ENDOSCOPIC PITUITARY SURGERY – A BEGINNER'S GUIDE

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Abstract

Endonasal endoscopic surgery is now the preferred technique to tackle pituitary tumours. Our paper describes the stepwise endoscopic approach for surgeons embarking on pituitary surgery. It also highlights the common pitfalls encountered during surgery and the ways to avoid them. We use the endonasal para-septal trans-sphenoidal approach. Surgery begins with gentle packing between the middle turbinate and septum to expose the anterior sphenoid wall and expose the sphenoid ostium. The ostium is then widened inferiorly and onto the opposite side to expose both sphenoid sinuses. The inter-sphenoid sinus and necessary mucosa is removed to expose the sella. We then use a bone flap technique or punches to open the sella. After incising the dura, tumour is removed with a suction curette. An endoscope holder facilitates the operation. The bone flap is replaced at the end of surgery to reconstruct the sella. This is especially important if a CSF leak is present. Nasal packing is usually not required.

Introduction:

Pituitary adenomas are slow growing tumours that constitute about 10-15% of all intracranial neoplasms. They can produce compression symptoms when enlarged or give rise to hormonal disturbances. These tumours are often diagnosed late or remain undiagnosed. Radiology is the best tool for diagnosis along with hormonal assays. These tumours can be treated medically, surgically or with radiotherapy.

Since the late 1970, the transsphenoid approach has been the preferred procedure for removal of these tumours[1]. With the advent of endoscopic surgery the endoscopes have now been applied to access these tumours with favourable result. The better magnification and illumination provided by the endoscopes has helped in precise delineation of the tumour and has ensured completeness of tumour removal[2]. It has also greatly reduced the postoperative morbidity.

Our paper describes the stepwise endoscopic approach for surgeons embarking on pituitary surgery. It also highlights the common pitfalls encountered during surgery and the ways to avoid them.

Surgical anatomy:

The pituitary gland is situated within the sella turcica - a part of the sphenoid bone at the base skull. Embryologically it is formed partly from brain tissue itself (the posterior lobe or neurohypophysis) and partly from upward extension of the Rathke's pouch. (anterior lobe or adenohypophysis). The average size of the pituitary gland is 12mm (transverse) x 8mm (sagittal) x 6mm (vertical). It secretes various hormones required to maintain normal metabolic and cellular functions within the body. The gland has important relations with the optic chiasm and the cavernous sinus which have to be borne in mind during endoscopic pituitary surgery. Approximately 8 – 13 mm above the pituitary gland is the optic chiasm. The cavernous sinuses are situated in the middle cranial fossa on either side of the pituitary gland. An intercavernous sinus is present in 76% of the population. Just above the optic tract is the hypothalamus which is connected to the gland by the pituitary stalk. The blood supply is from the superior hypophyseal and inferior hypophyseal arteries which arise from the internal carotid artery. Transverse anastomosis exists between the arteries. Anterior pituitary does not have any direct arterial supply.

The hormones secreted by the pituitary are as shown in the table.
The Anterior Lobe

1. Thyroid Stimulating Hormone (TSH)
2. Gonadotropins
    - Follicle Stimulating Hormone (FSH)
    - Luteinizing Hormone (LH)
3. Prolactin (PRL)
4. Growth Hormone (GH)
5. ACTH
6. Alpha Melanocyte-Stimulating Hormone (α-MSH)

The Posterior Lobe

- Antidiuretic Hormone (ADH)
- Oxytocin

The Intermediate Lobe

- Melanocyte stimulating hormone
- Gamma lipoprotein

Adenomas are the commonest benign epithelial tumours of the pituitary gland. Characteristically they are slow growing and mostly arise from the adenohypophysis. Depending upon their ability to secrete hormones, pituitary adenomas are further subdivided as functioning and non-functioning tumours. They can also be differentiated according to their size. Microadenomas are intrasellar tumours less than 1cm in diameter and are usually secretory (functional) tumours but having little impact on the visual system. Macroadenomas measure more than 1cm in diameter and cause sellar enlargement and pressure symptoms.

