The Endoscopic Endonasal Transsphenoidal Approach to the Suprasellar Cistern

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The transsphenoidal transplanum, transtuberculum approach to the suprasellar cistern, also called the "extended" transsphenoidal approach, has been used during the past 10 years by experienced transsphenoidal surgeons to remove a limited number of well-circumscribed suprasellar lesions (7, 8, 10, 17, 20–23, 29). Initially, a sublabial approach was generally used and visualization was provided with a microscope through a Hardy retractor. Many of the lesions were sellar-suprasellar, i.e., sellar lesions that extended through the diaphragma sellae into the suprasellar cistern. In a few instances, surgeons described removal of purely suprasellar lesions that rested above a normal-sized sella. However, the limited field of view provided by the Hardy retractor significantly impaired the widespread application of this approach.[6] More recently, with the increasing use of endonasal endoscopy, several authors have begun to adopt a purely endoscopic transsphenoidal approach to the suprasellar cistern.[3,4,9,16,18,19,25] The panoramic field of view provided by the endoscope, as well as the ability to use angled scopes, increases the use and applicability, as well as the safety of this approach to remove a variety of both prechiasmal (*Fig. 37.1A*) and postchiasmal (*Fig. 37.1B*) lesions. This approach is not only useful in removing lesions that extend into the sella but can also be applied to tumors that sit in the suprasellar cistern above a normal-sized sella.

INDICATIONS

The transplanum, transtuberculum approach is suitable for removing a variety of pathological entities in a few discrete locations (*Fig. 37.2*). Meningiomas of the planum sphenoidale or tuberculum sellae are particularly well suited for this approach (*Fig. 37.2, A and B*). These tumors are generally prechiasmal, and patients present with visual loss. Subfrontal and pterional transcranial approaches not only require brain retraction, but also place critical neurovascular structures, such as the optic nerves and carotid arteries, between the surgeon and the tumor.[2,12] The transtuberculum, transplanum approach permits the surgeon to internally de-

compress the majority of the tumor before encountering any vital structures.[25] Although gross total resection is possible with this approach and is generally the goal, the transtuberculum, transplanum approach also makes possible decompression of the optic apparatus in a frail or elderly patient who is losing vision in preparation for postresection radiation or observation. Another advantage of approaching these tumors from below is the ability to interrupt the dural vascular supply to the tumor early in the operation. This option is particularly important if preoperative embolization is not possible. In addition, the transtuberculum, transplanum approach potentially offers a higher likelihood of curing these meningiomas. Not only the dura but also the bone at the base of the tumor is removed during the approach. These are precisely the areas that may be infiltrated by tumor that are most difficult to remove from a transcranial route. In addition, wide opening of the optic canals bilaterally can ensure removal of tumor remnants that lie below the optic nerve, which would be very difficult to remove with a transcranial approach.

Suprasellar craniopharyngiomas can also be removed with the transtuberculum, transplanum approach[25] (*Fig. 37.2E*). These tumors arise from the posterior aspect of the stalk, and as many as 20% are uniquely suprasellar. Craniopharyngiomas are generally retrochiasmal and can extend far into the third ventricle, causing obstructive hydrocephalus. Symptoms of visual loss as well as pituitary dysfunction and even diabetes insipidus (DI) are common. Although some authors have advocated subtotal resection followed by radiation, gross total resection offers a reasonably high likelihood of cure, particularly if performed transsphenoidally.[11,25,33] Although a transplanum, transtuberculum approach places the stalk at high risk of injury, with a likelihood of DI and hypopituitarism, transcranial approaches equally jeopardize pituitary function, with rates of hypopituitarism reaching 70 to 80%.[5,15] In addition, it is possible to minimize injury to the pituitary gland and stalk either by mobilizing or partially resecting the pituitary gland to enlarge the surgical corridor. Another advantage of the endoscopic, transplanum, transtuberculum approach is the unobstructed view of the entire third ventricle from below, which cannot be obtained with a transcranial microscope-based approach. Hence, the likeli-
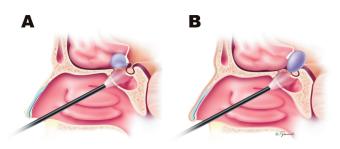
FIGURE 37.1. Endoscopic, endonasal transplanum, transtuberculum approach for removing both (*A*) prechiasmal and (*B*) postchiasmal suprasellar lesions. Reprinted with permission from Plural Publishing.
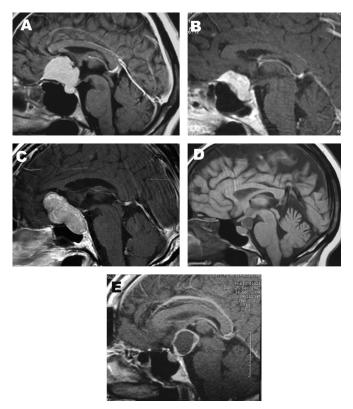

