# Combined Hybrid Microscopic and Endoscopic Transsphenoidal Surgery: Anatomy, Instrumentation, and Technique

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## Introduction

In 1906, Sir Victor HorseIy described his 1889 pituitary surgery using a transcranial approach [1], and in 1907 Hermann Schloffer, an otorhinolaryngologist, performed the first transsphenoidal pituitary operation approaching through a lateral rhinotomy. Unfortunately, the patient only survived for 2 months [2–4]. Since the advent of these approaches, surgical techniques for the management of pituitary pathology have undergone significant evolution. The early 1900s saw many variations of surgical technique including transnasal, transethmoidal, and infranasal approaches to the sella pioneered by Arnold Chiari, Allen Kanavel, Albert Halstead, Harvey Cushing, and Oskar Hirsch [3–6]. Hirsch's technique was remarkably similar to the more current technique of a submucosal transseptal approach, with a submucosal dissection along the septum to approach the sphenoid sinus [7]. Harvey Cushing's sublabial approach has endured the test of time; however, he later favored the transcranial approach citing better visual outcomes and easier reoperation [8]. Many surgeons

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followed his lead [9, 10]. The sublabial approach lost favor but was kept alive by Norman Dott who passed it on to Gerard Guiot, a French neurosurgeon [4]. Guiot's major contributions included the use of intraoperative fluoroscopy which allowed for real-time feedback on instrument position and tumor removal, as well as being the first to report the use of an endoscope. Jules Hardy learned the transsphenoidal technique while a fellow with Guiot and applied the operating microscope to the procedure to solve the problems of inadequate lighting and magnification [3, 5, 11]. These historic moments set the stage for the modern transnasal endoscopic approach to the pituitary gland [12].

The past decade has seen vast improvements in instrumentation including the lighting and resolution of endoscopes, the development of CCD chip cameras, and the development of angled endoscopes. These advances have stimulated shifts in practice patterns from microsurgical to endoscope-assisted microsurgery and more recently purely endoscopic transnasal approaches. Proponents of each method list limitations of the competing technique as evidence for the superiority of one method over the other. Champions of a purely microsurgical approach cite the three-dimensional view afforded by the microscope, the ability for bimanual operation without the need for a second surgeon or machine to hold the endoscope, and the increased space for operating instruments when a sublabial approach is utilized. The purely microsurgical approach avoids the purported "swordfighting" problem, where instruments touch, collide, and limit free motion. Conversely, advocates of a pure endoscopic approach rebut citing the wider field of view gained with the endoscope to visualize much more anatomy, use of angled scopes to see around corners and the ability to navigate around a fixed space. We believe that the on-going debate is analogous to the "clip-versus-coil" debate for intracranial aneurysm treatment, where there is no clear winner, but rather a time and place for each technique. The senior author (DSB) has utilized a hybrid approach in over 3500 patients. His hybrid approach is beyond endoscope-assisted microsurgery – both tools are on equal footing and are almost always both used during surgery at particular points in time or to address specific surgical issues. Both surgical approaches are utilized to achieve optimal outcome, and it is the senior author's belief that the debate emphasizes incorrect issues. The modern-day pituitary surgeon should feel equally at ease with both techniques and use both freely.

## Case Preparation

### Periprocedural Communication and Safety

Transsphenoidal removal of pituitary tumors is a rewarding operation with good patient outcomes; however, the innumerable details are paramount in order to avoid disaster. Standardized checklists have been created for a number of procedures and complex clinical situations to ensure a smooth operation and minimize confusion. Transsphenoidal operations involve many steps with a large amount of specialized equipment and lend itself well to this practice. Some checklists have been published and we have been published and we encourage others to develop their own and make its use standard [13, 14]. Ideally the operating room and its equipment should be set up and inspected prior to intubating the patient; otherwise, it must be accomplished before beginning the procedure. Broken or missing unique and critical instruments can create problematic scenarios.

Clear communication is paramount with all operating room personnel including the anesthesiologist, circulating nurse, and scrub nurse. The need for specialized, nonstandard equipment, such as a lumbar drain setup or micro Doppler, should be communicated to avoid delays. The surgeon should be present from the point the patient enters the room through extubation to monitor for any potentially serious complications. Patients with significant optic nerve compression can be susceptible to further nerve damage with periods of hypotension such as during induction or while the anesthesiologist is placing additional lines. The operative plan such as cavernous sinus dissection should be discussed prior to surgery. In this case, a precordial Doppler or central venous catheter is recommended to monitor or treat a potential venous air embolism.

## OR Setup

The operating room for the hybrid approach is set up for a right-sided craniotomy, with anesthesia positioned on the patient's left and the table in C-arm position (Fig. 11.1). The surgeon, assistant, scrub nurse, and back table are positioned on the patient's right. We use a room specially designed for endoscopic procedures with ceiling-mounted screens and a tower with endoscopic equipment (light source, recording unit, and endoscope irrigation system), cautery sources, and drill console positioned at the patient's feet. For quick access, the microscope is balanced and draped in the corner opposite anesthesia, closest to the sterile core. Monitors are positioned at the patient's head on a tower for displaying the patient's preoperative MRI for reference, fluoroscope output, and the endoscope view. We route the fluoroscope view to the same screen as the endoscope as a picture-in-picture, so the surgeon can focus on the same screen for comfort. The robotic Mitaka Point Setter® (Mitaka USA, Park City, Utah) is attached to the operating room table accessory rail on the patient's right side at approximately shoulder level to hold the endoscope. We routinely use intraoperative fluoroscopy for navigation in our procedures and position it at the head of the bed to acquire a lateral skull view magnified on the sella. Stereotactic navigation is also utilized in complex cases.

## Patient Positioning and Preparation

The operating table is in C-arm position with the cranial fixation attachment in place. The patient is in a modified semi-sitting position in our approach with the head elevated above the level of the heart. The patient is supine with the back flexed approximately 45° and the hips and knees in slight flexion with a lap belt placed so as to prevent the patient from sliding. The left arm rests on an airplane-style arm board at the level of the heart with an arterial line. Foam padding is used on the

**Fig. 11.1** Operating room setup for a hybrid transsphenoidal procedure: The room is setup for a right-sided craniotomy with anesthesia on the left and surgeon, assistant, scrub nurse, and instruments on the right. A C-arm is positioned for intraoperative fluoroscopy, the endoscope is affixed to the table with a Mitaka arm and the microscope is draped and ready to be used when required. A semi-sitting position is utilized for several reasons. First the position is much more comfortable for the surgeon rather than leaning over the patient. Even more important, though, is that the semi-sitting patient allows blood to settle in the bottom of the field, minimizing the obscuring effects of a small amount of venous oozing

volar surface of the right arm that wraps dorsal to cover the elbow and is secured in flexion at the elbow across the body to the contralateral shoulder. The left side of the body and legs are covered with a forced-air warming blanket, and the right lower quadrant of the abdomen is exposed for harvesting a fat graft. Inherent to this position is the possibility of venous air embolism. While one would expect that there is an increased risk of venous air embolism in the sitting position, the senior author (DSB) has never experienced this in over 4300 transsphenoidal procedures, despite frequent entry into the cavernous sinus in patients with large tumors. The cavernous sinus has many valves and baffles that inhibit transmission of air into it preventing venous air embolism; therefore, a central line is not routinely placed. A precordial Doppler is used in this position which is audible to the surgeon and anesthesiologist. A Foley catheter is also placed for the procedure, but may be discontinued prior to emergence from anesthesia. An arterial line is used for accurate blood pressure monitoring in the left radial artery (opposite the surgeon) on a lateral arm board, and is

**Fig. 11.2** Lateral skull fluoroscopy focused on the sella turcica. If one uses the C-arm, it is important to align the planum sphenoidale and the sphenoid wings properly to prevent parallax errors

zeroed at the level of the head, to ensure adequate cerebral perfusion. This is critically important in patients with significant optic apparatus compression where a relative hypotension may lead to optic nerve ischemia. The endotracheal tube is secured to the left, away from the surgeon, and the cuff is inflated so that air does not reflux into the nasal sinuses which can produce fogging of the endoscope lens.