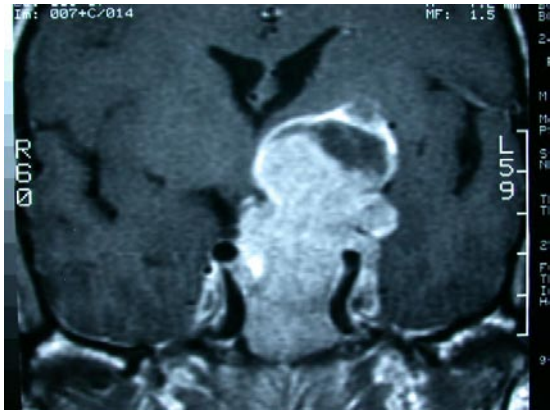
Prolactinomas are the most common functioning pituitary adenomas. Excess production of prolactin by these tumours can cause amenorrhea, galactorrhoea and infertility. Pituitary adenomas that produce excess adenocorticotrophic hormone cause Cushing's disease. Excess secretion of growth hormone produces gigantism in children which primarily affects the active growth plates and acromegaly in adults wherein the soft tissues of the body such as the hands, face, tongue and lips are affected. Thyroid stimulating hormone (TSH) producing adenomas are rare and can give rise to goitre or thyroid hyperfunction.

Pituitary adenomas produce three types of clinical disturbances: (a) Mechanical (b) hormonal and (c) pituitary dysfunction. Mechanical symptoms occur when the tumour enlarges to a considerable size to produce pressure effects such as headache, nausea and vomiting. Upwardly growing tumours can press upon the optic chiasm at its inferior aspect producing the characteristic bitemporal hemianopia. Other cranial nerves in the cavernous sinus can also be involved with lateral extension. Hormonal manifestations develop when hypo or hyper-secretion occurs. (as mentioned above)

Pituitary dysfunction occurs when the enlarged adenoma compresses the normal surrounding functional pituitary tissue.

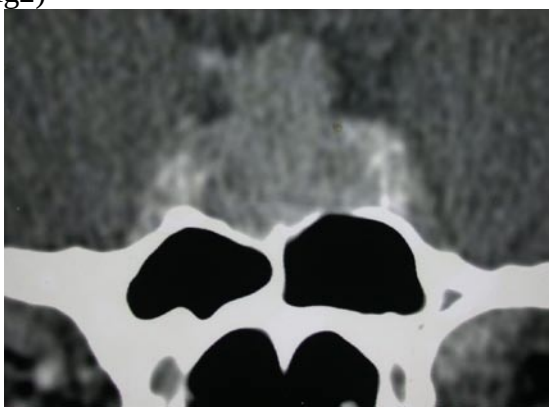
The diagnosis of pituitary tumours is both clinical and radiological. Secreting tumours are usually diagnosed by the endocrinologist while the non-secreting tumours by the ophthalmologists since they produce visual defects in the absence of any systemic signs. Both Computerised tomography (CT) scan and Magnetic Resonance Imaging (MRI) play an important role in the confirmation of the diagnosis of these tumours.

MRI with contrast is useful to (a) confirm the presence or absence of tumour (b) delineate the exact size and extension of the adenoma (c) to assess vascular relationships to the tumour (d) to detect invasion of the surrounding structures (e) to localize microadenomas and differentiate it from surrounding normal pituitary gland, and (f) post therapy to detect residual or recurrent tumour[3]. (fig1)

1. 

MRI Showing adenoma extensions with carotid artery

CT scan of the paranasal sinuses is a must before any endoscopic surgery. It serves as a "road map" for the surgeon. For endoscopic pituitary surgery, CT scan is required (a) to find out other anatomical variations that may obstruct the sphenoid sinus ostium (b) to know the extent of sphenoid sinus pneumatisation (c) to look for variations in the attachments of the intra and inter-sphenoid septae (d) to know the size of the sella, and (e) to ascertain sellar erosion and extent of tumour extension into the sphenoid sinus. (fig2)

2. 
CT Scan showing adenoma with inter sphenoid septum & erosion on left sella floor

When a pituitary tumour is suspected it is essential to carry out a complete hormonal assay (haematological and urinary hormonal studies) to assess the secretory function of the tumour. Also an ophthalmic examination including perimetry is important to rule out visual field defects.

