Recent Advances in Surgical Approaches to Parasellar Lesions

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Introduction

Recent advances in microsurgical instruments and refinement of surgical techniques have made it possible to operate the lesions situated at the medial end of the sphenoid wing, in the third ventricle, around the anterior tentorial hiatus, and in the interpeduncular fossa. Although these parasellar lesions are commonly encountered, they may be difficult to expose without considerable and potentially harmful brain retraction when approached by using the conventional surgical approaches, such as bifrontal, frontotemporal, or temporal craniotomy developed in the era of the dawn of brain surgery. Therefore, an alternative approach that avoids these difficulties would be welcome in appropriate circumstances. Jane et al. have refined the supraorbital approach originally developed by McArthur in 1912 and Frazier in 1913. More recently, various surgical techniques have been reported to offer an excellent exposure of the cranial base with minimal brain retraction and to avoid bothersome postoperative complications. In the present paper, these surgical approaches will be reviewed after learning anatomy and pathology of the parasellar region. Intrasellar lesions including pituitary adenomas will be excluded because surgical approaches are quite different from the lesions described here.

Anatomy and pathology of the parasellar region

Anatomical relations of the parasellar structures are complex (Fig. 1). The optic nerve proximal to its entrance into the optic canal is covered by a reflected leaf of dura, the falciform ligament, of which length may vary from less than 1 mm to as much as 1 cm. The relation of the optic chiasm to the sella is an important determinant of the ease with which the pituitary fossa may be exposed by the trans-frontal surgical route. The normal chiasm overlies the diaphragma sellae and the pituitary gland. In approximately 70 percent of cases, the chiasm is in the normal position. Of the remaining 30 percent, about half are prefixed and half postfixed. The diaphragma sellae, a special form of arachnoid membrane, forms the roof of the sella turcica. The diaphragma tends to be concave or convex rather than flat, and is rectangular and somewhat thicker at the periphery. All the arterial...
components of the circle of Willis and the adjacent carotid artery give origin to multiple perforating branches, which include the superior hypophyseal artery and other branches passing to the optic nerve, chiasm, anterior hypothalamic, and anterior perforated substance. The posterior communicating artery courses posteromedially above and medial to the oculomotor nerve and gives rise to multiple perforators. The anterior choroidal artery is directed posterolaterally below the optic tract. These arteries may become stretched over parasellar tumors and may feed them. The dura covering the anterior clinoid process lateral to the optic nerve and the carotid artery continues to the interclinoid ligament and the free edge of the tentorium cerebelli forming the roof of the dural osteum of cranial nerve III. This dural osteum is in the roof of the cavernous sinus. The oculomotor nerve perforates the dura at this osteum of the oculomotor trigone. Meckel’s cave containing Gasserian ganglion of the trigeminal nerve is located underneath the tentorium, posterolateral to the oculomotor trigone. The medial wall of Meckel’s cave consists of the wall of the cavernous sinus. The abducens nerve penetrates the dura inferomedial to Meckel’s cave. The trochlear nerve skirts the free edge of the tentorium cerebelli and joins the upper part of the cavernous sinus at the level of its posterolateral angle.

Parasellar lesions candidates for a surgical treatment include cerebral aneurysms, neoplasms, and rarely congenital lesions. Cerebral aneurysms are the most common among them. Since the introduction of endovascular coil embolization, the basilar quadripartition aneurysms are rarely treated with a direct surgery. Hence, the anterior circulation aneurysms are the subjects of this article. Meningiomas tend to arise at the tuberculum sellae, the paracoloidal region, the lateral wall of cavernous sinus, the upper clivus, or the cavernous sinus itself. Radiosurgery appears to take the place of the skull base surgery in the management of bona fide cavernous sinus meningiomas, because the perioperative morbidity and mortality associated with cavernous sinus surgery is appreciable due to the adjacent neurovascular structures. Craniohypophyseal complexes commonly grow underneath the opticohypothalamic complex to displace it superiorly, and occasionally in the third ventricle. Neurinomas may arise from Meckel’s cave. Dermoids or epidermoids may be encountered around the sellar region.

The conventional surgical approaches to the parasellar region

The conventional surgical approaches to the parasellar region are as follows: 1) anterior approaches, 2) anterolateral approaches, and 3) lateral approaches (Fig. 2).

