Pituitary and parasellar surgery

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1) Introduction:

Endoscopic pituitary and parasellar surgery (EPPS) is a well established technique for the treatment of sellar and parasellar tumors, specially pituitary adenomas, craniopharyngiomas, and meningiomas[1].

It offers some advantages compared to microscopic approaches such as a superior close-up view of the relevant anatomy and an enlarged working angle provided with an increased panoramic vision inside the surgical area[1,2].

Several studies shows that EPPS decreases the postoperative discomfort and hospitalization time as well as enables a quick recovery in patients operated in comparison with the conventional microscopic technique. Decreased operative time and decreased blood loss as compared with open transsphenoidal surgery have also been reported[1,2,3].

For its location, these regions, specially the pituitary gland, are well accessed through the nasal cavity and sphenoid sinus, and since the last century, several approaches had been described. From sublabial microscopic to fully endoscopic transsphenoidal approaches much had passed and several endoscopic approaches have been described in order to approach the sellar region and *planum sphenoidale*: transnasal direct, transseptal, modified transseptal and transnasal/transseptal binostril, recently described[1,2,4,5].

Because of the precise anatomical and functional knowledge of the nose and paranasal sinus, technical skills and appropriate instrumentation to work with endoscopes, usually an otolaryngologist (ENT) perform the surgical approach from the nasal cavity to the sphenoid sinus and a neurosurgeon perform the remotion of the tumor[1,5,6].

This multidisciplinary approach concept is very important nowadays. The team approach is still a relatively novel concept in medicine. Although the multi-disciplinary team (MDT) has evolved only in the last few decades, survival and complication rates, since the introduction of such an approach, have decreased.
This team approach should be done in the preoperative assessment, during the surgery and after the procedure with radiologists, intensive care doctors, endocrinologists, anesthesiologists and paramedical staff[5].

In order to improve the understanding of the EPPS, we decided to divide this chapter into sections: one about **pituitary surgery**, its approaches and our technique; and other about ***planum sphenoidale*** and **cavernous sinus** approaches.

2) Pituitary Surgery:

Pituitary tumor surgery is traditionally performed by neurosurgeons. Nowadays, ENT’s have become important partners in the surgical treatment of pituitary adenoma patients. The transsphenoidal approach, which traditionally was done by neurosurgeons with microscopes, has received contributions based on the knowledge that ENT’s have about naso-sinusal surgery, which has increased the pituitary exposure and minimized injury to nasal structures[5,6].

In many medical centers neurosurgeons, ENT’s, endocrinologists and anesthesiologists are part of a medical team for pituitary surgery, which had reduced complications such as endocrinologic problems, cerebrospinal leaks, septal perforation and other functional nasal problems[5].

2.1) Indications and contra-indications:

The indications for transnasal endoscopic pituitary surgery include: pituitary adenomas and secreting tumors, such as prolactinomas, GH and ACTH.

The contraindications for this surgery are: patient co-morbidities precluding them from prolonged general anesthesia; and lack of specialized equipment/instruments.

2.2) Instrumentation:

Adequate instrumentation is paramount for the endoscopic approach to the sellar and parasellar regions. The necessary equipment includes: high-quality endoscopes (zero- and 45-degree); video equipment (camera and monitor); long endoscopic bipolar forceps preferably suction bipolar; long and delicate drills; long dissection instruments, and hemostatic materials.

In conjunction with Karl Storz Inc., the authors developed a 5-mm wide-angled zero-degree endoscope for these procedures to increase the field of view and illumination[5]. **(Figure 1)**

2.2) Preoperative assessment:

This must include a careful clinical history, preoperative evaluation with physical examination and imaging studies. A physician-patient informed discussion with frank conversations about the diagnosis, surgical plan, possible complications, and the roles of both the physician and the patient in the anticipated postoperative care plan is mandatory.

The physical examination includes an endoscopic assessment of the nasal cavity to visualize any nasal lesions, document septal integrity, deviations and other anatomical findings.

2.3) Imaging:

Coronal, axial, and parasagittal CT images of the paranasal sinuses and skull base are essential in the preoperative assessment. It is also necessary to evaluate the size of the sphenoid sinus, the position of the internal carotid artery, and the presence of an Onodi cell **(Figure 2).**

MRI is important to demonstrate the size and extension of the tumor and any involvement of the internal carotid artery or cavernous sinus **(Figure 2).**

2.4) Approach:

Several transnasal endoscopic approaches to the pituitary have been described, such as transnasal direct and modified with the removal of the posterior nasal septum; transseptal direct and modified with also the removal of the posterior septum; transnasal co mbined with transethmoidal and the removal of the middle turbinate and the recently described transseptal/transnasal modified approach. Each one of these approaches have its advantages and disadvantages[5,6].

We are going to discuss the **binostril approach** (transseptal/transnasal), which was recently described. This approach requires a creation of a nasal septum flap at one side, pediculated at the sphenopalatine foramen, that can be used to close any dural defects and also avoids the large posterior nasal septal perforation[6].