Surgical therapy, medical therapy and radiation therapy are the three treatment options available for pituitary tumours. Prolactinomas respond best to medical line of treatment. Bromocriptine is the most commonly used drug[4]. Acromegaly can be treated with octreotide medication but does not respond as well as prolactinomas do with bromocriptine. Radiotherapy is usually reserved for tumours not responding to medical or surgical line of management or as an adjuvant for residual tumour.

Surgery remains an important and common option in pituitary adenomas.

Surgical Aspects

Endoscopic sinus surgery has transformed the otorhinolaryngologist's approach to pathology in the nose and the paranasal sinuses. We are now able to understand the

anatomy and physiology of the nose and sinuses much better and hence surgery can be done which is target-pathology specific and yet functional. However, despite the enhanced illumination and exposure, endoscopic surgery is not easy. One still needs a very thorough knowledge of anatomy in this complex area. This is even more valid when one crosses into relatively unknown territory such as we do for endoscopic pituitary surgery. This article attempts to simplify the procedure and helps the ENT surgeon who is ready to take on this exciting new surgery.

Pituitary surgery has been conventionally and still is done by neurosurgeons. It is imperative as ENT surgeons, entering into a new area, that we have a team approach with the neurosurgeons as we learn pituitary surgery. Whilst the ENT surgeons' knowledge of the anatomy of the nose and the paranasal sinuses is superior, the neurosurgeons' knowledge of the sellar and parasellar anatomy and pathology is far better. Therefore as we approach an intra-cranial sellar region via the endonasal transsphenoid approach, it is in the surgeon's and patient's benefit to work together. One must proceed in a gradual step-wise manner, starting from simple exposure of the sphenoid sinus towards complete endoscopic tumour removal, so as to develop our own skills, confidence and ability to tackle complications.

Usually by the time the ENT surgeon sees such patients requiring surgery, the patient has already been investigated by the endocrinologist, neurophysician or a neurosurgeon. It is especially important to be able to analyse the radiological data. The CT scan gives us invaluable information regarding the bony surgical anatomy of the nose and sphenoid sinus whilst the MRI is extremely useful for parasellar and vascular information. It is sometimes crucial to differentiate an adenoma from other pathologies such as a meningioma and even an aneurysm, prior to surgery. If there is any doubt an MR angiography can also be done.

The various advantages it offers include better illumination and exposure, decreased morbidity and quicker post-operative recovery. In effect, the procedure is quicker, avoids the complications of septal surgery, offers a panoramic view of the sphenoid sinus and excellent visualization of the sellar and surrounding structures, allows for more complete tumour removal and requires minimal nasal packing.

Surgery is indicated in the following cases:

1. Secretory tumours not responding to medical line of treatment or when there is no appropriate medical treatment.
2. Patients who develop side effects of medical treatment.
3. Tumour enlargement with pressure symptoms or evidence of compression of surrounding structures. (e.g. optic chiasm, cavernous sinus)
4. Patients who develop signs of pituitary insufficiency.

Contra-indications to transsphenoid surgery:

1. Extension anterior to tuberculum and over the planum sphenoidale
2. Behind the clivus into the posterior fossa
3. Tumour is dumbbell shaped and hence may not descend easily
4. Solid tumour – suction or curetting not possible

Pre-op preparation includes decongestion and antibiotics to be started two days prior to surgery. Decongestant nose drops are put into the nose 15 minutes prior to taking the patient inside the operation theatre.

STEPS OF SURGERY:

The surgery is done under general anaesthesia.

Position : The patient is supine on the operation table with the head resting on a horseshoe. The head is at a 30 degree angle to the shoulders and slightly rotated towards the surgeon who is on the right side of the patient. The nurse with the instrument trolley stands to the surgeon's left near the head end of the patient. There should be place near the head end of the patient to accommodate the C-arm if required. The monitor with the camera and light source (on the trolley) is on the left side near the patient's head, opposite to the surgeon. The assistant stands opposite to the surgeon. The microscope is kept ready on the left side to be used if required.

