

A review of the revisions and complications management procedure in sinus surgery

Sara Khademi¹, Aida Kazemi², Reza Divanbeigi³, Mohamadreza Afzalzadeh⁴

¹Shiraz University of Medical Sciences, Shiraz, ²Clinical Research Development Unit, Shafa Hospital, Kerman University of Medical Sciences, Kerman, ³Islamic Azad University, Qeshm Medical Branch, Qeshm, ⁴Sinus and Surgical Endoscopic Research Center, Mashhad University of Medical Sciences, Mashhad, Iran

ABSTRACT

One of the most standard and least invasive surgical procedures that could be applied mostly for the treatment of inflammation of the paranasal sinuses is endonasal endoscopic sinus surgery. The main objective of this study is to assess the available strategies for avoiding, diagnosis and also dealing with various kinds of potential complications of sinus disorders as well as the symptoms which specify the need for revision endoscopic sinus surgery mainly for the treatment of chronic rhinosinusitis. Based on the objectives of this study, the studies were categorized within four main groups; sinus disorders, diagnosis, management, and treatment. In this regard, wide research has been done in various scientific databases of PubMed, EMBASE, Europe PMC, HubMed, MEDLINE, Scientific Information Database (SID) and Google Scholar. From a total of 315 founded records, the final number of 91 records were reviewed. The rate of complication associated with endoscopic sinus surgery is not much and the improvement of surgical technology and experience could decrease its side effects. Performing immediate extensive surgery among patients who have inflammatory sinonasal disease could modify long-term consequences. Applying endoscopic sinus surgery could yield the most appropriate positive outcomes. For achieving the most suitable surgical consequences, the surgeon should be adequately qualified in diagnosis and facing with any possible complications during the operation in addition to cases with complex and revision problems.

Keywords: Diagnosis, endoscopic sinus surgery, functional endoscopic sinus surgery, management

Introduction

Chronic inflammation of the sinuses and nasal cavity which is estimated to be presented in more than 15% of adults and known as chronic rhinosinusitis (CRS) is one of the main causes of feeling pain in the areas of face, sinuses, back of the eyes, ear, or forehead.^[1] The treatment procedures of these kinds of chronic inflammations are various which mainly include multidrug therapy (MDT) with steroid hormones of corticosteroids, antibacterial agents, phenylpropanolamine (PPA), mucoactive

agent and nasal saline irrigation. In the situation when these kinds of therapies are not effective, functional endoscopic sinus surgery (FESS) would be suggested for the improvement of the disease-related symptoms.^[2]

Moreover, one of the other most frequent surgical procedures which could be carried out by rhinologists is functional endoscopic sinus surgery (FESS). In the world a lot of cases go under FESS operations mainly for persistent symptomatic inflammation of the sinus mucosa every year.^[3] Through enhancing the training, experience, convenience, and skills of applying FESS treatment, the rate of nearly all potential complications after application of this procedure could be decreased. With the increase of surgeon experience, the rate of major and minor surgical complications would decrease to lower than 1% and 5% respectively.^[4,5] In spite

Address for correspondence: Dr. Mohamadreza Afzalzadeh, Sinus and Surgical Endoscopic Research Center, Mashhad University of Medical Sciences, Mashhad, Iran.
E-mail: Afzalzadehmr@mums.ac.ir

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the fact that, in about 80% of patients just a single FESS operation is needed, but the remained rate of patients requires to undergo revision surgery for achieving the most appropriate outcomes.^[6,7]

Moreover, the procedure of FESS is one of the most impressive therapies for patients who do not respond to medical therapy. On the other hand, as reported by some researchers, in more than 80% of cases the application of FESS could improve the life quality among patients.^[2,8] The advancement of technology and improvements in surgical training as well as further comprehension of the disease pathophysiology could enhance the consequences FESS. While the most frequent complications of applying FESS procedure have not been described appropriately,^[9] based on the results achieved from Abdullah *et al.*^[10] studies the major FESS complications are including orbital injuries, meningitis, the cerebrospinal fluid (CSF) leak and abnormal bleeding.^[10]

The main objective of this study is to apply the information achieved from all available databases for determining the rate of major complications which could be presented after initial and revision FESS. Moreover, it is trying to assess current strategies for avoiding, diagnosis and also dealing with various kinds of available complications in addition to indications for revision endoscopic sinus surgery. Additionally, in the present study, it is tried to review the most effective strategies for achieving the most appropriate outcomes and also reducing both major and minor complications of FESS.

