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Optimization of the operative corridor for the resection of craniopharyngiomas in children: the combined frontoorbitozygomatic temporopolar approach

Technical note

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Complete extirpation of tumor remains the primary goal of neurosurgeons in treating intracranial craniopharyngiomas. The intimate relationship of these lesions with the structures of the skull base and the difficulties of obtaining adequate operative visualization often make total removal an elusive goal. The authors describe the use of a combined fronto-orbitozygomatic temporopolar craniotomy to maximize the operative corridor and thereby increase the probability of maximum tumor resection without morbidity and mortality. They applied this approach in four children with craniopharyngiomas that involved the sellar and parasellar, third ventricle, cavernous sinus, and interpeduncular fossa regions. The surgical results are summarized with a presentation of pre- and postoperative imaging from two illustrative cases. A detailed description of the operative procedure is provided with a comparison to other previously described surgical approaches.

Key Words * craniopharyngiomas * surgical approach * frontoorbitozygomatic temporopolar approach

Craniopharyngiomas are an unusual group of epithelial tumors thought to be derived from the embryonic remnants of an incompletely involuted hypophyseal-pharyngeal duct.[6] They are encountered primarily in the sellar and parasellar regions but can be found anywhere along the developmental path of Rathke's pouch.[13] They occur with a peak incidence in children and adolescents between 5 to 15 years of age but can present at any time.[16] Visual loss and impairment, headache, apathy, depression, incontinence, hypersomnia, cognitive deficits, memory loss, sexual dysfunction, and growth failure are typical symptoms. Hydrocephalus and endocrine disorders are often present at the time of diagnosis.[1,2] Due to the slow growth rate of these tumors, they are often quite large before becoming symptomatic. They typically originate within the sellar and suprasellar regions but can frequently extend to the cavernous sinus, interpeduncular fossa, hypothalamic, and third ventricle regions at the time of diagnosis. Their size and central location make achieving adequate surgical exposure generally problematic.[9,12,17]

Dissection is further complicated by the tumors' propensity to cause an intense gliosis and dense arachnoid adhesions to the surrounding brain parenchyma and neurovascular structures.[10] Greater than 60% of incompletely resected lesions will demonstrate tumor progression within 3 years of surgery.[16] Although recent advances in the past decade have demonstrated an encouraging role for adjuvant radiation in cases of subtotal tumor resection, total removal still offers the best chance of cure for the patient.

Historically, a diverse number of operative approaches have been used in the management of these lesions, including the subfrontal, bifrontal, pterional, translamina terminalis, transsphenoidal, transcallosal, and transcortical approaches.[1,7,10,12,17,18] Because each particular technique has both strengths and weaknesses, the surgeon must choose the approach that provides optimum exposure to maximize the chances for total resection. The specific operative corridor chosen will ultimately depend on the anatomy of each individual tumor as noted on preoperative magnetic resonance (MR) images and computerized tomography (CT) scans.

With this goal in mind, we used the fronto-orbitozygomatic temporopolar (FOZT) approach in four children with craniopharyngioma. Originally designed to gain improved access to basilar territory aneurysms, the FOZT approach is a combination of previously described zygomatic and temporopolar modifications of the classic pterional and subtemporal approaches.[3,4,7-9,14,15] The tenets underlying the FOZT approach in the treatment of craniopharyngioma include: 1) obtaining the shortest trajectory to the suprasellar region, interpeduncular fossa, and anterior third ventricle; 2) more aggressive bone removal (orbital roof, middle fossa, and sphenoid wing) to minimize brain retraction; 3) posterior mobilization of the temporal tip with preservation of the temporal tip veins; and 4) the skeletonization/decompression of cranial nerves and vascular structures to maximize their preservation during surgical manipulation. The clinical outcome was good to excellent in all cases with minimal associated morbidity. This new use of the FOZT approach in the resection of craniopharyngiomas is reported.