Anterior approaches and their refinement

Major anterior approaches to the parasellar region are an interhemispheric approach and a subfrontal approach.

In an approach through the frontal interhemispheric fissure, dividing the bridging veins associated with prolonged retraction often causes contusional hemorrhage in the frontal lobe. To avoid this complication, a craniotomy is made lower than that of the conventional bifrontal craniotomy because bridging veins are not found near the frontal base (Fig. 3). The lower the approach is, however, the more the chance of damaging the olfactory nerves. And the opening of the frontal sinus is inevitable. Fujitsu et al. developed the basal interfascial approach to overcome the complications described above. They made two trapezoid craniotomies just above the supraorbital bar. The basal portion of the frontal bone is split into two leaves with a dissector. There may be multiple tears and holes in the split falx that can protect the olfactory nerves. When wider exposure is needed, one or both of two leaves are cut. The author feels this technique is somewhat complex, and believes that meticulous dissection techniques of the arachnoid of the interhemispheric fissure and around the olfactory nerves following a simple division of the falx do not give away any harmful effect. In an approach through the frontal interhemispheric fissure, the lower craniotomy involving the central supraorbital bar is essential to access aneurysms of the anterior communicating artery complex or craniopharyngiomas in the third ventricle without damaging the structures around the corridor.

The subfrontal approach has been refined to develop new surgical techniques. The bifrontal transbasal approach originally developed by Demone and Guiot has now become one of the standard skull base surgical approaches and has been applied to various kinds of midline skull base lesions with some modification. Kawakami et al. described an extensive transbasal approach consisting of a bilateral frontal craniotomy followed by an
en bloc removal of the whole supraorbital bar in association with the orbital roofs (Fig. 4). With this refinement, retraction forces to the basal frontal lobe are apparently lessened and reconstruction of the skull base become to be much easier. The bifrontal transbasal approach not only permit a wider lateral field of vision which is not available with a transrhinoseptal or transpalatal approach, but also allows the surgeon to go deeply as far as the infrasellar region, the anterior margin of the foramen magnum, the anterior arch of the atlas and even the body of C2 (Fig. 5). Spetzler et al. \textsuperscript{14} reported a technique to spare the olfactory function because, in the bifrontal transbasal approach, the cribriform plate is usually removed.

No matter what way the surgeon takes, encroachment to the frontal sinus is inevitable. Therefore, great care should be paid to prevent postoperative infections. The following method is commonly used: the mucosa of the frontal sinus is removed, and the frontonasal ducts are sutured and covered by fibrin glue. The author uses this method when the supraorbital bar is totally removed to access parasellar lesions, and applies the pericranial flap to obliterate the space of opened frontal sinus.

It seems important not to leave any dead space in the cranial cavity (cranialization).

Reconstruction of the midline frontal base is also an important issue requiring a watertight separation between the cranial cavity and the upper respiratory tract, with a support for the brain. Various forms of reconstructive procedures have been reported including skin grafts, full-thickness scalp grafts, pericranial flaps\textsuperscript{15}, galeal frontalis myofascial flaps\textsuperscript{16}, and free flaps. The author routinely uses the...
pericranial flap because this technique is easy to perform and reliable to prevent infections as well as CSF rhinorrhea. To reinforce the structural support, cranial base bone defects anterior to the sella turcica is reconstructed by using a vascularized outer table calvarial bone graft. The author does not feel the necessity of bony reconstruction when the size of a bone defect is less than two thirds of the anteroposterior length of the anterior cranial fossa. The bone defect larger than that described above will be supported by titanium mesh.