Material and Method

Based on the objectives of this study, the studies were categorized within four main groups; sinus disorders, diagnosis, management and treatment. In this regard, wide research has been done in various scientific databases of PubMed, EMBASE, Europe PMC, HubMed, MEDLINE, Scientific Information Database (SID) and Google Scholar. The main keywords used in this research are such as Endoscopic sinus surgery, Functional endoscopic sinus surgery (FESS), Diagnosis, Prevention, Management, Treatment. A total number of 315 papers were found from the introduced databases that after screening and deleting records with similar and also less related content the final number of overviewed papers reached 91. The schematic diagram of the procedure of selecting applicable papers within the present study is demonstrated in [Figure 1] which is designed based on the PRISMA method.

Various aspects of endoscopic surgery of the paranasal sinuses

Due to the special aspect of endoscopic surgery of the paranasal sinuses administered for persistent inflammation of chronic rhinosinusitis (CRS), severe perceptual or technical standards could not be specified. The existence of these kinds of circumstances is mainly relying on the available knowledge gaps in addition to missing various nosological classification of chronic rhinosinusitis.^[11] On the other hand, because of the diversities among patients' anatomy and

also frequent mismatches among objective and subjective findings, the overall process of this surgical treatment could not be standardized well.^[12] As a result, a wide range of non-destructive therapeutic and surgical strategies could be developed. In this regard, based on the patients' opinion endoscopic endonasal surgery for chronic rhinosinusitis (CRS) situations could be beneficial. Moreover, the application of endoscopic surgery for the treatment of paranasal sinuses is an effective therapeutic procedure in comparison with diffuse nasal polyposis surgery.^[13]

However, the advantages of applying surgical procedures for removing the aimed inflammations in comparison with other conservative therapy procedures such as intensive medical therapy is still unclear.^[14] Moreover, the precise process of hidden polyp's removal within the maxillary sinus in the course of pansinus surgical procedures would not have superior outcomes in comparison with typical antrostomy.^[15] In general, besides the most conventional criteria's, it could be proved that perfect surgery in CRS conducted by more skillful surgeons could result in more favorable outcomes with the lowest rate of subsequent complication, decreased surgical interventions and also positive contrast to pharmacotherapy.^[6,16] However, among these patients, the surgical procedures are only admissible when conservative therapy could not be effective. Recently, the medical treatment with corticosteroids is preferred as the most effective therapy mainly due to the fact that their side effects such as acute gastritis, adrenal suppression, hyperglycemia, neuropsychological and functional changes and increased Intraocular pressure (IOP) is rarely presented.^[17,18]

Based on the various studies, the number of complications resulted from endonasal endoscopic sinus surgery in comparison with other similar procedures using an optical microscope is not known well. Generally, any surgical procedure of sinus has the potential of causing risk. It should be noted that, with increasing the rate of surgical errors, the resulted physical damages would be increased even to the rate of more than average.^[19,20]

Endonasal endoscopic sinus surgery complications

For knowing the most possible complications of endonasal endoscopic sinus surgery a general systemic classification of its complications should be carried out for assessment of any treatment outcomes. Based on the investigations carried out by the European Rhinologic Society (ERS)^[19] these complications could be classified into two severity levels of minor and major complications^[19] [Table 1]. However, the overall classifications contain four degrees of severity ranging from harmful side effects (Grade A) to death (Grade C):^[21,22]

- I: Harmful side effects; which would be treated spontaneously, and could be managed easily
- II: The complication of grade A; known as minor complications which require further surgical therapy without any permanent injuries