SURGICAL TECHNIQUE

This technique takes its roots from the standard pterional craniotomy. The temporopolar approach parallels the trajectories of both the pterional transsylvian and subtemporal approaches and is indicated for the treatment of lesions in and around the basilar bifurcation. Other indications include lesions above the dorsum sellae, posteriorly pointing apex lesions, and lesions adjacent to the posterior clinoid process. The temporopolar approach is based on a transsylvian pterional trajectory and also borrows heavily from principles of the classic exposures of Dolenc, et al.,[5] and Sano.[14] The principal advantages of the temporopolar approach are the preservation of anterior temporal draining veins, decreased brain retraction, and a wider operative corridor that allows for movement of the microscope through a nearly 90° arc.[14] The key features of this approach include removal of the extradural sphenoid wing and anterior clinoid process, skeletonization/decompression of the optic canal superior orbital fissure and foramen rotundum, extradural retraction of the temporal tip, transcavernous mobilization of the carotid and oculomotor nerve, and transcavernous removal of the posterior clinoid, if needed. Overall, the main advantage of the approach is its greater visualization of the tumor and its relationship to adjacent neural and vascular structures.

The initial preparation, positioning, and skin incision are similar to those used for a routine pterional approach. The side of the operative approach is dictated by the location of the tumor on preoperative MR

images. If there is no lateral extension to either the frontal or middle fossa region, the right side is preferentially chosen, as retraction would be limited to the nondominant hemisphere and is technically easier for right-handed surgeons. The skin incision extends inferiorly over the root of the zygoma. A more basal-to-vertex trajectory is usually required for exposure of tumors that extend above the dorsum sellae. Removal of the zygoma in combination with removal of the orbital rim adds significantly to the exposure (Fig. 1 left and right).[8,9] Removal of the zygoma allows for the operating microscope to be maneuvered into an inferior-superior trajectory. This is an important consideration when we approach large tumors extending into the suprasellar, interpeduncular, and clival regions. To allow for orbital retraction the orbital rim is removed with the bone flap as a single unit. This maneuver enhances the inferior-to-superior viewing angle from a more frontal direction.

Fig. 1. Left and right: Photographs detailing the outline of craniotomy flap.

Zygoma removal is initiated with a cut made parallel to the long axis of the zygoma at its junction with the temporal bone. The second cut, perpendicular to the first, is made along the orbital zygomatic process near the lateral orbital rim. This maneuver allows for inferior retraction of the temporalis muscle, enabling the operating microscope to be radically deviated to gain a more lateral-to-medial and inferior-to-superior trajectory. The zygoma is resecured at the end of the procedure using a titanium miniplate system. The temporalis muscle is then attached to the linea temporalis using either the miniplate system or perpendicular holes drilled in the temporal squama.[3]

Once the craniotomy flap is removed, dural elevation is initiated from the anterolateral middle fossa to expose the foramen rotundum and superior orbital fissure, and it is continued medially to expose the floor of the anterior cranial fossa. The lateral limit of dural elevation is the foramen ovale, and the medial limit is the anterior superior ethmoidal artery. The sphenoid ridge is shaved along with any irregularities of the orbital roof and anterior middle fossa floor using a high-speed drill with cutting and diamond burrs and copious irrigation. Continued meticulous drilling of the lateral dural wall of the superior orbital fissure allows for increased mobility of the superior orbital fissure. The foramen rotundum is then unroofed using the high-speed drill, beginning laterally and medially and finally over the nerve, exposing the second trigeminal branch. The optic canal is additionally unroofed extradurally to achieve modest mobility of the optic nerve. This is often helpful as the tumor often elevates the optic nerve and gives the appearance of a prefixed chiasm.

The anterior clinoid process is removed by initially drilling and debulking the center of the process. This

leaves a thin shell of bone that is progressively chipped away and then removed. One should be aware of the potential for a pneumatized anterior clinoid and in such cases the chance for a postoperative cerebrospinal fluid fistula. The optic strut is additionally flattened and removed. When the extradural bone removal is completed, the dura propria of the temporal tip is elevated from the inner cavernous membrane. The middle fossa dura is stripped away, allowing the extradural mobilization of the temporal tip. Further separation of the middle fossa dura from the true cavernous membrane will minimize temporal lobe retraction; this allows the trajectory of the operating microscope to be moved into an exaggerated lateral-to-medial axis during tumor resection. Initially, the meningo-orbital vessels are divided at the apex of the superior orbital fissure and a cleavage plane formed originating at the junction of the temporal dura and the periorbital fascia. The dura is then sharply elevated from the true cavernous membrane extending from the superior orbital fissure along the second trigeminal branch and continuing posteriorly to the foramen ovale. The true cavernous membrane is composed of thin connective tissue contiguous with the nerve sheaths of the third, fourth, and fifth cranial nerves and surrounds the venous plexus of the cavernous sinus. The limits of dural reflection of the true cavernous membrane are the third trigeminal branch posteriorly and the tentorial edge medially. Finally, the medial tentorial incisura is incised and separated from the inner cavernous membrane near the third cranial nerve.