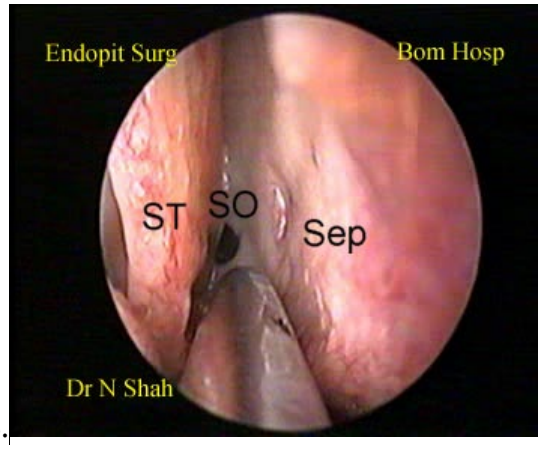
HINT: This position is especially useful when the microscope needs to be used as it allows the surgeon to operate comfortably without bending over the patient.

Preparation: Patient's face is prepared with betadine and saline and the nasal cavity swabbed with betadine. Patient's thigh is also prepared in case fascia lata and fat are required. Lumbar drain is inserted in all patients unless one is dealing with a microadenoma or a tumour without suprasellar extension, in which case the drain is not required. The nose is packed with xylocaine adrenaline cotton patties. The patient is draped leaving the nose and the thigh exposed.

Diagnostic endoscopy and decongestion: Diagnostic endoscopy is done to determine deviation of septum and hypertrophy or bullosa of the middle turbinate. The choice of operative side is made depending upon the side which offers more space and access. Most of the surgery is done using a 0° endoscope. Decongestion packing is done under endoscopic control between the middle turbinate and nasal septum. This packing should be done with utmost gentleness from antero-inferior part of the turbinate, going posteriorly and superiorly, so as to lateralise the middle turbinate without fracturing it. It is not our practice to cut the middle turbinate, and we find it unnecessary. Only in the event of there being a large or bilateral concha bullosa will an excision of the lateral plate be required, to allow the turbinate to be lateralised. This packing may have to be repeated twice or thrice so as to expose the anterior wall of the sphenoid sinus.

HINT: It is important that the packing be very gentle so as not to cause any trauma to the mucosa as it can lead to troublesome bleeding which can interfere with further surgery.

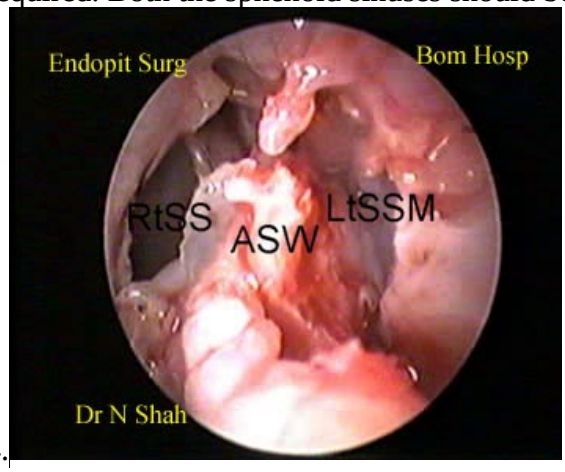
Localising sphenoid sinus ostium : Once the anterior wall of the sphenoid sinus has been exposed, the sphenoid sinus ostium may be seen about 1-1.5 cm above the nasopharynx. Often however, it is not seen, and one needs to lateralise the superior turbinate to see it. The superior turbinate is a very reliable landmark to localize the ostium, as it lies just behind the inferior aspect of the superior turbinate. If there is mucosal oedema obscuring the ostium, then gentle probing should be done in the region of the ostium. In case the ostium is still not seen despite all efforts then a blind puncture is made in the anterior sphenoid wall. This puncture is made about 1-1.2 cm above the superior aspect of the choana as close to the septum as possible. (fig3)

3. 