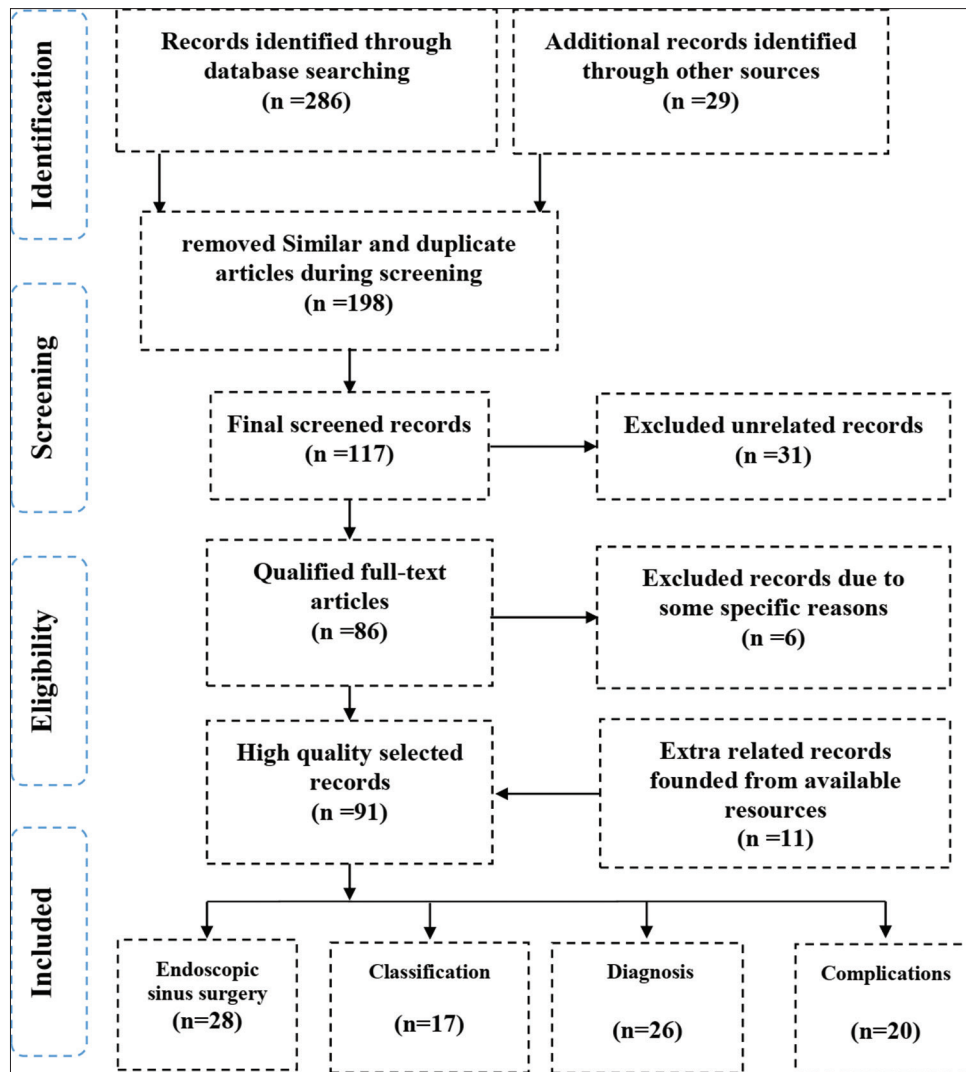


Figure 1: The process of selecting reviewed papers in the present study following the PRISMA method

III: Complications of grade B; known as major complications which could cause irreversible damages

IV: Complication of grade C; known as disastrous complication which could cause death

However, there is not a special classification which makes different lists of vascular traumas and diseases of the nervous system for some special issues of rhino-neurosurgical interventions. Finally, it should be noted that there is only one classification which has an increasing degree of complexity.^[23] Moreover, with the presence of surgical camera- and video systems there are not any documents on the reduction of complication rate.^[24] On the other hand, there is not any evidence on the increment of dramatic complications in the situation when there are not any optical aids applied. The rate of complications during the past decade has been reduced globally.^[25] Anyway, complication risk would increase within the following situations: ^[19,21,24,26,27]

- Advanced inflammatory disease of the paranasal sinuses which require a broader surgical procedure

- Revision endoscopic sinus surgery
- The patient who have intensive comorbidities
- The presence of anatomical abnormalities in patients which missed anatomical landmarks
- Increased risk of acute bleeding during the operation procedure
- The absence of a sufficiently experienced surgeon.

