Endoscopic Surgery on Lesions of the Sphenoid Sinus

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1) Introduction:

The classical concept of endoscopic sinus surgery (ESS) is to remove inflammatory tissue of critical points of mucocilliary clearance in order to treat inflammatory conditions of the nasal and paranasal sinuses cavities. Nowadays, the understanding of aerodynamic concepts allow surgeons to perform procedures, when dealing with inflammatory conditions, to get access of topic medication, ventilation and also nasal lavage into the paranasal sinuses cavities with minimal trauma to the mucosa and, in some selected cases, minimal disturbance of the anatomy[1].

This is different when dealing with tumoral lesions, however because of those differences the current concept of TESS or tailored endoscopic sinus surgery is very important and the correct understanding of several different techniques, using different instruments, to access each paranasal sinus is important to offer patients the best possible care for each personalized paranasal sinus, either for inflammatory or tumoral diseases[2].

However, in order to perform safe and effective ESS at the sphenoid sinus it is paramount for the surgeon to understand these functional aerodynamic concepts (when dealing with inflammatory diseases), to know the complex anatomy of this sinus and its relationship with crucial and important structures.

Before surgery imaging exams such as computer tomography (CT) and/or, depending on the problem, magnetic resonance imaging (MRI) should be carefully evaluated by the surgeon in order to understand the disease, its relationships with critical anatomic structures and possibly avoid complications, minimizing surgical trauma[2].

Nowadays, freeware DICOM readers, just like Osirix for Apple computers, allow surgeons to perform virtual endoscopies, segmenting and volume rendering to help in surgical planning and understanding of the

aerodynamics and the procedure (Figure 1).

The sphenoid sinus is a very important paranasal sinus due to its unique location, practically in the center of the skull in close contact with key structures, such as the first six cranial nerves, the internal carotid artery (ICA), the pituitary gland, the cavernous sinus, the pterygopalatine fossa and the brain itself (Figure 1).

Before endoscopic access to the sphenoid sinus it is important that the surgeon review some anatomical structures in the patient imaging exams such as: optic nerve, ICA, possible presence of an Onodi cell, which is a posterior ethmoid cell and, depending on the lesion, possible erosions of the bony wall of this sinus (Figures 2 and 3).

Depending on the disease or lesion, its location and relationship with critical structures, several endoscopic surgical techniques and instruments may be used to approach it. Currently, with the aid of the endoscope, the surgeon can view the sphenoid sinus with a great precision and proximity, with a multi-angle and wide view capability.

In addition, surgery can extrapolate the limit of its bony barriers, transforming the sphenoid sinus in an access route for neurosurgical procedures, such as for certain pituitary and intracranial tumors[3,4.]

2) Objectives:

At this chapter we will discuss the endoscopic surgical accesses for the sphenoid sinus to treat both inflammatory, tumoral and other lesions, discussing the advantages, disadvantages, instruments needed, techniques for reconstruction and the current aerodynamic concepts.

3) Brief surgical anatomy:

The sphenoid sinus is located in the center of the cranial base, and it is surrounded by numerous neurovascular structures. Pneumatization of the sphenoid sinus provides a dilating natural cavity through which wide areas of the skull base may be accessed. Pneumatization, which can be seen as early as 6 months of age, begins at the ostia and progresses in inferior, posterior, and lateral directions. Sinus expansion does not reach its full extent until adolescence and continues after puberty[3].

The sphenoid sinus is bordered by the ethmoidal air cells anteriorly, the clivus posteriorly, the cavernous sinuses laterally, the pituitary fossa and planum sphenoidale superiorly, and the choana inferiorly. The sphenoid sinus may show varying degrees and directions of pneumatization, with its various extensions bringing it in close relationship to the optic nerve, cavernous sinus, ICA, ventral surface of the brainstem, cranial nerves III to VI, and the pituitary gland. Some of these structures may underlie and produce bony prominences and related recesses inside the sinus[5,6,7].

The division of the sphenoid sinus into three types, conchal, presellar, and sellar, based on the extension of pneumatization around the sella turcica, as proposed by Hammer and Radberg, is still widely utilized.

In recent years, after the introduction of the endoscope, the trans-sphenoidal approach has been expanded from the sellar region to all areas bordering the sphenoid sinus including the planum sphenoidale, suprasellar region, cavernous sinus, middle cranial fossa, and clivus[4,5,6,7].

This demands a thorough knowledge of the endoscopic surgical anatomy and a huge amount of anatomical variations involving the sphenoid sinus (Figure 4).

