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Transsphenoidal Approaches to the Sella and Suprasellar Region

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◆ Abstract

The transsphenoidal approach is a surgical technique used to access the sella and suprasellar region, which contains critical neurovascular structures such as the pituitary gland, optic chiasm, and cavernous sinus. This technique involves accessing the region through the sphenoid sinus, thereby avoiding a craniotomy and minimizing morbidity associated with traditional approaches. Transsphenoidal approaches have evolved over the years and are now commonly used to treat a wide range of sellar and suprasellar lesions including pituitary tumors, craniopharyngiomas, meningiomas, and other rare tumors. The technique can be performed via a microscopic or endoscopic approach and involves careful dissection of the tumor and surrounding structures with the aim of achieving complete resection while minimizing complications. Oftentimes, these approaches require a multidisciplinary team with an otolaryngologist and neurosurgeon working in tandem. The choice of approach depends on several factors including the size and location of the lesion, the surgeon's preference, and the availability of resources. Despite its proven efficacy and safety, the technique requires a high level of expertise and experience to achieve optimal outcomes.

Keywords: transsphenoidal approach, pituitary gland, sella, suprasellar region, endoscopic approach, microscopic approach

◆ Introduction

Since its introduction over a century ago, transsphenoidal (TS) approach to the sella has undergone significant transformation. The initial successful removal of a pituitary tumor through a transethmoidal–transsphenoidal approach was performed by Schloffer in 1907. To improve cosmetic results, the procedure was further modified by surgeons such as Kochler, Kanavel, Mixter, Quakenboss, Halstead, and Hirsch, and finally evolved into the sublabial–transseptal approach. From 1910 to 1925, Cushing reported employing this approach in 231 patients with an operative mortality of 5.6%.[1] Despite this relative good outcome, he abandoned the TS approach for craniotomy because of the better optic nerve decompression achieved with the latter. Although many neurosurgeons in the North America followed suit, with the development and implementation of the operating microscope, the transnasal–transsphenoidal pituitary surgery once again became popular in the 1960s. This approach, as modified by Hardy, is presently used by many neurosurgeons to reach pituitary tumors.[1,2]

As described later, the classic TS approaches to the sella involve mucosal incisions and submucosal dissection of the anterior nasal septum.[3] Perhaps, this submucosal dissection of the septum was incorporated into the procedure to reduce the risk of postoperative meningitis seen during the early introduction of this technique. The extensive mucosal dissection and soft tissue trauma, however, is a drawback to the procedure and responsible for most of the postoperative pain and discomfort, and sinonasal complications such as septal perforation.[4] In 1987, the direct endonasal (EN) approach, which involves an anterior sphenoidotomy without mucosal dissection, was described by Griffith and Veerapen. Although this approach was used thereafter by others, it was not until the introduction of endoscopy that the EN approach became even more popular.[6] Studies have demonstrated the efficacy and safety of the endoscopic EN approach to be comparable to the classic approaches.[7] The transition from microscopic to endoscopic techniques does entail a learning curve, with surgical teams taking approximately nine cases to reduce the operating room time and the rate of cerebrospinal fluid (CSF) leaks.[8–11] The EN approach to the sella has become the procedure of choice for surgical treatment of most pituitary and intrasellar tumors.

In this chapter, we discuss the most popular TS approaches to the sella, namely, the direct endonasal (EN), the sublabial (SL), and the endonasal transseptal (**Fig. 1.1**). The EN procedure is described first because this approach provides adequate exposure for resection of most pituitary tumors. Surgeons' familiarity with the SL and TS approaches, however, is still necessary for their implementation in larger pituitary and superior clival tumors.[3,4,12] The traditional SL approach, although more invasive, provides wider view of the sella and the parasellar region and may be employed for removal of tumors with parasellar extension or in pediatric patients with small nasal passages.[13]

