Extended transsphenoidal approach with submucosal posterior ethmoidectomy for parasellar tumors

Technical note

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The authors have developed an extended transsphenoidal approach with submucosal posterior ethmoidectomy for resection of tumors located in the cavernous sinus or the suprasellar region that are difficult to remove via the conventional transsphenoidal approach. Surgery was performed using this approach in 14 patients with large pituitary adenomas, three patients with craniopharyngiomas, and one patient with a meningioma of the tuberculum sellae. The submucosal dissection of the nasal septum used in the conventional transsphenoidal approach was extended to the superior lateral wall of the nasal cavity to expose the bony surface of the superior turbinate lying under the nasal mucosa. Submucosal posterior ethmoidectomy widened the area visualized through the conventional transsphenoidal approach both superiorly and laterally. This provided a safer and less invasive access to lesions in the cavernous sinus or the suprasellar region through the sphenoid sinus. Using this approach the authors encountered no postoperative complications, such as olfactory disturbance, cranial nerve palsy, or arterial injury. In this article the authors present the surgical methods used in this approach.

KEY WORDS • transsphenoidal approach • ethmoidectomy • parasellar tumor • cavernous sinus • skull base surgery

The transsphenoidal approach is a standard surgical procedure used to treat pituitary tumors. One of the most important advantages of the transsphenoidal approach is direct visualization of the sella turcica without causing any damage to the brain. The major operative route is narrow, however. The surgical field can be widened inferiorly by removing the clivus, but widening is restricted superiorly by the bulge of the posterior ethmoid sinus. In the region anterior to the sella turcica, only a limited portion of the tuberculum sellae and the planum sphenoidale can be observed, and the optic canal and the bony convolution of the ICA bulging into the lateral sides of the sinus cannot be directly visualized. Therefore, excision of a tumor invading the cavernous sinus requires the use of curved curettes or aspirators attended by blind maneuvers around the ICA, which may result in serious operative complications.

To overcome this disadvantage of the transsphenoidal approach, many modified approaches have been reported, such as the transmaxillary approach through the maxillary sinus and the transethmoidal approach with ethmoidectomy through a facial incision. All these extensive approaches are considerably invasive, however, and some of them are performed via an incision in the face or through the nasal cavity. Consequently, they are not accepted widely. In anatomical research, by extensive opening of the anterior wall of the sphenoid sinus, it is possible to access the planum sphenoidale, tuberculum sellae, and cavernous sinus, in addition to the sella turcica through the nasal cavity. Fraioli, et al., have reported on a logical procedure to expand the inferolateral view in the standard transsphenoidal approach by adding a maxillary osteotomy or by fracturing the medial wall of the maxillary sinus. Although there are a few reports of tumor removal in the suprasellar region through the planum sphenoidale via modified transsphenoidal approaches, the concrete method for extending the superolateral view has not been described. The forceful opening of the speculum at the sphenoethmoidal recess may result in accidental skull-base fractures as a serious complication. Furthermore, in cases in which the walls of the posterior ethmoid air cells are tough, such as in young adults or individuals with acromegaly, the operative field cannot be sufficiently expanded without performing a posterior ethmoidectomy. In this report, we introduce less invasive procedures in which the surgical field obtained via the standard transsphenoidal approach can be consistently and safely enlarged by means of submucosal posterior ethmoidectomy.

Operative Procedure

Our approach is based on the standard transsphenoidal
After the patient has been placed in a semi-sitting position, the patient’s head is tilted to the left with a slight anterior bend so that it faces toward the surgeon, who stands on the right side of the patient’s chest. If cavernous sinus excision might be required, the upper half of the patient’s body should be elevated at an angle greater than 15˚. To make the intraoperative postural change easier, the patient’s head is secured with three-point pin fixation. Intraoperative fluoroscopy is not used; to ascertain the three-dimensional structure of the sphenoid sinus, we refer to preoperative three-dimensional computerized tomography images obtained in the same direction as the surgical approach. After the sublabial incision, the nasal mucosa of the bony septum is dissected to the anterior wall of the sphenoid sinus. To avoid postoperative nasal deformity, we do not enlarge the nasal orifice by osteotomy at the lateral edge of the piriform aperture. At this point, a transsphenoidal nasal speculum is inserted into the submucosal tunnel and positioned to provide a view of the natural ostium of the sphenoid sinus in the upper portion of the surgeon’s visual field.