FIGURE 37.2. Appropriate lesions for the transtuberculum, transplanum approach. *A*, planum meningioma; *B*, tuberculum sellae meningioma; *C*, sellar-suprasellar pituitary macroadenoma with anterior extension; *D*, suprasellar Rathke cleft cyst; and *E*, suprasellar craniopharyngioma. Reprinted with permission from Plural Publishing.

hood of gross total resection is theoretically higher. Rates of gross total resection after microscope-based transsphenoidal resections of these tumors are as low as 22 to 46%, with cerebrospinal fluid (CSF) leakage on the order of 20 to 33%.[10,28] In contrast, the endoscopic endonasal approach may have a risk of CSF leak less than 10%.[25] The risk of hyperphagia and hypothalamic injury with gross total resection

is based on the biological fact of tumor invasion, which is unchanged by the method of approach or visualization. Therefore, the risks of hyperphagia after gross total resection are likely to be roughly equivalent after endoscopic transsphenoidal as after microscope-based transcranial approaches. However, retraction of the hypothalamus is unnecessary from below. If the goal of surgery is partial resection and cyst decompression, this can also be easily achieved with an endoscopic, transsphenoidal, transtuberculum approach.

Other tumors suitable for the transplanum, transtuberculum approach include giant pituitary macroadenomas (*Fig. 37.2C*). Although some authors have recommended a combined transcranial-transsphenoidal approach to these tumors, the view is adequate with an endoscopic transtuberculum, transplanum approach to completely remove the tumor without a craniotomy. Suprasellar Rathke cleft cysts (*Fig. 37.2E*) and the rare pituitary tumor of the stalk or suprasellar hemangioblastoma are also amenable to this approach.[23,25,29]

CONTRAINDICATIONS AND CONSIDERATIONS

In all endonasal, endoscopic resections, close attention must be paid to the lateral extent of the tumor. Although it is possible to look and reach laterally with angled scopes and instruments, working directly over a shelf of bone can be tedious and disorienting. The width of the planum sphenoidale, between the laminae papyracea, has been measured in cadaver studies at 26 ± 4 mm, which narrows to 16 ± 3 mm at the posterior aspect of the tuberculum sellae.[16] In many cases, tumors that extend further laterally can be mobilized directly into the field of view after aggressive internal decompression (*Fig. 37.3*). Nevertheless, tumors with significant lateral extension should be considered for transcranial removal. In addition, the extent to which neurovascular structures are encased by the pathology must be carefully assessed. Although encasement is not a contraindication to this approach, any more so than it is a contraindication to an intracranial approach, the surgeon must judge his or her ability to safely dissect a tumor off a vital structure and should keep in mind the possibility of radiosurgery and fractionated radiation to control the growth of residual unresectable tumor. In some cases, what appears to be tumor encasement of a vessel on preoperative magnetic resonance imaging (MRI) scan turns out to represent a vessel coursing along the capsule of the tumor that can be separated by an excellent arachnoid plane (*Fig. 37.3*).

The critical normal structures that must be preserved in this approach are the optic chiasm and the pituitary gland and stalk. For this reason, four corridors can be described to reach pathology in this location (*Fig. 37.4*). The most anterior corridor lies in front of the optic chiasm and is most suitable for meningiomas of the planum and tuberculum sellae. These tumors are far enough in front of the chiasm that minimal retraction or manipulation is required. The second corridor is
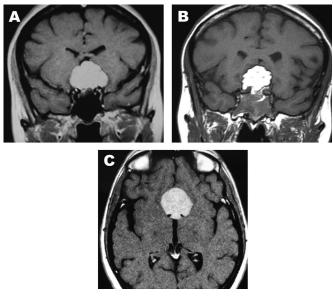
FIGURE 37.3. *A*, planum meningioma that extends laterally over the carotid artery for almost 1 cm is still resectable with the endoscopic, endonasal, transtuberculum, transplanum approach by internally decompressing the tumor and then mobilizing the borders into the resection cavity. *B*, postresection MRI scan without contrast shows a large fat graft filling the tumor cavity. *C*, the anterior cerebral arteries appear to be encased by this tumor. However, there was a clear arachnoid plane between the vessels and the tumor, which separated easily during surgery. Reprinted with permission from Plural Publishing.

FIGURE 37.4. Four corridors to reach the suprasellar cistern. The first corridor (*orange arrow*) passes in front of the chiasm. The second corridor (*green arrow*) passes over the chiasm and below the anterior communicating artery. The third corridor (*blue arrow*) passes below the chiasm and above the pituitary gland. The fourth corridor (*pink arrow*) passes below or around the pituitary gland. Reprinted with permission from Plural Publishing.