2.5) Preparation:

The surgery is performed under a hypotensive general anesthesia. The patient is placed in a supine position on the operating table, with the head elevated 30 degrees and with the neck slightly flexed and the head extended and turned towards the surgeon. High concentration adrenaline-soaked cottonoids (1:1000) are placed in the nasal cavity for 10 minutes before the surgical procedure begins.

The surgery begins with an infiltration of the nasal septum with a lidocaine 2 percent epinephrine 1:100.000 solution. A classic anterior incision for septoplasty is made, generally at the right side of the nose.

A mucoperichondrial/mucoperiosteal dissection is made at both sides. The posterior part of the nasal septum is removed, saving the inferior portion as a landmark for midline.

A nasal septum flap, pedicled at the sphenopalatine bundle, is created at one side. The creation of the flap starts with incisions at the choanal arch and brought forwards as anterior as necessary. Multiple modifications regarding length and width are possible **(Figure 3)**.

This binostril approach has several advantages. It allows two surgeons to simultaneously manipulate surgical instruments using both nostrils (instruments get into the surgical field either by the nasal septum at one side and the nasal cavity at the other side), it creates a very robust pediculated tissue to help in the closure of skull base defects, and it preserves the nasal septal mucosa of one side, avoiding posterior nasal septal posterior perforations[6].

At the creation of the nasal septal flap special attention should be given to the nasal septal free borders of the flap. Cauterization should be done and sometimes haemostatic absorbable material can be used at the septal edges of the flap in order to avoid nasal bleeding.

The anterior wall of the sphenoid sinus must be largely exposed and opened, facilitating the identification of the principal anatomical structures of the sphenoid sinus, such as the prominence of the internal carotid artery canals, optic nerves canals, clivus and planum sphenoidale. Any intersinus and or intra-sinus septae are resected using a strong cutting forceps. The mucoperiosteum of the sphenoid sinus covering the floor of the sella is displaced laterally.

The next step consists of widely resecting the floor of the sellar bone exposing the dura from one internal carotid artery (ICA) to the opposite ICA and from the planun sphenoidale to the clivus. This is usually performed with a diamond burr or a Micro Kerrison punch[5,6]. **(Figure 4)**

2.6) Dural quadrangular incision:

Conventionally, since microscopic approaches, the surgeons choose for opening the dura by making an “X-like” or cruciate shaped incision **(Figure 5)**. These incisions are considered the “gold standard” by many authors[6]. The traditional incision is usually made with a sickle knife or with a #11 blade and allows a creation of a dural flap that can be repositioned after the removal of the tumor. However, the dural flap, created with the cruciate incision, sometimes can disturb the surgeon, especially using suction devices. Attempts to bipolar cauterization and retraction of these flaps have been described.

We described and always perform a quadrangular dural incision, made very carefully, trying to visualize the precise localization of the cavernous sinus and the superior and inferior inter-cavernous sinuses, and of both internal carotid arteries through the exposed dura. These structures represent the anatomical limits of the dural opening. The quadrangular or, in some cases rectangular incision, have the following limits **(Figure 6)**:

a) **Lateral:** medial to both internal cartotid arteries and cavernous sinus;
b) **Superior:** inferior to the superior intercavernous sinus;
c) **Inferior**: superior to the inferior intercavernous sinus.

2.7) Ressection of the tumor:

The dura mater is removed along with any attached fragments of tumor, and sent for histopathological examination. Resection of the tumor begins laterally with a 45 degree angled endoscope and curved suction tube, first identifying the angle between the arachnoid and the ICA.

The arachnoid is the limit of the superior and posterior dissection (classicaly known as the diaphragma sella). When a complete removal is accomplished, the arachnoid frequently descends to fill the space ocupied by the tumor. This can partially obstruct the vision, and is one cause for incomplete tumor removal. In pituitary adenoma surgery, disection is more important than the use of the curette.

Occasional bleeding is carefully controlled by warm saline solution, surgicel, and bipolar cautery.

2.8) Reconstruction:

At the end of the surgery, a piece of the nasal quadrangular cartilage can be positioned in order to protect the arachnoid membrane. If a CSF leak occurs, a piece of fat or fascia lata can be positioned **(Figure 7)**.

The previously created nasal septal flap is positioned in its original position if no CSF leak occur or at the floor of the sella, in cases of perioperative CSF leak[5,6]. After, the sphenoid sinus cavity was filled with Spongostan® and the nasal cavity received a Merocel® pack **(Figure 7)**.

2.9) Nasal packing:

The nasal packing is removed according to the surgery. If no perioperative CSF leak occurs it is removed the day after surgery. In cases of perioperative CSF leak, it is removed between the 3^{rd} and 5^{th} postoperative day.

All patients routinely receive wide-spectrum antibiotics during the operation and for seven days postoperatively.

2.10) Post-operative care:

After the removal of the packing, some instructions are given to the patients, such as to avoid moderate or intense physical activities, straining, nose blowing and sneezing for approximatelly 30 days, specially in cases of perioperative CSF leak. To prevent constipation it is recommended a high-fiber soft diet. Also they are instructed to peform frequent nasal irrigations with 0.9% or 3% saline solution.