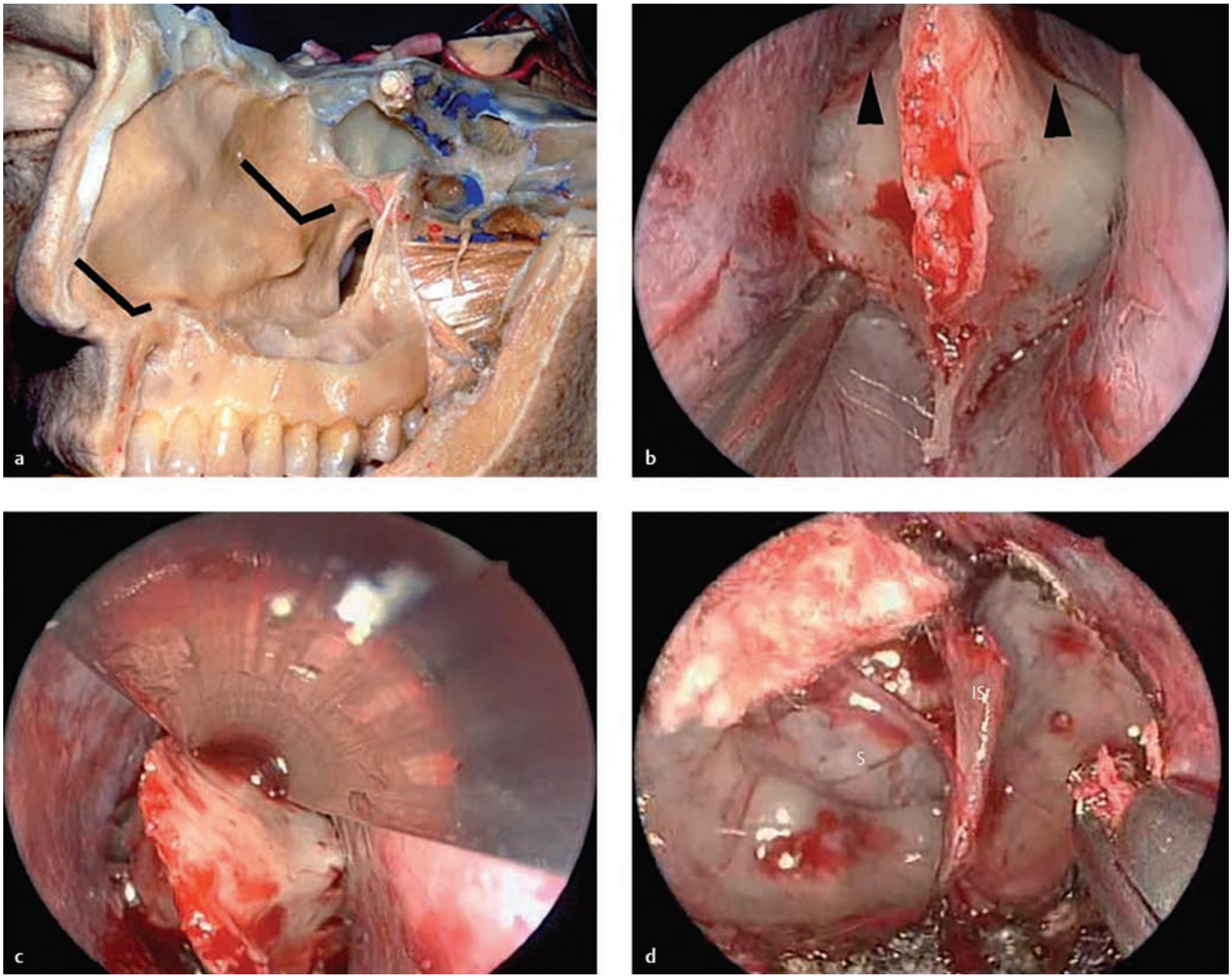

Fig. 1.1 Transseptal approach. **(a)** Traditionally an anterior septal incision is used; however, the technique may be modified to use a posterior incision. **(b)** Bilateral mucoperichondrial/mucoperiosteal flaps have been elevated and the posterior bony septum removed to expose the sphenoid rostrum. The flaps are elevated to identify the sphenoid sinus ostia (*arrowheads*). **(c)** Bony incisions are made using the osteotome. Vertical incisions are made from the natural ostia through the choanal rim. The vertical incisions are then joined with horizontal incisions inferiorly and superiorly between the ostia. **(d)** Following removal of the sphenoid rostrum, the sella is visible. The opening may be enlarged using a Kerrison rongeur. IS, intersinus septum; S, sella turcica. (Reproduced from Transethmoidal Approach. In: Stamm A, ed. Transnasal Endoscopic Skull Base and Brain Surgery: Tips and Pearls. 1st Edition. New York: Thieme; 2011.)

◆ Preoperative Evaluation

Preoperative assessment of patients undergoing pituitary surgery is of critical importance, no matter what surgical approach is employed. A full history and physical exam and detailed endocrine screening and neuro-ophthalmology evaluation should be completed prior to the planned operation. Routine endocrine tests include basal measurements of prolactin, growth hormone, insulin-like growth factor 1 (IGF-1), thyroxine, triiodothyronine, thyroid stimulating hormone (TSH), cortisol, adrenocorticotropic hormone (ACTH), follicle-stimulating hormone (FSH), luteinizing hormone (LH), and testosterone (in men). Dopamine agonists are considered the first line of treatment for patients with prolactin-secreting tumors even in the presence of chiasm compression.[14,15]

Review of the preoperative magnetic resonance imaging (MRI) studies is also crucial prior to every surgery. A dedicated pituitary MRI which consists of coronal and sagittal T1- and T2-weighted images before and after infusion of paramagnetic contrast (Gd-DTPA) is obtained in every patient. For patients with small microadenomas, a "dynamic" study, where sellar imaging is performed every 10 seconds during contrast infusion, may be helpful in delineation of the "hypoenhancing" tumor. Besides tumor characteristics, a number of other factors are inspected on

