Transsphenoidal Microsurgery

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ONLINE DIGITAL VIDEO

TRANSSPHENOIDAL MICROSURGERY IS a well-established neurosurgical procedure that has become the standard of care in the management of the majority of pituitary tumors and a select group of other sellar lesions. The safety of the procedure depends on the surgeon's adherence to certain anatomic concepts. Foremost among these concepts is the necessity of preserving the integrity of the arachnoid membrane covering the tumor dome and avoiding vascular injuries in the cavernous sinus. The objective of this article is to demonstrate the sequential steps of a transsphenoidal microsurgical procedure for the removal of a pituitary tumor in light of the anatomic concepts discussed, with the goal of preventing complications and achieving the best possible outcome.

KEY WORDS: Anatomic concepts, Pituitary tumors, Technique, Transsphenoidal microsurgery

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The roots of transsphenoidal pituitary surgical techniques can be traced to the late 19th century (8). Cushing (7) also used this approach to remove pituitary adenomas. The transsphenoidal microsurgical technique was ushered in by Hardy in 1962 (9). Transsphenoidal microsurgery is currently a proven, well-established neurosurgical procedure, as evidenced by the reports in the literature that attest to its safety and efficacy (10, 14, 18, 24, 25). Nevertheless, complications continue to be associated with this procedure (6, 15, 20). A review of the surgical technique of transsphenoidal microsurgery seems appropriate because it may contribute to further improvement in outcomes.

CONCEPTUAL NUANCES

The execution of a surgical procedure depends in large measure on the understanding of the surgical anatomy of the operative field. We consider the following three anatomic concepts that are fundamental to the safe execution of a transsphenoidal microsurgical procedure:

1. The pituitary gland is an extra-arachnoid structure.
2 The pituitary gland is strictly in the midline, with hazards to either side.
3. It is important to recognize the residual normal anterior pituitary, especially during operations to remove pituitary macroadenomas.

First, the pituitary gland is an extra-arachnoid structure (*Fig. 1A*) (6). Consequently, all pituitary adenomas originate in the extra-arachnoid space. As they expand out of the sella, pituitary adenomas distend the dural ring of the diaphragma sellae. At the same time, they elevate the arachnoid membrane of the diaphragma without penetrating it. Regardless of their size and shape, pituitary adenomas remain covered by a layer of arachnoid that separates them from the subarachnoid space (*Fig. 1B*). A transsphenoidal operation for the removal of a pituitary adenoma should be executed with respect for the preservation of the integrity of the arachnoid membrane, which acts as a protective shield between the surgical manipulation and the subarachnoid space, with its vital neurovascular structures. Thus, the surgical dissection should be performed along the tumor-arachnoid interface. Adherence to this simple anatomic concept is responsible for good surgical outcomes after transsphenoidal microsurgery; when this concept is violated, however, many of the complications associated with this procedure result (2, 6, 15, 20).

However, this anatomic concept does not necessarily apply to craniopharyngiomas as well. As a result of their developmental anatomy, craniopharyngiomas can be completely intrasellar and therefore completely extra-arachnoid; they can be partially intra- and

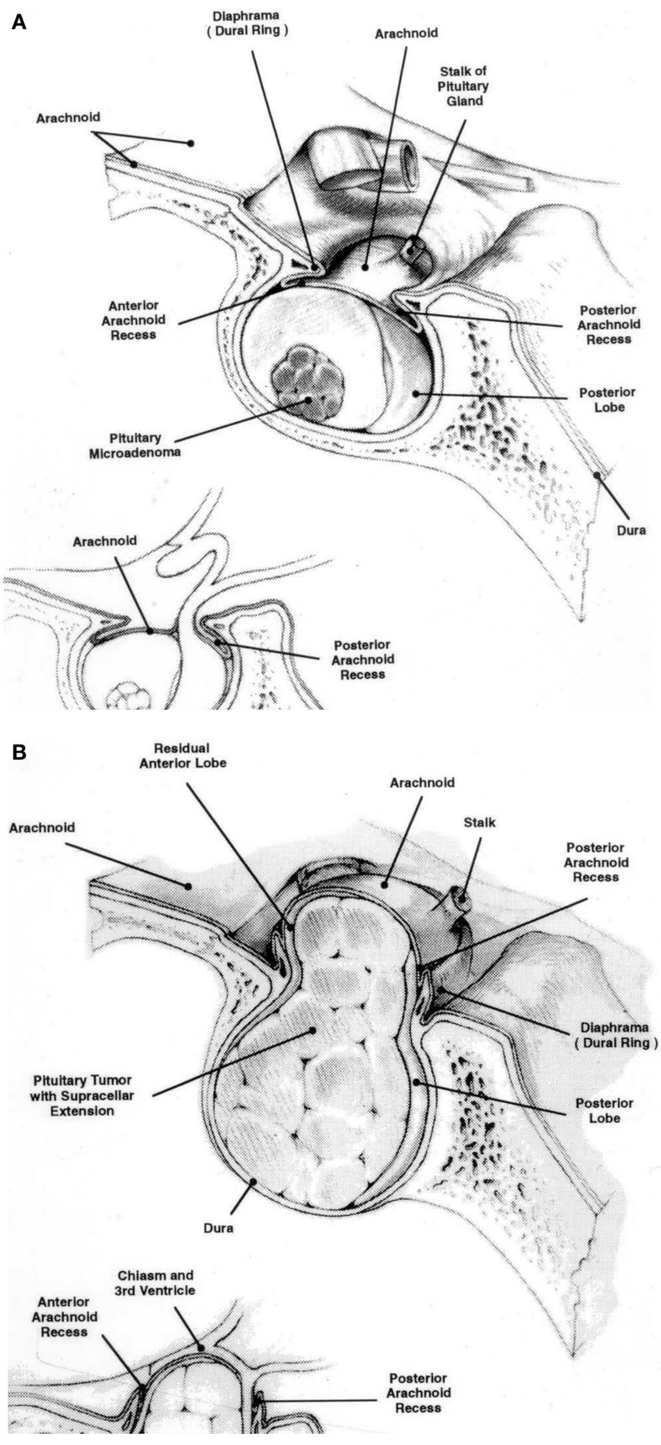

FIGURE 1. *Drawings illustrating anatomy.* A, *the pituitary gland is situated below the diaphragma sellae, which is composed of the dural ring and the overlying arachnoid.* B, *as a pituitary tumor develops and grows, it distends the dural ring of the diaphragma sellae while it elevates the arachnoid of the diaphragma. The tumor remains beneath the arachnoid regardless of its size. The anterior and posterior arachnoid recesses can be seen.*