At the fist visit, between the 7^{th} and 10^{th} day after the operation, we usually check for signs of infection, bleeding, crusting, nasal synechias, nasal septum integrity and CSF leakage. Nasal obstruction is a common immediate complaint of patients who undergo to this procedure.

3) ***Planum sphenoidale*** **and cavernous sinus:**

The endoscopic management of lesions involving the planum sphenoidale is a recentely novel concept in our medical field, but it offers some advantages when compared to traditional craniotomies because it optimizes the exposure, helping to minimize the risk of complications, and also avoids nerve damage and excessive brain retraction.

3.1) Indications and contra-indications:

The indications for these approaches include: lesions involving the planum sphenoidale and tuberculum sella, most typically meningiomas, but it is also useful for lesions that compromise the suprasellar cistern region and pre and post optic chismal lesions such as pituitary microadenomas, craniopharyngiomas, Rathke pouch cysts and even optic nerve gliomas.

The contra-indications include: patient co-morbidities precluding them from prolonged general anesthesia; unfavorable anatomy, such as small sphenoid sinus, small space between the internal carotid arteries and small space between the optic chiasma and the pituitary gland; and lack of specialized equipment/instruments.

3.2) Planum sphenoidale approach:

An uncinectomy with total ethmoidectomy is performed. The superior turbinate is resected to allow access to the entire front wall of the sphenoid. In some cases, the middle turbinates also need to be resected. Commencing at the sphenoid ostium, the maximum amount of the front wall is then removed. At this stage, a posterior pedicled mucoperiosteal flap, based on the septal branch of the sphenopalatine artery, is usually developed if available[7,8,9].

A posterior septectomy is performed and the mucosa of the posterior sphenoid wall removed. Drilling of the thick tuberculum sellae bone and the sella is the next step. An area the width of the entire intercarotid is thinned down to “egg shell” thickness with a high-speed drill and then removed. We are especially careful not to damage the optic nerves by excessive heat generated by the use of the drill, and use shorter periods of drilling and copious irrigation.

A Kerrison rongeur (Karl Storz, Tuttlingen, Germany) may be used for additional bone removal. The bone removal is much wider and higher than the area exposed in standard pituitary surgery. Bone removal continues along the sphenoid planum **(Figure 8).**

The posterior ethmoidal arteries are coagulated and sectioned. Then the dura mater is opened carefully above and below the intercavernous sinus, exposing the suprasellar region and optic chiasm, avoiding any damage to the attached vessels. The intercavernous sinus is coagulated or packed with hemostatic material.

The intradural dissection is critical and it is imperative to identify the internal carotid arteries in the paraclinoid region, the anterior cerebral arteries (A1 and A2), the anterior communicating artery and the recurrent artery of Heubner. The optic nerve and chiasm must be identified more superiorly and also the pituitary stalk.

Sharp extra-arachnoid dissection of the tumor proceeds with a two-surgeon binostril technique. One surgeon utilizes the endoscope and sharp dissection, and the co-surgeon provides suction and forceps for retraction. Dissection in the arachnoidal plane is highly recommended whenever possible, as is the avoidance of excessive coagulation and traction, in order to reduce the possibility of minor surgical trauma to neurovascular structures[7,8,9].

3.3) Reconstruction:

A pedicled rotation flap forms the foundation for defect repair. Free fat grafts are used to fill dead space and form a buttress for a subdural (or extradural intracranial) fascial graft. This is then covered with both pedicled mucoperiosteal/perichondrial flaps. Fibrin tissue glue is used to secure the repair. Gelfoam is layered to the area and followed by gauze packing. The packing is supported by a Foley balloon catheter.

3.4) Postoperative care:

Antibiotics are used perioperatively and continued postoperatively while nasal packing remains in situ. Packing is left in place for 7 to 14 days. The onset of diabetes insipidus is monitored with serum and urine sodium/osmolality measurements. Patients are confined to bed for 48 hours with 30° head elevation, and told to avoid straining, valsalva maneuvers, and nose blowing. Lumbar drains are not routinely used unless there is an additional comorbidity such as raised intracranial hypertension or prior radiotherapy. Discharge usually occurs 3 to 5 days postoperative.

3.5) Cavernous sinus:

The endoscopic transnasal approach permits the exploration not of the whole cavernous sinus, but of those areas adjacent to the sphenoid sinus. For this reason, at this time, only the parasellar and middle cranial fossa areas of the cavernous sinus can be explored.

At the present, pituitary adenomas extending inside the cavernous sinus are the main indication for such approaches **(Figure 9)**.

3.6) Surgical approach:

After a traditional approach, the same described at this chapter for pituitary surgery, a 45-degree is introduced in order to look to the most lateral parts of the tumor. After, a gently suction is performed with curved protected suction forceps. The completeness of the removal of the parasellar portion of the lesion usually is confirmed by the initation of venous bleeding, which can be controlled with gentle irrigation and packing with hemostatic material. When the lesion involves the entire cavernous sinus, a lateral compartment approach is indicated. Pituitary adenomas, because of their soft consistency, currently are the simplest lesion to remove through this approach[5,6].

The corridor lateral to the internal carotid artery is delineated by the intracavernous tract of the internal carotid artery posteriorly, by the vidian nerve inferiorly, and by the medial pterygoid process anteriorly.