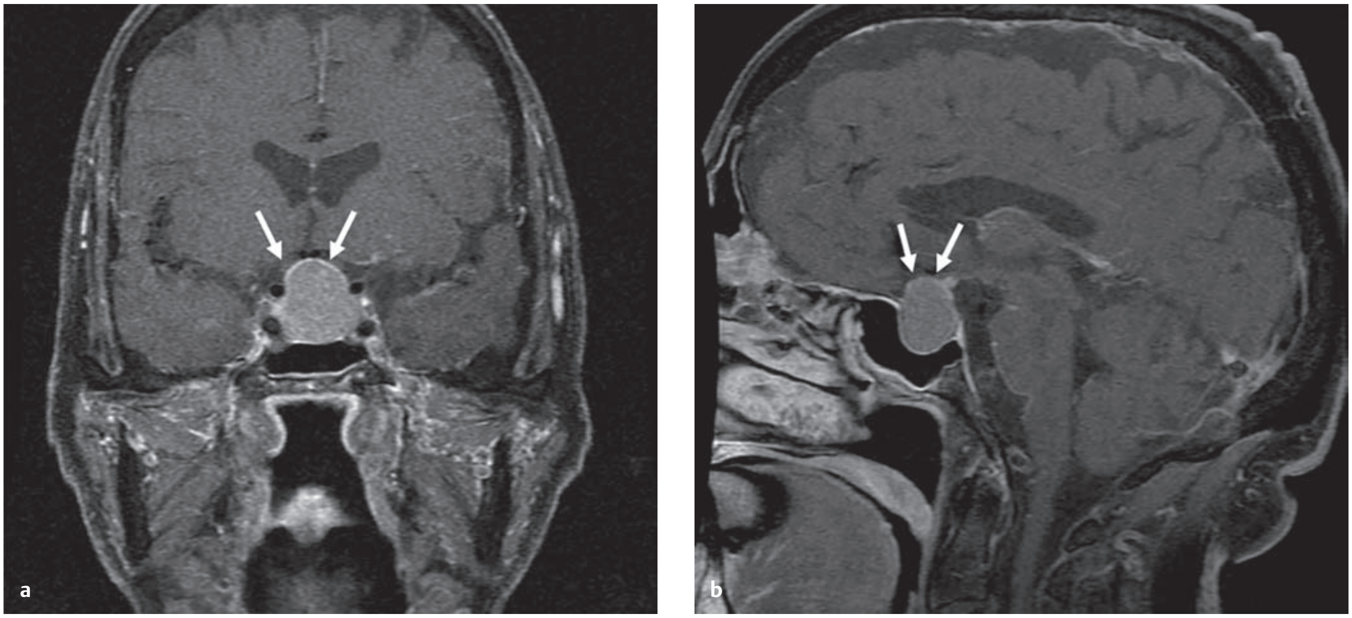

Fig. 1.2 T1-weighted coronal **(a)** and sagittal **(b)** magnetic resonance imaging (MRI) after administration of contrast demonstrating a macroadenoma with suprasellar extension. Note the location of the residual pituitary gland (*arrows*) which appears as a rim of enhancing tissue superior and posterior to the tumor.

preoperative images. Sphenoid sinus anatomy such as ossification and its septal anatomy should be closely evaluated. Furthermore, the location and the course of the carotid arteries should be careful observed. Ectatic carotid arteries that course too medially may minimize surgical exposure and even preclude the TS approach. Ectatic carotid arteries and sphenoid sinusitis are contraindications for a TS approach and a craniotomy can be considered in these circumstances.[16] Also when reviewing the MRI, it is important to recognize the location of the residual pituitary gland in macroadenomas as this structure appears as a thin rim of enhancement on coronal and sagittal images (**Fig. 1.2**).

◆ Direct Endonasal Approach

Positioning

The surgeon can be positioned above the head (particularly useful for wide-chested patients) or to the side of the patient. We describe the more traditional approach which is identical for all of the TS approaches discussed in this chapter (**Fig. 1.3**). The patient is placed supine with their right shoulder at the right-hand corner of the table. The endotracheal tube, nasogastric tube, and temperature probe are brought to the left side of the mouth. The head, slightly elevated to improve venous drainage, is placed in a Mayfield three-point clamp in order to incorporate frameless stereotaxy. The head is slightly tilted to the patient's left (10–15 degrees), rotated to right (10–20 degrees), and slightly extended. In our experience, the use of frameless stereotaxy for guidance to the sella turcica is superior to the traditional fluoroscopy because it provides guidance in the both vertical and lateral directions. Furthermore, frameless stereotaxy can be very valuable at teaching institutions where neurosurgical residents first become familiar with EN anatomy. There are also new systems that allow for stereotactic navigation without rigid fixation allowing for flexibility with head positioning during the procedure.[17]

Antiseptic solution (e.g., povidine) is applied to the nose and the left lower abdominal quadrant where adipose tissue may be harvested for repair of CSF leak. For EN surgeries, mucosal prepping is unnecessary. For the SL and TS approaches, however, lidocaine with 1:100,000 epinephrine is injected submucosally along the septum (only on the side of entry), the floor of each nostril, and upper buccal mucosa (for SL only). Preparing the nasal mucosa prior to induction with xylometazoline nasal drops can supplement lidocaine injections.[18] Finally, the oropharynx is packed with 2-inch gauze to avoid aspiration of blood during surgery.

Instrumentation

The EN approach presently used at our institution only requires a few additional tools besides the standard TS instruments. These include 0-, 30-, and 45-degree endoscopes, modified narrow nasal speculum, suction-monopolar-coagulator, and the SCANLAN *Advantage* Badie Bipolar (Scanlan International, Minneapolis, MN) (**Fig. 1.4**).

