

Isolated sphenoid sinus pathologies: a series of 40 cases*

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Background/aim: Isolated sphenoid sinus-derived lesions are rare and generally present with unclear symptoms. We are sharing our experience to be mindful of such lesions in differential diagnosis and to help accomplish successful treatment while avoiding revisions and complications.

Materials and methods: Data from patients who underwent isolated sphenoid sinus surgeries (ISSs) were retrospectively extracted from the period of January 2005 to August 2015. Demographic data, chief complaints and presenting symptoms, imaging findings, surgical management, and results were evaluated.

Results: There were 40 patients who underwent ISS. These patients had different pathologies. The chief complaint was nonspecific headache, except for cerebrospinal fluid leak patients who presented with serous rhinorrhea.

Conclusion: It is critical to investigate suspicious symptoms with clinical findings and imaging techniques to avoid late diagnoses of isolated sphenoid pathologies. The transnasal approach is more minimally invasive and tissue-sparing. In our experience, we have noted that excising the inferior one-third of the superior turbinate decreases revisions. On the other hand, results show that the presence of concomitant pathology and invasive fungal disease increases the risk of revision surgery and complications.

Key words: Sphenoid sinus, endoscopic surgical procedure, cerebrospinal fluid rhinorrhea

1. Introduction

Sphenoid sinus-derived lesions constitute 1% to 2% of paranasal pathologies having nonspecific symptoms (1). The sphenoid sinus is a sealed location at the center of the cranium and close to vital structures. In spite of this, pathologies present with vague symptoms. It is also not easily evaluated by otorhinolaryngology (ORL) examination. For these reasons, and because of the rarity of the pathologies, diagnoses are delayed (2). Generally, a diagnosis is made when there is suspicion from clinical findings and following imaging studies. However, in recent years, detection is more frequent because of the increased use of radiological imaging.

The sphenoid is an area surrounded by important structures: superiorly the pituitary gland, middle cranial fossa, and optic nerve are located; the cavernous sinus is positioned laterally, which involves the carotid artery, and within it cranial nerves 3, 4, and 6 and two branches of 5. Anteriorly the pterygoid canal and nasopharynx are seen, and posteriorly the cranial fossa (3,4).

With isolated sphenoid pathologies, the most common symptom is headache, followed by nasal obstruction, postnasal drip, visual problems, cranial nerve deficits, and recurrent meningitis (1–4). In contrast to other sphenoid pathologies, cerebrospinal fluid (CSF) leak patients almost always present with unilateral serous rhinorrhea and rarely with recurrent meningitis attack. The sphenoid sinus, along with the ethmoid roof, is also the most common location for spontaneous CSF leak (5).

In this paper, we have analyzed patients who underwent isolated sphenoid surgery in our department with the aim of earlier diagnosis, successful treatment, and avoiding revisions and complications.

2. Materials and methods

Data on 40 patients who underwent isolated sphenoid surgery in the Gazi University ORL Department from January 2005 to August 2015 were extracted from the surgical archive charts. The medical records, including clinical and surgical data and imaging findings, were

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evaluated. Pathologies derived only from the sphenoid were included and any involvement of other sinuses was excluded from the study.

First, all patients underwent ORL-ear, nose, and throat examination involving flexible nasopharyngoscopy. For all patients the diagnosis was verified with paranasal CT with and without contrast in the 2500–3000 rad bone window. Patient complaints were resistance to 2-week antibiotherapy (levofloxacin at 500 mg/day) and 6-week nasal steroid and nasal lavage combination (management applied to patients except those with CSF leak). Preoperatively because of single-side (left or right) lesions (which is more predictive of malignancy) patients were evaluated with MRI. Patients with a suspicion of CSF leak underwent a beta 2 transferrin confirmation under meningitis prophylaxis. Subsequently, CSF flow MRI was combined with CT.

Depending on the location of radiological images, we selected transnasal or transthemoid endoscopic approaches to sphenoidotomy.

Follow-up information was obtained by calling the patients. The postoperative pathology specified average follow-up duration of 35 months for fungal disease, 37.5 months for mucocele, 24.1 months for polypoid-retention cyst lesions, 30.1 months for CSF leak, 60.5 months for fibrous dysplasia, 29 months for hemangiopericytoma, 126 months for renal cell carcinoma, and 16 months for hemangioma.