FIGURE 37.5. *A*, the downward slope of the planum and cribriform plate may make the transtuberculum, transplanum approach difficult, particularly with a 0-degree scope. *B*, removal of the posterior ethmoid sinuses and the use of a 30-degree scope facilitates this approach. Reprinted with permission from Plural Publishing.

a prechiasmal approach to the third ventricle. This approach passes between the chiasm and the anterior communicating artery through the lamina terminalis and is suitable for pathology high in the third ventricle. The third corridor passes below the chiasm and above the pituitary gland. If the stalk is midline, the approach can be performed on either side of the stalk. Often the stalk is displaced laterally. This approach is suitable for tumors that arise from the back of the stalk and extend into the third ventricle. The fourth corridor passes beneath the pituitary gland. To reach the suprasellar cistern, the gland must be mobilized either laterally or superiorly by drilling the back wall of the sella (the top of the clivus) and, in some circumstances, the posterior clinoids must also be removed, depending on the lateral extent of the tumor. This last approach will not be described in this chapter because it requires a transclival approach.

The slope of the planum sphenoidale must be taken into account during the approach. In some patients, there is a significant downward anterior slope from the tuberculum sellae to the ethmoid sinuses, and a 0-degree scope will not be adequate to visualize the suprasellar cistern without significant drilling of the cribriform plate (*Fig. 37.5*). Although visualization can be improved with the use of an angled scope
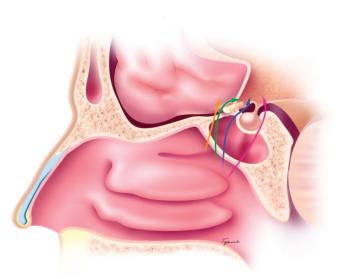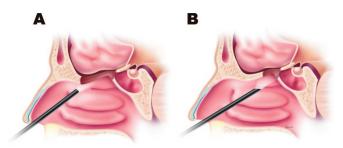
to minimize the amount of bone that must be drilled (*Fig. 37.5*), it can be difficult to advance straight instruments that do not have an upward curve into the planum. In this situation, drilling the planum can be challenging without an upwardly curved drill. Visualization can be facilitated by adding bilateral posterior ethmoidectomies to the opening, along with the use of an angled scope.

Highly vascular tumors are not a contraindication. Preoperative embolization may facilitate surgical removal by rendering the tumors softer and more necrotic and by decreasing the risk of intraoperative bleeding. Although intraopera-

tive bleeding can be managed by the experienced endoscopist, particularly if a team approach is used with the otolaryngologist and neurosurgeon working together, excessive bleeding can make the dissection tedious and necessitate frequent cleaning of the lens. In some circumstances, a computed tomographic (CT)-angiogram may be helpful to determine the relationship between the sinuses, sella, tumor, and carotid arteries and their parasellar branches.

PATIENT POSITIONING AND PREPARATION

The patient is placed under general anesthesia and administered antibiotics, glucocorticoids, and antihistamines. We routinely use cephazolin (2 g, intravenous), dexamethasone (10 mg, intravenous), and diphenhydramine (50 mg, intravenous). A Foley catheter is placed, as well as an arterial line. Optionally, a lumbar puncture is performed, and 0.2 ml of 10% fluorescein (AK-Fluor; Akorn, Buffalo Grove, IL) is injected in 10 ml of CSF to help visualize CSF leaks. A lumbar drain can be placed for postoperative drainage, although this is not necessary. The nasal mucosa is vasoconstricted with cottonoids soaked in 4 ml of 4% cocaine (topical). The patient's head is placed on a horseshoe, slightly extended, and turned slightly to the right. A 15-degree extension of the forehead chin line has been recommended.[16] The head is elevated above the heart to facilitate venous drainage. We avoid placing the head in rigid fixation, although this is an option, so that it can be moved during the case to improve exposure and to avoid postoperative discomfort of the pin-sites. The headset for neuronavigation is placed, and the patient is registered with the preoperative CT scan that is co-registered with an MRI scan. We generally use either the GE Instatrak or Brainlab system. The lateral thigh is prepared for autologous fat and fascia lata grafts. Through a 0-degree, 18-cm, 4-mm rigid endoscope (Karl Storz, Tuttlingen, Germany), the sphenopalatine arteries and middle turbinates are injected with a mixture of lidocaine 1% and epinephrine (1:100,000).