Localising the sphenoid ostium. ST- Superior turbinate; SO- Sphenoid ostium; Sep- Nasal septum

HINT: Try and find the superior turbinate as the ostium is quite easily found behind it. Sometimes one needs to search for the ostium not very close to the nasal septum, but a little more laterally.

Widening of the ostium and exposure of sphenoid sinus : Generally the sphenoid ostium represents the superior limit of anterior sphenoid wall removal and hence widening is done in an inferior direction. A downward Kerrison punch is used to widen the ostium inferiorly. The amount of bone removal depends upon the size of the sella. Large sella or the presence of a tumour in the sphenoid sinus will necessitate a wider exposure. Bleeding may sometimes be encountered from the nasopalatine artery, a branch of the sphenopalatine artery as it runs across the inferior part of the anterior sphenoid wall and this can be easily cauterized. Once the inferior limit of bone dissection is reached, we then use an upward Kerrison punch to cut across from the ostium horizontally and go to the opposite side across the back of the septum. Whilst doing this, the septum is dislocated from the anterior wall of the sphenoid at the rostrum. The downward Kerrison punch is used to remove the anterior sphenoid wall to the same inferior limit as the initial side. The inferior limits are then joined horizontally so as to remove the anterior wall in a single piece which may be used for sellar reconstruction if required. Both the sphenoid sinuses should be seen easily. (fig4)

4. 

Opening the anterior sphenoid wall. ASW- Anterior sphenoid wall; RtSS- Right sphenoid sinus; LtSSM- Left sphenoid sinus mucosa

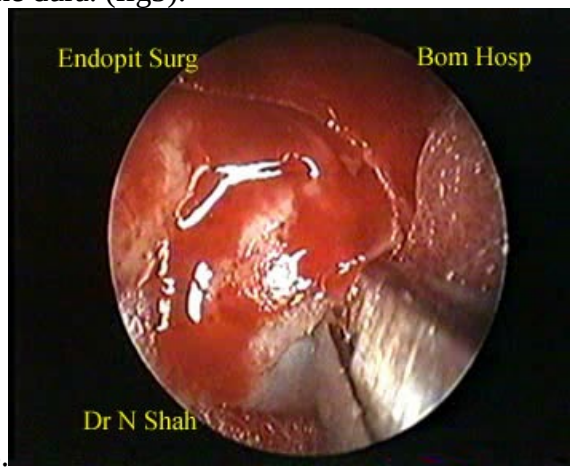
HINT: It is useful though not necessary to do cautery of the inferior sphenoid wall to reduce the likelihood of bleeding. A 1mm downward Kerrison punch is used initially to widen the ostium and then changed to a 2 mm punch once the ostium is widened. Occasionally a 3 mm punch or drill is required when the bone is hard, especially near the base of the sphenoid wall.

Exposure of the anterior sellar wall : There is always an intersphenoid septum. This septum needs to be removed in order to expose the anterior wall of the sella. The septum usually deviates to one side dividing the sinus into two unequal sinuses. Occasionally the septum deviates quite laterally and terminates on the carotid artery. This may be present in 32-40% of patients[5]. In this situation it is wise to use extreme caution while removing the terminal septum to prevent accidental and disastrous injury to the carotid artery[6]. If there are multiple (or) incomplete septae obstructing the view of the sella, they will also need removal. The mucosa over the sella is removed to expose the bone. Exposure of the sella includes visualization of the tuberculum sella superiorly, the bulge of the optic nerves at 10.00 and 2.00 o'clock, the area of the cavernous sinuses at 3.00 and 9.00 o'clock, the carotid bulge at 5.00 and 7.00 o'clock and the clivus inferiorly[2].

HINT: Whilst removing laterally deviated terminal septae it is important to note that usually the part attached to the carotid lies lateral to the sella and hence may not require removal. Therefore the anterior septum which obstructs the view of the sella can be removed safely and followed until the sella is seen completely and not necessarily having to remove the entire septum.