partially extra-arachnoid; they can be completely intra-arachnoid, even interdigitating with the neuroepithelium of the infundibular region of the hypothalamus; or they can be intraventricular (5). Consequently, the possibility of a postoperative cerebrospinal fluid (CSF) leak occurring in the wake of a transsphenoidal microsurgical procedure performed to remove a craniopharyngioma is considerably greater than one performed to remove a pituitary adenoma.

The second concept that the surgeon should keep in mind is that the pituitary gland is strictly in the midline, with hazards to either side. Veering off toward one side or the other beyond certain limits during the approach—and especially during surgical maneuvers inside the sella—exponentially increases the risk of complications from transsphenoidal surgery (1, 3, 4, 16, 21, 22) (*Fig. 2*).

The third anatomic concept worth remembering pertains to the recognition of the residual normal anterior pituitary, especially during operations to remove pituitary macroadenomas. As they expand, pituitary adenomas distend the residual normal anterior pituitary to a point at which it is eventually represented by a thin layer of tissue surrounding the adenoma (6). This tissue can be recognized on the preoperative T1-weighted magnetic resonance imaging (MRI) scan as a thin layer of increased signal intensity surrounding the pituitary adenoma, which usually demonstrates decreased signal intensity. When the preoperative MRI study of a macroadenoma is examined carefully, this layer can almost always be observed (*Fig. 3*). Recognition of this layer and its preservation will prevent a postoperative anterior pituitary insufficiency.

ENDOSCOPIC TRANSSPHENOIDAL SURGERY

Although we concentrate on transsphenoidal microsurgery of pituitary adenomas in this article, we also make several comments concerning endoscopic transsphenoidal surgery. Endoscopy is here to stay (11, 12). However, it will not replace microsurgery. The two techniques should viewed as being complementary, not mutually exclusive. They both lead to the same goal: they advance the surgeon to the sellar and supra-

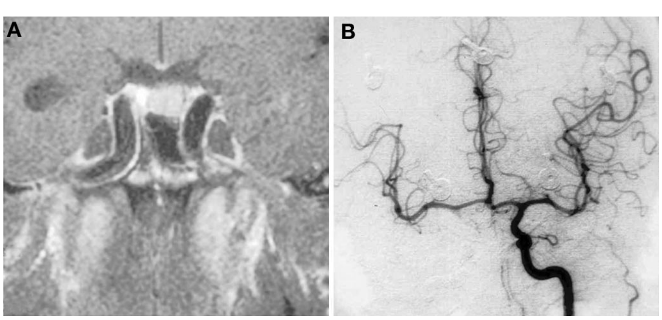

FIGURE 2. *Imaging studies in a patient with a growth hormone-secreting microadenoma.* A, *preoperative MRI scan; during surgery, the right carotid artery was injured in the cavernous sinus.* B, *postoperative angiogram revealing balloon occlusion of the right cavernous carotid.*

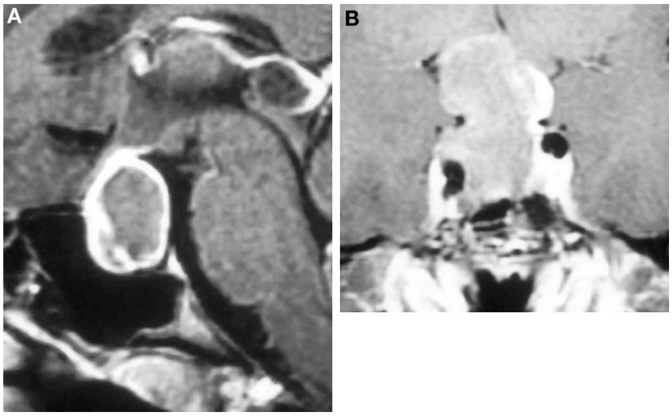

FIGURE 3. *MRI studies obtained from two patients with macroadenomas.* A, *sagittal T1-weighted MRI scan in a patient with a prolactin-secreting macroadenoma.* B, *coronal T1-weighted MRI scan in a patient with a nonsecreting macroadenoma. The peripheral rim of enhancing tissue can be seen, in both cases representing residual distended anterior pituitary.*

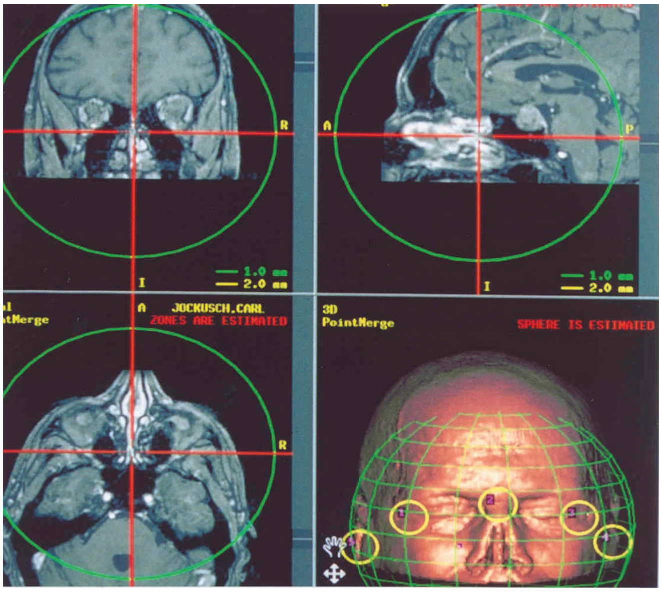

FIGURE 4. *MRI scans illustrating the anatomic landmarks (e.g., tragus, canthi, nasion) used as fiducials for MRI-based, computer-assisted frameless stereotaxy.*

sellar abnormality. Neither procedure should change how the neurosurgeon deals with the abnormality. Pituitary surgeons should be masters of both techniques and should use one or the other as the situation demands.