It is possible to expose the neurovascular structures inside the anterior part of the cavernous sinus. In this region, the oculomotor nerve (III), abducens nerve (VI) and maxillary branch of the trigeminal nerve (V2) form a plane on the inner wall, as opposed to the trochlear (IV) and the ophthalmic branch of the trigeminal nerve (V1), which are lateral.

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Figure legends :

Figure 1: Instrumentation. A : Novel 5-mm 0-degree endoscope (on the top) in comparison to the traditional 4-mm 0-degree endoscope (on the bottom). B: Art-work demonstrating the long and delicate drills.

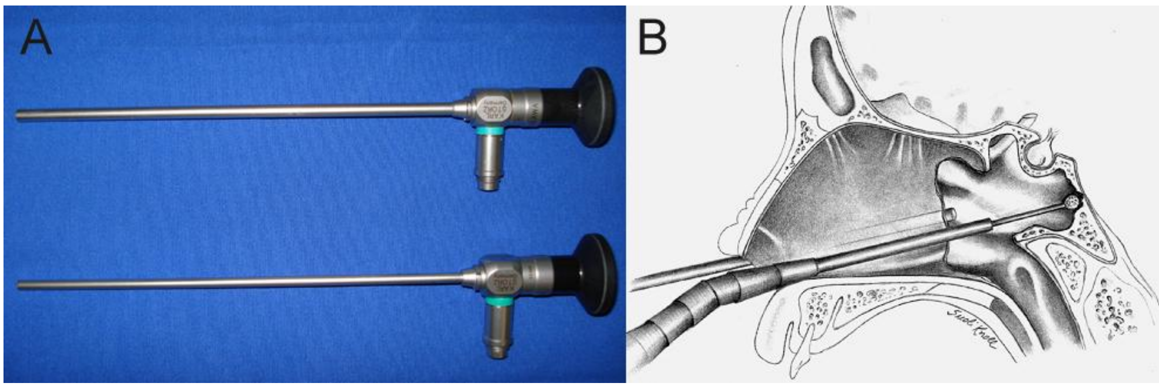

Figure 2: Imaging studies. A: Coronal computer tomography image showing the sphenoid sinus. B: Coronal magnetic resonance imaging (MRI) showing the relationship between the pituitary tumor, the internal carotid arteries and the sphenoid sinus. C: Axial MRI to evaluate the lateral extension of the tumor and any involvement of the cavernous sinus. D: Sagittal MRI.