The removal of the anterior clinoid process with skeletonization of the optic canal, superior orbital fissure, and foramen rotundum allows safe manipulation of the optic nerve, carotid artery, superior orbital fissure contents, and the second branch of the trigeminal nerve without compromise from overlying bony surfaces. For large craniopharyngiomas, adequate visualization is essential to prevent inadvertent injury during dissection. Additional mobility of the third cranial nerve is often helpful in gaining access to portions of tumor located in and around the cavernous sinus and interpeduncular fossa. Opening the porous oculomotorius will allow for extra length of the third cranial nerve to further improve retractibility and potentiate safe tumor removal from the third nerve and prevent injury. The dura is opened over the Sylvian fissure extending to the optic nerve sheath dura and then medially along the frontal base for 2 to 3 cm, forming an "L" shape. Perneczky's ring is opened and the carotid artery freed of its dural attachment laterally. If required, retractors are placed extradurally allowing for posterolateral retraction of the temporal lobe and posteromedial retraction of the frontal lobe. The temporal tip veins are thus protected and preserved with the anterior temporal dura. The anterior 2 to 3 cm of the Sylvian fissure is sharply opened, allowing for increased exposure of the superior aspect of the clival region. At this point, the tumor is commonly encountered and found to be densely adherent to the brain, cranial nerves, and vascular structures. The tumor is typically exposed by opening the cisternal arachnoid along the edge of the now removed sphenoid ridge, over the optic nerves, and over the tumor bulk. An attempt is made to distinguish the multiple layers of arachnoid and to differentiate the cisternal from the tumor arachnoidal plane and thus avoid unnecessary parenchymal injury. Accordingly, care is taken not to anneal arachnoid to the tumor capsule because this would obliterate the subarachnoid plane of dissection. With larger craniopharyngiomas, however, the cisternal and tumor arachnoidal layers are often fused over a significant portion of the tumor surface.

Continued slow, cautious, sharp dissection allows for visualization of the internal carotid artery (ICA) and proximal A₁ and M₁ segments. The triangle between the oculomotor and trochlear nerves (superior triangle of the cavernous sinus) can also be opened sharply if required. Tumor involvement in, around, and through this triangle is frequently seen. The oculomotor nerve is then exposed from its origin at the midbrain to its dural entrance into the superior orbital fissure. At this point in the approach, the oculomotor nerve and trochlear nerves can be mobilized as needed to maximize exposure of the tumor.

The third nerve can be gently retracted laterally only after first covering it with a soft cottonoid. The ICA can now also be mobilized medially or laterally as it has been freed from its dural attachment anteriorly. Mobilization of neurovascular structures is needed to inspect their surfaces for tumor and to gain further access to deep recesses of the lesion. The majority of craniopharyngiomas contain cystic portions that may or may not be well-visualized on MR imaging. Whenever possible an attempt is made to aspirate these cystic regions, as this often provides additional room for dissection. Care should be taken to avoid excessive spillage of cyst contents into the brain parenchyma as this has been associated with postoperative chemical inflammation of the meninges.

Sharp microdissection of the arachnoid as described will now allow for additional retraction in order to widen the corridors to the sella, posterior clinoid, and membrane of Lilliequist. In this fashion, several regions of the tumor surface can be dissected free from adjacent nerves and vessels. When enough of the tumor surface is exposed, the tumor is debulked internally. Calcifications are sometimes encountered that need to be crushed before they can be delivered through the small windows of access. As the tumor collapses, small arterial feeders are cautiously coagulated and divided. Typically the blood supply is derived primarily from small arterial feeders of the anterior circulation. Direct branches from the ICA, posterior-communicating artery, and cavernous sinuses were seen as well. Occasionally, lesions involving the third ventricle will parasitize blood from the posterior cerebral and basilar arteries although this is rare. Adequate visualization along the length of the major vessel surfaces is thus crucial in preventing unnecessary blood loss and ischemic injury to adjacent structures. Skeletonization of the major circle of Willis vessels with removal of as much tumor tissue as possible is a crucial part of achieving a gross-total resection. Unfortunately, tumor tissue is often so adherent to vessel walls that safe removal may be impossible.