Once the patient's body is secured, cranial fixation pins are placed in a position so as not to obstruct the fluoroscopy (Fig. 11.2). Although not routinely performed, stereotactic neural navigation is also utilized. Errors in registration are significant and can produce misleading information. Alternatively, a radiolucent holder can be used. The head is positioned slightly ventral in a sniffing position with slight neck extension and the head is rotated to the right to present the nostrils at a comfortable angle to the surgeon (Fig. 11.3). Proper alignment is important. If the surgeon places his or her thumbs at the level of the nostrils, and the index fingers on the most anterior aspect of the ear cartilage on both sides, this is the angle of entry into the sella.

This approach is usually uni-nostril; therefore, laterality is based on patient and tumor characteristics. The position of the tumor determines which nostril to approach through, as long as there are no anatomic contraindications in the anterior nasal passages. The most direct line of sight is achieved by approaching tumors that are eccentric to the left of midline through the right nostril and vice versa. This allows the surgeon to use an approach angle that maximizes visualization and maneuverability.

Saline moistened 2-inch cotton packing is placed in the oropharynx as a throat pack to catch any mucus, blood, or irrigation that may drain from the sinuses during the operation and decreases the risk of aspiration and postoperative emesis. It is important to truly pack the throat and not the mouth, so that a barrier to blood traveling down the esophagus is created.


**Fig. 11.3** Photograph demonstrating the positioning of Mayfield cranial pins and Mitaka arm so that an unobstructed lateral view of the sella can be obtained with intraoperative fluoroscopy. It is crucial to remain fairly superior with the points of fixation to avoid visualization of the pins in the lateral fluoroscopy

Oxymetazoline 0.05% spray, an alpha agonist, is administered in each nostril followed by cotton pledgets soaked in 4% cocaine solution; both act as potent vasoconstrictors. The pledgets are left in the nasal cavity throughout the prepping and removed at the start of the transnasal portion of the operation. To avoid corneal damage, the eyes are covered with an artificial tear gel and transparent film dressing before nasal cocaine application. Cocaine is classified as pregnancy category C and is avoided in pregnant patients. In addition, caution is advised in patients with a history of drug abuse and cardiovascular disease. Alternatively, the nasal mucosa can be injected with 1% lidocaine with epinephrine 1 : 100,000 dilution. The external nose and right lower quadrant of the abdomen are then prepped and draped in standard fashion.

## Lumbar Drain

The patient's imaging is studied with attention to the presence and degree of suprasellar tumor extension. If needed, a lumbar drain is placed after intubation prior to positioning. The lumbar drain is used to aid in the resection of the suprasellar component of large adenomas, and is particularly useful for those tumors that are soft in consistency. Following standard drain placement, a sterile system is

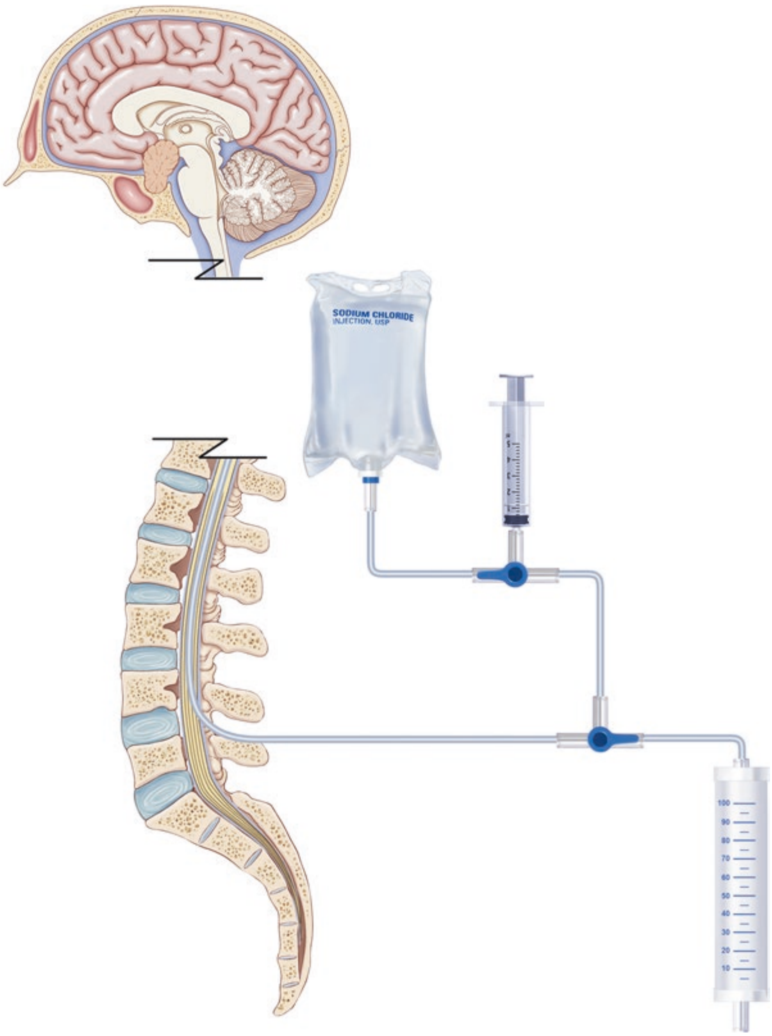


**Fig. 11.4** Artist's depiction of lumbar drain setup. A lumbar drain is placed and connected to a series of sterile tubing and three-way stop-cocks creating a sterile system for injecting preservative-free saline or removing CSF. This technique aids in tumor resection. The anesthesiologist can either inject into the patient to increase intracranial pressure and push the tumor and suprasellar cistern downward, or withdraw fluid from the patient to relax pressure and encourage upward migration of the suprasellar cistern to aid visualization of the posterior sellar region

constructed (Fig. 11.4) consisting of a 250-mL bag of injectable saline connected to a three-way stopcock with a 20-mL Luer lock syringe. The system continues to connect to an additional three-way stopcock, intercepting the proximal and distal portion of the drain line. The drain line stopcock is taped to be "off" to the collection system so injectable saline is directed toward the patient during the procedure. This arrangement allows sterile fluid to be introduced or removed from the intrathecal space, increasing or decreasing intracranial pressure, respectively. Adenomas that are soft can often be pushed down from the suprasellar position presenting itself to the surgeon in the sella when intracranial pressure is increased. This maneuver is expedient but must be performed with careful communication with the anesthesiologist. The intrasellar component of the tumor is resected prior to injecting the saline to make room for the descent of the remainder of the tumor. It is also recommended to relieve as much optic nerve compression as possible through manual tumor removal prior to injecting saline. If the tumor is firm and/or fibrous, the maneuver can still be of value. In order to avoid damage to vessels attached to the tumor surface, great care must be taken to not place undue traction force on the tumor as it descends. The maneuver is to gently peel the tumor away from the pseudocapsule and the arachnoid. This maneuver allows the tumor to come into view, descending into the sella and occasionally even the sphenoid sinus.