Sinonasal anatomy

Having a comprehensive knowledge of sinonasal anatomy with possible pathological and physiological variations in the field of functional endoscopic sinus surgery is very essential. This kind of science could be utilized for gaining more knowledge of individual patient's pathology. Moreover, administering a high-resolution CT scan combined with tri-planar reconstructions for scanning paranasal sinuses is accepted as a diagnostic technique for the visualization of inflammatory sinonasal disease.^[28] One of the most appropriate supplements is CLOSE mnemonic which could be applied for evaluating CT scans for proper detection of any possible pitfalls during the surgical procedure [Table 2]. The CLOSE

Table 1: Endonasal endoscopic sinus surgery-induced complications. derived in accordance with^[19]

Trauma types	Complications	
	Minor	Major
Orbital infection	orbital emphysema eyelid ecchymosis	orbital hematoma decrease visual acuity blindness posterior displacement of the eye tear duct trauma
Intracranial complication	uncomplicated cerebrospinal fluid (CSF) rhinorrhea	encephalocele cranial CSF leak tension pneumocephalus (PNC) meningitis cerebral abscess brain tissue direct trauma subarachnoid and intracerebral hemorrhage
Bleeding	minor hemorrhage without any need to transfusion of blood and will stop with nasal packing	anterior ethmoid artery sphenopalatine artery (SPA) injury internal carotid artery injury major bleeding which needs a transfusion of blood
Other traumas	ocular synechia slight bronchial asthma attacks microsomia paraffinoma osteitis bacterial infection chronic atrophic rhinitis methicillin-resistant Staphylococcus aureus (MRSA) infection after surgery spherocytosis irritation of the temporal infraorbital nerve teeth or lip hypoesthesia	the complete loss of smell acute bronchial asthma exacerbation toxic shock syndrome (TSS) death

term stands for; Cribriform plate, Lamina papyracea, Onodi cell, Sphenoid sinus pneumatization, and (anterior) Ethmoidal artery. However, the responsible surgeon should be capable of meeting with sudden pathological events during the surgery, mainly in situations when there is a lag between the FESS and CT scans.^[29]

Surgeon proficiency

The overall proficiency of the surgeon in functional endoscopic sinus surgery could be fitted on a learning curve. Moreover, the surgeon who performs the functional endoscopic sinus surgery must be responsible for conducting emergency procedures for treatment of patients and improving their acute complications like intraorbital hematoma.^[31,32] Under training surgeons during courses of cadaver dissection (CD) should be capable of gaining the taught skills and carrying out diagnostic endoscopic procedures. On the other hand, they should become capable of easily handling the endoscope tool, camera, positioning these tools in the nasal cavity and also interpreting two and three dimensional obtained images. However, performing the surgical procedure by a none or less experienced surgeon could cause a higher rate of complication.^[33]

Possible Complications

Hemorrhage

For being conscious about the possibility of bleeding risk during the operation, a pre-operative bleeding history of patients should be obtained. For normalizing the coagulation, the application

of blood thinners should be stopped at suitable time intervals. In this regard, when heparin-bridging therapy needed, clinical hematology examination must be conducted.^[34] Patients who suffer from abnormalities of the hemostatic system must be managed in accordance with the adopted protocols of hematologists. Due to the fact that the consumption of some over-the-counter (OTC) vitamins and herbal remedies could potentially affect the formation of the clot, the patients must be examined for this.^[35,36]

Mucous membrane hemorrhage

Accurate placement of the Hopkins rod-lens endoscope system and other implements would reduce oral mucosal lesions. Localized superficial hemorrhage could be controlled with topical cocaine-soaked patties while utilizing bipolar electrocautery for refractory hemorrhages. Administering of the technique of total intravenous anesthesia (TIVA) in endoscopic sinus surgery in the hypotensive situation could provide a more clearer surgical field with less spontaneous hemorrhage in comparison with inhalational anesthetic agents.^[37] The removal of nasal packing after conducting endoscopic sinus surgery could cause anxiety and destructive trauma to the mucous membrane of patients. Moreover, through administering dissolving nasal packs, any possible adhesions and bleeding following the operation could be decreased effectively.^[38,39]

Table 2: The approach of CLOSE mnemonic for evaluation of anatomical abnormalities during functional endoscopic sinus surgery. Derived in accordance with^[30]

Scan	Structure	Concern
Sagittal	skull/sphenoidal bone base anterior ethmoid artery	Attend lateral landmarks of the sphenoidal bone -
Coronal	skull/sphenoidal bone base anterior ethmoid artery the orbital lamina of the ethmoid bone Second cranial nerve/sphenoethmoidal air cell the transverse plate of cribriform	The sinus of sphenoidal bone specify the posterior skull base level Recognition of anterior ethmoidal canal (AEC) hanging on a set of mesentery tissues Orbital fat prolapse or dehiscences induced from previous surgeries Sphenoethmoidal air cell recognition Carotid in sphenoidal bone/protrusion and dehiscence of the optic nerve the absence of symmetry Keros classification