NASAL AND SINUS PORTION

Under endoscopic view, the inferior, middle, and superior turbinates are identified. The endoscope is advanced into the choana, which is limited by the tail of the interior turbinate laterally, the vomer medially, and the floor of the sphenoid sinus superiorly. The middle and superior turbinates are retracted laterally, and the sphenoid ostia are identified bilaterally. The ostium lies just above the sphenoethmoid recess, approximately 1.5 cm above the choana.[4] In some circumstances, the ostium is covered by a supreme turbinate, which can be gently retracted laterally or resected if necessary. The mucosa around the ostium is cauterized and enlarged with a mushroom punch and Kerrison rongeur. Care is taken not to wander inferolaterally into the territory of the sphenopalatine artery. A complete submucosal resection of

the nasal septum is performed via a hemitransfixion incision including vomeric bone. The hemitransfixion is closed with a 4–0 chromic suture. After the submucous resection of the septum is completed, the posterior third of the nasal septum adjacent to the vomeric bone and maxillary crest is resected with a tissue shaver. This step permits a panoramic view of the sphenoid sinus rostrum and the ostia bilaterally and provides the ability to use four separate instruments, two through each nostril, for the remainder of the procedure. The mucosa of the sphenoid sinus rostrum is retracted laterally, and the intersinus sphenoid septum is removed with a rongeur forceps. The middle turbinate on one side can be removed to increase the exposure if necessary. The posterior wall of the sphenoid sinus is, thus, brought into full view. Localization is confirmed with frameless stereotactic image guidance. A 0-degree, 30-cm rigid 4-mm endoscope (Karl Storz) is introduced through the left nostril and held in place with a flexible scope holder (Karl Storz). The carotid protuberance, optic protuberance, and opticocarotid recesses are identified (*Fig. 37.6*). The extent of bone removal will vary depending on the location of the pathology. We generally start by thinning the
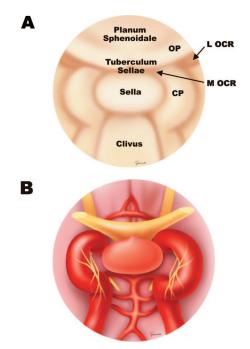

FIGURE 37.6. *A*, endoscopic view of the superior, posterior, and lateral walls of the sphenoid sinus. The bony anatomy over the sella, carotid arteries, and optic nerves can been seen. The lateral opticocarotid recess (*L OCR*) lies between the carotid protuberance (*CP*) and optic protuberance (*OP*) and forms the anterior clinoid intracranially. The medial opticocarotid recess (*M OCR*) becomes the middle clinoid. *B*, once the bone and dura are removed, the neurovascular anatomy of the anterior cranial base is apparent. Reprinted with permission from Plural Publishing.

tuberculum sellae with a high-speed diamond drill under constant irrigation. The opening extends between the middle clinoids, also called the "medial opticocarotid recess" (*Fig. 37.7*). The inferior extent of the bone opening extends approximately halfway down into the sella. If the pituitary gland is to be mobilized or the posterior clinoid removed, the sella must be opened widely, although this is not always necessary. The thinned bone is removed with a curette and Kerrison (*Fig. 37.7*). Care must be taken when opening over the intercavernous sinus to avoid tearing this vein, which can bleed profusely (*Fig. 37.7*). The opening is extended above the level of the diaphragma, and the planum sphenoidale is removed (*Fig. 37.7*). The anterior extent of removal of the planum is determined with image guidance to insure adequate exposure of the tumor. Often, this portion of the procedure requires a 30-degree, 30-cm rigid 4-mm endoscope (Karl Storz) to achieve adequate upward visualization. In some cases, bilateral posterior ethmoidectomies must be performed to adequately visualize the most anterior portion of the planum. Care must be taken to avoid injuring the posterior ethmoidal arteries. Likewise, aggressive removal of the ethmoids and septum can damage the olfactory epithelium, which can impair the sense of smell. The dura above and below the intracavernous sinus is opened with a sickle knife. If a meningioma is being removed, the dura can be cauterized before opening, to devascularize the tumor. This maneuver is safe because the bulk of the tumor will dissipate the heat and prevent neurovascular injury. The intercavernous sinus is then cauterized and transected. Cauterization can be performed with either a bipolar or, in the case of a tuberculum sellae meningioma that rests between the circular sinus and optic chiasm, a monopolar.

INTRACRANIAL PORTION

Prechiasmal Lesions

Prechiasmal tumors, generally meningiomas of the planum and tuberculum sellae (*Fig. 37.1A*), are immediately visualized once the dura is opened. Internal decompression is performed either with two upwardly curved suctions or, if the tumor is firm, with a Cavitron ultrasonic surgical aspirator (Valleylab, Boulder, CO) or an Ellman monopolar or ring cautery (Ellman, Oceanside, NY) as well as with microscissors. Visualization is obtained with a 30-degree, 30-cm rigid 4-mm endoscope (Karl Storz). Using the transtuberculum, transplanum approach, the blood supply is interrupted at the beginning of the dissection, and the tumor can be internally decompressed without having to work around the optic nerves and carotid arteries and their branches. The dural attachment of the meningioma and the bone most likely invaded by tumor are removed during the approach, which should theoretically decrease the rate of recurrence.