In cases where the tumor will not descend, the endoscope is very valuable. In this setting, the endoscope allows the surgeon to look upwards and free up fibrous bands or other structures that may be preventing the tumor from descending.

Contraindications to this maneuver include firm tumors that do not descend after injection, and contraindications to lumbar drain placement such as arachnoiditis. Intraoperative CSF leak is not a contraindication but caution is advised as increasing intracranial pressure may exacerbate the leak. Also, once there is a leak, it is difficult to increase intracranial pressure which is what encourages downward descent of the tumor. The increased intracranial pressure can cause potential complications, which include difficulties with lumbar drain displacement, optic apparatus damage, and CSF leak. We have never seen any major complications with this technique in our experience. If successful, the surgeon reduces the need to dissect around critical structures in the suprasellar compartment, where even with an angled endoscope, visualization can be difficult.

## Surgical Technique

A standardized time-out checklist procedure is used before beginning the procedure. Unless there is a clear indication, we minimize disruption of the native sinus anatomy as much as possible. To this end, we do not routinely resect the middle turbinate or harvest a nasal-septal flap. The abdominal portion of the procedure is rapid and uses comparatively few instruments. Completing this portion avoids cross contamination between the surgical trays, and the instruments can be passed off the field at the beginning. A 3 cm × 3 cm × 3 cm fat graft is usually sufficient for all operations, but the size should be determined based on review of the imaging prior to surgery. Ideally, the graft is harvested as one piece or with as few pieces as is feasible. This makes the graft easier to work with later in the procedure and maintains the microvascular structure within the graft. Multiple small pieces may result in more graft necrosis and increased nasal drainage postoperatively.

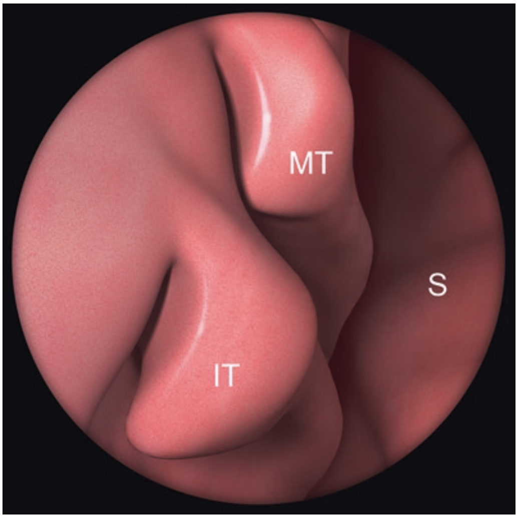


**Fig. 11.5** In the initial endoscopic view through the right nostril as one approaches the sella, the inferior turbinate (*IT*) and middle turbinate (*MT*) are seen laterally and the septum (*S*) medially

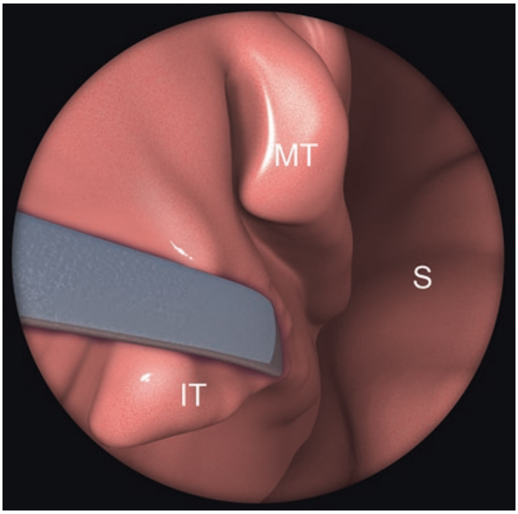


**Fig. 11.6** The blunt, curved end of a Cottle elevator is used to out-fracture and lateralize the inferior turbinate (*IT*) to increase the working area and enhance postoperative respiratory function. This maneuver is performed bilaterally, and significantly reduces postoperative nasal constriction and consequent nasal breathing problems

The cocaine pledgets are then removed and the endoscope inserted along the floor of the nasal cavity into the selected nostril. The right nostril will be used for the purposes of this description. The initial anatomy to be appreciated are the inferior and middle turbinates laterally with the nasal septum medially (Fig. 11.5). The first step is to fracture and displace the inferior turbinates laterally on both sides (Fig. 11.6). This fracture and displacement creates an increase in working space; however, the main benefit is to increase airflow and enhance quality of breathing postoperatively [15–18]. Similarly, the middle turbinate on the side of the planned entry into the sphenoid sinus is fractured and lateralized during the surgery (Fig. 11.7) to significantly enhance the exposure, but in this instance, it is medialized to the original position at the conclusion of surgery. We do not routinely perform a turbinate resection unless anatomic variations or abnormalities such as bulla formation significantly impair the approach. If the middle turbinate is divided and displaced inferiorly for more exposure, care must be taken not to damage the proximal portion of the sphenopalatine artery (SPA) [19]. The superior turbinate is now visible at the superior lateral aspect of the nasal cavity and the medial side can be followed to its base and then posteriorly to aid in identifying the ostium of the sphenoid sinus (Fig. 11.8). Alternatively, the ostium of the sphenoid sinus can be found by following the base of the inferior turbinate to the posterior nasal aperture (choana),

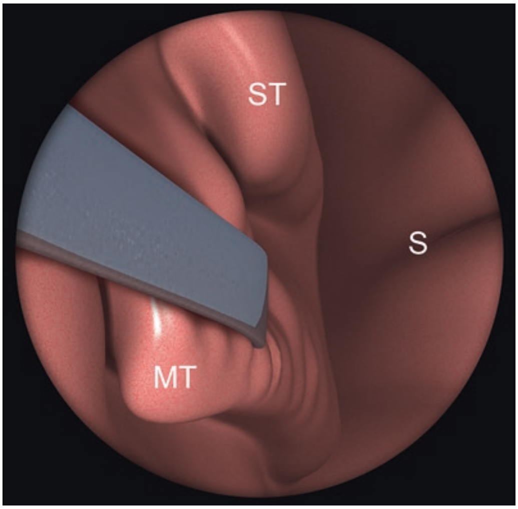


**Fig. 11.7** Following lateralization of the inferior turbinate (*IT*), the Cottle elevator is again used to perform the same maneuver on the middle turbinate (*MT*). The superior turbinate (*ST*) now comes into view in the lateral portion of the field superior to the MT