4) Instruments and setup:

In order to perform safe and effective endoscopic surgery at the sphenoid sinus, instruments may be useful and necessary (Figure 5).

High quality 4mm in diameter, 18cm in length, 0-degree and angled endoscopes, along with adequate 4mm optic fiber cable, adequate light source and high definition (HD) 3-chips camera are useful and very important, as you need to see properly in order to diagnose, understand and treat.

Although office procedures are a current trend in some countries in our specialty, we always operate using general hypotensive anesthesia, using total intravenous anesthetic agents. The patients are adequately positioned with the dorsum slightly elevated (approximately 30-degrees) with a neck hyperextension.

High concentrated adrenaline soaked cottonoids (1:2000) are placed at the nasal cavity for approximately 5 minutes before the first incision and usually no infiltrations are performed with anesthetic agents. If a naso-septal flap is needed to reconstruct skull base defects, we only use normally saline solution to infiltrate the septum in order to promote a hydro-dissection of the septal mucosa to facilitate the harvest of the naso-septal flap[4,8].

When dealing with inflammatory diseases, the understanding of the aerodynamic concepts is important and we always perform a septoplasty to correct septal deviations, in order to try to correct any disturbed airflows into the spheno-ethmoid recess to allow topic medication as well as ventilation and nasal lavage access to the sphenoid sinus.

5) Surgical techniques/approaches:

5.1) ***Balloon sphenoidotomy:***

Balloon instruments may be very useful to dilate and open the

sphenoid sinus natural ostium to allow access to the sphenoid sinus. It can be used in some inflammatory diseases, such as chronic rhinossinusitis (CRS) allowing a good opening (5mm or more in diameter) with a maximum preservation of the anatomy. Seldom complications are described, such as posterior septal hematoma, however it is a safe, effective and minimally invasive procedure[9].

The balloon guidecatheter is positioned at the spheno-ethmoid recess and the guidewire is passed through the sphenoid sinus natural ostium. This can be confirmed using fluoroscopy or, more commonly, using the light at the tip of the guidewire which will transilluminate the anterior wall of the sphenoid sinus. After, the balloon is passed and dilated at 12 atmospheres of pression. After a few seconds, the balloon is removed and the ostial region is remodeled. In some cases, the surgeon can pass an endoscope to inspect the sinus interior and a lavage, with a proper catheter is performed (Figure 6).

The surgeon should also understand that this can be used in patients with nosocomial infections, to collect secretions of the sphenoid sinus and debilitated patients with cannot be submitted to more radical procedures. However the costs of this instrument and, in some cases, difficulty to totally inspect the sphenoid sinus cavity may be a limiting factor of its use at the sphenoid sinus.

5.2) ***Sphenoidal sinusectomy:***

This provides a quick and direct route to the sphenoid sinus, with wide exposure of its interior. The surgeon identifies the choanal arc, middle and superior turbinates and the spheno-ethmoid recess. This recess is important since it is the natural route for the drainage pathway of the sphenoid sinus. The natural ostium of the sphenoid sinus normally lies between the superior

turbinate and the nasal septum. In cases of a supreme turbinate, the ostium also usually lies between the superior turbinate and nasal septum (Figure 7).

After identification of these anatomical landmarks a Kerrison-type forceps is used to open the sphenoidal sinus natural ostium. Next, a partial or complete removal of the sphenoid sinus anterior wall is performed with a Kerrison punch or a drill. Special care should be taken at the inferior limit of this opening to prevent lesions at the posterior septal artery.

Using this approach a good exposure of the sphenoid sinus can be achieved and it can be used to treat inflammatory, tumoral or other diseases, such as cerebrospinal fluid (CSF) leaks.

There can be minimal complaints of pain or discomfort at the postoperative period and endoscopy should be performed to clean the cavity and remove possible crosts blocking the correct drainage and ventilation of the cavity.

This technique can also be appended with the removal of the posterior third of the nasal septum and the rostrum of the sphenoid, to allow a binostril access to the sphenoid sinus. Also a partial or total removal of the superior and/or middle turbinates can be performed to increase the exposure and working space[10].

5.3) ***Trans-ethmoidal sphenoid approach:***

This approach requires complete removal of the anterior and posterior ethmoid cells to reach the sphenoid sinus. It is indicated when using joint ethmoid-sphenoid approaches (in cases of severe nasal polyposis) or when a large unilateral sphenoid exposure is required.