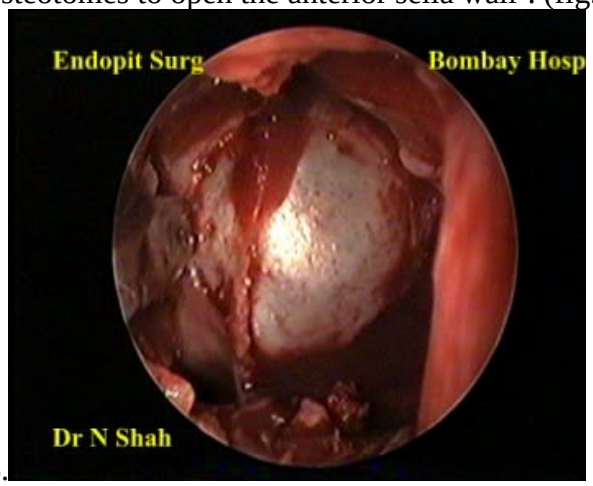
Removal of mucosa in the sphenoid sinus can lead to troublesome bleeding, and hence only the mucosa covering the sella needs removal, keeping the cautery ready for haemostasis[2]. Rarely bone wax may be required. If fat packing of the sphenoid sinus is required in the event of a CSF leak, then all the mucosa from the sphenoid sinus must be removed to prevent mucocele formation.

Opening of the sella: The position of the sella may be confirmed using the C-arm in case of microadenomas or if any doubt exists. Usually the C-arm is not required[2]. The sella can be opened in many different ways. If the tumour has eroded part of the bone then it is quite easy to use the smallest Kerrison punch to remove loose bone to expose the dura. (fig5).

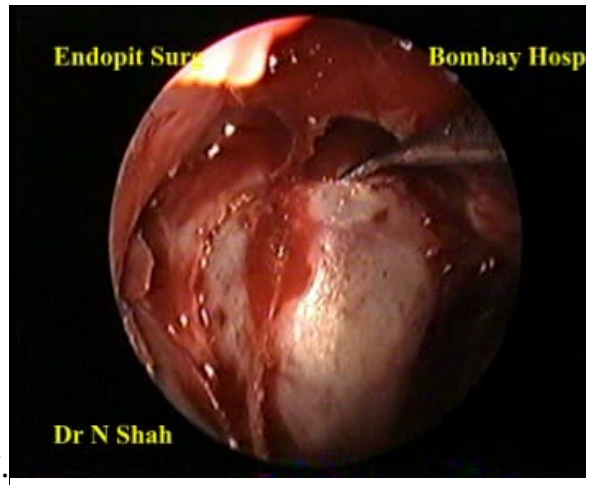
5. 

Using the punch to open anterior sella wall

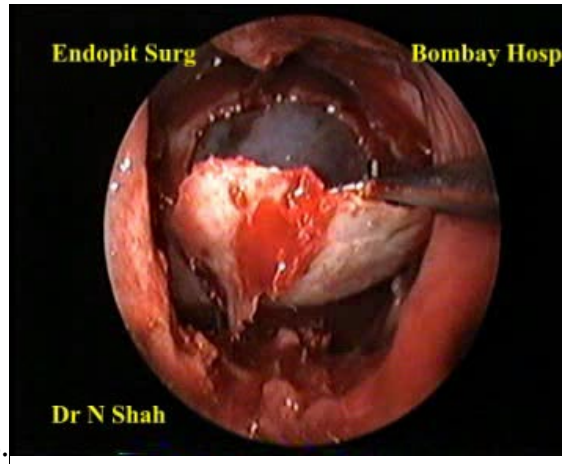
If the bone is firm and does not break easily with the pressure of the punch, then an osteotome may be used to make a window in the sella which can then be enlarged using punches. The third option is to use a drill to thin the bone prior to opening it. In our institute, we have developed a technique of creating a bone flap or window using osteotomes to open the anterior sella wall[2]. (fig.s 6,7,8,9)