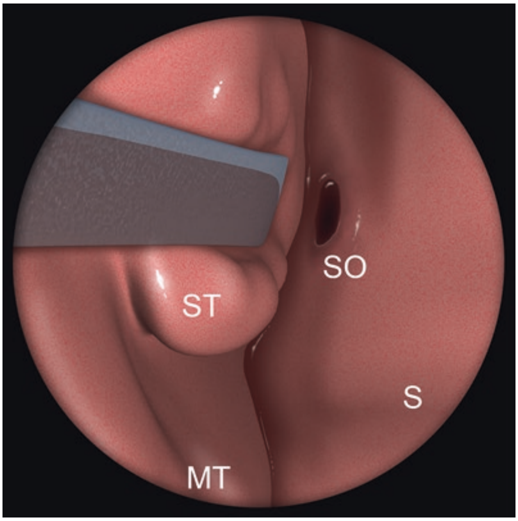


**Fig. 11.8** Above the middle turbinate (*MT*), the superior turbinate (*ST*) can be identified and its base is followed posterior to identify the ostium of the sphenoid sinus (SO) medial to the septum (*S*). A Cottle elevator can be inserted into the ostium to verify the location with fluoroscopy

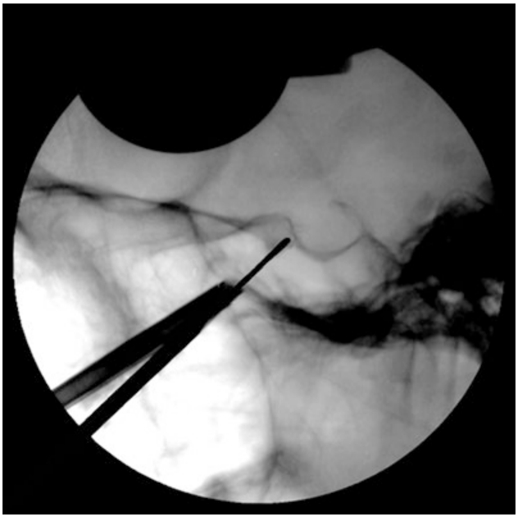

**Fig. 11.9** Lateral skull fluoroscopy focusing on the sella while using a Cottle elevator to confirm the entry to the sphenoid sinus

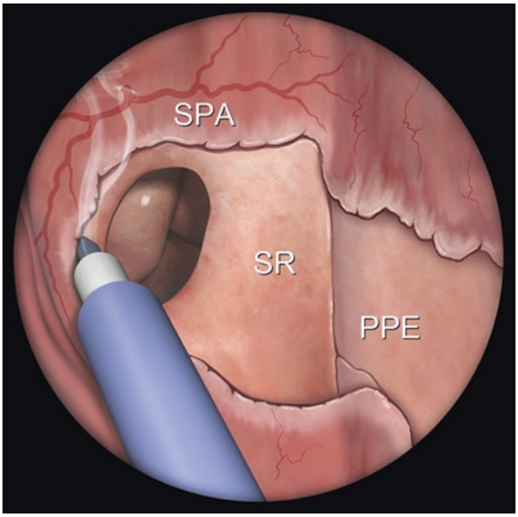


**Fig. 11.10** The needle Bovie electrocautery is used to remove the mucosa immediately surrounding the sphenoid ostium and covering the rostrum of the sphenoid sinus (*SR*). The dissection continues medially to expose the junction of the SR with the perpendicular plate of the ethmoid (*PPE*). Care must be taken to avoid the sphenopalatine artery (*SPA*)

which is bordered medially by a midline structure, the vomer, and superiorly by the sphenoid bone. The ostium of the sphenoid sinus is usually 1.5 cm [20] above the superior aspect of the posterior nasal aperture. Occasionally, the ostium can still be difficult to find and a navigation system or intraoperative fluoroscopy is useful as an aid to locate or confirm the location (Fig. 11.9). This usually occurs in the setting of sinusitis and chronic inflammation, where mucosa is thickened and grows over the ostial opening (Video 11.1).

Next needle-tip electrocautery is used to circumferentially cauterize the mucosa immediately around the ostium and more extensively medially along the sphenoid crest, and then inferiorly to expose the junction of the crest with the perpendicular plate of the ethmoid bone (Fig. 11.10). Excessive cauterization laterally or

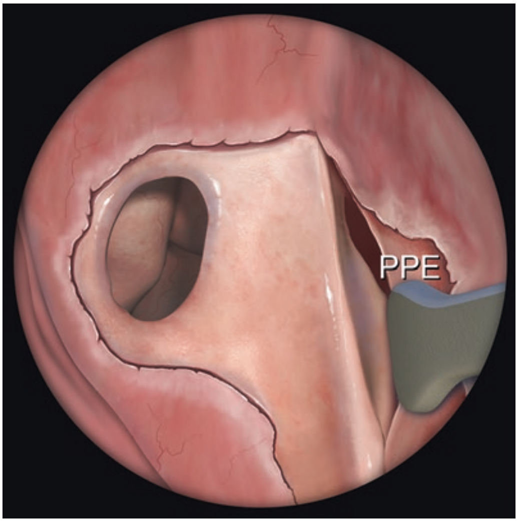


**Fig. 11.11** The junction of the sphenoid rostrum and the perpendicular plate of the ethmoid (*PPE*) are separated with the sharp end of the Cottle elevator and a submucosal dissection exposes the contralateral ostium. The PPE must be separated sufficiently to gain wide exposure of the contralateral ostium

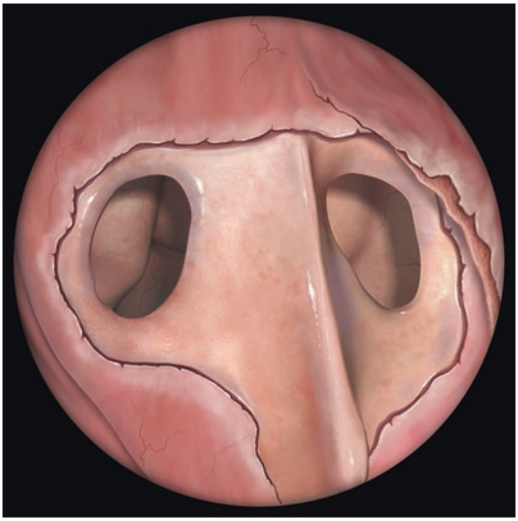

**Fig. 11.12** Here the completed dissection is seen with exposure of bilateral sphenoid ostia

inferiorly may sacrifice the sphenopalatine artery. Superiorly, care must be taken to not damage the olfactory mucosa or perforate the thin anterior skull base. A Cottle septal elevator or like instrument is then used to cleanly dissect the mucosa laterally, and then fracture the perpendicular plate of the ethmoid from its junction with the sphenoid crest (Fig. 11.11) away to the contralateral side, exposing the rostrum sphenoidale (Fig. 11.12). Using the Jansen-Middleton cutting forceps, a Hartman Conchotome or drill, bone is removed to connect the two sphenoid ostia into a singular opening (Fig. 11.13). A Kerrison rongeur may then be used to perform partial ethmoidectomies superiorly (Fig. 11.14) and expand the sphenoid sinus circumferentially (Fig. 11.15). Bleeding from branches of the posterior ethmoidal

