogram depicting the venous phase of a right internal carotid artery injection. Cortical venous drainage proceeds via a dilated vein of Labbé (black arrows)

Labbé. We then followed the tumor to where it abutted the normal-appearing section of superior sagittal sinus. The proximal normal sinus was ligated with a 3-0 Vicryl suture, and the sinus and falx were incised down to the straight sinus, which was not invaded and was preserved. We continued our resection to the torcula and left transverse sinus, both of which were extensively invaded and occluded. The involved walls were ligated and incised, and the tentorium was resected along with the tumor bulk. The right transverse sinus was not invaded. The remaining right transverse and straight sinus walls were repaired primarily using 6-0 Prolene sutures. Inspection of the surgical field revealed no gross tumor. Reconstruction was performed using a sutured Alloderm duroplasty and titanium mesh cranioplasty. The plastic surgery team then repositioned the patient to a lateral decubitus position and performed a left latissimus dorsi free flap for soft tissue coverage. The thoracodorsal artery was anastomosed to the left superficial temporal artery using 8-0 nylon suture, and the thoracodorsal vein was anastomosed to the superficial temporal vein using a 2-mm venous coupler. The muscle was inset over closed suction drains and then covered with a split thickness skin graft [Figure 6]. Last, a halo vest was applied to prevent pressure to the flap during the postoperative period.

Postoperative course

Postoperatively, the patient was transferred to the intensive care unit. Initially, he experienced surgery-related visual disturbances with diminished visual acuity, which gradually improved during inpatient rehabilitation. Final pathological diagnosis from the gross total resection was also meningioma, WHO Grade I. The halo vest was continued for 6 weeks. At his 6-month follow-up appointment, the patient was able to read a newspaper with reading glasses, but his

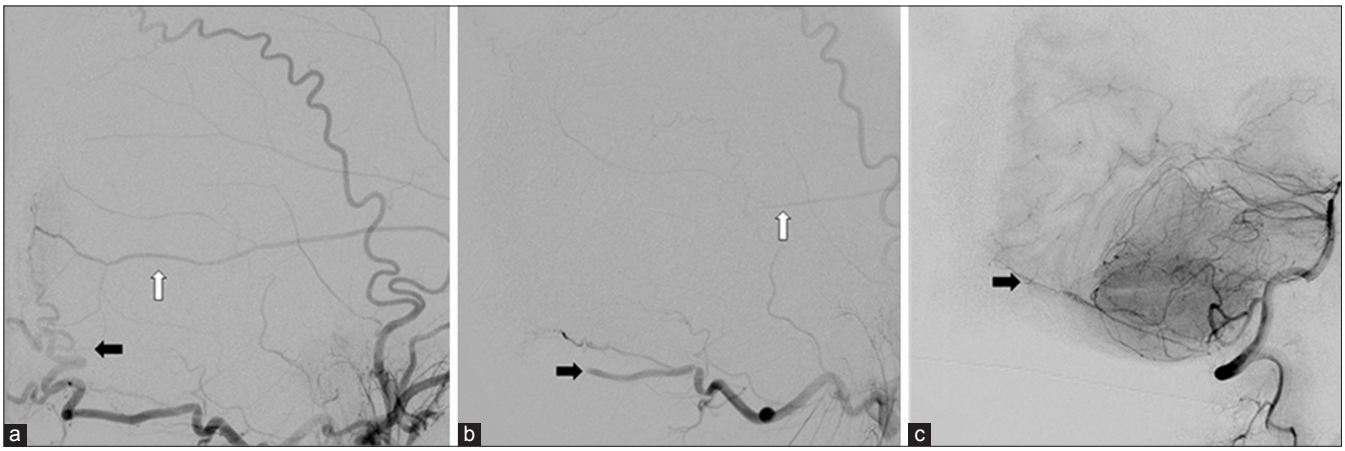

Figure 4: Pre (a)- and post (b)-embolization images of the left external carotid artery injection. Main arterial feeders include branches of the occipital (black arrows) and middle meningeal arteries (white arrows), which were successfully embolized. Arterial feeders were also embolized from similar branches of the right external carotid artery (not shown). (c) Right vertebral artery injection depicting a posterior meningeal artery branch arising from the posterior inferior cerebellar artery and feeding the meningioma. This branch was not embolized