Endoscopic imaging remains by and large monocular. Thus, the surgeon's visualization of the operative field via endoscopic imaging resembles what the neurosurgical assistant sees through the operating microscope. Advances are being made to improve endoscopic imaging by adding the third dimension with a variety of binocular attachments. Also, holders have been designed to secure the endoscope and thereby free the surgeon's hands for surgical manipulation. These innovations are not yet available on a large-scale, commercial basis, however. For the most part, such devices are used by only a few pioneer endoscopic neurosurgeons.

PREOPERATIVE WORKUP

Each patient undergoes a thorough medical and endocrinological workup, a detailed description of which is beyond the scope of this article. In patients with endocrinologically confirmed, pituitary-dependent Cushing's syndrome whose MRI scans are inconclusive for a discrete microadenoma, a petrosal sinus sampling test is performed in conjunction with corticotropin-releasing factor stimulation to search for an adrenocorticotropic hormone gradient.

During the past 2 years, we have abandoned the use of televised fluoroscopy (10) for trajectory and instrument position control in favor of performing the operation with the assistance of MRI-based, computer-assisted frameless stereotactic guidance (*Fig. 4*). The advantages of frameless stereotaxy over televised fluoroscopy are many. First, whereas televised fluoroscopy offers only a vertical orientation in a sagittal plane, frameless stereotaxy also provides for a horizontal orientation in the coronal plane, which is an important dimension, especially during operations in patients whose sellar anatomy is obliterated by the abnormality, during reoperations in patients with recurrent tumors, and when performing the extended transsphenoidal approach, which requires navigation through a relatively narrow corridor between the two supraclinoid carotid arteries. The use of frameless stereotaxy also shortens operative time: the preoperative MRI scan can be obtained on any day before the operation by the use of external anatomic landmarks (e.g., tragus, outer and inner canthi, nasion, tip of the nose) as fiducials. In our experience with more than 50 such cases, the accuracy of the use of anatomic landmarks as fiducials has truly been impressive, with the margin of error around the sella being no more than 1 mm and with the overall average margin of error being no more than 2.1 mm for the entire series. Finally, the use of frameless stereotaxy as a navigational tool removes intraoperative radiation exposure.

PREOPERATIVE PREPARATION

During the operation, the patient lies comfortably supine. The back and the knees are elevated by approximately 15 degrees. The head is tilted toward the left shoulder, with care being taken to account for the suppleness of the patient's neck. Care is also taken not to cause an obstruction of the jugular outflow on the left side and not to cause any stretch injury to the right brachial plexus. In patients with microadenoma, the bridge of the nose is kept parallel to the operating room floor; in patients with macroadenoma, the head is inclined slightly more toward the operating room floor. The patient's head is secured in this position in relation to the operating table with a three-point fixation clamp. We prefer rigid fixation to having

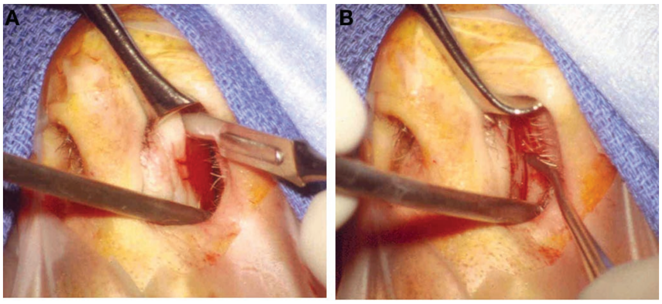

FIGURE 5. *Photographs illustrating the rhinoseptal approach on the left.* A, *incision.* B, *developing the submucosal tunnel.*

the patient's head lie on a head rest. The operating room table's capabilities for changes in position during the operation to adjust the field of view are used as needed throughout the procedure.

The nasal cavities and the surrounding facial skin are prepared with a povidone-iodine solution. Simultaneously, the right lower quadrant of the abdomen is prepared in a sterile manner for harvesting an autologous fat graft. If a submucosal approach is planned, the nasal mucosae are elevated on either side off the nasal septum by injecting approximately 10 to 12 ml of 0.5% Xylocaine (Astra Pharmaceuticals, L.P., Wayne, PA) mixed with a 1:200,000 epinephrine solution. This maneuver facilitates submucosal dissection and decreases the potential of bleeding. Such an injection is not administered, however, when a direct transnasal approach is planned.

APPROACH TO THE SPHENOID SINUS
(see video at web site)

The oldest of the modern approaches to the sphenoid sinus is the ororhinoseptal approach, as popularized by Hardy (9, 10). The sublabial incision exposes inferior aspects of both nasal mucosal sacs and the septum in between. The rhinoseptal approach is similar to the ororhinoseptal approach (14), except that the incision is made along the junction of the skin and the beginning of the medial septal mucosa of one naris (*Fig. 5A*). In either instance, an ipsilateral submucosal tunnel is developed along the nasal septum as far as the sphenoid rostrum posteriorly by creating first a superior and then an inferior tunnel before connecting the two tunnels (*Fig. 5B*).