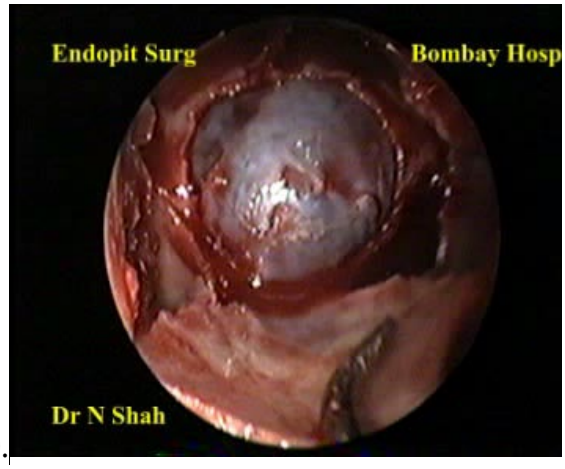
6. Using the osteotome to make the cuts for the sella bone flap



7. Using a hook to open the sella bone flap

8. 

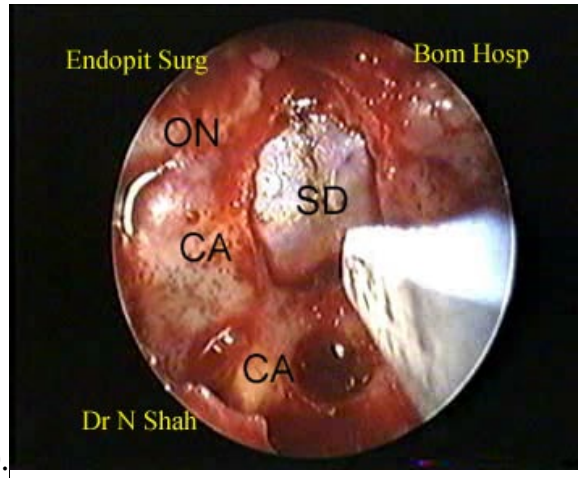
Sella bone flap half open

9. 

Fully opened sella bone flap with dura exposed

The amount of exposure depends on the size of the sella and tumour extension. The opening should be made as wide as possible being careful of the cavernous sinus laterally. The superior limit is the tuberculum sella and inferiorly the floor is removed if required. In cases of microadenoma, a small opening localized to the tumour is enough[7]. **HINT**: It is extremely important to be aware of the midline when opening the sella to avoid accidental injury to the carotid and cavernous area. The midline can be confirmed from the base of the sphenoid inferiorly (rostrum- vomer) or remaining anterior sphenoid wall- septum attachment superiorly. It is also possible to stay between the optic nerves and the carotid bulges. It is best to start with opening or widening sellas which are eroded with tumour (or) have very thin bone prior to using an osteotome or burrs under supervision of the neurosurgeons.

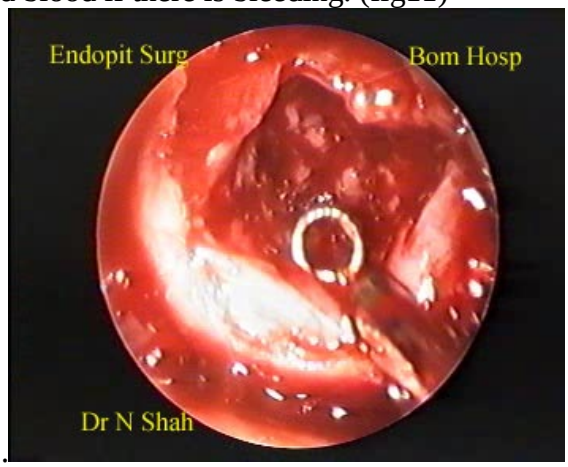
Incising the dura: The dura is incised using 15 number knife in a cruciate fashion. Occasionally there may be bleeding from the cut ends of the dura which needs to be cauterized with bipolar forceps. (fig10)

10. 

Incising the dura. CA- Carotid artery; ON- Optic Nerve; SD- Dura

HINT: It is advisable to stop the incision a few millimetres from the bone edge so that the cut edge of the dura does not retract under the bone and make cautery difficult in cases of bleeding. (In microadenomas the incision must be situated on the adenoma and not on the normal pituitary gland).