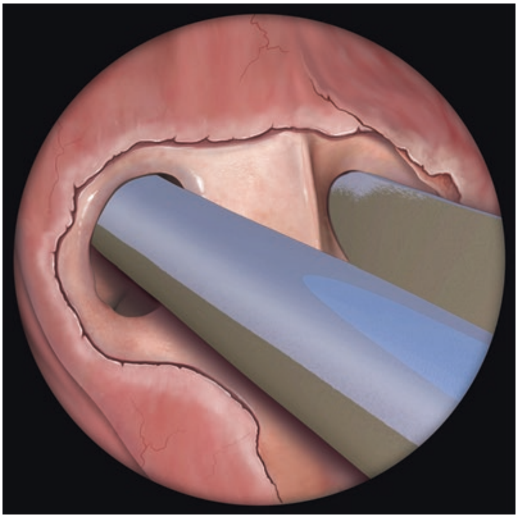

**Fig. 11.13** The Jansen-Middleton cutting forceps are used to remove the sphenoid rostrum separating the two ostia, enlarging the opening into the sphenoid sinus. Carefully placing each side of the forceps through the ostia slightly inside the sinus facilitates removal

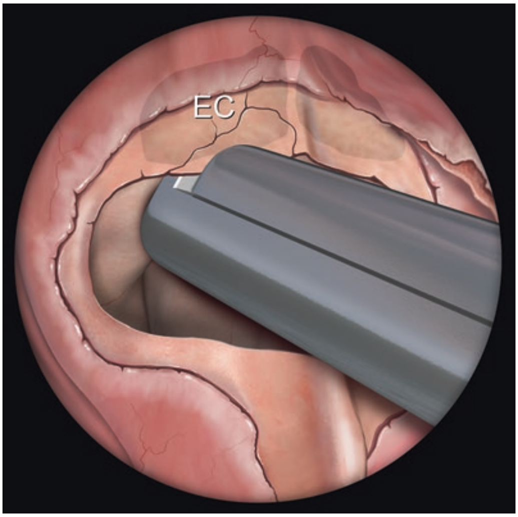


**Fig. 11.14** Kerrison or Conchotome rongeurs arethen used to circumferentially enlarge the opening of the sphenoid sinus and to perform a posterior ethmoidectomy, opening the ethmoid air cells (EC). Care must be taken not to exert upward pressure on the planum sphenoidale, as the bone is thin and violation of the dura can occur with vigorous upward pressure

arteries may be encountered and can be managed with judicious use of the needle-tip electrocautery or the bipolar forceps. The mucosa is reflected away from the sphenoid sinus inferiorly and preserved.

Several sphenoid sinus landmarks should be identified including the optic and carotid protuberances which generally demarcate the location of the optic nerves and internal carotid arteries, respectively (Fig. 11.16). There is usually a considerable degree of variation and distortion of the landmarks in both normal and pathological states from variations in sphenoid sinus pneumatization, arterial hypoplasia, and tumors to name a few. A firm understanding of the normal anatomical arrangement is needed before one can grasp the myriad of possible variations. In general,

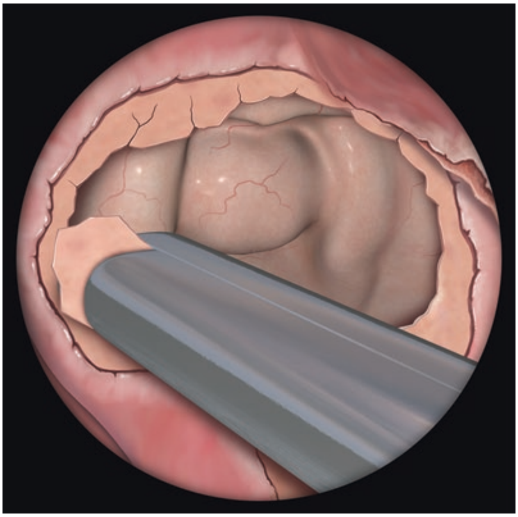

**Fig. 11.15** Further bony resection is performed to expand the sphenoid opening laterally. A wide sphenoidotomy is essential to prevent postoperative sphenoid sinusitis

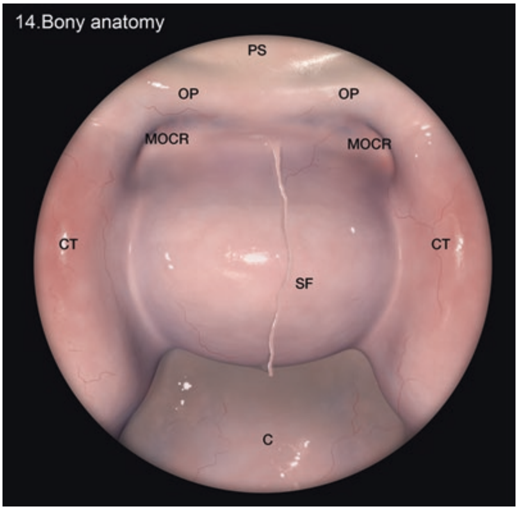


**Fig. 11.16** Adequate exposure is achieved once all critical landmarks can be identified including planum sphenoidale (*PS*), optic protuberances (*OP*), medial optico-carotid recess (*MOCR*), carotid tubercles (*CT*), clivus (*C*), and the sella floor (*SF*)

the safest approach is to open the sellar floor in what can best be identified as the center taking into consideration preoperative imaging, preserved midline landmarks such as the rostrum sphenoidale, and fluoroscopic or navigation guidance if available. A reliable way to assess the midline is to line up the columella with the center of the rostrum of the sphenoid sinus. Septations within the sphenoid sinus are not reliable midline landmarks. A micro-Doppler probe can be very helpful in identifying the carotid arteries. The floor of the sella is generally very thin, more so when an adenoma is present, and can usually be breached with gentle pressure from a micro-cup curette. The footplate of a Kerrison rongeur or other instrument can then be used to enlarge the opening in an extradural plane. The senior author strongly

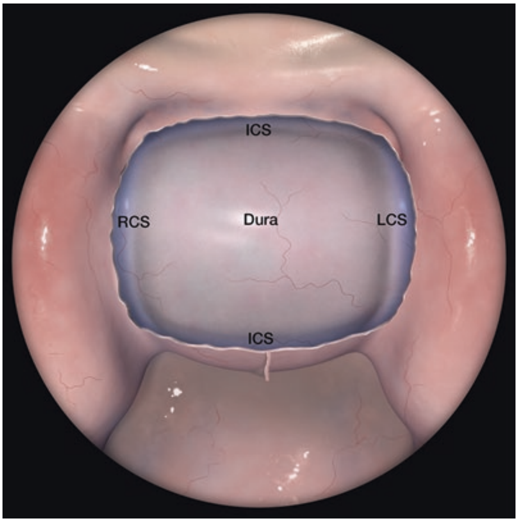


**Fig. 11.17** The sella floor is opened centrally and the opening is carefully expanded laterally, superiorly, and inferiorly to fully visualize the left and right cavernous sinus (*LCS* & *RCS*) laterally and the intercavernous sinuses (*ICS*) superiorly and inferiorly. A wide opening is essential

opposes the use of small chisels, for the path and excursion of these instruments cannot be sufficiently well controlled at times. Acromegalic patients are often an exception and cautious drilling is usually required. Our standard exposure enlarges the sella opening extradurally from medial to lateral to visualize the medial edges of both cavernous sinuses and anteriorly and posteriorly to the anterior and posterior intercavernous sinuses, respectively (Fig. 11.17). The intercavernous sinuses have been identified in 80–100% of specimens in cadaver studies [21, 22] but are not always complete. When the intercavernous sinuses cannot be visualized, the anterior exposure stops at the planum sphenoidale and inferiorly and posteriorly at the horizontal portion of the sellar floor at its junction with the upper clivus (Fig. 11.18) (Video 11.2). Many tumors can be resected without visualizing the cavernous sinuses; however, we feel that the safest approach is to be able to visualize the critical structures to preserve them. Making an assumption or educated guess as to the location of the venous sinuses or carotid arteries can lead to costly errors with inadvertent injury.