Operative Technique

Our endoscopic-guided pituitary operations are performed through only one nostril, usually the one opposite to the side of the tumor. For midline tumors, the wider nasal cavity is selected. The endoscope is initially inserted into the nostril and the anatomy of the turbinates is explored. For a wide nasal passage, the endoscope is then passed between the

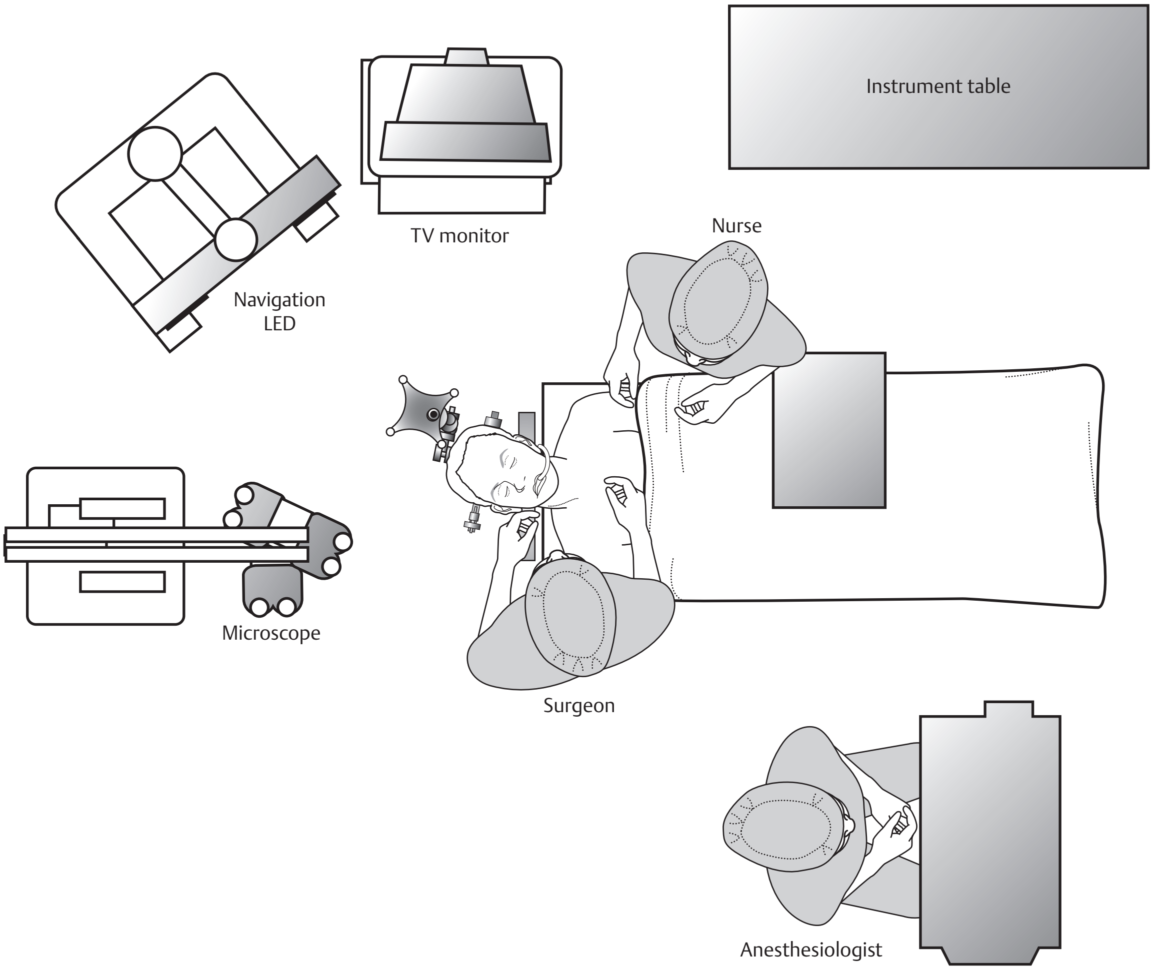

Fig. 1.3 Operating room and patient positioning for transsphenoidal surgery.