Tumour removal: Once the dura is incised, soft tumour usually pops out and a biopsy forceps is used to collect specimen for histopathology and frozen section. Further tumour removal is done using ring curettes. Tumour is removed in the inferior and lateral aspects first and then going superiorly to remove suprasellar tumour[2]. For this part of surgery we have developed a suction curette, so that with one hand it is possible to remove tumour and blood if there is bleeding. (fig11)

11. 

Using the suction curette to remove tumour within sella

We find this instrument very useful if we do not have an endoscope holder or are working in a very limited space – narrow nostril. At the end of tumour removal the diaphragm sellae descends and should be seen easily indicating that all superior tumour has been removed. A 30° or 45° endoscope is used to inspect the borders of the sellar cavity, specially the supero-lateral, lateral and inferior parts to confirm complete tumour removal. Any residual tumour can also be removed under vision. The use of air injection

via the lumbar drain may be done to push suprasellar tumour inferiorly so that it can be removed under vision. However one must remove lateral and inferior tumour first, as in some cases undue prolapse of the diaphragm sella or suprasellar cistern may block off the view laterally and posteriorly and make remaining tumour removal very difficult.
HINT: It is important to be extremely gentle while using the curette to avoid accidental CSF leaks or injury to the cavernous sinus and carotid artery. It is also advisable to restrict the use of forceps to hold and pull tumour in the sella. It is important to use the suction to remove blood and tumour superficially and not deep inside the sella. In cases with difficulty in tumour removal, one should insert a Hardy's nasal speculum and shift to a microscope to allow two hand surgery and for better depth perception, especially if a endoscope holder is not available.

Closure of Sella : After tumour removal, the tumour cavity may be left open without risk of complications. If there is bleeding, the use of surgicel may be required within the sella for haemostasis. Gelfoam can swell up considerably causing compression and should be avoided within the sella. In cases of large adenomas or prolapse of the diaphragm, fat packing is done in the sella to prevent an empty sella syndrome.
If a CSF leak is present, it is repaired using fascia lata and fat inside the sella, reconstructing the anterior sella wall with the bone flap window or using the bone from the anterior sphenoid wall or inter-sphenoid septum. Another layer of fascia with tissue glue is used on top of the bone to complete the closure. The sphenoid is left aerated.
HINT: It is useful to have intact pieces of bone from the anterior sphenoid wall, intersphenoid septum and anterior sellar wall or even the posterior end of the nasal septum to use for reconstruction of the sella.
Completion of surgery: One must remember to bring the laterally displaced middle turbinate back to its original position to prevent subsequent sinusitis. In case a nasal speculum has been used one must remember to relocate the nasal septum back to the midline. Usually nasal packing is not required but if there is oozing, unilateral or bilateral packing may be done.

Conclusion
The ENT surgeon must be familiar with endoscopic surgery and anatomy of the nose and paranasal sinuses. This surgery should primarily be done by experienced ENT surgeons in conjunction with neurosurgeons, comfortable with using the endoscope and instruments in the nose. It is a good idea for beginning ENT endoscopic surgeons to be trained in basic endoscopic sinus surgery before venturing to do transsphenoid surgery. It is also essential to perform cadaver dissections to obtain the necessary skill. From January 2000 till January 2008, more than 450 endoscopic and endoscopic assisted pituitary surgeries were done at Bombay Hospital. We initially did only an exposure of the sella and then gradually progressed to complete endoscopic tumour removal as we grew in confidence. Like in most surgeries, there is a learning curve which one must climb steadily.
A major concern with endoscopic surgery remains arterial or venous bleeding[7] and if significant, it may require a transfer to the microscopic approach. However, with experience, most cases with bleeding can be dealt with endoscopically. CSF repair can also be done easily with the endoscope.

The increased exposure, magnification and flexibility of the endoscope combined with the absence of skin incisions, brain retraction and cranial nerve dissection is an advantage of the endoscopic transsphenoid approach that cannot be denied[7].

Extended Scope

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