Anterolateral approaches and their refinement

Until recently, the most common approach to parasellar lesions has been widely used frontotemporal or pterional approach. As a matter of fact, most cerebral aneurysms have been successfully treated. However, this approach has often encountered excessive brain retraction and residual deficits of a disabling nature, when used to access medially located, large lesions. Various types of craniotomy including the supraorbital bar have been developed to lessen brain retraction. Al-Mefty modified the supraorbital approach refined by Jane et al., to enable to access cavernous sinus lesions by temporal extension of the craniotomy. A mobilization of the zygoma in addition to usual craniotomy has been reported to offer an excellent exposure of the cranial base with minimal retraction. Fujitsu and Kuwabara reported the zygomatic approach which involves detachment of the zygomatic arch of the temporal bone as well as a portion of the lateral orbital rim as a free bone flap, and described that their approach permitted obliquely upward access to the interpeduncular fossa using the lowest possible supratentorial route. Similar detachment of the zygomatic arch has been reported from several institutions. Hakuba et al. stressed that, in their orbitozygomatic infratemporal approach, manipulation of the vital structures in the skull base became to be much easier and safer than that with the conventional approach because the working distance to the lesions in the parasellar region and the interpeduncular fossa is about 3 cm shorter and the angle to the lesions about 1 or 2 cm lower than via either the perional or subtemporal approach. Taguchi et al. have developed a new surgical technique, the frontotemporal orbitozygomatico-alar approach, which combined a supraorbital approach with a detachment of the zygomatic arch. A similar surgical technique was reported by Zabramski et al. three years later. The author confirmed the advantages described above and added two more advantages: viewing the lesion multidirectionally and accessing the lesion medial to the optic canal much easier. However, the author realized that the techniques described previously needed skillful hands and inevitably resected a part of the basal bony structures of the orbital roof, the sphenoid ridge and the temporal bone resulting in enophthalmos or pulsating exophthalmos. Recently, Taguchi et al.

Fig. 5 a, b Photographs showing preoperative (a) and postoperative (b) T1-weighted MRI of sagittal view. Note that a large cystic mass (craniopharyngioma) in the spheno-nasopharynx is totally removed and no cerebral herniation is present.
have modified the frontotemporal orbitozygomatico-alar approach and developed the frontotemporal orbito-alar approach to reduce complex and extensive osteotomies on the zygoma. This approach consists of two bone flaps illustrated in Figure 6 providing a quite similar operative field to the frontotemporal orbitozygomatico-alar approach without basal bony defects (Fig. 7). This approach offers a definitive advantage in cranio-orbital approach by avoiding postoperative complications and by offering a simpler, less invasive surgical technique, in addition to the advantages already provided by the other cranio-orbital approaches that improve the angle of the surgeon’s vision and the space available for working. Similar modifications to the orbitozygomatic approach were reported more recently. 

Fig. 6 a, b Illustrations showing the frontotemporal orbito-alar approach. Burr holes and osteotomy incisions are shown on its outer aspect (a) and inner aspect (b).

Fig. 7 a, b Intraoperative photographs showing a wide working space offered by the frontotemporal orbito-alar approach: extradural view of the left approach (a) and intradural view of the right approach (b).
Lateral approaches and their refinement

Modern endovascular surgical techniques appear to take place the conventional surgical treatment of posterior circulation aneurysms. The subtemporal approach had widely been applied to obliterate basilar bifurcation aneurysms has now been on the wane. A large parasellar lesions extending to the middle fossa can be successfully managed with recently refined anterolateral approaches described before (Fig. 8). Hence, lateral approaches have become to be used to access around Meckel’s cave or the lesions behind the dorsum sellae (Fig. 9). The subtemporal-transtentorial approach offers a surgical field encompassing the upper clivus, but in which the petrous ridge obscures the surgical view behind the petrous bone. A common disadvantage of this approach has been damage to the temporal lobe caused by retraction, particularly if the venous drainage is interrupted\(^\text{20, 36}\). In order to conquer this disadvantage, Kawase et al.\(^\text{37, 38}\) developed an anterior transpetrosal-transtentorial approach. They drilled away the anterior petrous bone via the epidural route after making a temporal craniotomy, that is surrounded by the trigeminal impression anteriorly, the eminentia arcuata posteriorly, the major petrosal groove laterally, and the carotid canal and the internal carotid artery inferiorly. Although the superior petrosal sinus is sacrificed inevitably, the sphenopetroclival region down to the internal auditory meatus can be accessed with ease. The author, however, recommended a combination of a subtemporal-transtentorial approach and an anterior transpetrosal-transtentorial approach, because the latter provided a fairly limited working space and access to the petrous apex extradurally is limited by the subtemporal dura.

Conclusions

Regardless of various techniques described here, there would be a number of advantages, including 1) reducing the brain retraction; 2) shortening the distance to the target; 3) viewing the lesion directly with a wide working space; and 4) accessing easily to regions used to be no man’s land.

References


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