After the complete ethmoidectomy, the surgeon should identify the rostrum of the sphenoid, the base of the skull and superior turbinate, which can be partially resected. After, an identification of the sphenoid sinus

natural ostium is performed and the sphenoid sinus is opened. It is important that the opening of the ostium is really wide and extend for skull base and lateral wall of the orbit to avoid postoperative stenosis[11] (Figure 8).

This approach can be performed in patients with fibrous-osseous lesions into the sphenoid sinus that require a big exposition (Figure 9).

5.4) ***Trans-septal approaches:***

This approach uses the nasal septum as a corridor to the sphenoid rostrum and the sphenoid sinus. It can be modified to allow to creation of naso-septal flaps for skull base reconstruction.

After infiltration of the nasal septum with saline solution, an anterior incision is performed and a mucoperichondrial and mucoperiostal dissection is done to allow access to the spenoid rostrum. The nasal septum is partially removed and the rostrum can be drilled or opened using chisels to allow access to the sphenoid sinus (Figure 10).

It has the main advantage to keep the surgery in the middle line of the nasal cavity, fact that may help specially in tumoral cases with disturbed anatomy. It can be associated with resection of posterior third of the nasal septum, being called "direct trans-septal modified"[11].

The main indications of this approach are tumors at the sinus or the skull base, such as pituitary tumors.

6) Conclusion:

Endoscopic surgery on lesions of the sphenoid sinus is a very interesting but complex topic. There are many lesions into the sphenoid sinus itself but also this cavity can serve as a corridor to access skull base

lesions into the anterior, middle or posterior fossa. Due to its complex anatomy and increasing evolution of technology, instruments, surgical techniques and limits also are in constant change. The recent aerodynamic concepts also allow a better underdestanding of the surgical treatment of some inflammatory conditions. However the surgeon should have a profound knowledge of the endoscopic anatomy of the sphenoid sinus and its important relationships to other important structures to allow the best possible approach and treatment for the patients.

7) References:

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8) Figure Legends:

Figure 1:

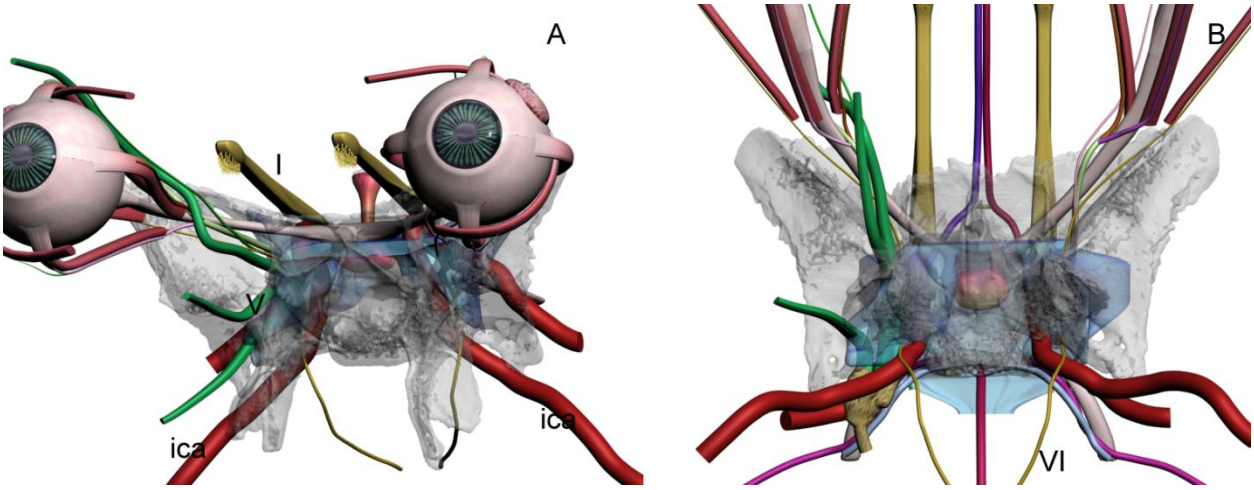

Figure 1: Computer images generated from DICOM files from CT scans showing the sphenoid bone (gray), sphenoid sinus (light blue) and its relationship with important structures such as internal carotid artery (ica), VI cranial nerve (VI) (yellow), V cranial nerve and its branches (green), I cranial nerve (I), among other important structures. These reconstructions can be very useful in locating the disease and planning the surgical approach.

