Surgical Approaches to Petroclival Meningiomas Part II: Extended Approaches

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In Part I, the classification, clinical presentation, and upper and midclival surgical approaches were discussed. This lesson covers extended surgical approaches, results, complications, and adjuvant therapy.

Extended Approaches

In large tumors, especially those with an extensive dural attachment or invasion into adjacent nasal sinuses or oropharynx, a combined approach may be necessary. These combined approaches may refer either to intradual/extradural or to supratentorial/infratentorial routes of access as dictated by the anatomical location of the tumor.

Petrosal Approach

As originally popularized by Malis, the combined supra- and infratentorial transpetrosal (or simply, petrosal) approach is ideal for tumors centered about the petrous apex with a large basal attachment necessitating extensive basal exposure. As emphasized by Al-Mefty and Smith, the combined petrosal approach offers several advantages, including minimal retraction of the temporal lobe and cerebellum, removal of lateral bone (which affords the surgeon a direct line of sight to anterior brainstem and clivus regions), preservation of the transverse and sigmoid sinuses (including the drainage of the vein of Labbé), interruption of the tumor's vascular supply early in the operative procedure with bony removal, and shortening of the operative distance to the clivus (Fig. 1). In agreement with these authors, we have had a favorable experience utilizing the combined supra- and infratentorial approach to these tumors; it is currently our approach of choice for those lesions with extensive basal attachment centered about the petrous apex. The approach may be combined with any of the standard transtemporal exposures (i.e., translabyrinthine, transcochlear) depending upon the status of hearing, tumor attachment, etc. Following the combined suboccipital/temporal craniotomy (burr holes are carefully placed to enable separation of the adherent dura of the transverse and sigmoid sinus from the overlying bone prior to using the craniotome) and temporal bone drilling, the dura is carefully opened anterior to the sinuses, taking care not to interfere with the vein of Labbé as it enters the transverse-sigmoid junction. The superior petrosal sinus is ligated and the tentorium is divided which allows retraction of the temporal lobe and cerebellum together, without interfering with the drainage of the sinus. As with any extensive skull base approach, air cells and any nasal sinuses that are entered must be closed meticulously to prevent the later development of a cerebrospinal fluid fistula. With the combined petrosal approach, or any transtemporal approach, the closure of the dura may become problematic, especially in those cases in which dura and/or overlying temporal bone has been drilled. The use of fascial and/or fat grafts within the temporal bone defect, with reapproximation of the outer table of the mastoid with titanium miniplates to tamponade the graft, may enhance watertight closure and avoid the undesirable cosmetic deformity resulting from temporal bone drilling.

Infratemporal Fossa Approach

Rarely, petroclival tumors may extend anterior and lateral to the clivus to involve the region of the infratemporal fossa. In such cases, one of the

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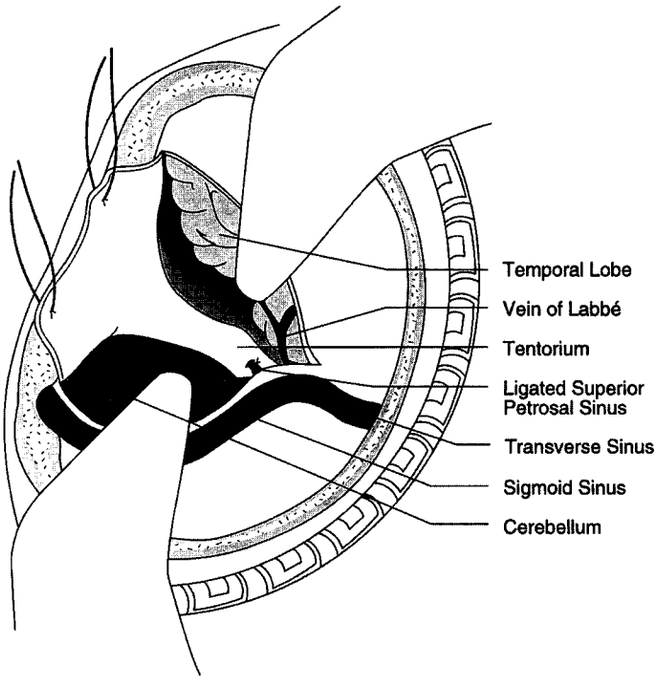

Figure 1. Combined supra- and infratentorial (petrosal) approach is our preferred approach to lesions with extensive supra-and infratentorial attachment. It enables exposure of the entire basal attachment without interference with major venous drainage. Following a combined suboccipital/temporal craniotomy and drilling of the temporal bone (retrolabyrinthine, translabyrinthine or transcochlear), the dura is opened along the base, and the superior petrosal sinus is ligated at its junction with the transverse/sigmoid sinus. With sectioning of the tentorium, this allows free retraction of both the posterior temporal lobe and the cerebellum for unimpeded access to the region of the petrous apex.