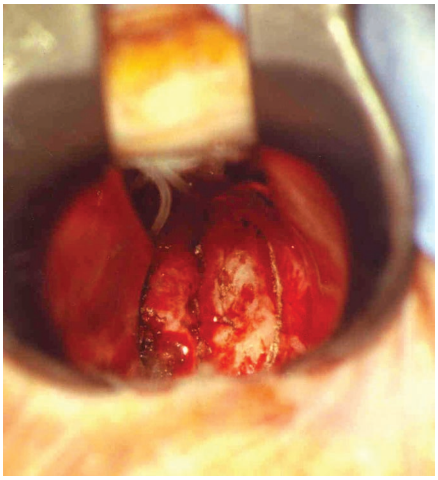

FIGURE 7. *Photograph illustrating the bivalve speculum locked in place anterior to the sphenoid rostrum.*

The nasal cartilage is then weakened along its base with a shallow incision made with a no. 15-blade knife. This maneuver facilitates the dislocation of the cartilage together with the opposite mucosal sac toward the contralateral side as a single mucoperichondrial flap. It prevents the formation of anterior nasal septum defects. These defects tend to occur when the nasal mucosae are lifted off the cartilaginous septum on either side, promoting the formation of bilateral opposing medial mucosal tears that more often than not fail to heal. As the nasal cartilage is dislocated to the contralateral side with a speculum, the junction of the cartilage and the bony septum is seen (*Fig. 6A*). This junction is then divided with a dissecting instrument that is also used to create a posterior tunnel on the contralateral side of the bony septum as far back as the sphenoid rostrum (*Fig. 6B*).

Before removing the inferior portion of the bony septum, it is advisable to separate sharply the bony septum from the perpendicular plate of the ethmoid to avoid applying traction

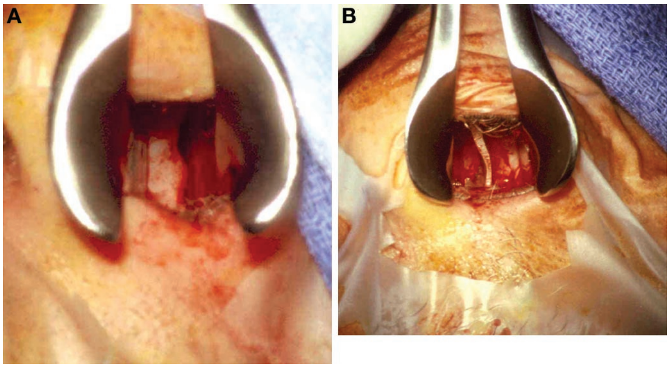

FIGURE 6. *Photographs illustrating the surgical procedure.* A, *the nasal cartilage is dislocated toward the contralateral side, together with the opposite nasal mucosal sac. This maneuver displays the cartilage-bony septum junction.* B, *a posterior submucosal tunnel is developed in the opposite, right side of the bony septum as well.*

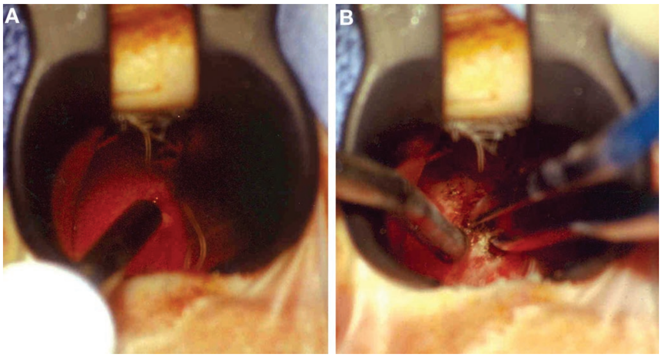

FIGURE 8. *Photographs illustrating the direct transnasal approach on the right.* A, *nasal mucosa visualized as it reflects from the bony septum over the rostrum of the sphenoid bone.* B, *nasal mucosa opened over the rostrum of the sphenoid. It is important that both sides of the rostrum be visualized.*

against the cribriform plate, which could potentially cause CSF leak. With the bony septum removed, the rhinoscope is replaced with a bivalve speculum, which is locked in place anterior to the sphenoid rostrum. If the nasal mucosal sacs are redundant and thus obscure the visualization of the sphenoid rostrum, they can be displaced laterally with a dissecting instrument by applying gentle compression against the posterior portion of the turbinates. This maneuver usually allows the speculum to be advanced further so that it can be placed into contact with the sphenoid rostrum (*Fig. 7*). If the nasal mucosal sacs are still redundant, their posterior portion can be shrunk by means of bipolar or monopolar coagulation. A bloodless field usually indicates a proper submucosal trajectory; if bleeding occurs during the approach, the surgeon more likely than not has veered off into the nasal cavity.

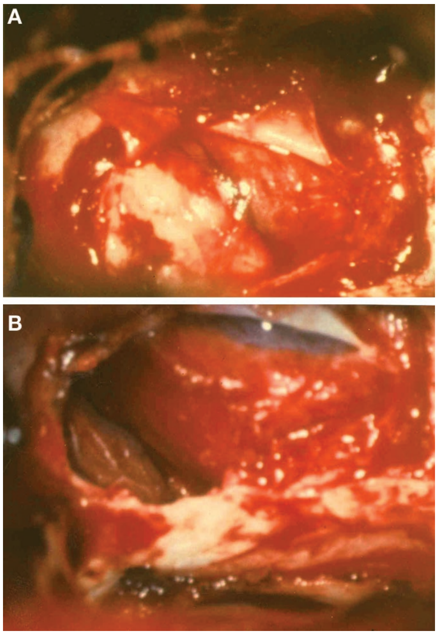

FIGURE 9. *Photographs of a pituitary macroadenoma.* A, *pituitary macroadenoma. Note that the anterior arachnoid recess is not visualized—the result of compression by the tumor.* B, *photograph showing that the anterior arachnoid recess can be seen clearly after tumor removal. The residual anterior pituitary is on the right.*

Our preferred approach is the direct transnasal approach. The entire operative procedure is performed with the use of the operating microscope. The bivalve speculum is advanced toward the depth of the nose along a track, as assessed by performing intermittent spot checks with the stereotactic probe, until the region of the mucosa that sweeps from the posterior bony septum over the sphenoid rostrum is reached (*Fig. 8A*). At this point, the mucosa is opened with bipolar coagulation, and redundant mucosa also can be excised (*Fig. 8B*). After visualizing the ipsilateral side of the sphenoid rostrum, the surgeon should identify the midline with the stereotactic probe and continue the dissection of the nasal mucosa on the contralateral side of the sphenoid rostrum. It is important that the speculum lock into place on either side of the sphenoid rostrum, at which point the operative exposure is identical to that created in the submucosal approaches (*Fig. 7*).