Figure 2:

Figure 2: Computer tomography (coronal view) showing the sphenoid sinus (ss) with a presence of an Onodi cell (oc), which is a posterior ethmoid cell. The importance of the preoperative evaluation and identification of an Onodi cell is its relationship with the optic nerve (on) and internal carotid artery (ica). The Onodi cell can vary in shape and size and should always be identified preoperatively.

Figure 3:

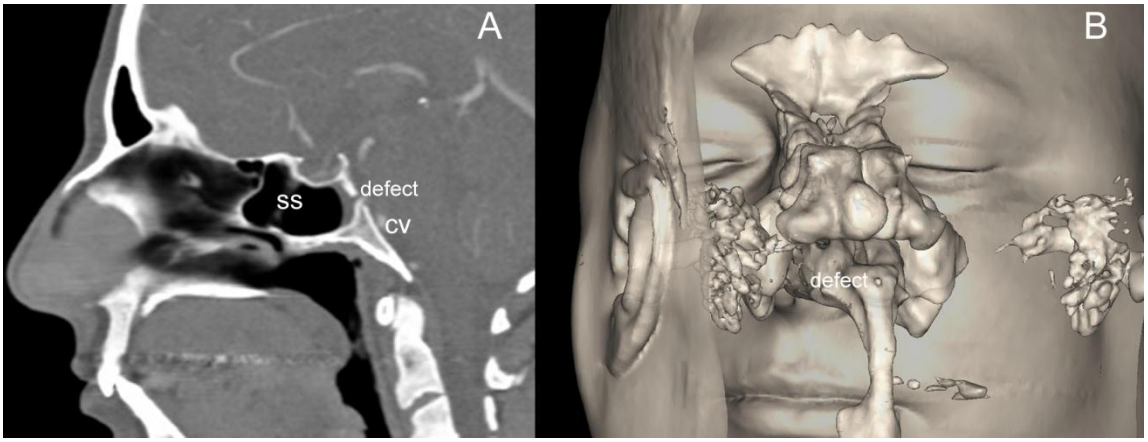

Figure 3: A: Sagittal view of a computer tomography exam showing the sphenoid sinus (ss), the clival bone (cv), which is a part of the occipital bone, and a defect at its wall. B: 3D reconstruction showing the defect at the clival bone.

Figure 4:

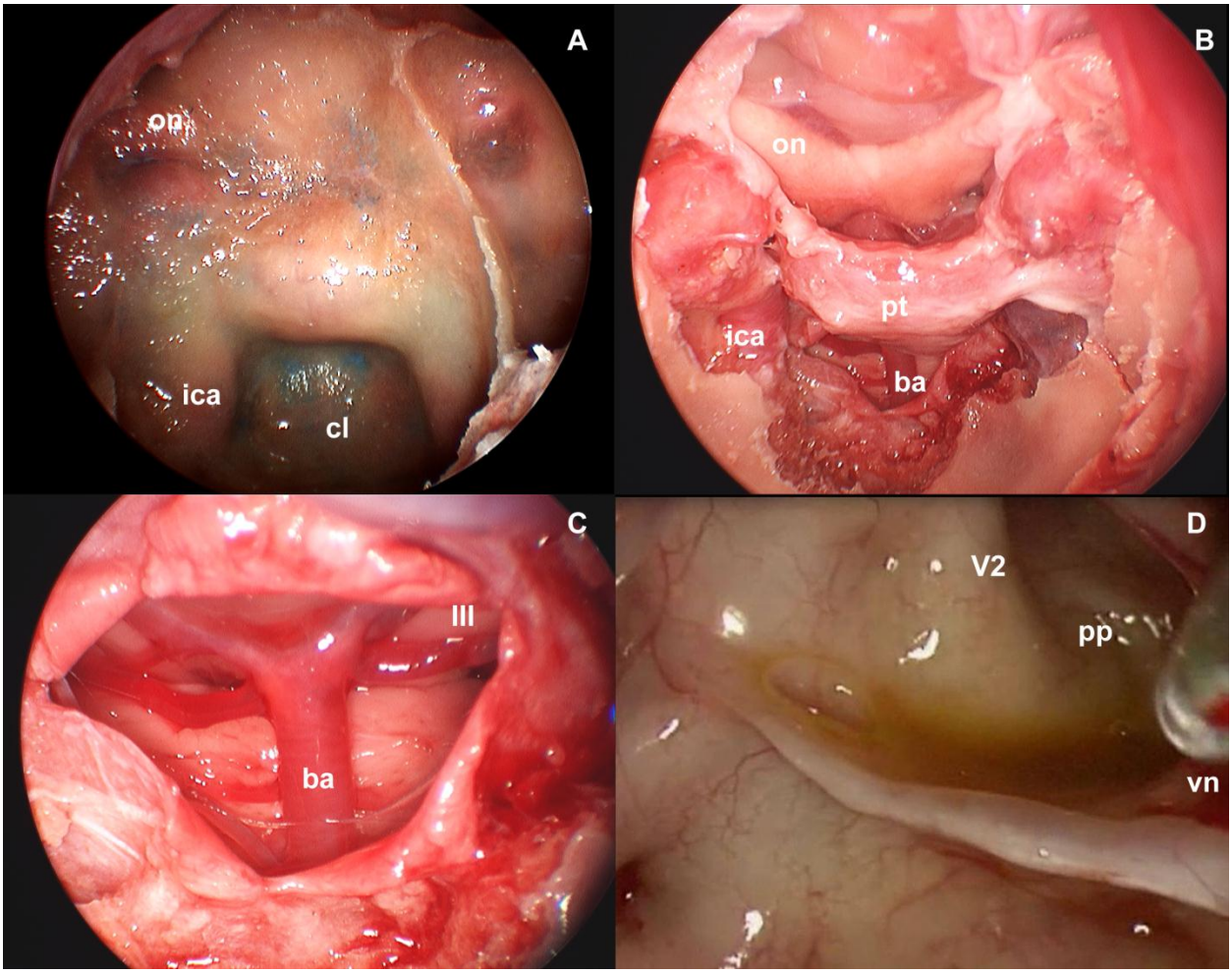

Figure 4: Endoscopic surgical anatomy of the sphenoid sinus and its relationships. A: 0-degree endoscopic view of the sphenoid sinus showing the cavity with its inter-sinus septum (which is generaly not at the mid-line) with some projections of important structures, such as the internal carotid artery (ica), clivus (cl) and optic nerve (on). B: 45-degree endoscopic view of important structures beyond the sphenoid sinus, just as the internal carotid artery (ica), basilar artery (ba), pituitary gland (pt), optic nerve (on) and its chiasma. C: 0-degree endoscopic view of the posterior fossa with the basilar artery (ba), its branches, superior cerebellar artery and posterior cerebral artery and between these, the III cranial nerve. D: 45-degree

endoscopic view of the lateral recess of the sphenoid sinus, which can be present in some patients. This is also called the pterygoid pneumatization (pp) of the sphenoid sinus and can be a site of some lesions such as CSF leaks, meningoceles, and tumors. Note the projections of the V2 and Vidian nerves (vn).

Figure 5:

Figure 5: Instruments. A: high definition 3-chips camera, which needs to be used with high quality endoscopes (0-degree and angulated); B: shaver and long hand piece drills; C: image guidance system, which is not essential to all cases, but it may help specially in fibrous-osseous lesions.

Figure 6:

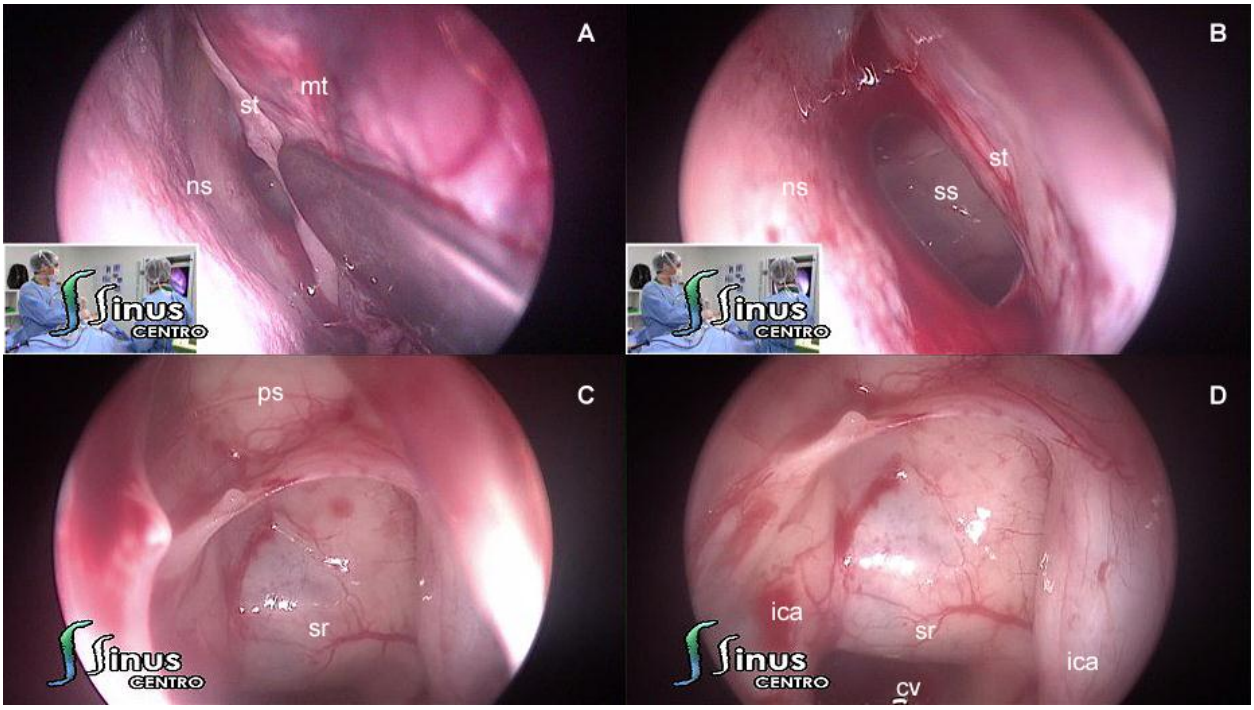

Figure 6: Balloon sinuplasty at the left side sphenoid sinus. A: the location of the spheno-ethmoid recess, which is a space between the nasal septum (ns) and the superior turbinate (st). B: Sphenoid sinus ostium after dilation, showing the sphenoid sinus (ss). C: 0-degree endoscopic view of the sphenoid sinus after the dilation. Note the sellar region (sr). D: 0-degree endoscopic view of the sphenoid sinus showing more interesting anatomy, such as the internal carotid artery (ica), clivus (cv) and sellar region (sr). This was done with a 4mm endoscope to show the possibility after the dilation with a 5mm balloon of the sphenoid sinus natural ostium.

Figure 7:

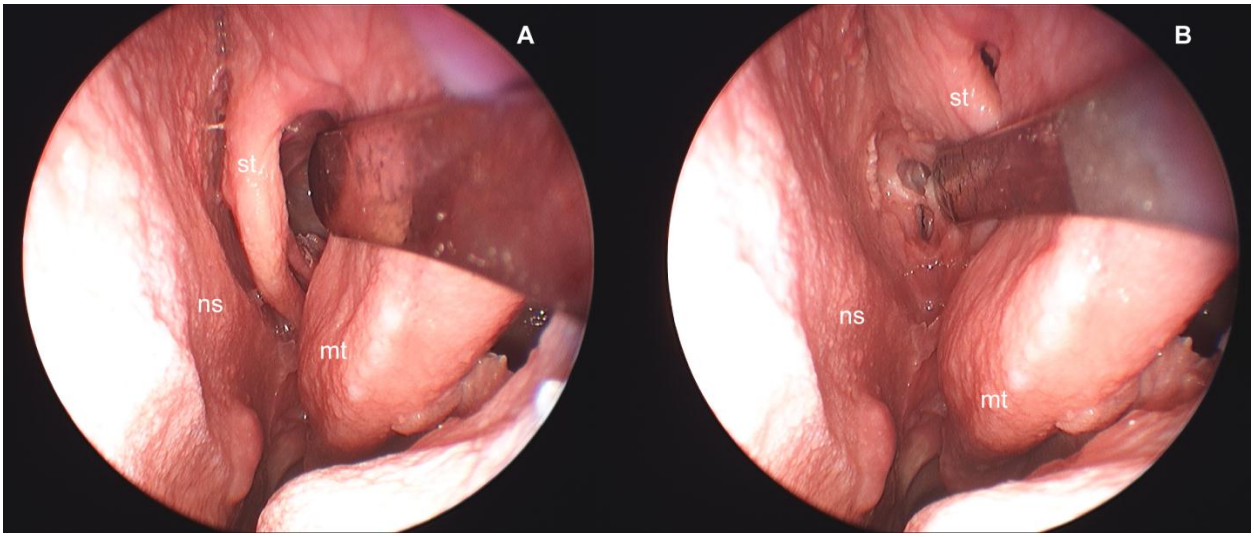

Figure 7: 0-degree endoscopic view of the left side spheno-ethmoid recess during a trans-nasal direct approach. A: this approach is direct so the surgeon finds the sphenoid sinus natural ostium region which is between the superior turbinate (st) and nasal septum (ns). Note the middle turbinate (mt). B: 0-degree endoscopic view of the location of the sphenoid sinus natural ostium.