3. Results

As we show in the summary of the demographic and clinical data of isolated sphenoid pathologies in the Table, 18 (45%) of the 40 cases were inflammatory disease, which consisted of 7 (17.5%) cases of fungal disease, 6 (15%) of mucocele, and 5 (12.5%) of polypoid-retention cyst lesions. The remaining 22 cases included 10 (25%) of CSF leak, 8 (20%) of fibrous dysplasia, 3 (7.5%) of malignancy, and 1 (2.5%) of hemangioma lesion.

The average ages for patients with the different pathologies were 55.4 years for fungal disease, 50.3 years for mucocele, 28.4 years for polypoid-retention cyst lesions, 46.5 years for CSF leak, and 33.5 years for fibrous dysplasia. Additionally, the hemangioma patient was 27 years old, and the patients with hemangiopericytoma, plasmacytoma, and renal cell carcinoma were 72, 61, and 51 years old, respectively.

While all of the CSF leak patients presented with serous rhinorrhea, the chief symptom of the remaining patients was nonspecific headache in 23 patients (76.6%), followed by nasal obstruction and postnasal drip in 11 patients (36.6%), epistaxis in 2 patients (6.6%), and diplopia-transient visual loss in 1 patient (3.3%). One patient presented with general poor health and an isolated

sphenoid lesion on CT. Added to these were three patients with isolated sphenoid lesion found incidentally.

Though a transnasal approach was performed on 32 patients (80%), a transthemoid approach was performed on 8 patients (20%). There was one complication (2.5%) postoperatively and 5 patients (12.5%) underwent revision surgery. For fungus disease cases, the needs for revision due to complications were in the invasive fungal disease patient and in a patient having a concomitant disease (fibrous dysplasia). From the CSF leak revision patient, we have learned that if the defective area is not identified, there is a risk of revision. Lastly, for mucocele the revision was due to a foreign body reaction. Therefore, to decrease revisions, a preoperative evaluation must also focus on concomitant diseases and other pathologies.

Nasal endoscopy with flexible nasopharyngoscopy did not reveal sufficient information (except edema and discharge from the ostium in some cases) if the lesion did not proceed outside the sphenoid sinus. Additionally, the CSF leak locations also could not be accurately determined with nasopharyngoscopy because of the difficulties of the approach to the sinus and differentiation of rhinorrhea from other causes.

3.1. Fungal sphenoid infection

Seven patients who underwent isolated sphenoid sinus surgeries (ISSs) were determined as having fungal infection; 5 were women, 2 were men; 4 were settled on the left side and 3 were settled on the right side. They were encountered in the age range of 22–80 years and the average age was 55.4 years. The main symptoms were retroorbital and retrofrontal headache, nasal obstruction, and postnasal drip. In addition to these, one patient was diagnosed with an imaging study following a general poor health examination. There was no comorbid disease or use of drugs affecting the immune system. While six patients had a fungus ball, one was diagnosed as having invasive fungal disease with definitive pathology. During the surgeries, necrotic crusts were seen for the invasive case and carotid dehiscence was seen for one of the fungus ball patients, who was 80 years old. We performed 5 transnasal approaches, as shown in Figure 1A, and two transthemoid approaches because of lateral settling and need of exposure. Except for the patient with dehiscence, we irrigated the sinuses to wash out all fungal debris, as seen in Figures 1B and 1C. Two of the patients underwent revision surgery. The first patient had invasive fungal disease, who was referred to us with headache 6 months after the first surgery. We saw one complication (pyocele) because of bacterial superinfection and this was drained. A second revision was performed for a fungus ball patient, who underwent surgery 3 months after the first surgery. A biopsy was taken and showed fibrous dysplasia. Therefore, the acute diagnosis before the first surgery is important for

Table. Demographic and clinical data of isolated sphenoid pathologies.