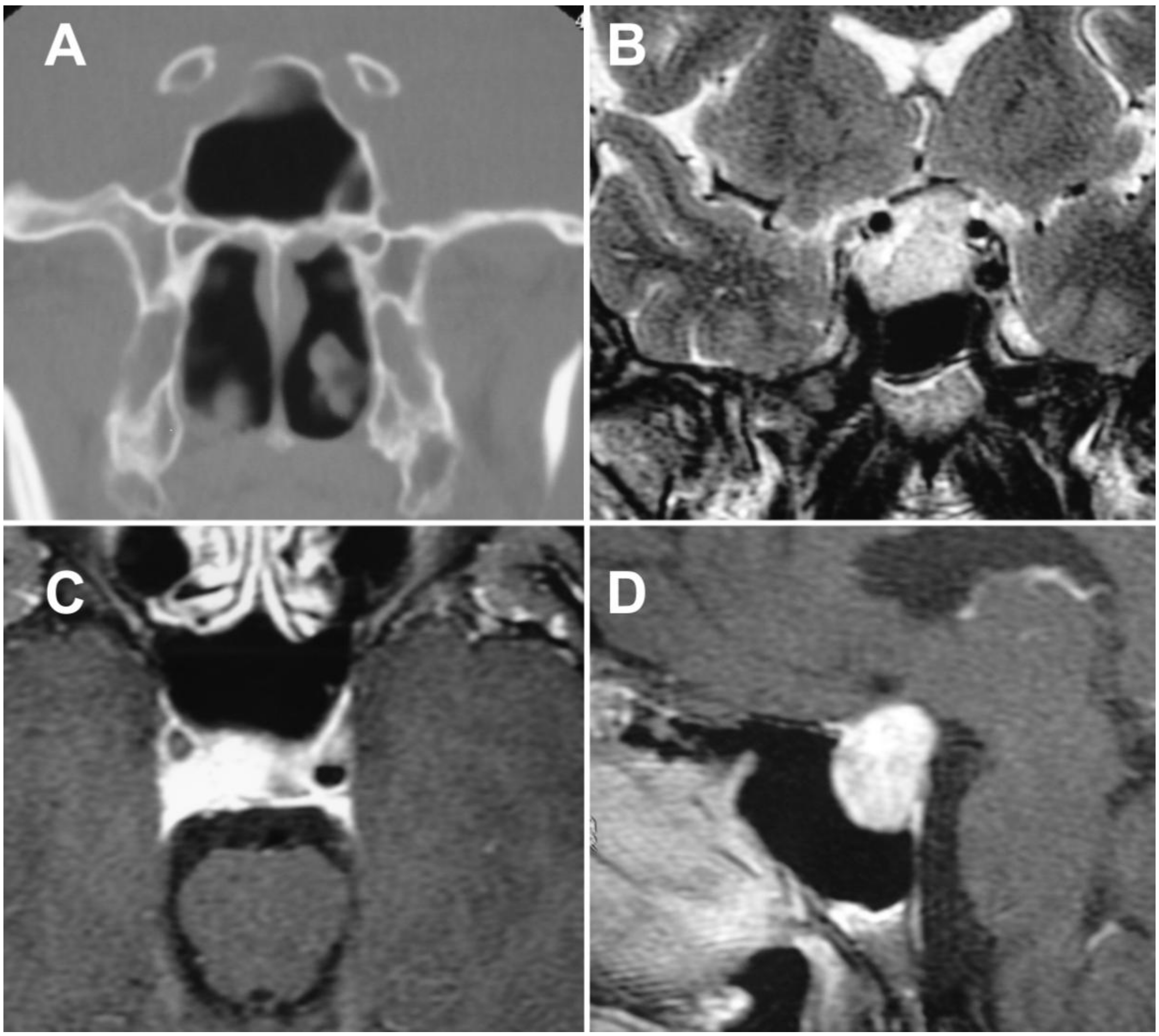

Figure 3: Creation of the nasal septal flap. A: Endoscopic view (0-degree endoscope) of left nasal cavity. The vertical anterior septal incision was made with a surgical blade. B: Horizontal incisions. C: Positioning of the nasal septal flap into rhinopharynx. D: final position of the nasal septal flap. Note the nasal septal integrity at the end of the procedure.

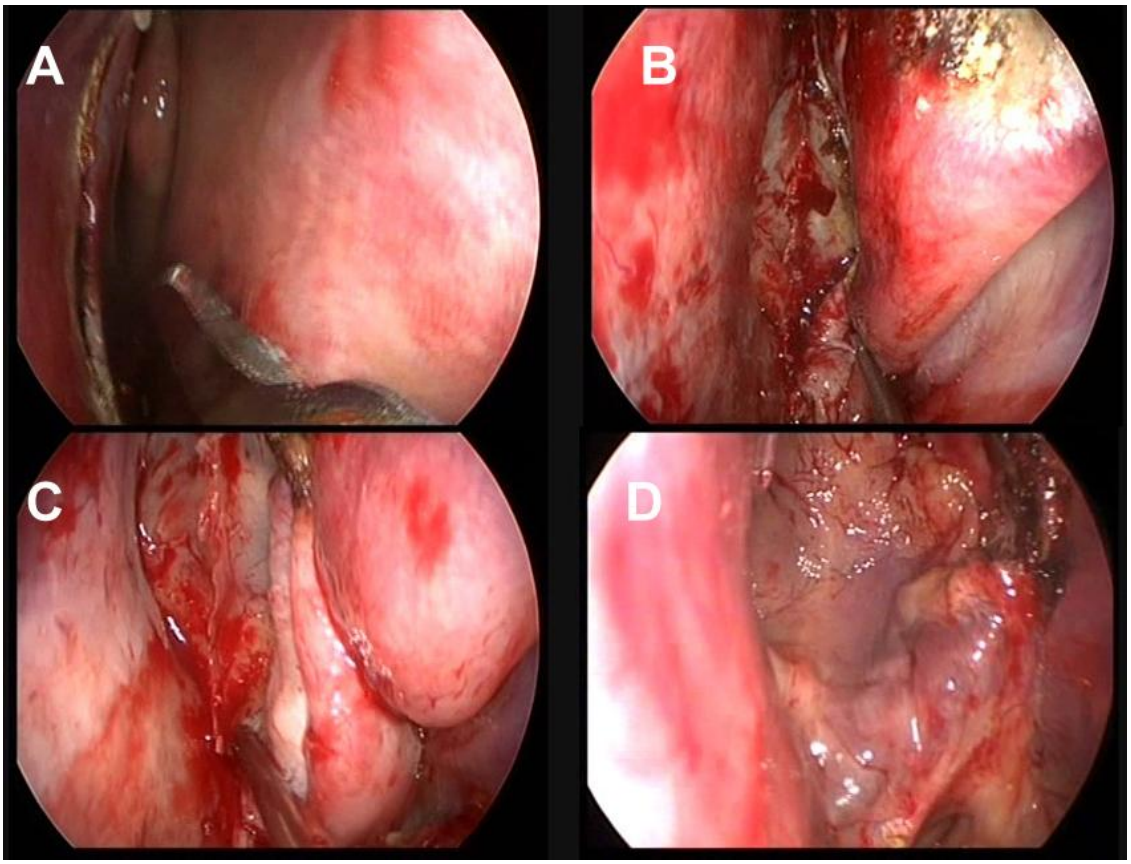

Figure 4: Wide exposition. This is the key to this surgery. A: Floor of the sellar bone exposed. B: Exposed dura from one internal carotid artery (ICA) to the opposite ICA and from the planun sphenoidale to the clivus. This is usually performed with a diamond burr.