Figure 8:

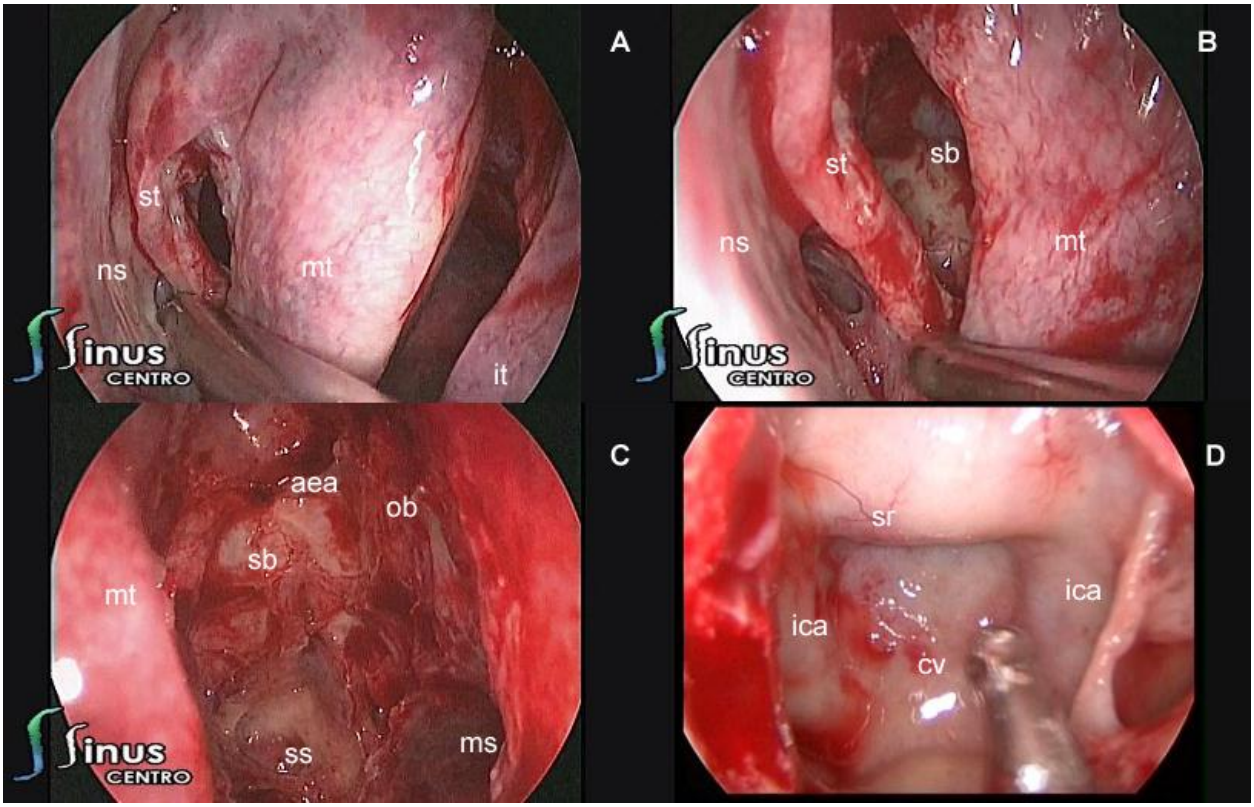

Figure 8: Endoscopic view of the left side trans-ethmoidal approach to the sphenoid sinus. A: 0-degree endoscopic view of the spheno-ethmoid recess. B: Note the superior turbinate (st) and the skull base (sb) after complete ethmoidectomy. C: 0-degree endoscopic view of the middle meatus showing the limits of a complete ethmoidectomy; lateral: orbit (ob); medial: middle turbinate (mt); superior: skull base (sb) with the anterior ethmoidal artery (aea). Note the maxillary sinus (ms) and the sphenoid sinus (ss). D: 0-degree endoscopic view inside the sphenoid sinus showing the projections of the internal carotid artery (ica), clivus (cv) and sellar region (sr).

Figure 9:

Figure 9: Image guidance screen shot showing a fibrous-osseous lesion at the sphenoid bone and sinus. The endoscopic removal can be achieved using some different approaches.