infratemporal fossa approaches (as popularized by Fisch) may be indicated, enabling exposure and removal of the extracranial component. Depending upon the intracranial mass, the approach may be performed primarily or combined with one of the more conventional intracranial approaches described above. The infratemporal fossa approach provides exposure to the jugular foramen and petrous apex, clivus proper, and anteriorly to the parasphenoidal region (Fig. 2). The procedure may be tailored to the pathology, but one of the major advantages to this approach is early control of the extracranial internal carotid artery. In addition, it offers wide access over the entire clivus without opening the pharyngeal wall, thereby avoiding contamination of the operative wound. The disadvantages include transposition of the facial nerve in the more extended infratemporal approach, resulting in potential facial weakness (type b or c approaches), and permanent conductive hearing loss if the middle ear cleft is to be obliterated.

Facial Translocation

Facial translocation may be used to approach lesions of the nasopharynx, clivus, and infratemporal fossa. Primarily intended for anterolateral cranial base lesions, it provides a surgical field extending from the contralateral eustachian tube to the ipsilateral cervical carotid artery encompassing the nasopharynx, clivus, and sphenoid sinus. Advantages to these extensive transfacial approaches are wide anterolateral exposure of the base of the skull and early access and control of extracranial vessels. Disadvantages, which include significant operative times and, as mentioned previously, operating in

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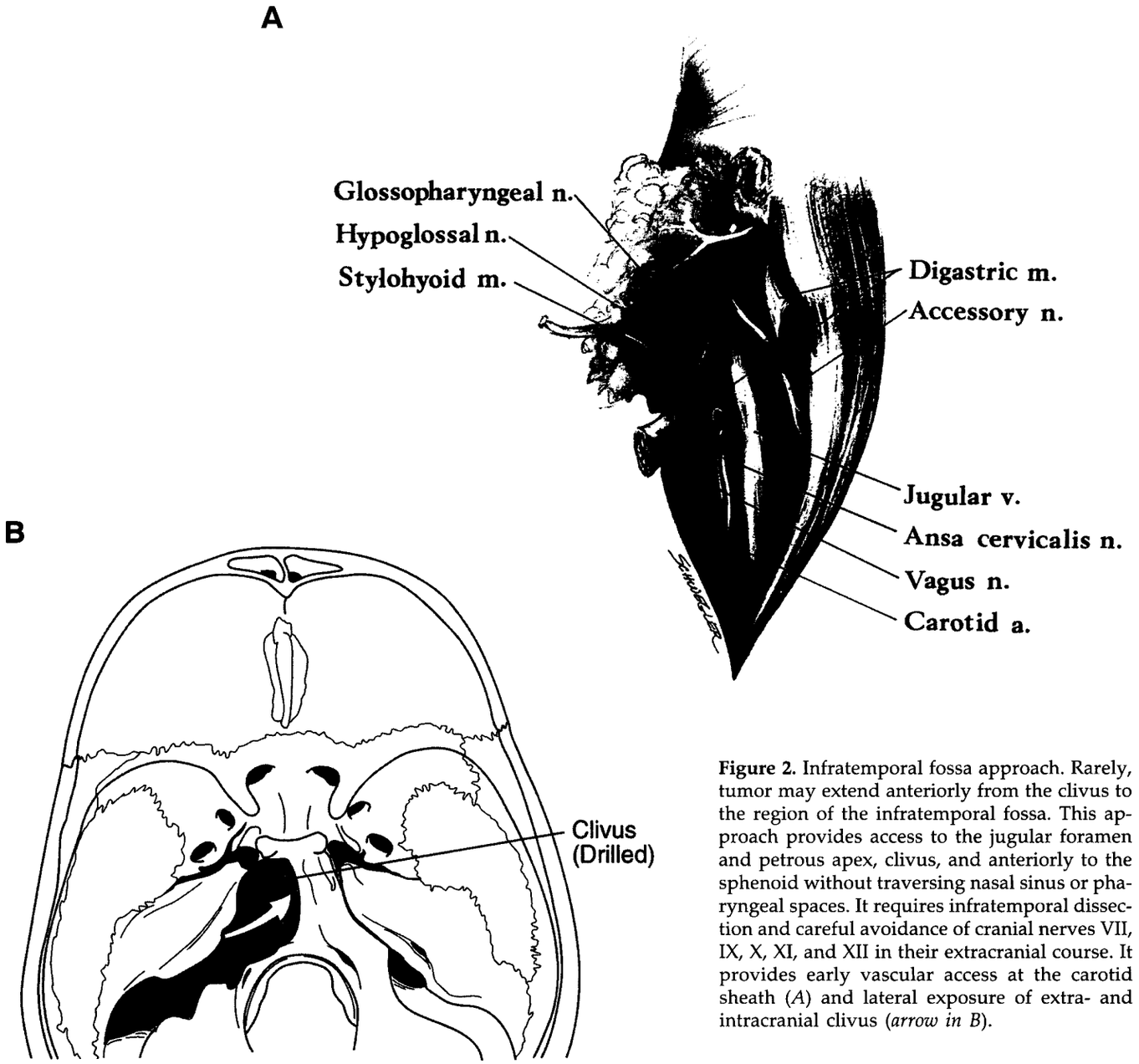