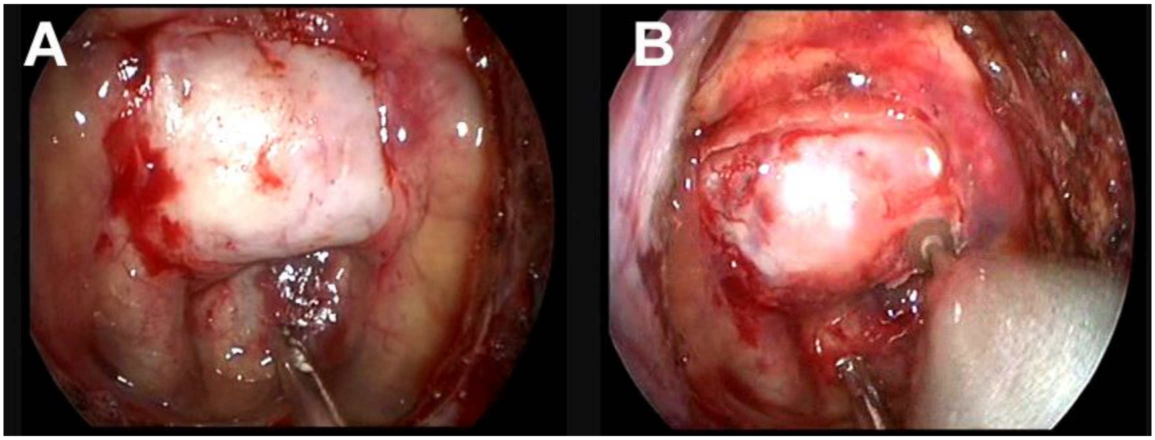

Figure 5: Art-work of traditional sellar dura incision, cruciate or "X-like" shaped, classically described in the literature.

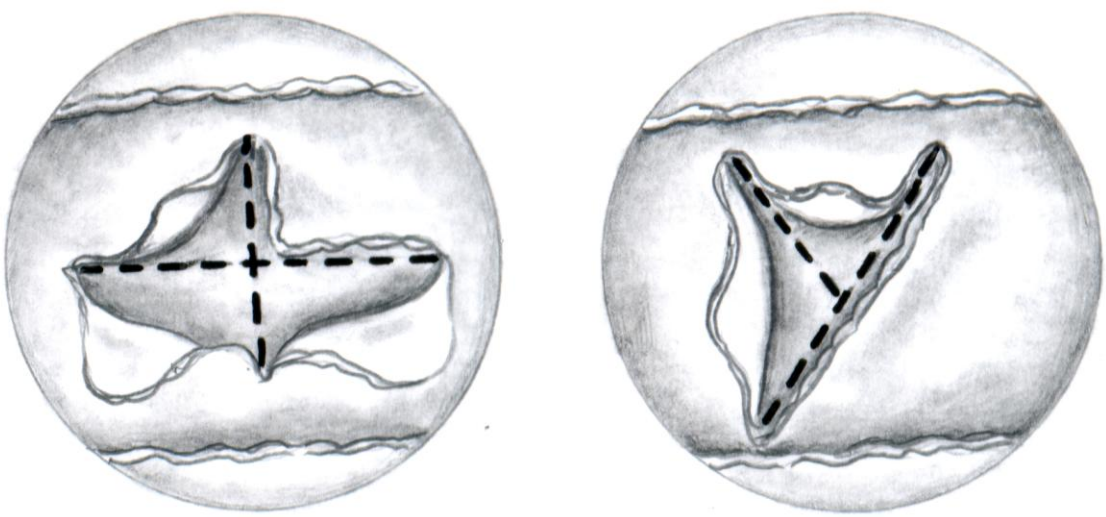

Figure 6: Quadrangular incision. A: Exposure of sellar dura. B: Incisions for a quadrangular or rectangular area in sellar dura. C: Complete incisions. D: Exposure.