Lamina papyracea damages

One of the main kind of minor complications which could be resulted from conducting endonasal sinus surgery would be induced from the lamina papyracea damages. lamina papyracea which also called orbital lamina of the ethmoid bone is a smooth and oblong bone plate that has the main role in forming the lateral surface of the labyrinth of the ethmoid bone within the skull.^[40] This would be happening in a situation when endoscopic uncinectomy with or without maxillary antrostomy is carrying out, mainly at the right side. The presence of this kind of injury mostly could be happening by surgeons with less surgical knowledge and skills.^[41]

Maxillary sinus hypoplasia (MSH) as one of rare paranasal sinuses abnormalities would happen in four percent of cases, could be considered as one of the most potential causes of lamina papyracea injuries. Moreover, patients who suffer from hypoplasia of the ethmoid sinuses are seriously at risk of death. On the other hand, within the frontal plane, the ostium of the maxillary sinus is placed at the lateral side of the medial orbital wall convexity.^[42] After the surgery or trauma, the congenital deficiency of medial orbital walls is the main possible risk that could be presented in 0.5% of cases. The occurrence of lamina papyracea natural dehiscence with orbital content prolapse is very rare. The dehiscence sites are usually positioned near to the ethmoid bulla and at the front side of the middle turbinate basal lamella.^[42,43]

The occurrence rate of periorbital tissues trauma is just about two percentages. The happening of this condition, generally could cause the prolapse of orbital fat into the field of surgery and moreover, result in small venous orbital bleeding.^[44,45] It should be noted that the immediate identification of these injuries could prevent subsequent potential damages. In the situation, when there is the possibility of occurrence of lamina papyracea trauma, conducting the pressure test for reducing the intraoperative edema is an effective procedure. However, applying pressure to the outside of eyeball constantly generates the bulging fat corresponding movements.^[46]

Nasopalatine artery

As the sphenopalatine artery, the nasopalatine artery is commonly

introduced as the epistaxis artery.^[47] The nasopalatine artery is a branch of the maxillary artery which passes through the sphenopalatine foramen into the nasal cavity. When the nasopalatine artery leaves the foramen, it branches to the posterior septal artery and the posterior lateral artery in the nose.^[48] Moreover, the infraorbital artery enters the maxillary sinus through the inferior orbital fissure (IOF) in the roof of the maxillary sinus and the ascends cranially to the orbital cavity.^[49]

Infraorbital artery (IOA) and sphenopalatine artery would not be affected via hemorrhage complications during lateral wall sinus elevation due to their standard anatomical position. Anyway, aggressive reflection and incorrect incision locations would damage the blood vessels. In the situation when hemorrhage happens, the bleeding could be managed easily by applying topical hemostatic agents and pressure.^[50] Moreover, the nasopalatine artery may be injured at its exit point through sphenopalatine foramen at the time when the middle meatal antrostomy is expanding. On the other hand, the surgeon must be capable of carrying out bipolar cauterisation or endoscopic variceal ligation (EVL) of this vessel in essential situations. Any changes in submucosal elevation of the mucous membrane placed on the sphenoid face before expanding the bone plate over the antrostomy in maxillary sinus immediately prevent damages to the septal coronary branches.^[51]

Intraorbital hematoma

During conducting FESS as a minimally invasive surgical treatment, the anterior ethmoid artery (AEA) could be recognized as it overpasses indirectly through the fovea ethmoidalis of the frontal bone which is positioned anterior in the basal lamella attachment and posterior to the bulla ethmoidalis. On the other hand, any trauma to the AEA would cause hemorrhage, retrobulbar hemorrhage (RBH) and the AEA reaction to the orbit.^[52] These traumas increase intraocular pressure which may exert extra damages to the vision. Moreover, these kinds of traumas could cause Waardenburg's syndrome which is a rare dominant inheritance that results in autosomal recessive disorder. This disorder could be specified through facial features characteristics, abnormal pigmentation or/and sudden, deep congenital sensorineural hearing loss (SSHL).^[53] One of the rare disorders which could be induced from AEA damage during

FESS is orbital hematoma with an incidence rate lower than one percent.^[54] The AEA damages would happen in the anterior ethmoidal foramen within the base of the skull, dehiscent in about 40% and/or posterior cranial fossa in more than half of cases^[55] [Figure 1].