It is not uncommon to encounter bleeding from the dura surrounding the cavernous and intercavernous sinuses during exposure, or often from an edge of these sinuses that is opened during the dural incision. This bleeding can be quickly controlled with an absorbable hemostatic agent. We favor the use of either Surgicel or Floseal. The key to managing small or large venous hemorrhages is to remain calm and be patient, avoid using large or bulky pieces of hemostatic agents. Apply just enough to cover the area of concern rather than the entire field, followed by an appropriately sized cotton patty. A single cotton patty can be gently held in place or wedged between the hemostatic agent and bony edge until the bleeding stops. Another trick that can be used is to place the hemostatic agent, and then take a tiny piece of bone wax and place it over the material. Then, using a tiny cotton pledget, one can wedge the bone wax against and/or under the bony edge, which will be a

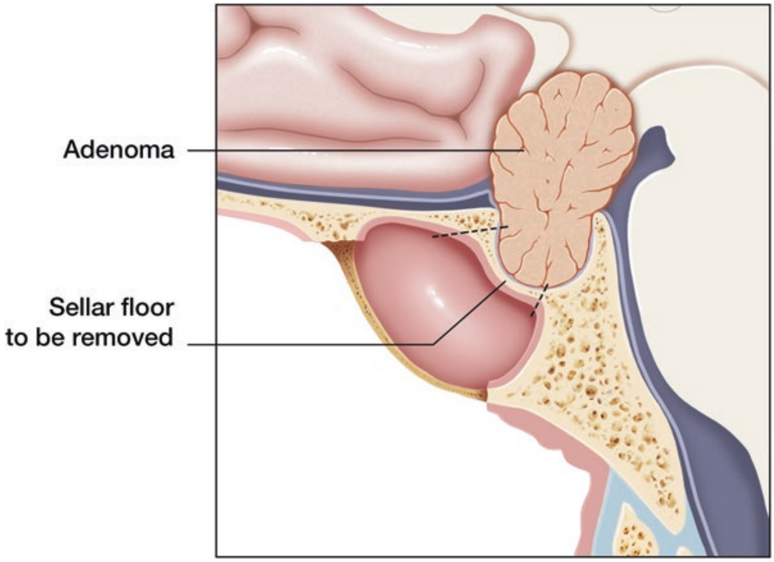


**Fig. 11.18** Artist's depiction of a sagittal view of the operative site depicting the extent of sella floor to be removed between the planum sphenoidale and clivus

way to apply continuous pressure to the material underneath it. With patience, bleeding from the venous structures will always stop and the procedure can continue. The magnification created by the endoscope or microscope exaggerates the true rate and volume of bleeding.

We next use the bipolar cautery on the dura in the center of the sella floor and open it sharply with pituitary scissors in a cruciate fashion followed by bipolar cauterization of the dural leaflets. The opening is then expanded in the same manner up to the edge of the venous sinuses. A biopsy is taken followed by tumor resection (Fig. 11.19). Care must be taken to identify the compressed pituitary gland and preserve it; it may often be found posteriorly (Fig. 11.20) (Video 11.3).

We have found a combination of bayonetted Hardy curettes and suction to be most useful. Tumors with significant suprasellar extension can be challenging to achieve a total resection safely. In this instance, provided no CSF leak has been identified, and the sellar portion of the tumor has been resected, we use injection into the lumbar drain to assist in pushing the suprasellar component of the tumor inferior into the sella. The drain has been inserted and constructed as described previously in the chapter and the anesthesiologist has been instructed on the procedure prior to surgery. The anesthesiologist slowly and gently injects 5–10 cc of preservative-free injectable saline at a time as directed by the surgeon. As the intracranial pressure increases from the injection, the tumor is pushed down through the diaphragma sella into the sella where it can be easily and safely resected with direct visualization. The maneuver is repeated as needed. The surgeon constantly monitors and reassesses the situation; if the tumor is not presenting as expected, an equivalent

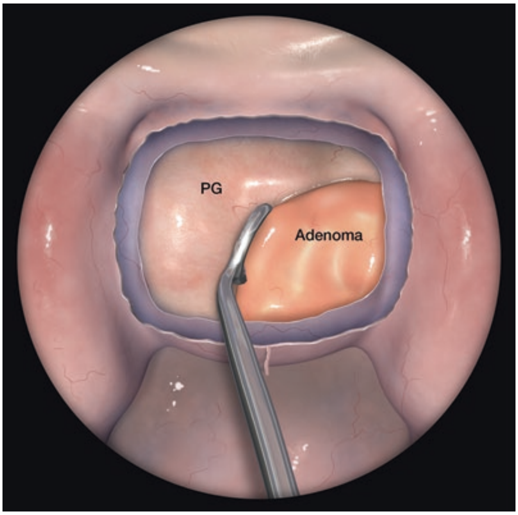


**Fig. 11.19** In the case of microadenomas, ringed curettes can be used to help perform an extracapsular dissection of the tumor while preserving the pituitary gland (*PG*)

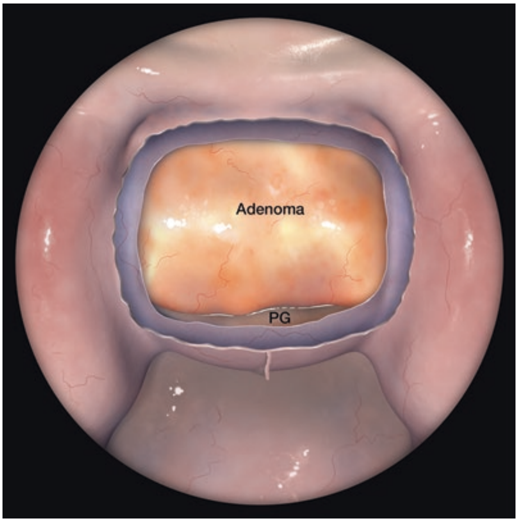


**Fig. 11.20** Often times a macroadenoma displaces and compresses the pituitary gland (*PG*) posteriorly

volume of saline is removed, more tumor is resected and then the procedure attempted again. When resection is completed, saline is removed so that the arachnoid membrane is not tense or bulging into the sella (Video 11.4). A CSF leak is not an absolute contraindication to the lumbar drain maneuver but one has to be mindful that injection may enlarge a hole in the arachnoid, and that the period of time with increased pressure will be short, as CSF will leak through the hole and diminish the effectiveness of the maneuver.