Pathology	Number of patients	Average age / range of age	Female / male ratio	Location: left / right	Surgical approach: transnasal / transethmoid	Pathology	Revision surgeries
<i>CSF leak</i>	10	46.5 / 39-69	6 / 4	4 / 5 1 bilateral	7 / 3	B2 transferrin +	1
<i>Fungal disease</i>	7	55.4 / 22-80	5 / 2	4 / 3	5 / 2	1 invasive fungal disease 6 fungus balls (1 with concomitant fibrous dysplasia)	2
<i>Mucocele</i>	6	50.3 / 17-60	3 / 3	4 / 2	6 / 0	6 chronic inflammation (1 with concomitant foreign body reaction)	1
<i>Polyp-retention lesion</i>	5	28.4 / 17-60	3 / 2	3 / 2	5 / 0	3 retention cysts 1 isolated polyp 1 sphenoidal polyp	0
<i>Fibrous dysplasia</i>	8	33.5 / 9-57	5 / 3	7 / 1	6 / 2	Fibrous dysplasia	0
<i>Hemangiopericytoma</i>	1	72	1 / 0	1 / 0	1 / 0	Hemangiopericytoma, WHO grade 3	0
<i>Plasmacytoma</i>	1	61	1 / 0	1 / 0	1 / 0	Extramedullary plasmacytoma	0
<i>Renal clear cell</i>	1	51	0 / 1	0 / 1	0 / 1	Renal clear cell	0
<i>Hemangioma</i>	1	27	1 / 0	Bilateral	1 / 0	Hemangioma	1



Figure 1. Endoscopic views of transnasal fungus case: A) fungus lesion in sphenoid; B) fungus medial to the middle turbinate after sphenoid sinus irrigation; c) fungus debris; D) inferior one-third excised superior turbinate with widened sphenoid ostium (white star = fungus; black arrow = septum; orange arrow = middle turbinate; white arrow = inferior one-third excised superior turbinate).

avoiding revision. All of the fungal diseases were confirmed by histopathology evaluation and, except for one, all of them were cases of fungus ball. The postoperative average duration was 35 months and no recurrence was seen.

3.2. Mucocele

We observed mucocele in 6 of our patients: the average age was 50.3 years and the age range was 17 to 60 years old; male and female cases were equal in number; and 4 were left-sided and 2 were right-sided. They presented dominantly with retroorbital headache, except for one patient who consulted after a neurosurgical operation. Flexible nasopharyngoscopic examination did not add any information except mucosal edema. While we saw a lesion with minimal cortical erosions on CT, MRI revealed a cyst lesion full of fluid. All of the pathologies were treated with a transnasal endoscopic approach. One of our patient's definitive pathologies showed a foreign body reaction that needed revision after the first surgery. The postoperative average duration was 37.5 months and no cases of recurrence occurred.

3.3. Polypoid-retention cyst lesions

We encountered chronic inflammation with isolated sphenoid sinus polypoid and/or retention lesions in 5 patients; the age range was 17–60 years, the average age was 28.4 years, and three of the patients were women. In all of the patients, the presenting symptom was nonlocalized headache together with postnasal drip and nasal obstruction of variable severity. Except for sphenochanal polypoid lesion, flexible nasopharyngoscopy did not reveal any abnormality. CT showed increased soft tissue without distinguishing the lesion but MRI distinguished cyst and polypoid lesions. Three of the pathologies were on the left side and two were on the right side; three were retention cysts, one was an isolated sphenoid polyp, and one was a sphenochanal polyp. All of the lesions were treated with a transnasal approach and no revision was needed. The postoperative average duration was 24.1 months and no relapse occurred.

3.4. CSF leak

There were 10 CSF leak patients who underwent ISS: the age range was 39 to 69 years old and the average age was 46.5 years old; six patients were women and four were men. We estimated the average body mass index to be 34.1 at the time of diagnosis and patients had concomitant diseases that included one case of coronary artery disease, two with diabetes, two with hypertension, and two with Behçet disease. The percentages are shown in Figure 2. Five patients underwent right-sided surgery, four of the patients underwent left-sided surgery, and one was bilateral. All of the patients presented with symptoms of serous rhinorrhea and all were confirmed with beta 2 transferrin. Two of the patients consulted after a neurosurgical operation (iatrogenic); one was a revision surgery consulting from an external ORL department and the remaining were primary spontaneous CSF leaks. CT and CSF flow MRI synergism determined the sphenoid location for 90% of cases. Intrathecal fluorescein was routinely used preoperatively and three of the defects were determined to be lateral and 6 were posterior. While the transthemoid approach was used for the lateral defects (3 patients), the transnasal approach was used for the other cases (7 patients). Encephalocele was seen for one of the lateral defects, and protruding mucosa was seen for one of the lateral and one of the posterior defects. The defective area was refreshed, and to repair the defect we used the middle concha or pedicled flap in 5 patients, septum cartilage in 4 patients, fascia lata in 4 patients, adipose tissue in 4 patients, and fibrin glue in 4 patients. As this implies, we have used different combined techniques in seven of the patients, depending on the need preoperatively. In one patient the defective area could not be detected and 1 year after the first surgery a revision was performed. At the revision, the sphenoid mucosa was fully excised and after laying the fascia the sphenoid was covered with adipose tissue and fibrin was applied, with no relapse occurring. Postoperatively, lumbar drainage was performed in all