Larger lesions that extend farther superiorly in the suprasellar region involving the basilar region and interpeduncular fossa or extend into the third ventricle require additional surgical exposure. To gain increased visualization of the interpeduncular fossa region, the arachnoid membrane is sharply opened lateral to the ICA. To complete the exposure, the posterior clinoid can be removed intradurally with a high-speed drill. This increases the exposure of the basilar artery below the sella. Removal of the posterior clinoid process expands the working space for management of giant lesions as well as providing for temporary occlusion of the midportion of the basilar artery if warranted. The superior and posterior aspects of tumors in this region and those that extend into the third ventricle typically do not have a major arterial supply. Dense arachnoid adhesions are, however, often encountered where the tumor is adjacent to the basilar and posterior cerebral arteries.

After resection of the tumor mass, a careful inspection of the sellar and parasellar structures is made to ensure that no resectable portions of tumor tissue remain. Copious irrigation with Ringer's lactate is then performed to identify any additional areas of bleeding and to obtain meticulous hemostasis. At the conclusion of the procedure, the dura is closed in a watertight fashion, using pericranium and fibrin glue. The pericranium is preserved during opening for this purpose. The en-bloc free bone flap and zygomatic arch are then reattached with the use of titanium miniplates. For cosmetic purposes, the anterior and superior portions of the bone flap are preferentially aligned.

ILLUSTRATIVE CASES

Case 1

This 5-year-old boy was originally admitted to the Children's Hospital of Los Angeles for a 1-year

history of headache, progressive visual loss, and difficulty with ambulation. The family also reported that he would often trip while walking and had a history of several serious falls. He was also having great difficulty dressing himself. He had experienced an acute deterioration over the last 3 weeks with sudden worsening of his chronic headache and frequent episodes of nausea with vomiting. At admission, neurological examination was consistent with a right visual field defect: decreased right visual acuity with optic pallor. There was also prominent weakness of his right lower extremity. The patient was noted to have signs and symptoms of panhypopituitarism which was verified on subsequent laboratory investigation. The initial head CT scan revealed hydrocephalus and a 5- X 3-cm hypodensity involving the hypothalamic and suprasellar regions with invasion of the third ventricle up to the level of the interventricular foramen. A gadolinium-enhanced MR image of the brain was obtained that further defined tumor location and characteristics (Fig. 2 upper left, center, and right). Hormonal replacement therapy and intravenous dexamethasone were administered. Due to the lesion's large size and wide extension both superiorly and posteriorly, the decision to attempt resection through a FOZT approach was made. Intraoperatively, an excellent exposure of the suprasellar and third ventricular region of the tumor was afforded by the surgical corridor. The exaggerated rostrocaudal arc for the microscope was particularly helpful in visualizing the uppermost extent of the tumor that was densely adherent to the surrounding structures. A gross-total resection was achieved without intraoperative complication (Fig. 2 lower left and right). Except for worsening of his preexisting diabetes insipidus and a transient third nerve palsy, the postoperative course was unremarkable.

Fig. 2. Case 1. Upper: Preoperative gadolinium-enhanced T₁-weighted coronal (left), sagittal (center), and T₂-weighted nonenhanced axial (right) MR images documenting a

large inhomogenous lesion with extension into the interpeduncular fossa and superiorly into the third ventricle. Lower: Postoperative gadolinium-enhanced axial (left) and sagittal (right) T₁-weighted images documenting surgical resection.