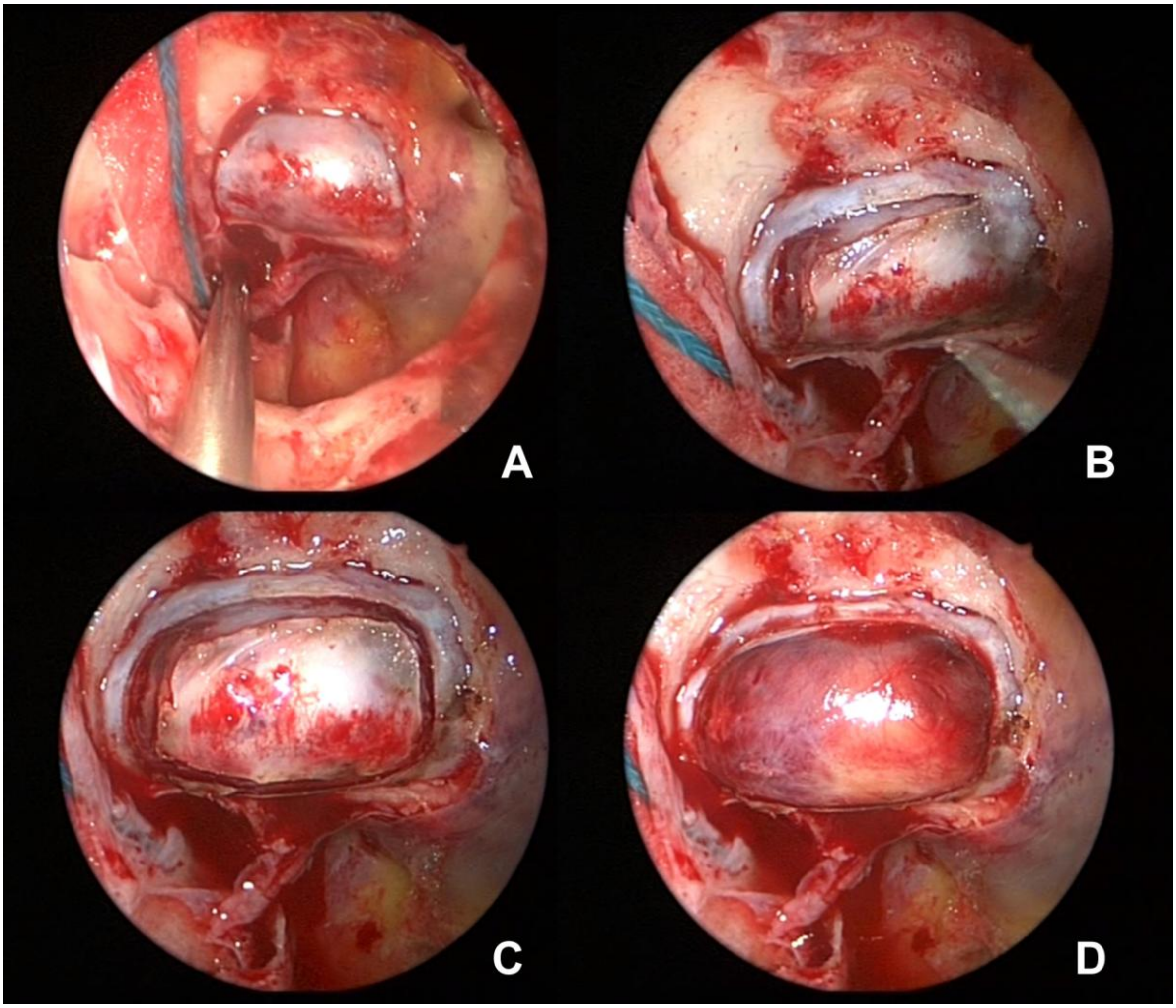

Figure 7: Reconstruction. A: In cases of CSF leak, a piece of fat and B: Fascia lata is positioned. C: Piece of the nasal quadrangular cartilage can be positioned in order to protect the arachnoid membrane. D: Nasal septal flap repositioned to cover the dural defect.