Once decompressed, the tumor capsule can be mobilized, and the anterior communicating artery complex and perforators are dissected sharply off the tumor capsule. Care must be taken to preserve the recurrent artery of Heubner and the subchiasmatic perforating vessels. The optic nerves and pituitary stalk are clearly seen posterior and inferior to the tumor and are easily dissected off the back of the tumor with preservation of the arachnoidal plane (*Fig. 37.8*). Avoidance
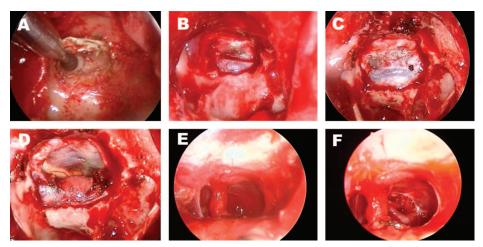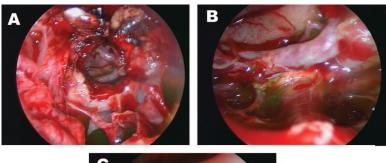

FIGURE 37.7. *A*, the tuberculum sellae is removed with a high-speed drill. *B*, as the bone opening extends downward, the intercavernous sinus is exposed. *C*, the bone opening extends halfway down the sella to expose the dura over the pituitary gland. *D*, the planum sphenoidale is removed to expose the optic chiasm, optic nerves, and pituitary gland. *E*, a corridor can be opened between the optic chiasm and the pituitary gland by gentle retraction inferiorly on the pituitary gland and superiorly on the optic chiasm. The pituitary stalk is visualized. *F*, behind the stalk lie the basilar tip, posterior cerebral arteries, and the mammillary bodies in the interpeduncular cistern. Reprinted with permission from Plural Publishing.
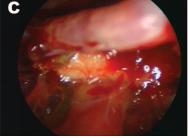
FIGURE 37.8. The 45-degree endoscope is advanced into the resection cavity after removal of a tuberculum sellae meningioma. *A*, the bone opening of the transtuberculum, transplanum approach is seen from below. *B*, the scope is advanced into the cavity to reveal the pituitary stalk, which has been pushed backward by the tumor. The chiasm, now well decompressed, is seen above the stalk. Above the chiasm is the right A1 segment leading into the anterior communicating artery and left A1. The gyrus rectus appears above. *C*, closer view of the right A1, chiasm, and pituitary stalk. Reprinted with permission from Plural Publishing.

of coagulation and "pulling" are critical to the preservation of vital neurovascular structures. The remaining capsule is removed completely. The resection bed is examined with a 45-degree, 18-cm rigid 4-mm endoscope (Karl Storz) to ensure the absence of any residual tumor (*Fig. 37.8*). Curved suctions, angled micropituitary rongeurs, and dissectors can be used to reach residual pieces of tumor. The key to the success of this approach is then to investigate the optic canals, which have been opened from below, to ensure that there is no residual tumor. The area inferior and medial to the optic nerves is a region of poor visualization by a transcranial approach, which is more easily seen with the endonasal, endoscopic, transplanum, transtuberculum approach.

Postchiasmal Lesions

Postchiasmal tumors generally are cystic, either craniopharyngiomas or Rathke cleft cysts, which arise from the back of the pituitary stalk and extend into the third ventricle behind the optic chiasm (*Fig. 37.1B*). Because the approach usually extends posteriorly into the third ventricle, removal of the entire planum is usually not necessary. Dissection can often be performed with a 0-degree, 30-cm rigid 4-mm endoscope (Karl Storz), although the 30-degree scope may be useful at times. After the dura is opened above and below the intercavernous sinus, the arachnoid of the suprasellar cistern is incised and a corridor is opened between the pituitary gland below and the optic chiasm above (*Fig. 37.7, E and F*). In some cases, the stalk is encountered in front of the tumor (*Fig. 37.9A*). In other cases, the stalk is infiltrated or off to the side (*Fig. 37.9B*). If the tumor is immediately apparent and is pushing up the chiasm, there may be adequate room to safely remove the tumor. Slight upward pressure on the chiasm and downward pressure on the pituitary gland can be tolerated. If
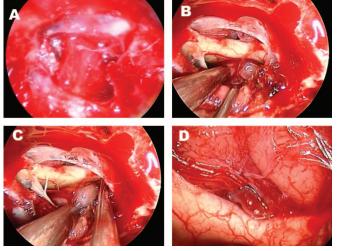