Case 2

This 4.5-year-old boy was referred to the Children's Hospital of Los Angeles for a history of incompletely resected craniopharyngioma in the suprasellar and right cavernous sinus region. He had originally presented with hydrocephalus and had been operated on via a right pterional approach. Early postoperative MR imaging after his first surgery revealed residual tumor adjacent to the circle of Willis and around the right cavernous sinus region. The patient had also suffered a postoperative venous infarct at that time, with multiple small right hemispheric infarcts and an exvacuo dilation of the right lateral ventricle noted. Adjuvant radiation had been withheld to avoid any delayed cognitive deficits. He had been managed expectantly with surveillance contrast-enhanced MR images of his brain every 6 months. Although stable for several years, his most recent MR image had demonstrated significant interval increase of the lesion. Several new tumor nodules with multiple enlarging cysts were seen in the right parasellar, cavernous sinus, and third ventricular regions (Fig. 3 upper left and right). The patient suffered from hypopituitarism and had been receiving hormone replacement therapy. His neurological status had otherwise remained stable since his first operation. Although adjuvant therapeutic radiation was now considered, the risk of delayed cognitive deficits was still believed to be quite high. Given these considerations, it was believed that the patient would benefit from a second operation to maximally debulk the tumor and thus allow additional time for brain maturation before irradiation. Given the far-lateral extension of the tumor, its intimate involvement with the sellar and circle of Willis structures, and evidence of third ventricular involvement, a wide corridor of surgical access was needed. The FOZT approach provided an excellent exposure of the tumor, sellar, third ventricle, and cavernous sinus regions. Posterior mobilization of the temporal tip with gentle traction and sparing of the bridging veins provided improved visualization of the third ventricular region without increased risk of venous infarct as had occurred during the first operation. A generous but subtotal resection was achieved (Fig. 3 lower left and right). No intraoperative surgical complications were encountered. The patient was returned to the intensive care unit in stable condition. The postoperative course was marked with the expected episode of diabetes insipidus and third nerve palsy.

Fig. 3. Case 2. Upper: Preoperative gadolinium-enhanced T₁-weighted coronal (left) and sagittal (right) MR images demonstrating residual tumor progression. Lower: Postoperative axial (left) and sagittal (right) gadolinium-enhanced T₁-weighted images following resection of tumor. Note the encephalomalacia of the right temporal tip that was present preoperatively.

DISCUSSION

Craniopharyngiomas possess certain characteristics that make their surgical extirpation particularly challenging. Their central location and large size often make complete resection through any one surgical corridor extremely difficult. The tumors are usually intimately involved with several areas of the skull base that in and of themselves often require specialized approaches. These include the perithird ventricular and interlaminar regions, the interpeduncular fossa, clivus, and the cavernous sinus region. Our experience as well as that of others has been that such widespread tumor extension can sometimes necessitate a staged operative procedure.[1]

The intense glial reaction that usually accompanies these lesions further complicates operative dissection.[11] These tumors are tenaciously adherent to the major arteries, nerves, and perforators located at the skull base.[18] As craniopharyngiomas are thought to be noninvasive tumors, some authors have advocated dissection along this "glial envelope." [9,12,17] When possible, we attempted to remain within this subarachnoid plane as delineated by the cisternal arachnoid membrane, but this was often

broadly fused to the tumoral arachnoid membrane. The dense calcifications and multiple cysts that we encountered also contributed to an already piecemeal delivery of the lesion.

Although these obstacles represent a formidable challenge during tumor dissection, the surgeon should strive for the removal of all tumor that can be safely resected. Careful inspection of all neural and vascular structures trapped within and adjacent to the tumor must be attempted. This often requires additional skeletonization and mobilization of vessels and nerves. When needed, further bony drilling, both intra- and extradurally, is helpful as well. As long as such aggressive exposure and dissection does not compromise the underlying tissue, an attempt should be made to remove any tumor tissue that is encountered. Residual tumor along the arteries of the circle of Willis, hypothalamus, and pituitary stalk are the most common sites of recurrence.[1,16,18] Craniopharyngiomas commonly derive the bulk of their blood supply from the anterior circulation.[1,2,10,12] Although tumor feeders are seen in this region, the perforators from the circle of Willis also concurrently supply the undersurface of the chiasm and optic tracts. Accidental division of these feeders can lead to visual loss and hypothalamic injury.[1] As mentioned, particular care must also be taken to preserve the arterial anastomotic ring surrounding the median eminence. Toward this end, an extended subfrontal exposure is provided by the FOZT approach by drilling the sphenoid and removing the orbital roof down to the superior orbital fissure. This allows for direct visualization of the median eminence, its anastomotic vascular ring, and the pituitary stalk in many cases. Using its unique portal vein striations to differentiate it from surrounding suprasellar structures, the pituitary stalk can often be located as it penetrates the diaphragma sellae.[1,2] Identification of the stalk is basic to its preservation. The good visualization provided by the FOZT approach in this region thereby helps to ensure its integrity. The benefit of this approach over a subfrontal one is that the surgeon has direct visualization of the tumor in relationship to the inferior aspect of the optic chiasm. Tumor dissection can thus be completed sharply with the preservation of all inferior perforating vessels to the chiasm while minimizing the chance of causing ischemic compromise to the optic apparatus.