Opening the speculum against the lateral nasal walls can easily fracture the middle turbinate body that runs across the approach route. The nasal cavity superior to the sphenoid ostium becomes steeply narrowed due to the bony protrusion of the posterior ethmoid sinus on both sides (Fig. 1). If the blades of the speculum are directed superiorly to expand the upper surgical field, sufficient opening of its blades will be impossible. If the speculum is forcefully opened at the sphenethmoidal recess, causing fracture of the posterior ethmoid sinus by the tip of the speculum blades, a fracture of the optic canal or of the orbit may develop. In addition, the nasal mucosa of the superior turbinate will constitute an overlapping obstacle in the upper surgical field. Therefore, the area of submucosal dissection of the nasal septum is extended to the lateral wall of the nasal cavity along to the sphenoethmoidal recess (Fig. 2). The mucosal connection between the nasal cavity and the sphenoid sinus should be cauterized and interrupted at the natural ostium to achieve complete detachment of the mucosa from the sphenethmoidal recess. The detached mucosa is withdrawn toward the front and pressed to both sides by the blades of the speculum. Occasionally, the mucosa adheres to the roof of the nasal cavity and the superior turbinate, and a mucosal tear may be produced. A small tear will not result in a serious postoperative complication. It is important to minimize the mucosal dissection from the ethmoid bone to prevent postoperative olfactory disturbance and CSF rhinorrhea. The angle formed by the roof of the nasal cavity and the anterior surface of the sphenoid bone defines the superior limit of the submucosal dissection of the nasal septum.

The exposed bony surface of the superior turbinate is removed and the posterior ethmoid sinus is opened (Fig. 2c). The air cells of the posterior ethmoid sinus are opened, one after another, to the medial wall of the orbit, and the blade of the speculum can be opened in a more superiorly directed position. The anterior wall of the sphenoid sinus is removed using a chisel. Once the septum and mucosa in the sphenoid sinus are removed to combine the sphenoid and posterior ethmoid sinuses into one cavity, a nearly square-shaped complete interior view of the sphenoid sinus is provided. The opening of the sella floor can
be extended anteriorly to the planum sphenoidale and laterally until the optic canal and the entire inferior wall of the cavernous sinus are exposed. If the sphenoid sinus is not well pneumatized, a diamond-tipped air drill should be used to remove the cancellous bone.

At this stage, care should be taken not to injure the optic nerve, ICA, cavernous sinus, and maxillary nerve. These structures run lateral to the sella turcica, and their courses can be recognized by bony convolutions inside the sphenoid sinus. The route of the optic canal can be identified by the bony bulge of its inferomedial wall, which runs from both sides of the tuberculum sellae. Portions of the ICA—the vertical segment medial to the trigeminal ganglion (C5), the transverse segment through the cavernous sinus (C4), and the anterior bend (C3)—course along to a groove at the lateral wall of the body of the sphenoid bone and form the osseous convolutions on the inner surface of the sphenoid sinus.

In patients in whom the sella turcica is not enlarged, the intercavernous sinus may sometimes cross the surgical field. When it is necessary to cut it, only the outer wall of the intercavernous sinus is longitudinally incised initially, and both sides of the sinus are packed with oxy-cellulose before complete repair. When the cavernous sinus is expected to be opened, it is necessary to widen the opening of the sella floor until the inferior wall of the cavernous sinus can be directly observed. The tumor in the cavernous sinus is resected through an incision made in the inferior and/or medial wall of the cavernous sinus.

During this resection, it is important to confirm the course of the ICA frequently by using a microvascular ultrasound Doppler probe. In the visual field, as observed through a surgical microscope, the C3 segment of the ICA is in the center and the C5 segment runs from the dorsal sella almost parallel to the surgeon’s line of sight.