FIGURE 37.9. Postchiasmal tumor removal. *A*, once the dura is opened, the pituitary stalk is sometimes encountered immediately, pushed forward by the tumor. Dissection must be performed on both sides to try to preserve the pituitary-hypothalamic axis. *B*, dissection is performed below the chiasm and above the pituitary gland. *C*, care is taken to preserve perforating blood vessels. *D*, small perforators of the anterior communicating artery can be well visualized above the chiasm. Reprinted with permission from Plural Publishing.

the patient is already hypopituitary with DI, one can work directly through the gland or the stalk. If the goal is to preserve pituitary function and there is no corridor between the pituitary and the chiasm, it is possible to lateralize the pituitary gland and remove the posterior clinoid with a diamond drill to create more room. The gland can also be mobilized superiorly if care is taken to preserve the superior hypophyseal artery.

The solid components are carefully dissected free from the optic chiasm and stalk. Internal decompression may facilitate mobilization of the capsule and sharp dissection. It is important to visualize and preserve critical neurovascular structures such as the carotid arteries, anterior communicating artery complex, and hypothalamic and chiasmal perforators. Once the tumor is partially removed, the location of the stalk may become apparent if it was previously obfuscated by tumor, and one can safely work on either side of the stalk if the gland is not mobilized (*Fig. 37.9, B* and *C*). At this point, any associated cyst will have been opened and the fluid drained. The cyst wall is then carefully dissected off the hypothalamus and third ventricle. If invasion is noted, it may be prudent to leave the cyst wall to prevent hypothalamic injury and treat the residual with radiation.

Once the tumor and cyst wall are completely removed, the resection bed is examined with a 45-degree, 18-cm rigid 4-mm endoscope (Karl Storz) to ensure the absence of residual tumor. In most cases, the third ventricle ependyma is clearly seen, including the foramen of Monro and aqueduct of Sylvius (*Fig. 37.10*). The interpeduncular cistern is also apparent, including the basilar tip, posterior cerebral artery, superior cerebellar artery, and third nerve (*Fig. 37.10F*).

CLOSURE

The use of intrathecal fluorescein helps to ensure adequate closure at each stage. CSF leakage is a necessity of this approach and is not of concern. However, residual CSF leak is unacceptable at the end of the closure, and fluorescein is useful to ensure a watertight closure so that a spinal drain can be avoided.

Prechiasmal

Closure is performed in a multilayer fashion. First, fat is placed within the cavity. It is important to use enough fat to obliterate the dead space without causing compression of the optic chiasm (*Fig. 37.11*). Hence we do not "pack" fat but merely place it (*Fig. 37.11A*). The second layer is an inlay of fascia lata (*Fig. 37.11, B* and *C*). If fascia lata is not available, we use a dural substitute. A more rigid dural substitute is preferable to avoid flopping out of the cavity; we recommend Dura-Guard (Synovis, St. Paul, MN), as opposed to Duragen (Integra, Plainsboro, NJ). These two layers are buttressed by a rigid piece of vomer (*Fig. 37.11, D* and *E*). If no autologous bone is available, we have used a small titanium plate for this purpose with good results (*Fig. 37.11F*). Finally, a watertight closure is achieved with the use of either fibrin matrix (Tisseel; Baxter, Deerfield, IL) (*Fig. 37.11H*) or polymerized hydrogel (Duraseal; Confluent Surgical, Waltham, MA) (*Fig. 37.11I*). We use a 16-gauge angiocatheter within a small ring curette to apply the sealant accurately. In our experience, Duraseal is superior. The sphenoid sinus is filled with thrombin-infused gelatin matrix (FloSeal; Baxter) to buttress the closure and aid in hemostasis. We do not place fat in the sphenoid sinus because fat can necrose over time, causing a foul smell. A small piece of Telfa is placed in each nostril overnight to absorb any drainage and is removed in the morning.
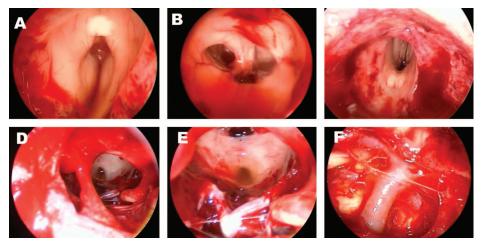