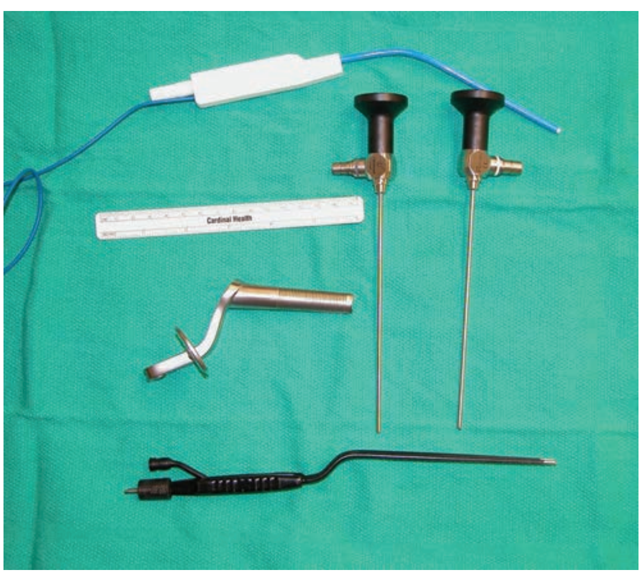

Fig. 1.4 Additional transsphenoidal instruments used for endonasal pituitary surgery include 0-, 30-, and 45-degree endoscopes, modified narrow nasal speculum, suction-monopolar-coagulator, and the SCANLAN *Advantage* Badie™ bipolar.

septum medially and the middle turbinate laterally. The middle turbinate is gently pushed laterally as the endoscope is passed deeper into the nasal cavity. For narrower corridors, we use the larger space between the inferior turbinate and the nasal septum to visualize the choana, and as the scope is angulated in a cephalad direction, the shaft of the endoscope is used to displace the middle turbinate. The posterior attachment of the middle turbinate is used as a landmark to localize the sphenoid sinus. After the location of the entry into the sphenoid sinus is confirmed with the navigation system, mucosa over the sphenoid sinus is cut using a suction-monopolar-coagulator and the posterior aspect of the nasal septum is fractured from the vomer. A narrow speculum is then advanced under endoscopic guidance to the sphenoid face. An anterior sphenoidotomy is then performed.

While the endoscope is still used to optimize the extent of anterior sphenoidotomy and exposure of the sella, the actual tumor removal is performed using a microscope. By freeing the surgeon's hands and providing stereoscopic visualization, the microscope can reduce the operative time and allow for easier control of bleeding.

Once inside the sphenoid sinus, the endoscope is used to inspect the septal anatomy and localize the sella. The optic and carotid prominences can also be easily visualized through the endoscope. The sphenoid mucosa is preserved and is only partially coagulated to reveal the anterior wall of the sella turcica. Frameless stereotactic guidance is also useful to target the floor of the sella turcica which generally reveals itself as a smooth bulge in the superior midline region of the sinus.

The sella can then be opened with a small dissector, curette, drill, or osteotome. The opening should not extend to the chiasmatic sulcus or tuberculum sellae because this can increase the likelihood of a postoperative CSF leak. The opening can be extended using a micro-Kerrison punch. All bone taken from the opening should be saved for the final sellar reconstruction at the end of the case.

The dura is opened in a cruciate fashion consisting of a midline vertical and a horizontal incision. Diagonal incisions increase the risk of injury to the carotid arteries, which may deviate to midline at the upper aspect of the sella. We typically make the vertical incision first. A horizontal incision may result in the tumor decompression and descent of the arachnoid superiorly, which may be inadvertently opened with a subsequent vertical cut.