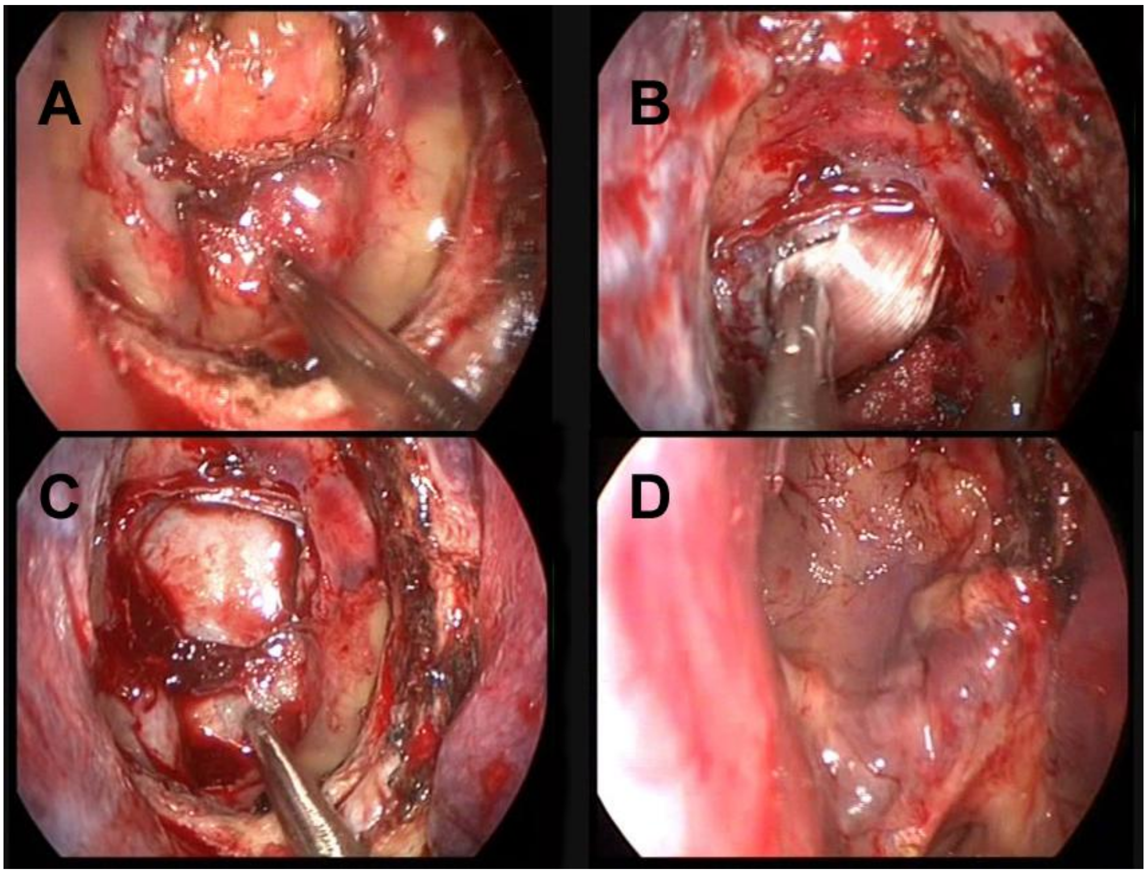

Figure 8: Planum sphenoidale approach. A: The bone removal is much wider and higher than the area exposed in standard pituitary surgery. Bone removal continues along the sphenoid planum. B: Opening of the dura. C: Visualization and dissection of the tumor. Special attention should be given to identify the internal carotid arteries in the paraclinoid region, the anterior cerebral arteries (A1 and A2), the anterior communicating artery and the recurrent artery of Heubner. The optic nerve and chiasm must be identified more superiorly and also the pituitary stalk. D: Visualization of the basilar artery, its branches, and the third cranial nerve.

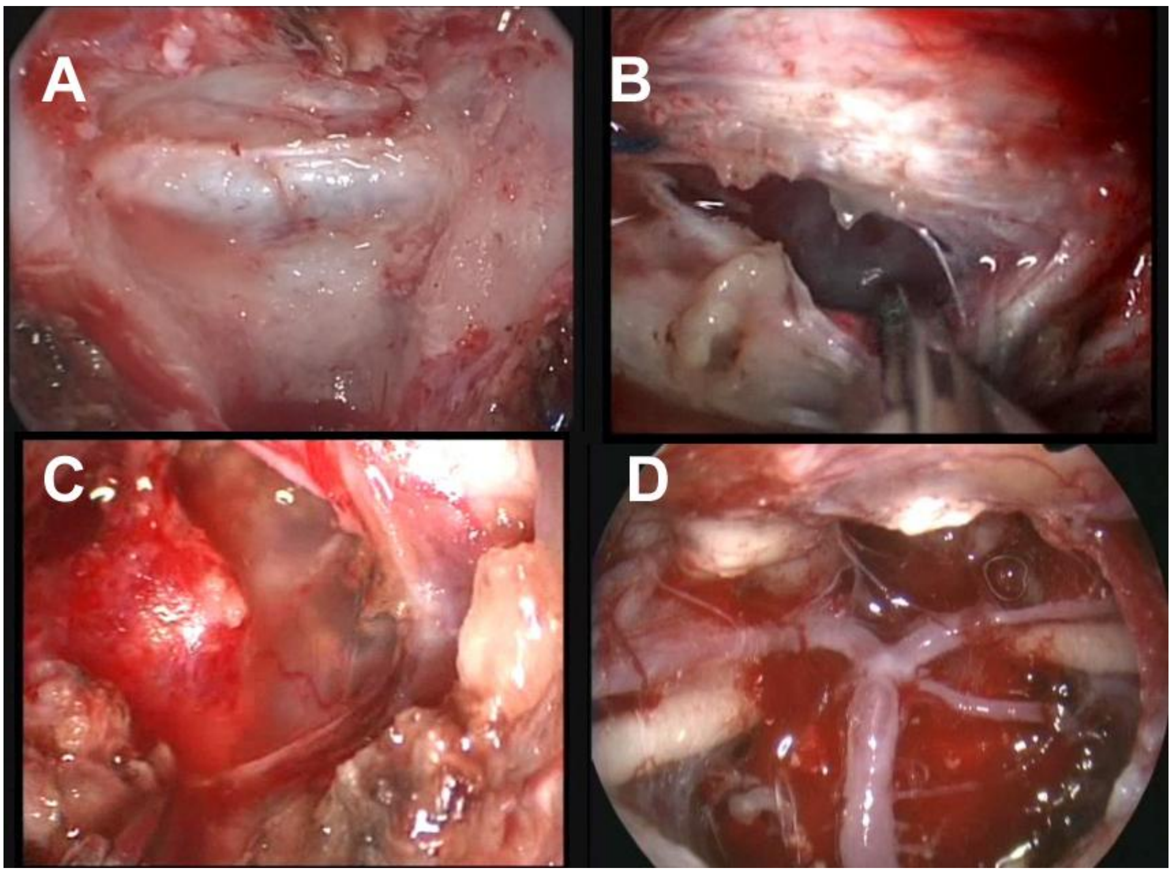

Figure 9: Magnetic resonance imaging (MRI) of pituitary adenoma with cavernous sinus invasion: A: Coronal image. Note the position of the internal carotid arteries. B: Sagittal