Figure 10:

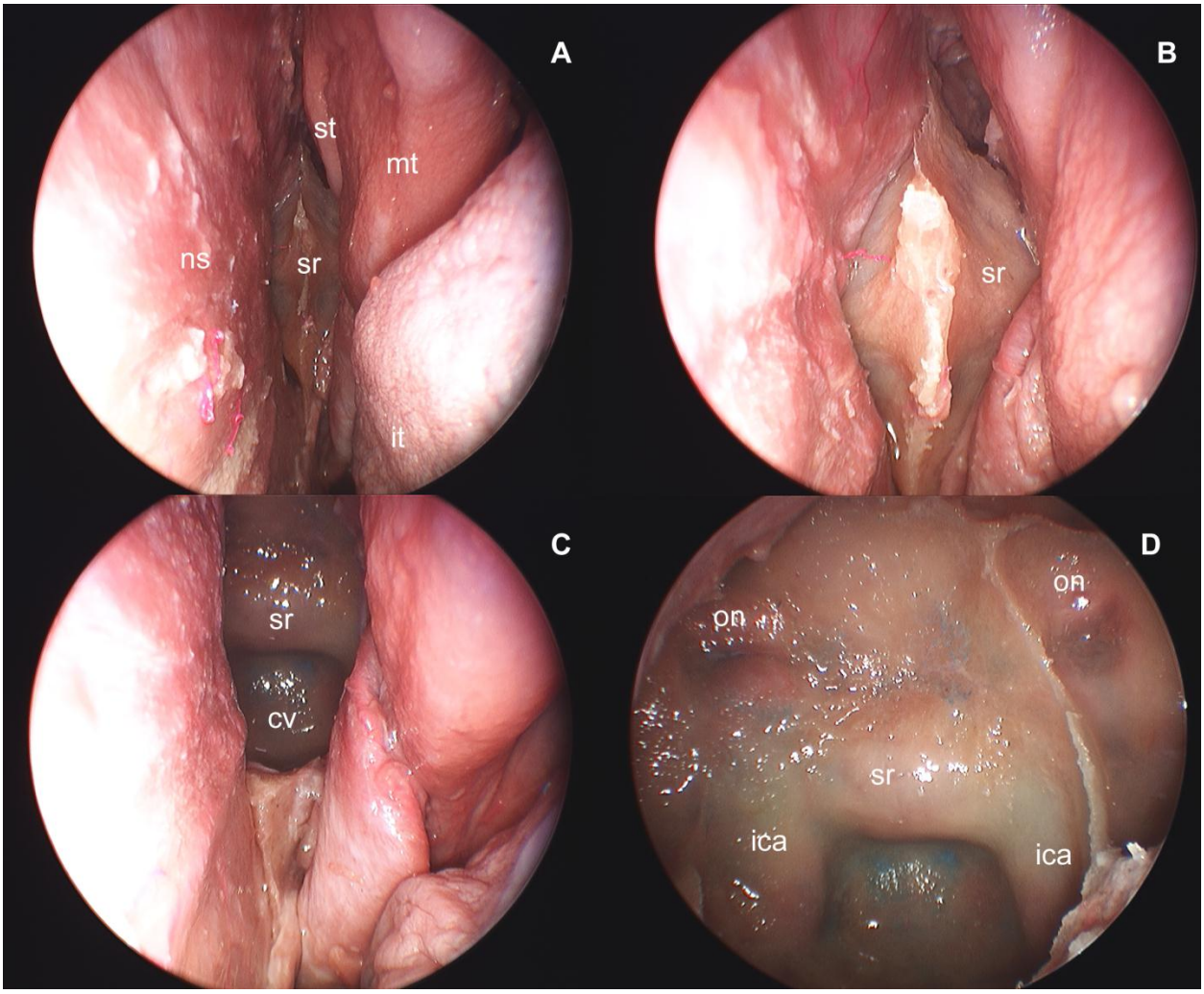

Figure 10: Endoscopic view of a trans-septal, trans-nasal approach. This can be an alternative interesting approach to the sphenoid sinus. A: Note the spheoid rostrum (sr), the nasal septal mucosa (ns) at one side (right side) and a window at the left side, which was opened to create a nasal septal pediculated flap, for the skull base reconstruction. B: 0-degree endoscopic close-up view of the sphenoid rostrum (sr). C: Openning of the sphenoid rostrum and visualization with a 0-degree endoscope of the sphenoid sinus and the projections of the sellar region and the clivus. D: Inside the

sphenoid sinus with the projection of the sellar region (sr), internal carotid artery (ica), optic nerve (on), among other important structures.