Tumor Removal

A typical macroadenoma appears as a soft grayish, granular-textured mass and can be distinguished from the remnants of the pituitary gland which appears as thin orange–yellow tissue with firmer consistency. Tumor removal should be accomplished in an orderly fashion, beginning inferiorly and then proceeding laterally and superiorly on both sides of the sella. A ringed curette is used to enter the tumor and the tissue is loosened and removed with blunt curettes and aspiration. It is helpful to first proceed with the more laterally situated regions of the tumor followed by the more central segments. This prevents entrapment of the lateral portions of the tumor by a prematurely descending diaphragma sellae. In order to avoid damage to the pituitary stalk, and secondarily the hypothalamus, it is important to delay superior dissection until the tumor is relatively freed inferiorly. Adherent tumor fragments should not be pulled down as this may result in stalk traction and irreversible diabetes insipidus (DA). Often with removal and decompression of the intrasellar portion of the tumor, the suprasellar tumor will prolapse into view. If this does not occur often a Valsalva maneuver by the anesthesiologist will facilitate herniation of residual tumor. Thus, early arachnoid tears and CSF leaks should be avoided to maintain an adequate intracranial pressure necessary for this maneuver. Finally, visual inspection with 30- and 45-degree endoscopes should be performed to look for any residual tumor located laterally and superiorly. Hemostasis can often be achieved using soft Gelfoam packing.

Microadenomas that are not present on the surface of the pituitary require a systemic search through seemingly normal-appearing gland. After the dura is opened, a transverse incision is made in the gland and blunt dissection is then carried out around the normal-appearing tissue to search for the tumor.

Closure Technique

Careful inspection of the resection bed should be carried out to evaluate for evidence of CSF leak or arachnoid tears. If no obvious CSF leak is noted, simple packing of the sella with Gelfoam is sufficient. Otherwise, small pieces of abdominal fat wrapped in oxidized cellulose (Surgicel) are placed intradurally. The posterior sellar wall is then reconstructed by intradural placement of a small flat piece of bone removed at the initial exposure or a synthetic implant. To avoid injury to the arachnoid membrane situated superiorly, the bone should be placed in a horizontal orientation and locked into place against dural or bone edges. If indicated, the reconstruction will be reinforced with fibrin glue. The sphenoid sinus itself is not packed with fat. If the dural leak is large, which can often be signified by pooling of CSF in the sphenoid sinus, the patient should have a lumbar drain placed at the end of the case. Some neurosurgeons use a nasoseptal flap in nearly all cases which also aids in decreasing the sequelae of complications from a potential CSF leak.[19,20]

After the nasal speculum is removed, the middle turbinate and the nasal septum are realigned into normal anatomical orientation. Insertion of a lubricated fifth digit into the contralateral nares is often sufficient to check for the septal alignment. Postoperative nasal packing is not used.

Since our first reported experience with the endoscopic-guided direct EN route to the sella 4 years ago, we have used this approach in nearly 200 patients with pituitary tumors. We have not experienced any cosmetic complications or nasal perforations using this technique. Most patients are discharged to home within 48 hours.

◆ Sublabial and Transseptal Approaches

SL and TS approaches provide a larger surgical corridor and are more suitable for tumors with parasellar extension. The SL approach, however, has fallen out of favor for resection of most pituitary tumors as it requires extensive submucosal dissection which, often performed by ear, nose, and throat surgeons, tends to increase postoperative patient discomfort and recovery time.

The SL approach begins along the buccogingival margin and extends submucosally to the sphenoid face. Patient positioning remains identical to the EN approach. For the SL approach, the upper lip is retracted and an incision is carried out along the buccogingival junction from one canine tooth to the other approximately 3.5 to 4 cm leaving a generous cuff of mucosa to reapproximate at closure. The mucosa from the maxillary ridge along the anterior nasal spine is elevated with dissectors or a bovie on low setting until the inferior border to the piriform aperture is reached. A submucoperichondrial flap is then developed along one side of the nasal septum and submucosal dissection is extended into the nasal floor on both sides. Using a curved dissector, the mucosa inferior to either nares is dissected away from the surface of the hard palate superiorly back to the perpendicular plate of the ethmoid. Connecting the corner joined by the vertical plane of the submucoperichondrial flap to horizontal plane of the binasal submucosal dissection can be challenging. Removing a small portion of the bony nasal spine to expose the junction of the nasal spine and the nasal cartilage can facilitate the connection. The cartilaginous nasal septum is then dislocated and reflected to the opposite side using firm blunt dissection.