FIGURE 37.10. After removal of a large cystic craniopharyngioma, a 45-degree scope can be advanced into the third ventricle to ensure complete tumor removal. *A*, the roof and walls of the third ventricle are clear of tumor, and the choroids plexus comes into view. *B*, larger tumors will expand the third ventricle, and the foramina of Monro as well as the fornices can be seen. *C*, as the scope is withdrawn, the hypothalamus is seen where the ependyma has been eroded by the tumor. *D*, if the scope is angled downward toward the floor of the third ventricle, the aqueduct of Sylvius comes into view behind the pituitary stalk. *E*, a closer view reveals the basilar tip in the interpeduncular cistern and the posterior cerebral arteries. *F*, if the basilar artery has been pushed backwards, the transtuberculum, transplanum approach can reveal the basilar artery on the mesencephalon, and the origin of the third cranial nerve between the posterior cerebral and superior cerebellar arteries. Reprinted with permission from Plural Publishing.
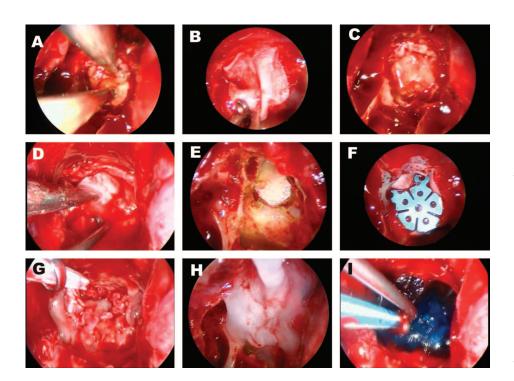
FIGURE 37.11. Multilayer closure. *A,* for prechiasmal pathology, the dead space is filled, but not packed, with autologous fat. *B,* autologous fascia lata is then tucked into the cavity as (*C*) an inlay graft. *D,* a buttress is placed of vomer or cartilaginous septum, also an inlay, which should (*E*) stay in place on its own. *F,* a miniplate can be used if no vomer is available. *G,* a 14-gauge angiocatheter directed with a small ring curette can be used to place (*H*) fibrin glue or (*I*) DuraSeal for a watertight closure. Reprinted with permission from Plural Publishing.

Postchiasmal

If the third ventricle is opened widely at the end of the case, abdominal fat is not used as the first step in the closure to avoid the risk of obstruction of the third ventricle should this raft be dislodged. The dura is first repaired with an inlay of either fascia lata or dural substitute (Dura-Guard) (*Fig. 37.11, B* and *C*), buttressed with either vomer or a miniplate if no vomer is available (*Fig. 37.11D*–*F*). This step is followed by either Tisseel fibrin glue (*Fig. 37.11H*) or, preferably, DuraSeal (*Fig. 37.11I*) administered with a 16-gauge angiocatheter within a small ring curette, and then FloSeal, as described above. A small piece of Telfa is placed in each nostril overnight to absorb any drainage and is removed in the morning.

LUMBAR DRAINAGE

If no fluorescein is evident at the end of the closure, we do not routinely place a lumbar drain. However, if the patient is obese, or if there is reason to suspect high intracranial pressure, a lumbar drain can be placed to help avoid CSF leakage. It is preferable to place the lumbar drain before beginning the resection because the loss of CSF during the operation will make placement harder at the end of the case. Lumbar drainage carries its own potential complications; it causes significant back pain and risk of spinal leak after removal, and increases the length of stay. Hence, avoiding lumbar drainage is preferable.

POSTOPERATIVE CARE

Once the surgery is complete, extubation must be performed smoothly without "bucking" to avoid dislodgment of the closure. The patient is brought to the recovery room, and the head of the bed is kept at 30 degrees. Patients are monitored for DI by checking the urine output as well as its specific gravity hourly. If there is evidence of DI, we try to avoid medical therapy if the patient is able to keep up with oral fluid intake. The serum sodium level is monitored frequently. Treatment is initiated only if there is a notable rise in the serum sodium level, the patient is unable to keep up with the urine output, or the DI lasts for more than 1 to 2 days. Antibiotics are continued for two postoperative doses. Despite the transnasal trajectory, the risk of meningitis seems low, assuming there is no persistent CSF leak. Patients are administered a small dose of glucocorticoids the night after surgery and the next morning. If there is clearly damage to the pituitary-hypothalamic axis or preoperative hypocortisolism, glucocorticoids are continued for the patient's hospital stay and are tapered by the endocrinologist after discharge. Otherwise, a fasting morning cortisol level is obtained on the morning of the second postoperative day, and cortisol replacement is initiated only if the level is abnormally low. If no lumbar drain has been placed, patients ambulate on the second postoperative day and may be discharged on the third postoperative day, or as soon as they are ambulating and eating well. A postoperative MRI scan usually is obtained on the second postoperative day and then 3 months after surgery.

If a large fat graft is in place, it may be useful to obtain fat-suppressed images.