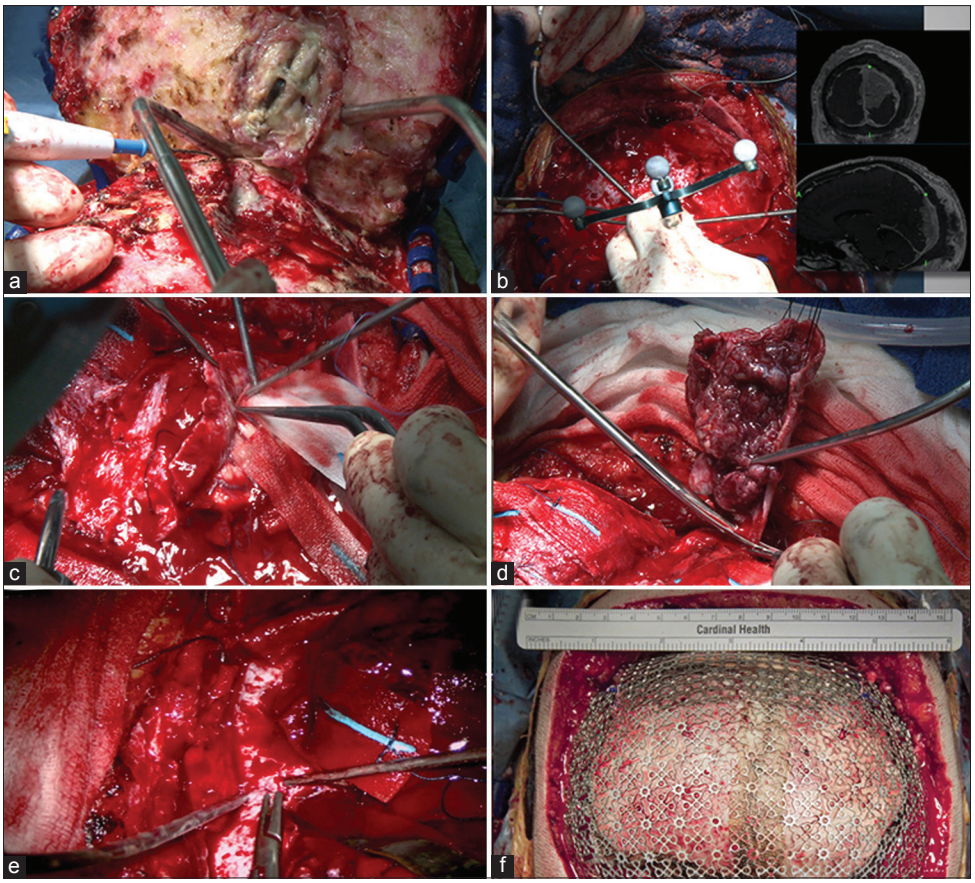

Figure 5: Intraoperative photographs depicting (a) extension of the meningioma from the bone to scalp; (b) use of neuronavigation to identify the margin of venous sinuses for ligation; (c) dissection of tumor that has invaded the pia and into the occipital lobe; (d) gross resection of the tumor and its dural attachment; (e) primary repair of the torcula suture after the intrasinusal tumor portions are removed; (f) duroplasty and overlying titanium mesh cranioplasty prior to placement of latissimus dorsi free flap

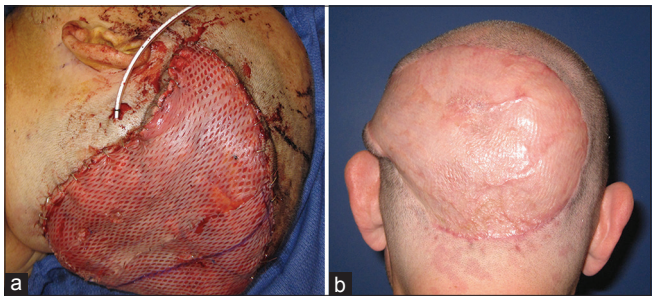

Figure 6: Postoperative radiographs of latissimus dorsi free flap with split-thickness skin graft immediately after surgery (a) and at 3 months (b)

preoperative inferior hemianopsia remained stable. A minor revision of scalp reconstruction was performed to remove a lateral dog-ear deformity, but otherwise, he healed without complication. Routine follow-up MRI at 18 months demonstrated no evidence of recurrence or regrowth [Figure 7].