Once the resection is felt to be complete, or when visualization is suboptimal because of continued oozing, the operating microscope is then brought into the field looking through a self-retaining nasal speculum for the final stages of tumor resection.

The microscope field of view is limited by the speculum but gives the surgeon better tissue differentiation and depth perception. It is particularly useful to work along the medial edge of the cavernous sinus and skull base, dissecting around the carotid and the cavernous sinus, as well as for inspecting the arachnoid membrane of the suprasellar cistern and arachnoid-cavernous interface. The enhanced tissue differentiation also helps distinguish normal pituitary gland to be preserved from tumor. In many cases the microscope and endoscope can be used alternately and repetitively, until the goal of surgery is achieved.

Following tumor resection, the surgical cavity is then irrigated with absolute alcohol if no CSF leak is present [23, 24]. This chemical cauterization aids in hemostasis and lysis of microscopic rests of tumor cells if present. We have not experienced any complications from this approach but alcohol penetrating any arachnoid defect or opening in the cavernous sinus could result in damage to critical structures [25]. We do not allow the alcohol to remain in the area for more than a 10–15 s, and application is followed by copious saline irrigation to completely wash the alcohol away.

Hemostasis is achieved and the closure begins with reconstruction of the skull base. The previously harvested abdominal fat graft is trimmed to a size that will occupy the cavity created, but not packed so tightly so as to cause compression of the surrounding structures (Fig. 11.21). If there is a CSF leak, a portion of the fat is placed in the hole in the arachnoid to aid in producing a tight seal. The sella floor is then reconstructed with a Medpor polyethylene implant (Stryker; Kalamazoo, MI) that is trimmed to a size just larger than the sellar opening [26]. The implant is wedged between the fat graft and inner dural surface (Fig. 11.22). Absorbable dural sealant material is then sprayed over the area of reconstruction (Figs. 11.23 and 11.24) and the sphenoid sinus mucosa is replaced if preserved (Video 11.5).

We have found that a nasal-septal flap is not necessary to repair most intraoperative CSF leaks, as long as one can get fat up against the hole in the arachnoid and

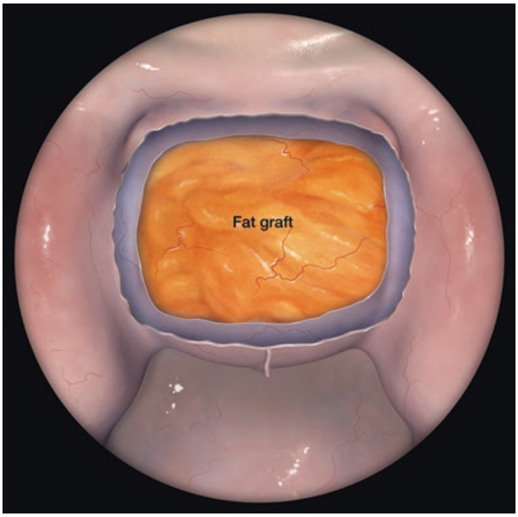


**Fig. 11.21** Reconstruction of the sella floor begins with placing a fat graft large enough to fill the void previously occupied by tumor

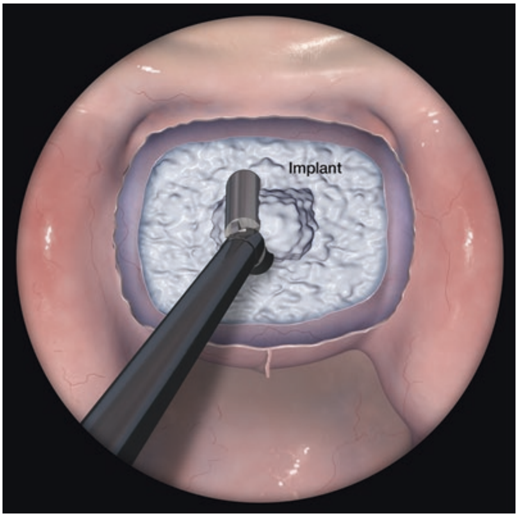


**Fig. 11.22** The Medpor implant is placed deep to the dural so that it is affixed between the fat graft and dura and held in place by the overlying dural edges. If insufficient dura is available, it can be wedged deep to the bone opening

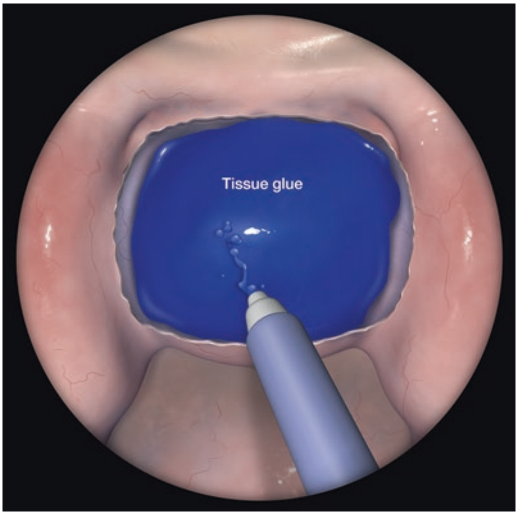


**Fig. 11.23** Tissue glue is placed over the Medpor implant to complete the reconstruction

preferably through it as a type of tissue plug, and one can get a tight reconstruction with the Medpor graft held firmly in place either by dura and/or bone. We take great care to use precise carpentry when shaping and placing the graft, so the fat is held firmly in place, and the chance of the Medpor dislodging is minimal. In cases where it is difficult to get good purchase intradurally, the Medpor is placed extradurally and tightly lodged and held into place by shaping it so it fits under the bony edges of the opening in all directions.

While many believe that reconstructing the skull base in the absence of a CSF leak is not mandatory, we feel that it creates a biologic barrier to infection and reduces the risk of optic chiasm herniation in the future by ensuring that the fat graft

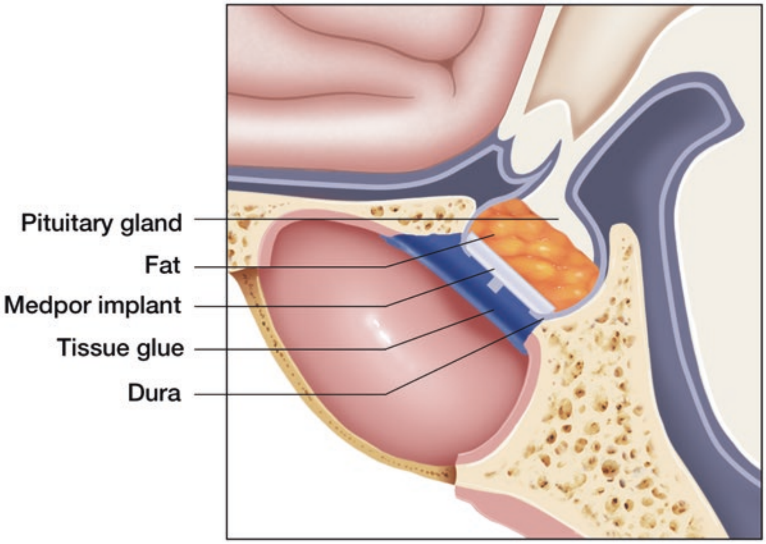


**Fig. 11.24** Artist's depiction of a sagittal view of the skull base reconstruction demonstrating the Medpor implant between the fat and dural, covered by tissue glue