The TS retractor can then be introduced and gently opened. With the retractor in place, the keel of the vomer should be well visualized and removed. The mucosa on the rostrum of the sphenoid is elevated laterally on both sides until the sphenoid ostia are visualized. A standard anterior sphenoidotomy is then performed under microscope. The tips of the nasal speculum should never be placed into the sphenoid sinus after the completion of the anterior sphenoidotomy. Overexpansion of the nasal speculum in such instances can fracture the sphenoid bone and the optic canals, and thus result in catastrophic optic nerve injury.

For the TS approach, an intranasal incision just behind the mucosal-cutaneous junction is made. A submucoperichondrial plane is then developed and the submucosal dissection is extended onto the nasal floor on one side. The nasal septum can then be fractured to the other side or partially excised to reach the vomer. The rest of the operation is similar to the EN and SL approaches.

At the completion of the surgery, the nasal septum is reapproximated in the midline and the mucosal and buccogingival incisions closed with 4–0 catgut or Vicryl sutures. For the SL approach, postoperative nasal packing can be used for 1 to 2 days to prevent septal hematomas or bleeding. For TS approach, we do not routinely use nasal packing postoperatively unless there is difficulty with hemostasis.

◆ Postoperative Care

The patient should be observed for further CSF leak which may require lumbar drainage or re-exploration. Also, the patient's fluid balance should be strictly monitored. Postoperative diuresis is not uncommon in any surgical patient but urine outputs greater than 300 mL/h for 2 consecutive hours often trigger serum sodium and urine-specific gravity measures. In our patient population, DI is uncommon, but if seen, only transient. Permanent or transient DI occurs in less than 10% of patients who undergo endoscopic TS surgery.[21] We do not treat the patients with vasopressin right away but rather liberalize the patient's fluid intake in order to keep up with output. If the DI persists beyond 24 hours, or if the patient is unable to match their input and output, then vasopressin is administered intranasally. Serum sodium levels are then monitored daily to avoid hypernatremia. Few patients may have hyponatremia 4 to 7 days after surgery.[22] Therefore, if patients complain of symptoms such as nausea, vomiting, confusion, and weakness, an outpatient sodium level should be obtained.

Exogenous steroid treatment is tapered fairly rapidly postoperatively. If there is concern for decrease in pituitary-adrenal axis function, then maintenance doses of steroids are administered until appropriate endocrine follow-up can be obtained. For GH- or ACTH-secreting tumors, hormone levels need to be checked in the postoperative period and somatostatin analogues (i.e., pasireotide) or adrenal steroidogenesis inhibitors are, respectively, administered for patients in whom surgery was not curative.[14,23] Follow-up formal ophthalmic examination can be completed following surgery. Progressive recovery of visual field deficits are seen in approximately 95% of patients who had a macroadenoma removed via a TS approach. Recovery of visual field deficits can occur over several years, but the majority of recovery is seen in the first 3 to 6 months postoperatively.[24]

Our patients also receive prophylactic antibiotics postoperatively. Augmentin (750 mg/d orally for 14 days) has been effective in reducing postoperative sinusitis.

◆ Conclusion

In our experience, TS operations can be efficiently, effectively, and safely performed through an EN approach. Combination of the endoscope, operating microscope, and frameless stereotaxy has been instrumental in improving this approach. The translabial approach is used less frequently but can be helpful in the approach to larger tumors with parasellar extension. The key to a successful TS operation remains strict adherence to the midline, preservation of normal tissue, and careful postoperative care.

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