Figure 2. Infratemporal fossa approach. Rarely, tumor may extend anteriorly from the clivus to the region of the infratemporal fossa. This approach provides access to the jugular foramen and petrous apex, clivus, and anteriorly to the sphenoid without traversing nasal sinus or pharyngeal spaces. It requires infratemporal dissection and careful avoidance of cranial nerves VII, IX, X, XI, and XII in their extracranial course. It provides early vascular access at the carotid sheath (*A*) and lateral exposure of extra- and intracranial clivus (*arrow in B*).

regions exposed to contaminated sinus cavities, limit the desirability for use of these approaches unless the pathology dictates that such an exposure is necessary. As with other extended skull base exposures, the risks of cerebrospinal fluid leakage, meningitis, and postoperative hematomas with airway compromise must be monitored carefully in the postoperative period. Specific disadvantages to this approach include the need for facial incisions, risk to branches of the facial and trigeminal nerves, and multiple osteotomies for removal of the maxillofacial skeleton depending upon the tumor exposure needed. Only in rare instances will facial translocation be indicated in petroclival meningioma surgery; this subject has been well reviewed by Sekhar and Janecka.

Staged Resections

In our experience, the application of the combined petrosal approach has all but eliminated staging large tumor removal for anatomical (e.g., supra- or infratentorial exposure) limitations. However, there remain some circumstances where a staged procedure may be indicated.

Surprisingly, one of the more common reasons for staging procedures in our series has been limitations imposed regarding blood transfusion. Religious beliefs are always respected in these cases, but every attempt is made to employ the intraoperative erythrocyte recirculating (i.e., autotransfusion) device if the patient consents. However, some patients will not agree to any

blood product infusion regardless of the source, and, in these instances, a staged procedure may be necessary if intraoperative blood loss becomes a problem. If the tumor is located both supra- and infratentorially, the bulk of the mass is targeted at the initial approach to afford the maximum decompression. Preoperatively, it is imperative that the patient fully understand the handicap; a combined decision should be made between the anesthesiologist and the surgeon regarding the appropriate time to abort the procedure. This will depend upon the preoperative status of the individual patient and the attendant risks to the individual for myocardial or neurological ischemia with continued anemia.

As discussed in more detail below, large tumors with significant intradural mass and contiguous involvement of the cavernous sinus with minimal cranial nerve deficit pose a difficult dilemma. In these instances, removal of the large intradural component may be accomplished at the primary resection, but one may choose not to explore the cavernous component until significant cranial nerve dysfunction develops. At the subsequent surgery, radical resection of the cavernous component may then be attempted.

Goals of Surgical Resection

When defining the goals of surgery for these lesions, it is important to consider the age of the patient, the location of the tumor, and the presenting symptomatology. Our experience would indicate that aggressive surgical removal should be the goal if at all possible; this certainly prevails as the best hope for a cure or extended tumor control. Exceptions to this rule arise if the risk of increasing neurological deficit is prohibitive with attempted total removal.

Some intraoperative conditions may preempt attempting total removal; most notable of these include the liability for significant morbidity from tumor involvement of cranial nerves and/or brainstem vasculature.

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Large tumors in this location may be difficult to remove without producing injury to cranial nerves. Because of the common source of origin of many of these tumors involving Meckel's cave, often there is obvious cavernous sinus involvement radiographically with little or no cavernous cranial neuropathy. Mere radiographic cavernous sinus extension of tumor presently represents a controversial indication for attempted total removal. It is our practice to limit removal or exploration of this region if the patient has functional binocular vision (i.e., no significant diplopia) and facial sensation that is not significantly impaired. In such patients we would plan a staged approach, with observation of the intracavernous component until such time as the patient develops progressive cranial neuropathies from tumor in this location. If or when binocular vision is impaired and/or facial pain or hypesthesia is apparent, consideration should be given to a radical intracavernous exploration and removal. In a younger patient, this may require an aggressive approach with radical cavernous sinus resection, including the involved portion of the internal carotid artery. In these cases a preoperative balloon occlusion test is performed to assess collateral flow; if the patient successfully passes the test, then a saphenous vein-internal carotid artery bypass is recommended to decrease the late complication rate of carotid sacrifice.