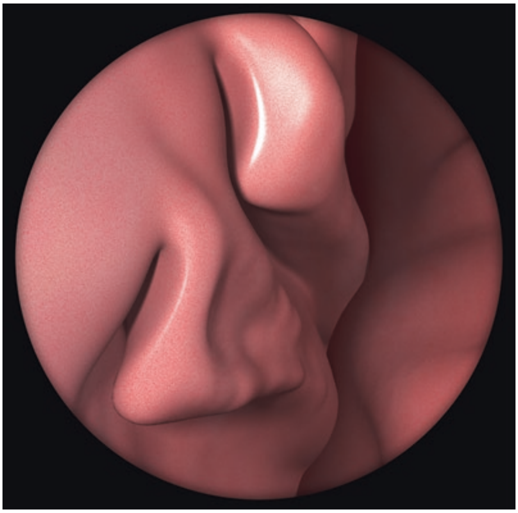

**Fig. 11.25** At the conclusion of the procedure, the middle turbinate (*MT*) is restored to its original position while the inferior turbinate (*IT*) remains lateralized. Failure to restore the middle turbinate to its anatomic position can lead to ethmoid sinusitis

remains in place. Moreover, it produces a universally watertight closure, in case there is a CSF leak that was not identified at the time of surgery.

When skull base reconstruction is complete, the middle turbinate is returned to its original position and the approach corridor is inspected for good hemostasis (Fig. 11.25). The septum and perpendicular plate of the ethmoid are returned to midline. Septal deviations that are obvious are repaired by resecting the appropriate amount of bone and cartilage. The inferior turbinates remain lateralized as previously discussed. The external nares are then inspected for mucosa tears that can be repaired with absorbable suture. We do not use any form of nasal packing at the end of the procedure. Only a small piece of cotton gauze taped externally is placed until the following morning to catch any anterior drainage. The throat pack is removed while suctioning with a Yankauer suction tip to ensure that no blood remains, which greatly lessens the likelihood of postoperative nausea and vomiting.

## Postoperative Care

We observe our patients in the intensive care unit for at least one night after surgery and the lumbar drain remains in place. If no CSF leak was seen at the time of surgery, the drain remains closed overnight and removed the following morning after confirming the absence of a leak. If a CSF leak is observed during surgery, the drain remains closed for 6 h before opening at the level of the shoulder. Closing initially allows intracranial pressure to normalize, increases the pressure at the surgical site, and may tamponade any venous bleeding that may occur. Additionally, it reduces the risk of over drainage with nursing staff that may be unfamiliar with the device in the recovery room. Should a CSF leak require diversion, we typically drain for 3 days prior to closing the drain and observe for a leak prior to removing it. We also begin treatment with antihistamines, decongestants, and gentle saline nasal flushes on the first postoperative day. Routine considerations for pituitary surgery patients are also implemented including monitoring urine output specific gravity, and sodium levels.

## Conclusion

The technique for transnasal transsphenoidal pituitary surgery involves approaching the sphenoid sinus, expansion of the sinus opening, entry into the sella, tumor resection, and reconstruction. There are many nuances and variations to the procedure that should be tailored to the pathology and to the patient. The endoscope and microscope are complementary tools, each with unique capabilities. The majority of neurosurgeons have used the operating microscope for decades and are extremely comfortable with its view. The endoscope is relatively newer to the field, but is now standard in many centers and training programs.

The endoscope provides a sharp, clear picture with excellent illumination. The endoscope is not constrained by a nasal speculum in its line of sight, and angled scopes can help view around edges of structures (Fig. 11.26). The angled view and shorter distance from lens to tissue is particularly advantageous when dissecting within the suprasellar cistern. These benefits are reduced with tumors restricted to the sella. The endoscope does require a holder whether mechanical or in the form of an assistant, and occupies precious space in the constrained nasal passage limiting instrument movement. These limitations are diminished with experience and practice but not removed altogether.

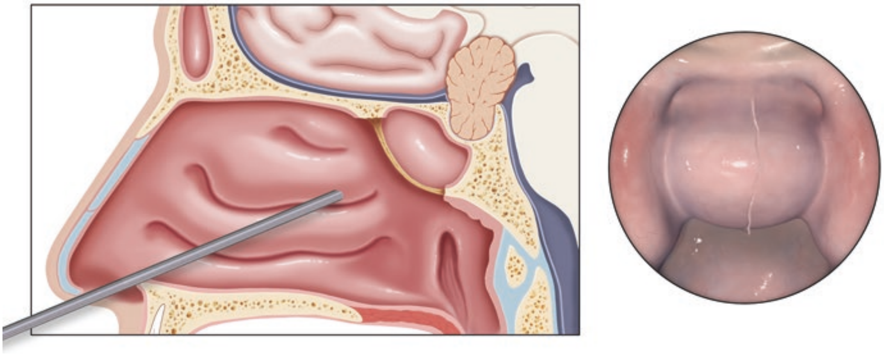

**Fig. 11.26** Artist's depiction of the position of the endoscope camera during a transnasal transsphenoidal operation (*left*) and the field of view seen through this instrument (*right*)

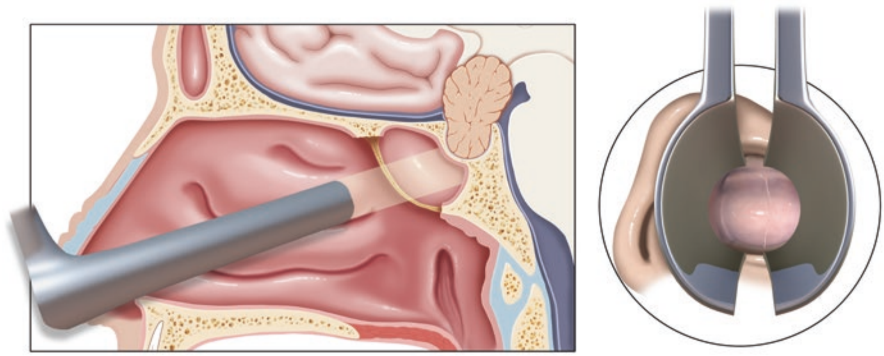

**Fig. 11.27** Artist's depiction of the microscopic portion of a transnasal transsphenoidal operation with the position of the nasal speculum (*left*) and the field of view seen with the microscope (*right*)

Operating microscopes also provide a sharp, clear picture but with a three-dimensional view and superior tissue differentiation (Fig. 11.27). It does not require a holder and the increased distance from the lens to the operative site eliminates problems of fogging, smudging, or contact with blood. The line of sight is constrained by the need for a nasal speculum limiting the surgeon's field of view. We find that the enhanced tissue differentiation is particularly helpful when clearing tumor from normal gland or clearing the wall of the cavernous sinus. The improved depth perception is also advantageous when removing tumor around the carotid artery or within the cavernous sinus.

Endoscopic and microscopic techniques for pituitary surgery are not adversarial, but rather complementary. Surgeons should be trained in both techniques and versatile enough to switch back and forth between each modality during each surgical procedure, as the clinical situation dictates.

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