



## Complete Cavernous Sinus Resection: An Analysis of Complications

Robert C. Rennert<sup>1</sup>, Kristine Ravina<sup>2</sup>, Ben A. Strickland<sup>3</sup>, Joshua Bakhsheshian<sup>3</sup>, Vance L. Fredrickson<sup>3</sup>, Jonathan J. Russin<sup>2</sup>

**■ BACKGROUND:** Complete cavernous sinus resection has been described for patients with malignant or recurrent cavernous sinus tumors without other therapeutic options but has been associated with high morbidity and mortality rates. We reviewed the complications associated with complete cavernous sinus resection to gain insights for future complication avoidance.

**■ METHODS:** A retrospective analysis of a prospective, single-institution database was performed to identify patients who had undergone complete cavernous sinus resection from July 2014 to October 2017. Patient- and disease-specific data, surgical complications, and clinical outcomes were recorded.

**■ RESULTS:** Two male patients underwent complete cavernous sinus resection (aged 60 and 47 years) for recurrent maxillary tumors with secondary cavernous sinus extension. Revascularization was performed based on balloon test occlusion (BTO) results, with extracranial-to-intracranial bypass performed in 1 patient with a concerning hemispheric flow pattern found during BTO. Vascularized free flaps were used in both patients to assist with closure of the resulting skull base defect. Three complications related to surgery occurred in 1 patient (thigh hematoma, recurrent cerebrospinal fluid leak, and meningitis). One patient died of pneumonia approximately 2 weeks postoperatively, and the other experienced an acceptable neurologic and oncologic outcome.

**■ CONCLUSIONS:** Despite the high peri- and postoperative risks, complete cavernous sinus resection can be considered for select patients with tumors involving the cavernous

sinus without other treatment options. Familiarity with cerebral bypass and free flap reconstruction of skull base defects is critical for complication avoidance and management.

### INTRODUCTION

An increased understanding of cavernous sinus anatomy has made surgery within and around the cavernous sinus increasingly safe.<sup>1,2</sup> Complete resection of the cavernous sinus, nonetheless, represents an aggressive surgical option reserved for patients with progressive or recurrent cavernous sinus tumors without palatable medical or radiotherapy options.<sup>3</sup> Cerebral bypass is often indicated as part of this procedure to ensure adequate anterior circulation perfusion before sacrifice and resection of the cavernous carotid artery. Although the loss of ipsilateral function of cranial nerves II–VI can be expected with this procedure, rates of additional morbidity and mortality have also been high.<sup>3</sup>

Given the technical challenges and operative risk associated with complete cavernous sinus resection, the recent neurosurgical data on this topic are limited to 1 series of 8 patients.<sup>3</sup> We explored the complications associated with 2 cases of complete cavernous sinus resection for recurrent tumors to identify potential clinical and surgical insights for future avoidance of complications.

### METHODS

The present study was performed in accordance with the Health Insurance Portability and Accountability Act

#### Key words

- Cavernous sinus
- Cerebral bypass
- Free flap
- Radical resection

#### Abbreviations and Acronyms

- ACOM:** anterior communicating artery  
**ALT:** anterolateral thigh  
**BTO:** balloon test occlusion  
**CSF:** cerebrospinal fluid  
**ENT:** ear, nose, and throat  
**ICA:** internal carotid artery  
**MRI:** magnetic resonance imaging  
**SPECT:** single photon emission computed tomography

From the <sup>1</sup>Department of Neurological Surgery, University of California-San Diego, San Diego, California, USA; and <sup>2</sup>Neurorestoration Center, <sup>3</sup>Department of Neurological Surgery, University of Southern California Keck School of Medicine, Los Angeles, California, USA

To whom correspondence should be addressed: Jonathan J. Russin, M.D.  
 [E-mail: [jonathan.russin@med.usc.edu](mailto:jonathan.russin@med.usc.edu)]

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regulations. Patient consent for data collection and review, and for surgical procedures was attained in compliance with institutional guidelines.

A retrospective analysis of an institutional review board–approved prospective database was performed spanning a 3-year period (July 2014 to October 2017) at a single institution to identify patients who had undergone complete cavernous sinus resection. Recorded data included patient demographics (age, gender), disease-specifics, surgical complications, and clinical outcomes. Oncologic management plans were created in accordance with the recommendations of an institutional tumor board. Surgical plans were devised in consultation with the otolaryngology and neurovascular teams. The decision to pursue a bypass was based on the interpretation of a balloon test occlusion (BTO). The BTO included 30 minutes of ischemia time, angiographic assessment of collateral flow through the anterior and posterior communicating arteries, and radionuclide injection during a period of induced hypotension for subsequent cerebral perfusion single photon emission computed tomography (SPECT), as a surrogate to assess the ischemic risk with carotid sacrifice.