Ultimately, the choice of surgical access is dictated by the individual characteristics of the tumor. Preoperative high-resolution imaging is essential in visualizing the sagittal relationships of craniopharyngiomas to the optic nerve and the anterior portion of the circle of Willis. It is also important to appreciate the inferior extent of the tumor and erosion of the sella turcica, the relationship of the tumor to the third ventricle, any cavernous sinus involvement, and the degree of obstruction of the cerebrospinal fluid pathways. By clearly defining the three-dimensional boundaries of the tumor and its relationship to entrapped and adjacent structures, an appropriate corridor of surgical access can be chosen to maximize the chances of gross- or near-total resection.

A multitude of options exist including a subfrontal, transcallosal, transsphenoidal, supraorbital or orbitocranial, transzygomatic, pterional, subtemporal, third ventricular, and the FOZT approach. A large percentage of craniopharyngiomas have been successfully treated via a subfrontal, orbitocranial, and pterional craniotomy.[1,2,10,18] Lesions that rise high in the suprasellar and third ventricle region have often required a concurrent or subsequent transcallosal or third ventricular procedure. Given the exophytic nature of the portion of tumor that frequently invades the third ventricle, we have found that the FOZT approach allows for complete resection of the ventricular component without necessitating a combined approach. Far-posterior lesions in the clival and interpeduncular regions are often beyond the reach of traditional approaches as well. Indeed, it is the posterior and superior extent of the tumor that frequently limits the degree of surgical resection. Whereas pterional and frontal corridors provide ample access to the subfrontal and sellar aspects of the tumor, further removed portions of tumor are often

inaccessible. Subtemporal and transzygomatic approaches are helpful in addressing these troubled areas but sacrifice a degree of frontal access. Thus, the ability of the surgeon to posteriorly mobilize the temporal tip in the FOZT approach is particularly appealing. This allows for a combination of an increased posterior and superior trajectory without losing any subfrontal or anterior exposure. Our modification of the zygomatic and subtemporal approach also places an increased emphasis on the extradural exposure in order to preserve the temporal tip veins and avoid venous infarction. The posterior mobilization of the temporal lobe along with the optional removal of the zygomatic process allows for the microscope to be deflected in a more lateral-to-medial and inferior-to-superior direction such that superiorly placed tumors can be approached with relative ease. Skeletonization of the carotid artery, mobilization of the third cranial nerve from the porous oculomotorius, and removal of the posterior clinoid process also dramatically improve the surgical maneuverability needed for dealing with giant lesions in this region. The increased corridor of visualization with the microscope provided by the FOZT approach allows for safer and more thorough dissection of the tumor from underlying structures.

CONCLUSIONS

From our limited experience with the FOZT approach, we have found the procedure to be both safe and effective. We believe that a greater extent of surgical resection was achieved than would have been accomplished through other more limited approaches. There are several difficulties with the approach that need to be considered during patient selection. 1) There is increased surgical time due to the additional bony and intracranial exposure. Although a fundamental knowledge of the anatomy is a prerequisite for the approach, our experience has demonstrated that the operation length decreases rapidly as one becomes familiar with the technical aspects of the procedure. We greatly recommend that time be spent in a skull base dissection laboratory in preparation for the FOZT approach.[4] 2) There can be additional blood loss and larger fluid shifts from the additional drilling and dissection. 3) One may damage blood vessels and nerves from the additional skeletonization and mobilization of these structures. We often encountered postoperative third cranial nerve palsies, but these were usually transient in nature. Attention to drilling technique is of the utmost importance in preventing accidental injury during skeletonization.[4] 4) There is limited access to far posterolateral lesions. In lesions that extend further laterally along the petrous ridge, a rhomboid approach may be indicated. 5) In cases in which an aggressive unroofing of the orbit is pursued, decreased cosmesis may result from poor bony reapproximation of the en-bloc flap and also, rarely, from pulsatile exophthalmos.