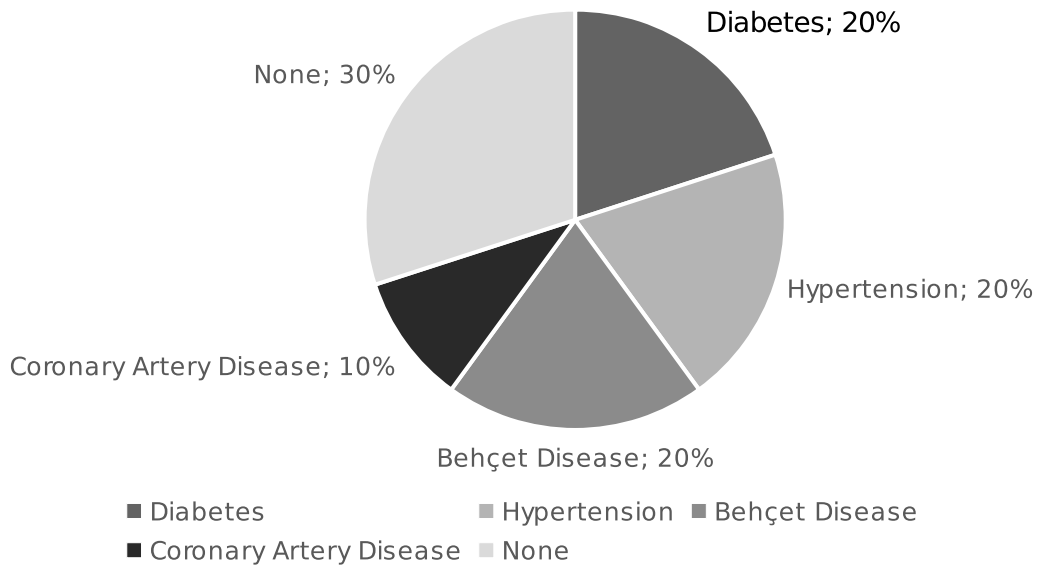


Figure 2. Concomitant diseases with CSF leak.

patients. The postoperative average follow-up duration was 30.1 months and no other relapse occurred. The success rate was 90% in the first surgery and 96% in the second surgery. We must note that the iatrogenic defects were larger than the spontaneous ones.

3.5. Fibrous dysplasia

ISS was performed on 8 patients diagnosed with fibrous dysplasia: the age range was 9 to 57 years old and the average age was 33.5 years old; 5 patients were women and 3 were men. All of the pathologies were dominantly located on the left side, 6 patients complained of headache, 1 of them presented with transient visual loss, and 1 was a nasopharynx cancer patient in remission. Fibrous dysplasia presented a ground-glass pattern on CT and typically showed a heterogeneous pattern hypointense at T1 and intermediate intense at T2. A transnasal approach was performed for 6 patients and if possible the lesion was excised. For differential diagnosis, a biopsy was taken and fibrous dysplasia was confirmed by pathology. Steroid therapy was applied for the patient with visual loss and the patient recovered. The postoperative average follow-up duration was 60.5 months and because of no further complaints no other surgeries were performed.

3.6. Malignancies

Three of the patients for whom ISS was performed were diagnosed with malignancies, which were hemangiopericytoma, extramedullary plasmacytoma, and renal clear cell carcinoma metastasis.