During the approach, care should be taken to avoid injuring the nasal mucosa inferolaterally so as to avoid injuring a branch of the sphenopalatine artery, which, even when coagulated, can recanalize in the postoperative period, resulting in major epistaxis. Our experience has been that patients tolerate the direct transnasal approach better and have a shorter convalescence than they do when the transnasal-submucosal approach is used, and that the direct transnasal approach is also better than the ororhinoseptal approach. The direct transnasal approach is limited, however, by the width of the nares, which, if relatively small, may not accommodate a bivalve speculum.

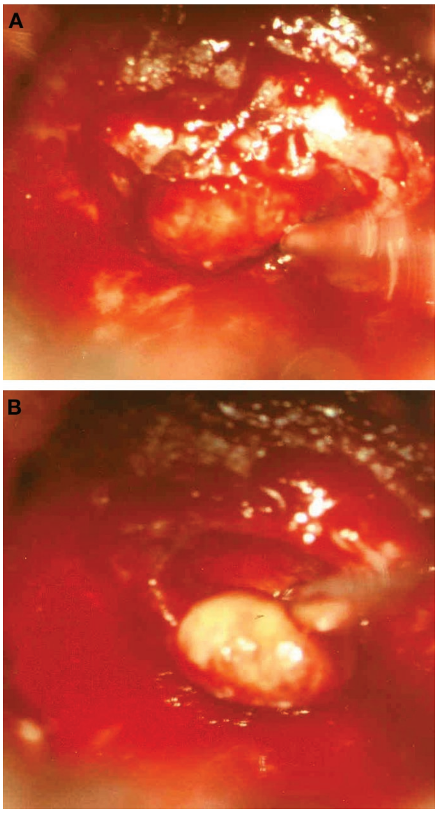

FIGURE 10. *Photographs illustrating pituitary microadenoma before* (A) *and after* (B) *excision.*

In some patients, the anterior wall of the sphenoid sinus—the sphenoid rostrum—can be sturdy and thick, especially in patients with acromegaly. Several techniques can be used to open the sphenoid sinus. For example, one can use a vertically biting instrument or a chisel to penetrate the sinus. When prominent, sphenoid sinus ostia also can be used to initiate the opening into the sinus. Throughout this procedure, frameless stereotactic guidance should be used for vertical and horizontal orientation. After opening the sphenoid sinus, the surgeon should review the anatomy of the sphenoid sinus septa by MRI before they are removed. The insertion of the septum along the anterior sella wall may be a useful anatomic landmark for the location of either a microadenoma or the medial extent of the cavernous sinus. The sphenoid sinus septa, along with the sphenoid sinus mucosa, are then removed as completely as possible. The removal of the sphenoid sinus mucosa prevents the postoperative formation of a sphenoid sinus mucocele.

The bone over the carotid tubercles may be missing (23); because of this possibility, the exenteration of the sphenoid sinus mucosa could be injurious to the underlying carotid arteries. We have not observed this phenomenon in any of our patients. As the sphenoid sinus is exposed, it often seems that the exposure is inadequate or narrow. In this event, shrinking the surrounding nasal mucosal veils with bipolar or monopolar coagulation exposes just enough of the remaining anterior wall of the sphenoid sinus circumferentially for it to be removed with a fine, thin-lipped punch rongeur. A gain of 1 or 2 mm in either direction is sufficient to enhance the ease of operative manipulation in the sphenoid sinus and sella considerably.

It has been our practice to expose the sphenoid sinus so that in every patient we can visualize the clivus, the planum, and both carotid tubercles laterally. Because the bivalve speculum sometimes has a tendency gradually to dislodge inferiorly as it is locked into place anterior to the sphenoid rostrum, it maybe advantageous to advance the speculum into the sphenoid sinus itself. When locked into place in this position, the speculum is in line with the sella as the target. Care should be taken not to open the speculum too forcefully inside the sphenoid sinus, because too much force can result in a fracture of the sphenoid bone that may involve the optic nerve canals superolaterally (19), with injury to the optic nerves. Conversely, the fracture may be inferolateral, in which case it may result in a carotid artery injury (16).

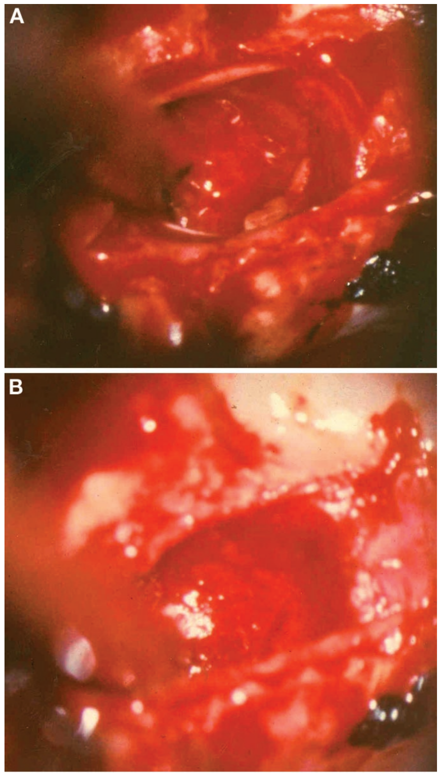

FIGURE 11. *Photographs of the pseudocapsule.* A, *pseudocapsule, a compressed layer of tissue consisting of admixture of adenoma and anterior pituitary tissue.* B, *after excision of pseudocapsule.*