In a patient harboring a pituitary tumor that extends to the suprasellar region, the principle of tumor removal is intracapsular resection, to avoid possible postoperative bleeding from the residual tumor into the subarachnoid space. By means of a careful intracapsular maneuver in which a 70°-angled, 4-mm-diameter rigid endoscope is inserted into the sella turcica to confirm the tumor capsule, tumor resection can be performed easily and safely, even when the tumor is located near the optic nerve or the ICA.

For resection of suprasellar tumors such as tuberculum sellae meningiomas or craniopharyngiomas, the dura mater on the planum sphenoidale and tuberculum sellae is incised at the midline to reach the prechiasmatic cistern. The tumors can then be resected while keeping the arachnoid plane around the tumor intact, with direct visualization of the optic nerve, optic chiasm, pituitary stalk, anterior cerebral artery, and ICA.

If the sella turcica is enlarged, it should be filled with pieces of fat and the sella floor should be reconstructed by inserting a piece of bone from the septum already resected; the fat and bone should be affixed to the sella turcica with fibrin glue. In the event that there is a massive CSF leakage during the surgical procedure, a watertight closure is desirable. The dural window is patched with fascia and sutured with No. 5-0 nylon in a watertight fashion. The long bayonet microinstruments designed for microvascular anastomosis, which include needle holders (models FD99 and FD96; Aesculap, Tuttlingen, Germany), fine-tipped forceps (model BD851; Aesculap), and 7-mm-long half-circle needles, are used for suturing in a deep and narrow operative field. The intradural space is irrigated with saline before suturing is completed. If a small amount of leakage is observed, an additional suture is added to create a watertight dural closure. Lumbar drainage of CSF is maintained for approximately 5 days.

**Illustrative Case**

This 22-year-old woman presented with a 2-month history of progressive visual deterioration. An MR imaging examination revealed a suprasellar cystic tumor (Fig. 3 upper). During the operation, the tumor was totally removed via an extended transsphenoidal approach (Fig. 4). The optic chiasm, which initially lay outside of the operative field, descended after cyst puncture. The tumor cap-
sule adherent to the inferior aspect of the optic chiasm was dissected under direct vision. Small vessels and fibrous tissue connecting the tumor and the pituitary stalk were cut to remove the tumor. The dural opening was sutured with a piece of fascia and the anterior wall of the sella turcica was reconstructed with a ceramic plate. Histological diagnosis in this case was craniopharyngioma. Postoperatively, the patient experienced transient diabetes insipidus. The patient’s visual function and pituitary function had recovered completely. Follow-up MR images obtained at 3 months postoperatively demonstrated no residual or recurrent tumor (Fig. 3 lower).

Results

We performed tumor resection using this approach in 14 patients with pituitary tumors, three patients with craniopharyngiomas, and one patient with a meningioma of the tuberculum sellae with no postoperative nasal complications such as olfactory disturbance. In six cases, the cavernous sinus was opened without creating any cranial nerve palsy or arterial injury, although abducent nerve palsy was temporarily observed in one patient postoperatively. Two of five patients in whom there was massive CSF leakage during surgery required repair of the dural closure because they experienced postoperative CSF rhinorrhea, but this complication did not develop in the other patients in whom a fascial patch was sutured in a watertight fashion.

Discussion

The sphenoid sinus is a cavity, roughly cubic in shape, in the sphenoid bone that lies adjacent to the pituitary gland, optic nerve, cavernous sinus, and ICA. When the sphenoid sinus is well developed, structures adjacent to its lateral wall produce bony protrusions inside the sinus. Removing the thin wall of the sphenoid sinus may directly expose the optic nerve, the cavernous sinus, and the ICA. This anatomical relationship offers the possibility of a less invasive approach to these middle skull-base structures. In using the standard transsphenoidal approach, however, extension of the upper portion of the surgical field is difficult due to a protrusion of the posterior ethmoid sinus, which results in a lack of direct visualization of the optic canal or the cavernous sinus located on the superior lateral side of the sphenoid sinus. The transethmoidal approach and the transmaxillary approach have been reported to be modifications of the sphenoidal approach designed to reach this region, but they have the following disadvantages: a facial incision is needed, bleeding cannot be neglected, and the surgical orientation is not easy to determine because of the oblique approach. Although transnasal posterior ethmoidectomy is also performed by otorhinolaryngologists, this procedure requires an intranasal maneuver.