DISCUSSION

The extended transsphenoidal approach extends operative exposure beyond the sella by removing the tuberculum sellae and a portion of the planum sphenoidale.[8,32] With the additional visualization gained by using the endoscope, this approach becomes more versatile and applicable to a wider variety of lesions. The advantages of the extended transsphenoidal approach over a traditional craniotomy are the avoidance of frontal or temporal lobe retraction or sylvian fissure dissection and the potential associated brain injury. Approximately 10% of all transcranial cranial base procedures result in some form of retraction injury to the brain.[1] However, it has generally been thought that an enlarged sella, secondary to the lesions' extension, was required to safely reach a suprasellar lesion through a transsphenoidal approach.[1,6,26,30] This caveat is partially based on the use of the traditional operating microscope, because the light source and lens are a long distance from the lesion, and visualization is limited by long, narrow retractors.[23] The endoscope circumvents this problem by bringing the light source and lens closer to the pathology. A panoramic view is provided that can be augmented by the use of angled endoscopes.[9,16,25,31]

In this chapter, we show that a purely endoscopic extended approach can be used for resection not only of large sellar-suprasellar pathology, but also uniquely suprasellar, supradiaphragmatic lesions above a normal-sized sella. In most recent case reports of purely endoscopic approaches to suprasellar lesions, there was extensive disease within the sella and an extended approach was not used.[13] In fact, Frank et al.[13] recently reported 16 Rathke cleft cysts removed endoscopically, many of which extended from the sella into the suprasellar region, but cautioned that the endoscopic approach may not be suitable for lesions that are purely suprasellar. Although craniopharyngiomas and Rathke cleft cysts are often managed with a transsphenoidal approach, most authors caution that this approach is appropriate only for tumors with "subdiaphragmatic extension".[7,11,24,26,27]

Microscope-based removal of purely suprasellar craniopharyngiomas and meningiomas has been associated with a 20 to 33% rate of CSF leak[10,28] and a gross total resection rate of only 22 to 46%.[10,28] For craniopharyngiomas, postoperative rates of DI and panhypopituitarism occur in roughly 70%.[5,15] In our smaller preliminary series, using the endoscopic endonasal approach, we resected 100% of the craniopharyngiomas with a risk of postoperative CSF leak of 0% and comparable endocrinological morbidity.[25] We found that the visualization provided by the endoscope is outstanding for the extended approach to purely suprasellar pathology. This advantage can potentially minimize the risk of morbidity to vital neurovascular structures and also decrease the risk of CSF leakage because closure is more secure, aided by improved visualization. In addition, because the lens and light source are at the tip of the endoscope, the endonasal approach does not limit visibility in the lateral dimension, as occurs with the microscope. Thus, even extended approaches can be performed with the same minimally invasive, mucosa-sparing endonasal approach, as opposed to the microscope-based approaches that often require a sublabial incision and extensive submucosal dissection.[22,23]

Despite the minimally invasive approach and the use of the endoscope, these endoscopic cases are not without morbidity. However, removal of these lesions using a traditional microscope-based transcranial or transsphenoidal also has a potentially high morbidity and mortality rate.[5,14,15,33] Whether the morbidity rate would have been greater with a microscope-based approach is unknown and will require a larger patient series with longer follow-up.

Although we do occasionally use spinal drainage, this maneuver may promote slumping of the brain away from the operative site and may be counterproductive if a graft inlay is used for closure. In addition, spinal drainage necessitates a longer postoperative stay. We have begun exploring our ability to close extended transsphenoidal approaches without lumbar drainage, and the risk of CSF leakage does not seem to be increased. The success of this maneuver requires meticulous closure with dural graft inlay, either fascia lata or Dura-Guard, rigid buttressing with either vomer or a metal plate and the use of sealants, such as DuraSeal. We emphasize that extended endoscopic transsphenoidal procedures are not without risk and should be performed only by surgeons with significant experience in both transsphenoidal and endoscopic surgery, preferably after practice on a cadaveric specimen. As the learning curve plateaus for these extensive endoscopic approaches, direct comparisons with microscope-based surgeries will be forthcoming.

CONCLUSIONS

The endoscopic transsphenoidal transtuberculum transplanum approach is the most direct and least invasive method of reaching the suprasellar cistern. Angled endoscopes permit easy visualization of the area that extends from the anterior aspect of the planum sphenoidale back to the interpeduncular cistern, reaching from orbit to orbit. Intracranially, angled endoscopes and angled instruments extend the visualization over the orbits for a reach of a few millimeters. In addition, the surgeon can reach up to the roof of the third ventricle, particularly if the lesion has opened a channel into this region. Although it is possible for a single surgeon to perform this surgery, we prefer a team approach. Once the initial approach is complete, both the neurosurgeon and otolaryngologist are generally present for the remainder of the case. In some situations, it is helpful to have an extra set of hands and four instruments in the field, with the scope on a scope-

holder. In other circumstances, the otolaryngologist must manually manipulate the scope to optimize the visualization, particularly near the end of the case when the angled scopes are used and the field of view is constantly changing.

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