We prefer to open the sella by removing the anterior sellar wall from just below the planum to the floor and from the medial border of one cavernous sinus to the medial border of the other. In microadenomas that are in a posterior position in the anterior lobe, we may remove a portion of the sella floor in accordance with the location of the microadenoma. Different techniques can be used to open the bony sella. If the anterior sellar wall is relatively thick, one can use a chisel to initiate the opening. Conversely, if the sellar wall is paper-thin, a microhook or a microcurette can be used to begin opening the sella. The remainder of the opening is performed with fine, 2- or 3-mm punch rongeurs. When the instruments are used, the surgeon can lean them gently against the walls of the speculum to enhance the steadiness and the safety of the surgical manipulations. Generally speaking, the suction tip is usually brought into the speculum with the left hand (in right-handed surgeons) from approximately the 10 o'clock position, with the other instruments entering the speculum at approximately the 5 o'clock position.

An inspection of the dura of the sellar reveals in almost every case a small, centrally positioned arterial vessel emanating from the dura; however, variations may occur. When opening the dura, it is probably better to open the middle and inferior segments of the dura first so as not to disturb a possible deep anterior arachnoid recess that, if opened, could result in a CSF fistula. In patients with macroadenomas, such a recess can be occluded by the adenoma (*Fig. 9A*), only to open as the adenoma is removed (*Fig. 9B*). We prefer to start with a cruciate incision and then to perform an excision of the four dural leaves. Additional exposure is then obtained by shrinking the periphery of the dura opening by means of bipolar coagulation.

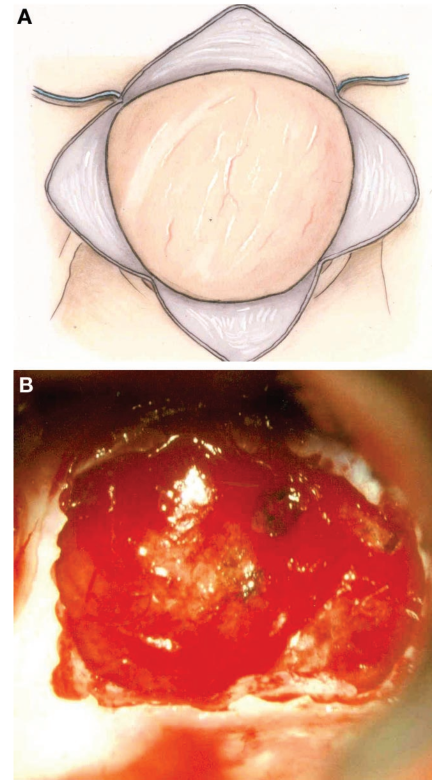

FIGURE 12. *Pituitary macroadenoma.* A, *schematic.* B, *view through operating microscope.*

REMOVAL OF MICROADENOMAS

When removing a microadenoma that is visible either on the surface or through a much-distended layer of normal pituitary, we usually look for a cleavage plane between the microadenoma and the residual normal anterior pituitary. This plane can easily be established with a no. 11-blade knife and subsequently can be developed with loop curettes and other dissectors, working in an alternating manner from opposite sides of the microadenoma (*Fig. 10*). We prefer the use of loop curettes to ring curettes because of the absence of any sharp edges in loop curettes that could prove injurious to the surrounding structures, such as the cavernous sinus and the overlying arachnoid.

When the microadenoma is not on the surface, the surgeon should look for any change in the appearance of the overlying anterior pituitary, such as discoloration or attenuated texture, before making the incision along the surface between the changed and the more normal-appearing anterior pituitary. At times, it is necessary to remove a small portion of the normal anterior pituitary to gain sufficient exposure for the complete removal of a microadenoma.

Once the microadenoma has been removed, the surgeon should inspect the tumor bed for the presence of the so-called pseudocapsule. The pseudocapsule is a condensed layer of tissue along the surface of the adenoma and consists of a mixture of adenoma tissue and compressed residual normal anterior pituitary (*Fig. 11A*). This layer is usually distinct and separable from both the microadenoma and the residual normal anterior pituitary. It is removed circumferentially to ensure endocrinological cure (*Fig. 11B*).

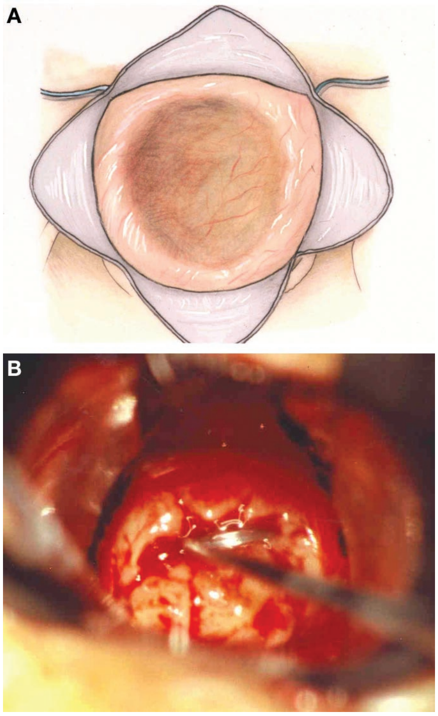

FIGURE 13. *Internal decompression of pituitary macroadenoma.* A, *schematic.* B, *view through operating microscope.*

REMOVAL OF MACROADENOMAS

The removal of macroadenomas (*Fig. 12*) may be challenging, especially if they are sanguinous. Internal decompression of the intrasellar tumor component is probably the best first maneuver (*Fig. 13*). After hemostasis is reached at the major bleeding points, we prefer to separate the tumor from the dura of the sella floor, working toward both cavernous sinuses in an alternating manner. The dissection is then performed along the cavernous sinus wall from the bottom up until the reflection of the arachnoid membrane of the diaphragma sellae is observed superolaterally on one or the other side as it slopes toward the dural ring of the diaphragma sellae (*Fig. 14*). Recognition of the arachnoid, which is usually covered by a thin layer of residual normal anterior pituitary, is a critical point in the operation. Failure to identify the arachnoid and distinguish it from the surrounding suprasellar tumor can lead to penetration into the subarachnoid space, with the possibility of injuring the subarachnoid neurovascular structures.