DISCUSSION

Complex meningiomas invading the torcula are uncommon. Published series of meningiomas involving the tentorium or major dural sinuses include only a few cases of tumors with torcular involvement.[2,6,19,26] Most of the evidence regarding the management of these lesions must be extrapolated from studies of meningiomas involving the superior sagittal, transverse, and sigmoid sinuses. Addressing these complex lesions requires extensive preoperative planning, and surgery should be performed at tertiary and quaternary care centers with access to multiple specialist teams. The operative strategy is determined by tumor location, extent of invasion into local structures including the brain, sinuses, skull, and scalp, as well as histologic grading of the tumor. The desire to achieve a complete or low Simpson grade resection must be balanced with providing the best possible outcome for the patient.[21,28] Many surgeons advocate complete or near-total resection of meningiomas to prevent regrowth, particularly in younger patients. Others argue that the risk of additional morbidity may not warrant an aggressive resection of tumor around critical structures, such as the dural venous sinuses. With modern microsurgical technique, recurrence may be similar among Simpson grades, at least in the short term,[21,28] given that today's surgeons are able to operate more

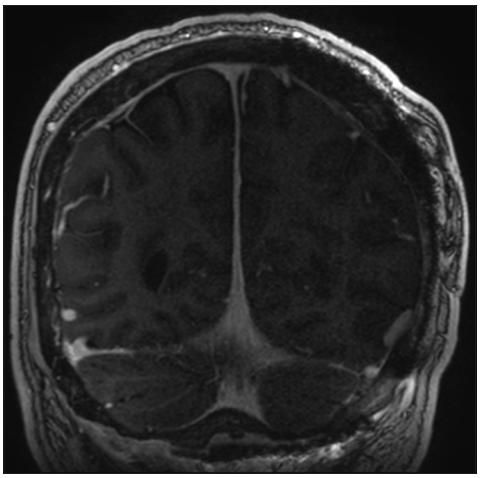

Figure 7: Coronal contrast-enhanced T1-weighted MRI at 18 months depicts gross-total resection of the transosseous meningioma with no evidence of recurrence or regrowth

aggressively so that portions of tumor remaining around nerves and blood vessels are much smaller than in the past. The literature does not provide guidance on how the extent of resection in the modern era affects long-term recurrence rates. A gross-total resection is preferred if the additional resection does not carry a significant risk of morbidity. For meningiomas invading the dural sinuses, the extent of resection often depends on the surgeon's experience and comfort in dealing with the venous anatomy.

Management of dural venous sinuses

Radical resection of meningiomas invading the dural venous sinuses is controversial. Some authors advocate performing a complete resection to prevent tumor recurrence or regrowth,[18,26] which may include opening the involved sinuses, removing the intravascular portions of tumor, and restoring venous drainage with direct suturing or autologous graft materials. Others prefer a more conservative approach, electing to debulk the extravascular portions of tumor from the outer walls of the sinuses and treating residual tumor with adjuvant radiation or observation.[2,6,23]

It is generally accepted that patients can tolerate resecting portions of the venous sinuses that are completely occluded. Nonetheless, surgical resection of meningiomas invading the sinuses must be balanced with avoidance of venous outflow obstruction, which could cause neurological complications, such as brain swelling, cerebrospinal fluid obstruction, seizures, hemorrhage, infarction, and death. Some surgeons are in favor of flow restoration with sinus reconstruction or bypass even when the sinus is completely occluded. Because the reconstructed outflow tract allows time for compensatory collateral circulation to form, patients may better tolerate alterations in venous drainage that occur after the meningioma is resected. Delayed complications from cerebral edema have occurred in patients who had meningiomas occluding the sinus who did not undergo venous restoration.[26] Despite these risks, recent studies have shown that good outcomes can be achieved after radical resection by experienced surgeons.[19,26]

Sindou and Alvernia[26] reported a complication rate of 8% and mortality rate of 3% in 100 consecutive cases of meningiomas involving the major dural sinuses. Gross-total resection was achieved in 93%, and sinus reconstruction was performed in 45%. Similarly, Montovani *et al*.[18] reported a series of 38 patients in which complete tumor removal was attempted whenever possible and the sinuses were reconstructed. Complete surgical resection occurred in 33 of 38 patients, and there were only 2 recurrences (5.3%) after a mean follow-up of 26 months. One patient experienced a major complication related to the venous repair, but there were no deaths. At our institution, we have had success performing gross-total or near-total resection in patients with meningiomas invading a dural sinus.[19] If the sinus is incompletely occluded, we prefer to repair the defect in the sinus wall primarily with a dural graft or allogeneic tissue patch using monofilament suture (Prolene, 6-0 or 7-0). Aspirin is administered per rectum in the operating room along with an intravenous heparin bolus to prevent sinus thrombosis after the repair. Aspirin is continued postoperatively for several weeks.