One of the advantages of the transsphenoidal approach is that the nasal mucosa can remain intact to avoid direct contact with bacterial flora in the nasal cavity. This is accomplished by the creation of a relatively wide submu-
cosal space following a dissection of the nasal septal mucosa that extends bilaterally and a resection of the nasal septum. The characteristic modifications in our approach include extensions of the dissection of the septal mucosa to the lateral wall of the nasal cavity and resection of the superior turbinate and posterior ethmoidectomy performed in the submucosal space. These modifications enable us to resect both sides of the posterior ethmoid sinus under direct vision without loss of the advantages gained using the conventional transsphenoidal approach. Also, it is possible to expand the surgical field in a minimally invasive fashion, avoiding possible injury to the optic nerve or the orbit due to blind opening of a speculum. In addition, because this approach requires no other incisions or pathways to reach the lesion, the standard transsphenoidal approach can be converted to our extended transsphenoidal approach during an operation by addition of posterior ethmoidectomy, if necessary.

One of the most serious complications that can arise from our approach is olfactory disturbance or CSF rhinorhoea from the cribiform plate due to excessive abrasion of the mucosa. The olfactory epithelium is distributed on the upper third of the nasal cavity. Excessive dissection of the nasal mucosa can injure the epithelium, resulting in anosmia. As long as the upper limit of mucosal dissection is defined as the transition zone to the anterior skull base in the upper-most portion of the anterior wall of the sphenoid sinus, there is no risk of injuring the cribiform plate. Restriction of mucosal dissection within this limit will keep the olfactory epithelia intact and will avoid the development of olfactory disturbance. Posterior ethmoidectomy provides wider surgical field than the standard transsphenoidal approach. It has been conventionally believed that no aggressive maneuver in the cavernous sinus should be performed during the transsphenoidal approach. Once a wide exposure of the inferior wall of the cavernous sinus is achieved, however, the transsphenoidal approach is superior to the transcranial approach in many respects. 1) Pituitary adenomas extend through the medial wall into the cavernous sinus. It is reasonable to remove these tumors in the same direction as their extension. 2) The oculomotor, trochlear, abducent, and trigeminal nerves are located next to the lateral wall of the cavernous sinus, whereas no cranial nerves are adjacent to the medial and inferior walls of the cavernous sinus. Therefore, the risk of injury to these cranial nerves may be smaller via the transsphenoidal approach than via the transcranial approach. 3) In using our transsphenoidal approach, the inferior wall of the cavernous sinus can be opened widely. This allows for safer tumor resection after confirming the entire course of the ICA in the cavernous sinus under direct view. 4) The proximal control of the ICA is possible at segment C1 in our surgical field. 5) It is difficult to resect a tumor located on the medial side of the cavernous sinus via the transcranial approach. 6) Control of bleeding from the cavernous sinus is usually performed using compression by packing oxycellulose, and there is no significant difference in this respect be-
tween the transsphenoidal approach and the transcranial approach.

In expanding the surgical field by performing posterior ethmoidectomy, the prechiasmatic cistern can be reached via the planum sphenoidale. The dissection of the inferior or surface of the third ventricle and the chiasm via an approach from the skull base, which is a crucial maneuver in the resection of craniopharyngiomas, can be performed under direct view. For meningiomas of the tuberculum sellae, a median incision of the dura mater close to the attachment of the tumor and a homeostatic maneuver at this site will dramatically reduce bleeding during subsequent tumor resection. Although meningiomas tend to extend along the same direction of its growth, they can be concluded that our method makes it possible to approach the cavernous sinus by opening its inferior wall through the planum sphenoidale and/or to reach the prechiasmatic cistern through the planum sphenoidale.

References


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