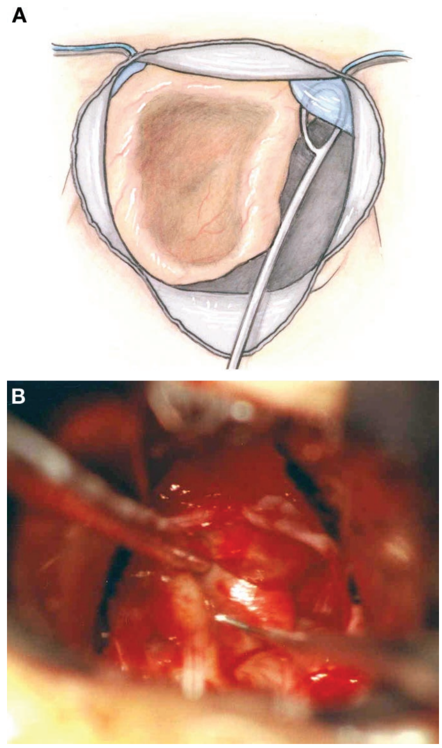

FIGURE 14. *The decompressed macroadenoma is dissected away from the sella floor and left cavernous sinus. The reflection of the arachnoid where it joins the dural ring of the diaphragma laterally can be seen.* A, *schematic.* B, *view through the operating microscope.*

At this point, the decompressed and slack intrasellar portion of the tumor is excised to gain maneuvering room for the removal of the suprasellar tumor component. We do not use any intrathecal techniques to deliver the residual suprasellar tumor into the sella. We may, however, ask the anesthesiologist to increase

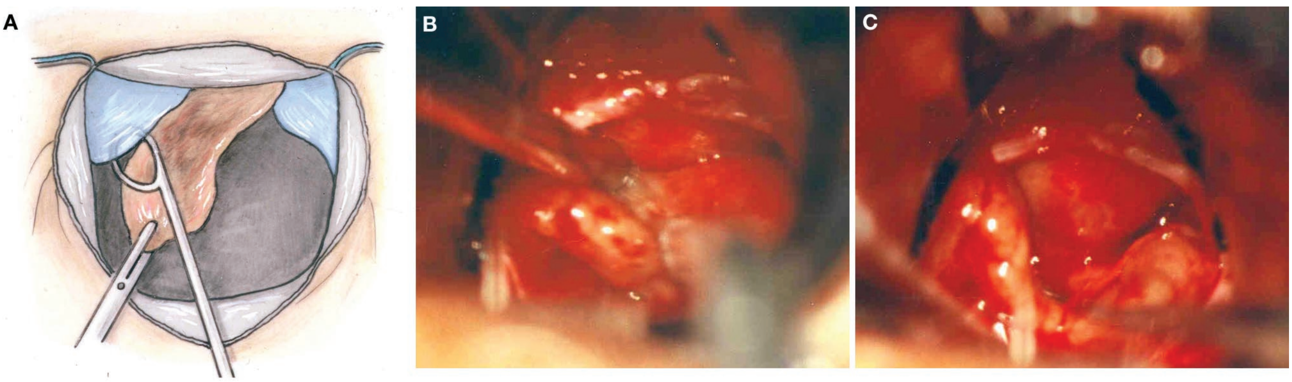

FIGURE 15. *After being adequately decompressed, gentle traction can be applied against the slackened residue of the suprasellar tumor extension* (A, *schematic) while the tumor is dissected away from the arachnoid of the diaphragma sellae with a microsuction with perforations at the tip* (B, *view through the operating microscope) or with loop curettes* (C, *view through the operating microscope). The inverted arachnoid can be seen.*

the intrathoracic pressure to cause the diaphragma sellae and the tumor beneath it to descend into the sella. This event will not occur unless the suprasellar tumor component is first adequately decompressed. As the suprasellar tumor comes into view, its further removal can be facilitated by applying gentle traction against the tumor margin while dissecting the tumor off the arachnoid and the thin layer of residual normal anterior pituitary tissue attached to it (*Fig. 15*). The dissection usually proceeds in a lateral-to-medial direction from the point where the reflection of the arachnoid meets the dural ring of the diaphragma sellae and toward the still elevated dome of the tumor. The dissection is performed with either a loop curette or a microsuction device with perforations at the tip. As the tumor removal proceeds, the arachnoid of the diaphragma sellae gradually descends into the sella until it becomes completely inverted toward the sella floor (*Fig. 16*).

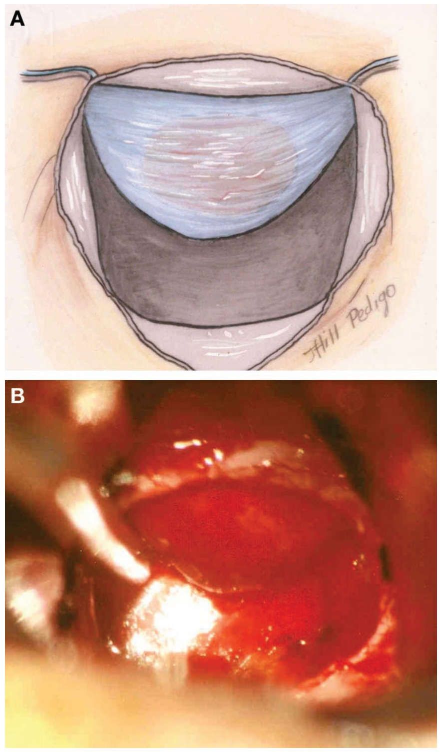

FIGURE 16. *After complete tumor removal, the arachnoid of the diaphragma sellae inverts into the sella. A thin layer of residual normal anterior pituitary is attached to the undersurface of the arachnoid.* A, *schematic.* B, *view through operating microscope.*

In patients with large suprasellar tumor components in whom the arachnoid was significantly distended by the expanding tumor, the inversion of the arachnoid into the sella after the tumor is removed occurs in a redundant fashion with several folds of arachnoid crowding into the sella. These folds can be separated gently with a microsuction tip to look for any residual tumor tissue and to accomplish hemostasis. At no time should the arachnoid be penetrated.