3.6.1. Hemangiopericytoma

Hemangiopericytoma was detected in one 72-year-old woman who presented with recurrent epistaxis. Flexible nasopharyngoscopy and imaging studies showed a

vascularized lesion derived from the sphenoid and expanded to the ethmoid recess. Because of the vascular character, angiography was performed and showed an atypical heterogeneous vascular mass feeding from the ophthalmic artery (branch of the internal jugular artery) and the internal maxillary artery (branch of the external jugular artery). Embolization was performed preoperatively to the feeding branches and the lesion was excised totally through a transnasal approach. Definitive pathology revealed WHO grade 3 hemangiopericytoma and the follow-up duration was 30 months with no sign of recurrence.

3.6.2. Plasmacytoma

A 61-year-old woman applied to us with a headache. Imaging studies revealed a mass starting from the sphenoid and continuing to the clivus. After receiving the pathology results, which noted an extramedullary plasmacytoma, the patient consulted with medical oncology and received chemotherapy. It has been 58 months since the therapy and the patient is in remission.

3.6.3. Renal clear cell carcinoma

A 51-year-old man who had undergone nephrectomy 3 years earlier consulted with a sphenoid mass expanding to the septum posteriorly, which was detected incidentally during control imaging studies. After biopsy revealed renal clear cell carcinoma, the lesion was excised totally, but after 1 year it recurred with epistaxis and he was given chemotherapy.

3.7. Hemangioma

A 27-year-old woman applied with epistaxis and headache. She underwent transnasal endoscopic surgery on the right side and 3 years later underwent left-side surgery.

The pathology revealed a hemangioma and at 17 months of follow-up the patient's complaints of headaches were highly decreased while epistaxis was eliminated.

4. Discussion

The sphenoid sinus can be affected by the pathologies seen in other sinuses. These include inflammatory diseases, neoplasms, osteofibrotic diseases, and vascular pathologies. Isolated sphenoid sinus pathologies are rare and account for 2%–3% of the overall paranasal pathologies (2). In spite of nonspecified symptoms, the widespread use of CT and MRI has allowed increased awareness and decreased missed diagnoses.

Isolated sphenoid pathologies, regardless of character and location, present with a nonspecific headache or resemble benign situations such as septum deviation with nasal obstruction symptoms or postnasal drip. While the major part of the patients present with headache, the results of affected neighboring structures, such as diplopia, meningitis, and visual loss, can be the presenting symptoms (1–4).

Our experience has shown that if the lesion is limited to the sphenoid and does not extend to the nasal cavity or nasopharynx, flexible nasopharyngoscopy gives limited information. Endoscopy reveals 30% to 60% normal view of important pathologies (2–4). If the nasal cavity or nasopharynx is affected, as we see for hemangiopericytoma, sphenochanal polyps, and extramedullary plasmacytoma, flexible nasopharyngoscopy shows the mass, epistaxis, discharge, and mucosal edema. In our view, the literature information showing that preoperative endoscopic examination gives 60% findings is a result of rigid endoscopic examination after decongesting and lateralization of the middle concha. It is apparent that obtaining information on the sphenoid through flexible nasopharyngoscopy is greatly limited. Therefore, we can consider that if imaging studies reveal any suspicion of isolated sphenoid lesion, rigid endoscopic examination can be performed routinely under local anesthesia after decongestion and lateralization of the middle concha. Additionally, if the mass is not a vascular lesion, a concomitant biopsy can be obtained.

With the growing use of CT for all types of sinus disease, there has been an increase in the detection of isolated sphenoid sinus lesions. In combination with MRI, there has been an advancement in providing information on lesions. Imaging gives locational (medial or lateral) and characteristic (cystic, solid, or invasive) information. Additionally, it reveals information on the presence of bone defects, encephalocele, and Onodi cells. Furthermore, proximity to the optic nerve, carotid artery, and cerebral structures can be seen (6). This preoperative information is important for avoiding complications.

There are alternative surgical approaches to the sphenoid: transnasal, transetmoid, and transseptal. First, we do not use the transseptal approach, mainly since this is an option for neurosurgeons because of less experience in endoscopy in their field. However, it is more destructive than other methods, so multidisciplinary approaches are feasible. In our surgical practice we prefer to use a transnasal approach if the lesion is medially positioned. It is minimally invasive, respecting the natural anatomy without disadvantage. As seen in Figure 1, excision of one-third of the inferior part of the superior concha gives a better visualization and postoperatively avoids synechiae, which decreases the possibility of revision surgery. However, if the pathology is settled laterally or if there is a need for wide exposure, transnasal and transetmoid approaches are combined.