### Surgical Technique

**Positioning and Bypass.** The patients were taken to the operating room and intubated, and a lumbar drain was placed for cerebrospinal fluid (CSF) diversion. The patients were then positioned supine on the operating room table, with the head affixed in a Mayfield head holder clamp and turned to expose the operative side, and neuromonitoring signals were obtained. The frontotemporal skull and ipsilateral neck were cleaned and prepared. If a bypass was indicated, this was performed initially using a standard technique for a high-flow proximal internal carotid artery (ICA) to M2 bypass with a radial artery interposition graft. Specifically, a frontotemporal or orbitozygomatic craniotomy was performed, and an insular M2 vessel was dissected free. The radial artery was harvested and prepared before being anastomosed in an end-to-side fashion to the M2 using 10-0 suture. The free end of the radial artery was then tunneled to the neck and anastomosed in an end-to-side fashion to the proximal internal carotid artery using 9-0 suture. The proximal internal carotid after the bypass takeoff was then occluded with a permanent aneurysm clip. All bypasses were performed under anesthetic burst suppression.

The Sylvian fissure was then split to the opticocarotid cistern, and the anterior clinoid was removed via an intradural approach using a number 2 and number 3 coarse diamond drill. The distal internal carotid was then occluded with a permanent aneurysm clip positioned between the ophthalmic and posterior communicating arteries (with the proximal carotid occluded after the bypass, as previously described, or endovascularly sacrificed preoperatively if the patient had had suitable BTO findings).

**Cavernous Sinus Resection.** The key anatomy relating to cavernous sinus resection is highlighted in **Figure 1**. A maxillectomy and orbital exenteration were first performed

as needed based on the tumor location, in conjunction with the otolaryngology team. The optic nerve and optic artery were divided intracranially, and the contents of the optic canal were resected in bulk. The contents of the superior orbital fissure were sharply divided. The distal dural ring was then opened, and the cavernous sinus was entered. Hemostasis was achieved with a combination of liquid hemostatic agents and bipolar electrocautery. The posterolateral wall of the cavernous sinus was then resected from the porous oculomotorius to the dura overlying the floor of the middle cranial fossa using bipolar electrocautery and microscissors. The anterior portion of Meckel's cave was also resected. The cavernous carotid was then transected distally, and the proximal cavernous carotid was elevated to its entrance into the petrous bone and transected. The cavernous sinus contents were then resected en bloc. Skull base drilling and bony resection involving the sphenoid and ethmoidal sinuses, as well as the petrous ridge and sphenoid wing were performed as needed based on tumor involvement. Tissue samples from the operative margins were sent for intraoperative pathologic analysis to ensure complete tumor resection.

Closure was tailored based on the operative defect and risk of CSF leak. If previous surgeries had been performed in the region and closed with a free flap that provided adequate soft tissue coverage, the dura was reapproximated, the bone was plated, and a simple layered closure was used. If additional soft tissue coverage was needed at the time of cavernous sinus resection, an anterolateral thigh (ALT) vascularized free flap buttressing the dura was used to aid in closure, with assistance from the otolaryngology team. Lumbar drains were kept in place postoperatively and weaned slowly after testing for CSF leakage.

### RESULTS

Two male patients, aged 60 and 47 years, underwent complete cavernous sinus resection for recurrent maxillary tumors with secondary spread to the cavernous sinus (**Table 1**). Gross total resection was achieved in both cases. Although both patients passed a BTO, an extracranial-to-intracranial bypass was performed in 1 patient because of a concerning hemispheric flow pattern during the test ICA occlusion. ALT free flaps for wound closure were used for both patients. In 1 patient, the free flap was performed as part of an immediately preceding partial resection of the cavernous sinus tumor. In the other patient, it was performed with the complete cavernous sinus resection.

Complications related to surgery occurred in 1 of the 2 patients and included a thigh hematoma requiring evacuation, a recurrent CSF leak requiring a fat graft and subsequent shunt, and meningitis. One of the patients died of pneumonia approximately 2 weeks postoperatively. However, the other experienced an acceptable functional and oncologic outcome.

### Case Presentations

**Patient 1.** A 60-year-old man with a recurrent, high-grade osteosarcoma originating in the left maxillary sinus who had previously undergone radical resection with ALT free flap reconstruction and

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