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Surgical management of skull base tumors

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ABSTRACT

Aim: To present a review of the contemporary surgical management of skull base tumors.
Background: Over the last two decades, the treatment of skull base tumors has evolved from observation, to partial resection combined with other therapy modalities, to gross total resection and no adjuvant treatment with good surgical results and excellent clinical outcomes.
Materials and methods: The literature review of current surgical strategies and management of skull base tumors was performed and complemented with the experience of Barrow Neurological Institute.
Results: Skull base tumors include meningiomas, pituitary tumors, sellar/parasellar tumors, vestibular and trigeminal schwannomas, esthesioneuroblastomas, chordomas, chondrosarcomas, and metastases. Surgical approaches include the modified orbitozygomatic, pterional, middle fossa, retrosigmoid, far lateral craniotomy, midline suboccipital craniotomy, and a combination of these approaches. The selection of an appropriate surgical approach depends on the characteristics of the patient and the tumor, as well as the experience of the neurosurgeon.
Conclusion: Modern microsurgical techniques, diagnostic imaging, intraoperative neuronavigation, and endoscopic technology have remarkably changed the concept of skull base surgery. These refinements have extended the boundaries of tumor resection with minimal morbidity.

1. Background

Until the later decades of 20th century, lesions located at the base of the skull were considered inoperable. The introduction of microsurgical techniques, advances in neuroanesthesiology, magnetic resonance imaging (MRI), neuronavigation, endoscopy, high-speed drills, and hemostatic agents have dramatically changed the management of these tumors. The main goal of these techniques is to enhance surgical exposure by means of bony resection in order to minimize the need for brain retraction. When brain retraction is necessary, experienced neurosurgeons have replaced fixed retraction with dynamic retraction, thus limiting the risk of

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injury to underlying brain.[1] Patient positioning that enhances gravity retraction, extensive dissection of arachnoid planes, the refinement of microsurgical instrumentation, appropriate selection of operative corridors, and neuronavigation have all been used to improve patient outcomes and reduce morbidities.[1–4] The key principle of skull base surgery is to deconstruct the bony skull base around the brain to create safe apertures to resect deep-seated pathologies.

2. Materials and methods

A review of English-language literature was performed on PubMed on contemporary surgical strategies and management of skull base tumors was performed. This review was complemented with knowledge gained from surgical results and the clinical outcome experience of patients treated at Barrow Neurological Institute.

3. Results

Skull base tumors include meningiomas, pituitary tumors, sellar/parasellar tumors, vestibular and trigeminal schwannomas, esthesioneuroblastomas, chordomas, chondrosarcomas, and metastases. Surgical approaches to the anterior and middle skull base include orbitozygomatic craniotomy or modified orbitozygomatic craniotomy, pterional craniotomy, and middle fossa craniotomy, anterior and posterior transpetrosal approach. Surgical approaches to the posterior fossa include retrosigmoid craniotomy, extended (mastoidectomy, petrosectomy) retrosigmoid craniotomy, far lateral craniotomy, and midline suboccipital craniotomy. The selection of an appropriate surgical approach depends on the characteristics of the tumor (size, type, vascularity, and anatomical relations with the normal brain and/or brainstem) and the experience of the neurosurgeon.

4. Discussion

4.1. *General classifications and epidemiology*

Skull base tumors can generally be classified as either benign (meningiomas, sellar/parasellar tumors, vestibular and trigeminal schwannomas)[5] or malignant (chordoma, chondrosarcoma, metastasis),[5] although there is a crossover. The incidence of skull base meningiomas is 2 per 100,000 per year. The incidence of pituitary tumors and vestibular schwannomas is 1 per 100,000 per year.[5] Skull base metastases are more common and have an incidence of 18 per 100,000 per year.[6] The skull base can be invaded by malignancies originating from the sinonasal tract (esthesioneuroblastoma),[7] the nasopharynx (squamous cell carcinoma),[8] the oropharynx, the ear region, and the orbit (meningioma, osteoma, rhabdomyosarcoma).[5]

4.2. *Meningiomas*

Meningiomas are the most common primary skull base tumors.[5] The mainstay of treatment for skull base meningiomas is surgical resection. The surgical approach depends upon the location and size of the tumor. Large tumors may need to be resected in several stages and may require more than one surgical approach. Surgical planning is tailored according to the tumor location and size. Complete surgical resection should be the primary goal. Occasionally, tumors can be firmly attached to the arteries and cranial nerves, making gross total resection impossible. Preoperative angiography and tumor embolization can be useful, but they are rarely necessary.[9] The 5-year recurrence rate for a totally resected World Health Organization grade I meningioma is 5%, 40% for grade II, and 50–80% for grade III.

4.3. *Anterior and middle skull base meningiomas*

Anterior skull base meningiomas include olfactory groove, planum sphenoidale, and tuberculum sellae meningiomas (Figs. 1 and 2).[10–13] The blood supply to these tumors can come from branches of the ethmoidal, meningeal, and ophthalmic arteries. Large tumors can also be supplied by branches of the anterior cerebral artery (A2, frontopolar) (Fig. 2). The olfactory nerves are typically involved, being either displaced or adherent to the tumor. Although preservation of these nerves is challenging, it should be attempted. Even though patients might present as anosmic, return of olfaction after the tumor resection is possible (Fig. 1).[14] Surgical approaches to these tumors include unilateral frontal, bilateral frontal, modified orbitozygomatic, and pterional approaches.[5] The decision for an approach is made based on the tumor size, extension, size of the frontal sinus, and surgeon's preference. After exposing the lesion, in general, early devascularization of the tumor is preferred. The next step is tumor debulking, which begins with internal debulking and is followed by dissecting the capsule from adjacent structures and folding it in. Reaching the posterior tumor capsule can be the most challenging step, because branches of the anterior cerebral artery might be attached to or encased in the tumor. Even though there is usually an arachnoid plane between the tumor and optic nerve, meticulous dissection is needed to prevent optic nerve damage (Figs. 1 and 2).

Sphenoid wing meningiomas are typically favorable for surgical resection; however, they have the potential to increase the internal carotid artery (ICA), cavernous sinus, and optic apparatus. Based on location, sphenoid wing meningiomas can be subclassified in spheno-orbital (en plaque or hyperostotic) and globoid meningiomas.[15,16] Sphenoid wing meningiomas can be resected through a pterional or orbitozygomatic craniotomy. Lateral sphenoid wing meningiomas are frequently associated with hyperostosis. In those cases, the craniotomy should be planned to extend beyond the bony infiltration, and extensive skull base drilling is frequently required to completely remove the lesion. Extradural approaches facilitate access to the orbit, middle fossa, the superior and inferior orbital fissures, as well as the cavernous sinus, while minimizing trauma to the brain from retraction.

Ideally, a 1-cm tumor free margin of dura should be removed; however, this is frequently not possible when dealing with skull base lesions. Common complications associated with resection of anterior and middle fossa meningiomas