Fungus balls are most commonly seen in the maxillary sinus and secondly in the sphenoid sinus. The main treatment is obtaining appropriate ventilation and drainage of the sinus with surgery (7). According to the literature, fungus disease is seen at over 50 years old and mostly in women (8). In our experience, two of the fungus patients required revision surgery; one had invasive fungal disease and the other had concomitant fibrous dysplasia at the same location. Accordingly, we can conclude that invasive fungal disease and concomitant pathologies are risk factors for revision surgery. To decrease the mortality and morbidity rate with invasive fungal disease, there is a high suspicion for diabetic and immunocompromised patients, where quickly planning surgery and aggressive medical treatment are essential points. We have diagnosed incidentally and not seen visual changes or other symptoms, as stated in the literature (7,9). In the operation, thick, viscous, and black-brown crust was seen in the invasive fungal case.

Fungus balls reveal isointense or decreased signal intensity at T1 with more decreased signal intensity and sometimes surrounded by hyperdensity because of hyperplastic mucosa at T2 (6). With gadolinium application, the signal will increase in the surrounding mucosa but not in a fungus ball (7). CT shows thickening of the mucosa, total or partial heterogeneous opacification and sclerosis, and thickening and osteitis in the surrounding bone. Fungal disease must be treated even if it is asymptomatic because serious complications (for example, meningitis or cerebellar empyema) can occur through bone erosions and defects (7–9).

Mucoceleles are seen in the sphenoid in 2% of cases and, as mentioned before, the location makes it important because of the proximity to vital structures. Again, revision of the mucocele revealed a concomitant pathology, with foreign body reaction.

In accordance with the literature, we attribute the visual loss to be due to optic neuritis in the fibrous dysplasia patient and this was resolved with steroid therapy. In clinical practice, if the case is not symptomatic and there is no suspicion of other pathologies, we follow up after these lesions.

CSF flow MRI detects the defective area of leakage with 90% achievement (6). We do also use fluorescein intrathecally, as stated in approximately 30 studies. While the application dose varies, we dilute 1 mL of 10% fluorescein with 10 mL of CSF and have not encountered any complications. In contrast to its widespread use, two studies mentioned complications such as generalized seizure and ectopic ventricular beats, but this was considered to be a dose-dependent result. Therefore, it can be considered negligible (5,6,10). As shown, and concordant with the literature, most of the surgeries performed for primary nontraumatic spontaneous CSF leaks resulted in a good success rate (5).

We have used the fascia lata, cartilage, middle concha bone and mucosa, abdominal fat, and fibrin glue for repairs. Different combinations were used in 7 patients to repair the CSF leak, while in the remaining patients we used only the middle concha, which is a strong option. Selecting the combination depended on the pressure of the CSF leak. If the pressure was intense, use of combination materials increased. Obesity, middle age, and increased intracranial pressure can negatively affect the success (10).

The sphenoid is an extremely rare location for malignancy and renal clear cell metastasis is the most common malignancy seen, as in our one case. Additionally, lung, breast, seminoma, gastrointestinal, thyroid, malignant melanoma, and prostate cancer metastasis are seen at this location (6,11–15).

Extramedullary plasmacytoma constitutes 3% of plasmacytomas and to date there have been 20 cases, with

our case in a sphenoid location. Medical oncology must follow these patients long term for recurrence, metastasis, and transformation to multiple myeloma (11).

While head and neck hemangiopericytomas account for 15% of the overall cases, their proportion decreases to 1% in the paranasal sinus. Pathological attitudes of increased cellularity and mitotic activity, necrosis, and hemorrhage are risk factors for recurrence and metastasis (14).

Renal clear cell cancer can occur with metastasis in 30% of cases after nephrectomy. Most often metastasis is seen in the first 5 years after surgery. In contrast to this, however, there are reported cases of metastasis 17 years after nephrectomy; therefore, long term follow-up is necessary for renal clear cell cancer, as well (15).