An additional difficulty arises when tumor lies between the basilar artery and the brainstem. In such instances extreme care must be exercised in removing this tumor, as interruption of perforating vasculature may result in brainstem infarction. An intraoperative decision must be made as to whether removal of the tumor in this location is justified. Certainly, in those cases in which removal is difficult, or the tumor is adherent to vascular structures or the brainstem, a more conservative approach is advocated. In such cases we do not hesitate to leave a thin portion (< 2-3 mm) of capsule adherent to these anatomic structures.

Since many of the tumors in this location are slow growing, asymptomatic lesions in elderly patients may warrant a conservative observation period before attempting surgical removal.

Surgical Results and Complications

Surgical results in our cases are in agreement with other contemporary series which present much lower morbidity and mortality than historical reports. Among 109 patients in our series undergoing surgery for tumors in this location, there were 60 significant complications in 39 patients. Death occurred in 4 patients, related to postoperative complications of depressed neurological status and disability (pulmonary embolus in 1 patient, sepsis secondary to pneumonia in 3 patients). Major morbidity from significant brainstem infarction resulting in hemiparesis or gait instability occurred in 16 patients. Four patients experienced postoperative hematomas, with 2 of these requiring surgical removal and resulting in permanent neurological deficits. Permanent cranial nerve deficits occurred in 36 patients, the most frequent involved the nerves in the cavernous sinus (III, IV, V, VI). Five patients had complete sensorineuronal hearing loss resulting from surgery (excluding planned transtemporal approaches). Two patients developed vocal cord paralysis with resulting aspiration, requiring temporary tracheostomy.Thus, a review of our series indicates that while results of surgical resection of these tumors have improved significantly, these tumors still pose a significant surgical challenge.

However, progression and recurrence rates of tumors subtotally or gross totally resected, respectively, are relatively low. In our series, a 13.6% rate of recurrence or progression was noted with a mean follow-up period of over 6 years. A small percentage of these tumors were of histologically malignant character (< 5 %). Routine imaging studies (MRI, CT) should be obtained in all cases to observe for late recurrence and to monitor the need and effectiveness of adjuvant therapy.

Adjuvant Therapy

Total resection of tumors either may not be feasible or may be ill-advised in certain patients. In such instances, radiation therapy may be a useful adjunct following subtotal surgical resection to obtain tumor control while preserving neurological function. Several retrospective studies have documented efficacy of radiation therapy following surgery for subtotally resected meningiomas. Recently, the advent of focal radiosurgical techniques, which enable a steep radiation falloff to limit radiation to nontumor locations has heralded a new era in radiation therapy. Meningiomas, which are characterized by well-defined radiographic margins, no brain invasion in benign cases, and vascularity which may be obliterated with radiation therapy, can be treated with this type of therapy. Little published data with extended follow-up evaluation exist, but preliminary reports by Lunsford et al. suggest that > 90% 4-year actuarial tumor control rates may be achieved with gamma-knife therapy of skull base meningiomas. Specifically, with tumors of the cavernous sinus, they noted a 6% incidence of delayed cranial nerve compromise. If this experience is substantiated by other centers, then this therapy should become a regular adjuvant in the overall management of these lesions.

Currently, a Southwestern Oncology Group (SWOG) cooperative study using the antiprogestational agent mefipristone (RU 486) is underway in the U.S. At present, only limited pilot study information is available. Preliminary results of this study suggest a modest response to this type of therapy for unresected recurrent benign skull base meningiomas. This mode of therapy potentially may represent a welcome option if proven efficacious for tumors in this location.

Summary

The proximity of petroclival meningiomas to the brainstem, perforating vessels, and cranial nerves all contribute to the risk involved with surgical resection. Earlier reports of prohibitive morbidity and mortality are not representative of more contemporary series, which report a mortality of < 10%. However, the continued surgical risks to cranial nerve function are formidable, amounting to 32% (35 of 109 patients) in our own series. The goals of surgery must be firmly established by the surgeon, and are a function of the patient's age and presenting cranial neuropathies. While gross total resection should be the optimal objective in all cases, contiguous cavernous sinus involvement, often the case in tumors with attachment in the vicinity of Meckel's cave, associated with minimal cranial neuropathies may not justify attempts at radical resection at initial surgery. In such instances adjuvant therapy may be indicated to achieve the overall goals of management, which must include tumor control while minimizing patient morbidity.

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