The strength of the FOZT approach rests in its ability to provide both an extended inferior and subfrontal exposure along with an increased visualization of the clival, suprasellar, third ventricular, and interpeduncular regions. It shortens the distance to deep-seated tumors, allows for a more basal approach, minimizes brain retraction, and provides multiple routes of dissection while attempting to preserve anatomical structures. A highly versatile approach, it can be altered with regards to its exact position and extent. The surgeon has the options of drilling the sphenoid wing, unroofing the orbit, and transcavernous drilling of the posterior clinoids, thus allowing for additional customization of the procedure. In our cases of childhood craniopharyngioma, the FOZT approach has greatly enhanced our degree of surgical resection as demonstrated by postoperative MR imaging. In addition to the increased survival afforded by these larger resections, the chances of a second surgery with its attendant risks are minimized. As experience with this particular technique grows, we believe that its utility will be recognized in the management of other types of intracranial tumors as well.

References

1. Carmel PW: Craniopharyngiomas, in Wilkins RR, Rengachary SS (eds): **Neurosurgery**. New York: McGraw-Hill, 1985, Vol 1, pp 905-916
2. Carmel PW, Antunes JL, Chang CH: Craniopharyngiomas in children. **Neurosurgery** **11**:382-389, 1982
3. Day JD, Levy M, Fukushima T: Temporal muscle fixation. **J Neurosurg** **82**:701-702, 1995 (Letter)
4. Day JD, Tschabitscher M: **Microsurgical Dissection of the Cranial Base**. New York: Churchill Livingstone, 1996, pp 44-59
5. Dolenc VV, Skrap M, Sustersic J, et al: A transcavernous-transsellar approach to the basilar tip aneurysms. **Br J Neurosurg** **1**:251-259, 1987
6. Erdheim J: Ueber Hypophysengangsgeschwülste und Hirncholesteatome. **Sitzungsber Akad Wiss** **113**:537-726, 1904
7. Fujitsu K, Kuwabara T: Zygomatic approach for lesions in the interpeduncular cistern. **J Neurosurg** **62**:340-343, 1985
8. Ikeda K, Yamashita J, Hashimoto M, et al: Orbitozygomatic temporopolar approach for a high basilar tip aneurysm associated with a short intracranial internal carotid artery: a new surgical approach. **Neurosurgery** **28**:105-110, 1991
9. Hakuba A, Liu S, Nishimura S: The orbitozygomatic infratemporal approach: a new surgical technique. **Surg Neurol** **26**:271-276, 1986
10. Kempe LG: **Operative Neurosurgery**. New York: Springer-Verlag, 1968, Vol 1, pp 90-93
11. Landolt AM: Die Ultrastruktur des Kraniopharyngeoms. **Schweiz Arch Neurol Neurochir Psychiatr** **111**:313-329, 1972
12. Matson DD, Crigler JF Jr: Management of craniopharyngioma in childhood. **J Neurosurg** **30**:377-390, 1969
13. Podoshin L, Rolan L, Altman MM, et al: 'Pharyngeal' craniopharyngioma. **J Laryngol Otol** **84**:93-99, 1970
14. Sano K: Temporo-polar approach to aneurysms of the basilar artery at and around the distal bifurcation: technical note. **Neurol Res** **2**:361-367, 1980
15. Sugita K, Kobayashi S, Shintani A, et al: Microneurosurgery for aneurysms of the basilar artery. **J Neurosurg** **51**:615-620, 1979
16. Sung DI, Chang CH, Harisiadis L, et al: Treatment results of craniopharyngiomas. **Cancer** **47**:847-852, 1981
17. Sweet WH: Craniopharyngiomas (with a note on Rathke's cleft or epithelial cysts and on suprasellar cysts), in Schmidek HH, Sweet WH (eds): **Operative Neurosurgical Techniques. Indications, Methods and Results, ed 2**. Orlando: Grune & Stratton, 1988, Vol 1, pp 349-379

18. Symon L, Sprich W: Radical excision of craniopharyngioma. Results in 20 patients. **J Neurosurg** **62**:174-181, 1985

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