In conclusion, isolated sphenoid pathologies are rare. Therefore, preoperatively knowing and being reminded of the possible isolated sphenoid pathologies that can occur is important. In preoperative evaluation, endoscopic examination under local anesthesia and the performing of imaging studies (MRI supplementing CT) are critical points in determining pathologies and approaching the operation safely.

The transnasal approach is preferred because it is minimally invasive and respects the natural tissue. Adding to transnasal sphenoidotomy, we have found that excision of the inferior one-third of the superior concha gives increased exposure and decreased synechiae with revision. If required, a transthemoid approach is combined to reach lateral CSF leak defects and lateral settled pathologies.

In ISS, concomitant pathologies and invasive fungal disease increase the risk for revision. However, complications, revisions, and morbidities can be avoided when there is high suspicion by good preoperative evaluation for concomitant pathologies and with early surgery.

References

1. Marcolini TR, Safraider MC, Socher JA, Lucena GO. Differential diagnosis and treatment of isolated pathologies of the sphenoid sinus: retrospective study of 46 cases. *Int Arch Otorhinolaryngol* 2015; 19: 124-129.
2. Sieskiewicz A, Lyson T, Olszewska E, Chlabicz M, Buonamassa S, Rogowski M. Isolated sphenoid sinus pathologies--the problem of delayed diagnosis. *Med Sci Monit* 2011; 17: CR180-184.
3. Manjula BV, Nair AB, Balasubramanyam AM, Tandon S, Nayar RC. Isolated sphenoid sinus disease - a retrospective analysis. *Indian J Otolaryngol Head Neck Surg* 2010; 62: 69-74.
4. Socher JA, Cassano M, Filho CA, Cassano P, Felippu A. Diagnosis and treatment of isolated sphenoid sinus disease: a review of 109 cases. *Acta Otolaryngol* 2008; 128: 1004-1010.
5. Psaltis AJ, Schlosser RJ, Banks CA, Yawn J, Soler ZM. A systematic review of the endoscopic repair of cerebrospinal fluid leaks. *Otolaryngol Head Neck Surg* 2012; 147: 196-203.
6. Burke MC, Taheri R, Bhojwani R, Singh A. A practical approach to the imaging interpretation of sphenoid sinus pathology. *Curr Probl Diagn Radiol* 2015; 44: 360-370.
7. Karkas A, Rtail R, Reyt E, Timi N, Righini CA. Sphenoid sinus fungus ball. *Eur Arch Otorhinolaryngol* 2013; 270: 893-898.
8. Thery A, Espitalier F, Cassagnau E, Durand N, Malard O. Clinical features and outcome of sphenoid sinus aspergillosis: a retrospective series of 15 cases. *Eur Ann Otorhinolaryngol Head Neck Dis* 2012; 129: 179-184.

9. Bansal S, Grover G, Grover M, Gupta AK. Isolated sphenoid mucormycosis presenting as visual impairment: changing trends? *Am J Otolaryngol* 2010; 31: 64-66.
10. Melo NA, Borges BB, Magliarelli Filho PA, Godoy MD, Pereira LV, de Rezende Pinna F, Voegels RL. Lateral sphenoid sinus recess cerebrospinal fluid leak: a case series. *Eur Arch Otorhinolaryngol* 2014; 271: 2587-2594.
11. Ozdemir S, Tarkan O, Tuncer U, Surmelioglu O, Dogrusoz M, Ergin M. A case of extramedullary plasmacytoma in the sphenoid sinus with unilateral loss of vision. *J Craniomaxillofac Surg* 2013; 41: 140-143.
12. Tsukahara K, Nakamura K, Motohashi R, Endo M, Sato H. A case report of malignant melanoma of the sphenoid sinus. *Case Rep Otolaryngol* 2013; 2013: 613472.
13. Petersson F, Hui TS, Loke D, Putti TC. Metastasis of occult prostatic carcinoma to the sphenoid sinus: report of a rare case and a review of the literature. *Head Neck Pathol* 2012; 6: 258-263.
14. Shobha BV, Shivakumar BN, Reddy S, Dutta N. Sinonasal hemangiopericytoma: a rare case report with review of literature. *J Oral Maxillofac Pathol* 2015; 19: 107.
15. Terada T. Renal cell carcinoma metastatic to the nasal cavity. *Int J Clin Exp Pathol* 2012; 5: 588-591.