EXTENDED TRANSSPHENOIDAL APPROACH

Until recently, craniotomy was thought to be the only alternative to transsphenoidal microsurgery in patients with large and asymmetrically extending suprasellar tumor components and in patients with a significantly constricted diaphragma sellae. Some of these pituitary tumors, however, can be reached and successfully removed using an extended transsphenoidal microsurgical approach

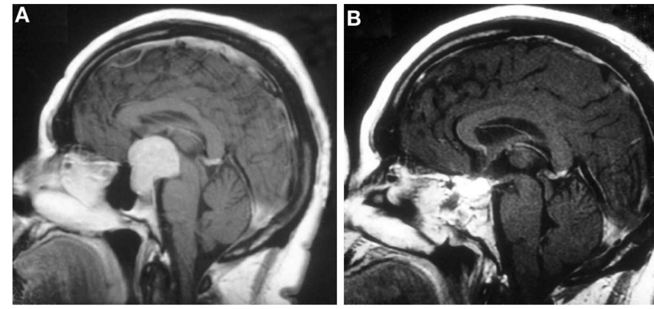

FIGURE 17. *Preoperative* (A) *and postoperative* (B) *MRI scans of a pituitary adenoma removed by means of the extended transsphenoidal approach.*

(*Fig. 17*) (13, 17). After opening the anterior sella wall up to the tuberculum sellae, the posterior portion of the planum is drilled out with the use of a microdrill with a diamond burr. The intervening bone of the tuberculum sella is drilled out last. Intracranial navigation is useful to open the dura at the midline above and below the superior circular sinus, which is then coagulated and divided, again strictly at the midline. The remaining dura can be shrunk with bipolar coagulation. The surgeon thus gains access to the suprasellar space along a trajectory that allows for direct, unobstructed visualization of the suprasellar tumor. The dissection of the tumor again proceeds along the tumor arachnoid interface, with the goal always being to maintain the integrity of the arachnoid membrane. When the procedure is completed, there is copious inversion of the arachnoid membrane into the created cranial base defect (*Fig. 18*).

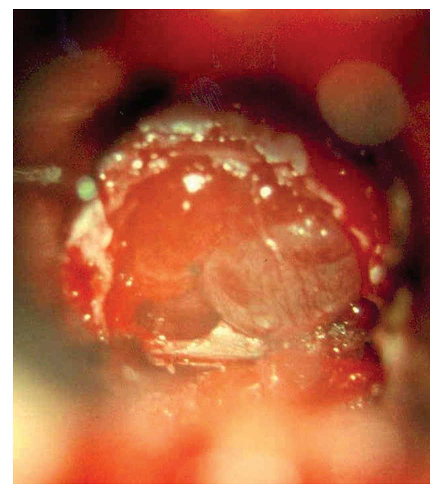

FIGURE 18. *Photograph illustrating the copious inversion of the arachnoid after the extended transsphenoidal approach.*

CLOSURE

If definitive evidence of CSF escape during the operation exists, the inverted arachnoid and the defect in it should be covered with an autologous fascia graft removed from either the fascia lata or the abdominal fascia. The fascia is covered with a layer of autologous fat. If possible, the removed sella floor should be reconstructed with a fragment of the bony nasal septum or the rostrum of the sphenoid bone. This fragment should be placed between the dura and the bony openings of the sella. Bony reconstruction is more difficult and often is not possible after the use of an extended transsphenoidal approach. In such cases, a fat graft also can be placed into the sphenoid sinus. Autologous fibrin glue can be used to hold the fat graft in place and seal all of the gaps around it. If evidence of significant CSF escape during the operation is found, especially during an extended transsphenoidal approach, a lumbar subarachnoid drain should be placed in the patient for several days after the operation.

At the end of the procedure, after the bivalve retractor has been removed, secure hemostasis is achieved along the nasal passages, and the operative field is irrigated copiously with an antibiotic solution. In patients who undergo the ororhinoseptal procedure and in those who undergo the submucosal transnasal approach, the sublabial gingiva and the nasal mucosa, respectively, are sutured back into place with resorbable suture material. The nasal cartilage is relocated back to the midline. It is usually not necessary to pack the nose. After the oral cavity is cleansed and the gastric contents are evacuated, the patient is awakened and extubated. Patients with acromegaly, especially those with sleep apnea, should not be extubated before they are fully awake.

CONCLUSIONS

The outcome of a transsphenoidal operative procedure depends largely on the surgeon's adherence to certain anatomic and surgical principles. We consider the following three principal notions to be important in the execution of transsphenoidal microsurgical procedures to treat patients with pituitary adenomas. First, pituitary adenomas are extra-arachnoid lesions; therefore, a transsphenoidal microsurgical operation to remove a pituitary adenoma should be performed outside the arachnoid membrane without penetration into the subarachnoid space. Second, pituitary adenomas are largely midline lesions that are surrounded on both sides by important neurovascular structures; therefore, the surgeon's respect for the midline and avoidance of far lateral approaches and techniques is associated with fewer complications. Third, pituitary adenomas originate within the pituitary parenchyma, and, as they grow, they distend the residual normal anterior pituitary. Consequently, the residual normal anterior pituitary invariably is situated on the surface of the adenoma.

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