Because fractionated radiation therapy and stereotactic radiosurgery of small meningiomas can achieve acceptable tumor control rates,[15] some surgeons prefer to perform a subtotal resection and treat residual tumor with radiation initially or at the time of recurrence. However, reports of long-term outcomes after radiosurgery are lacking in the literature, and radiation is generally not used for large, symptomatic tumors, such as this case. Moreover, radiosurgery is not without risks. Irradiation of peritumoral blood vessels can cause venous occlusive complications and resultant cerebral edema. This may account for the higher morbidity rate following radiosurgery in meningiomas involving the venous sinuses.[15,27] Given our patient's youth and the massive size of the tumor, we elected to proceed with complete resection to decrease his risk of recurrence or regrowth.

Ligation of the occluded sections of the venous sinuses was necessary to completely excise the involved sinus walls and resect the extensive intravascular portions of tumor. To minimize risk of venous complications in these cases, many authors, including us, recommend preoperative angiography to verify a widely open contralateral transverse sinus or evidence of sufficient venous collateral formation.[19,20,24,25] In this case, care

was taken to ensure that the aberrant superficial and deep venous pathways remained patent; however, preoperative angiography must be interpreted cautiously. The extent of sinus invasion may be greatly underestimated on imaging.[2,13,27] Even if the sinus does not appear patent, it may have functional importance, since venous complications have been reported after resection of portions of a completely occluded sinus.[4,8,12,26] In our experience, an involved sinus may appear occluded radiographically but be patent upon surgical exploration. In these cases, we prefer to perform sinus reconstruction because collateralization may not have had enough time to develop and sinus ligation may precipitate venous hypertension. When the decision is made to open a partially occluded sinus, it is crucial that venous drainage remains patent after the repair. Mantovani *et al*.[18] described techniques to decrease the risk of postoperative sinus thrombosis. These include limiting the resection to involved sinus walls while leaving normal walls intact, performing the proximal closure first and allowing back bleeding to occur during suturing of the graft, and using autologous materials such as native dura or fascia. We frequently give patients aspirin per rectum intraoperatively and continue antiplatelet therapy for several weeks to prevent postoperative thrombosis.

Patients with meningiomas involving the posterior third of the superior sagittal sinus frequently present with visual disturbances or visual field deficits that impact their quality of life.[3,12] Biroli *et al*.[3] reported that visual disturbances resolved in most and visual field deficits improved in nearly half of patients who underwent resection of meningiomas in this region with sparing of the visual cortex. Improvement is often observed in cases in which the visual deficit is surgery induced; however, given that our patient underwent complete resection of meningioma that had invaded his occipital lobes, his modest improvement in vision on his 6-month follow-up appointment was unexpected.

Management of skull and scalp defects

In addition to the removal of the intradural and intravascular portions of this transosseous meningioma, wide excision of the involved calvaria and overlying scalp was required to prevent recurrence. Histological analysis has shown that meningothelial tumor cells infiltrate the Haversian canals of hyperostotic bone.[22] In our patient, tumor cells were identified not only in the bone but also in the scalp. For large scalp defects (>25 cm^2), free tissue transfer is often the reconstructive method of choice as it enables placement of well-vascularized tissue directly over the prosthetic cranioplasty.[11,17] Latissimus dorsi is an excellent donor flap for the scalp because of its large size, excellent vascularity for compromised beds, and ability to contour well to the scalp. While the latissimus dorsi flap can be harvested with a skin paddle, a skin graft over the muscle flap allows for a thinner flap, which is a better match for the surrounding scalp skin.[17] The placement of a halo vest during the postoperative period is a useful adjunct for protection of a flap when the defect is in a posterior location as the muscle flap and the overlying skin graft are particularly vulnerable to pressure necrosis.[31]

CONCLUSIONS

We describe the complete resection of a large transosseous meningioma that invaded the occipital lobes, posterior section of the superior sagittal sinus, torcula, transverse sinus, calvaria, and scalp. Collateral venous drainage of the cortex via the veins of Labbé and deep structures via an occipital sinus allowed for the resection of the involved walls of the venous sinuses without complication. Scalp reconstruction with a latissimus dorsi free flap enabled the complete removal of tumor that had invaded the scalp.

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