An avulsed injury of the anterior ethmoid artery may retract to the orbital socket of the skull which could be presented with a firm eye and some rapidly progressive proptosis. Consequently, it is recommended to use endoscopic cutting tools within the ethmoid roof. The urgent management by medicine skill of lateral canthotomy for medial wall orbital decompression is needed for preventing anterior ischemic optic neuropathy (AION) and sudden vision loss.^[56,57]

The onset of postoperative AEA hemorrhage with a delay would be presented within the recovery suite, potentially with a contusion of the eyelid and a discoloration of the skin before proptosis progression. During less than one hour before irreversible neurodegeneration of retinal ganglion cell (RGC), emergent orbital decompression by lateral canthotomy within the recovery suite would be needed. On the other hand, when required the patients may be going back to the operating theater for endoscopic medial orbital decompression.^[58]

Mucous membrane uncomplicated hemorrhage

The hemorrhage in the area of surgery prevents clear vision, so may cause some delays in operation procedure and also some mistakes during the operation and maybe some surgical complications. Principally, various circulatory systems mainly being affected by various hemodynamic systems, are the main hemorrhage origin.^[59] The arterial hemorrhage would happen at the average blood pressure within the circulatory system of the artery, while venous hemorrhage would occur at the mean blood pressure in the vascular territories of the veins. The blood flow of the capillary vessels in their respective vascular bed is the main influencing factor.^[60] However, the capillary vessels are the layer of an uncomplicated mucous membrane hemorrhage during the endoscopic paranasal sinus surgery.^[61,62]

Special consideration of the remedial methods should be carried out before conducting the operation mainly during the time when the patient's history is recording. All patients who use non-steroidal inflammatory drugs or vitamin K antagonist drugs must be considered significantly. Based on some pharmacological literature, various alternative or herbal remedies such as maidenhair tree, allium sativum and/or Asian Ginseng may possibly cause an increase in hemorrhage.^[61,62] Anyway, less than 30% of patients are reported to use these preparations and also in most cases the application of these preparations is undisclosed, unfortunately. On the other hand, endonasal endoscopic sinus surgery under the impression of acetylsalicylic acid (ASS) as an anti-inflammatory drugs could increase the hemorrhage risk. In general, secondary hemorrhage risk in the otorhinolaryngology field is nearly lower than in other surgical fields.^[63,64]

Internal Carotid Artery

Any damages to the internal carotid artery (ICA) with standard functional endoscopic sinus surgery is very rare, with enhancing the experience and skills of the surgeon, improving the quality of CT scan its incidence rate would be decreased more.^[65] Because of the relation of the sphenoid sinus lateral wall with the cavernous segment of ICA, during the surgical opening of the sphenoid sinus, the ICA would be placed at risk. In about 15% of cases, the internal carotid artery would be remarkably imposed to the sphenoid sinus. However, in about 20% of cases, the overlying bone may be thin and also in 15% of cases it may be dehiscent. Moreover, less than one percent of patients would be affected by intersinus septal cell (ISSC) connecting with the internal carotid artery.^[41] The Onodi cells would be seen nearly in about half of patients and the internal carotid artery would be dehiscent in these kinds of cells and consequently at more risk of damages [Figure 2].^[66]

The skull base surgery by means of the endoscopy procedure requires more considerable exposure to the anterior and ventral skull base and would increase the ICA injury risks. It's while through increasing the skill and experience of the surgeon the incidence rate of ICA injury through this procedure reduces to the lowest rate.^[67] Moreover, preoperative contrast-enhanced computed tomography scan and magnetic resonance imaging (MRI) arteriography provide the possibility of comprehension of deformation and alternation within pathways of the internal carotid artery because of the existence of invading and surrounding mass lesions. Anyway, the internal carotid artery could be damaged at any point all over the path, it's while the left segment of the cavernous sinus is still mostly at risk.^[68]

In situations when, internal carotid artery injury happens, an experienced surgeon must gain quick local control through applying direct pressure, using a combination of irrigation and suction for clarifying the surgical field, gaining distal and proximal control and also evaluate the internal carotid artery injury for determining salvage treatment options. It should be noted that, approximately over than 70% of patients would tolerate internal carotid artery sacrifice.^[8] However, the procedure of controlling hemorrhage must be carried out through carotid artery balloon test occlusion (BTO) and/or immediate coronary angiography. Performing postoperative conventional angiography, after the management of patients with internal carotid artery traumas, is very compulsory. The presence of residual active hemorrhage or a false aneurysm formation is a known sign of endovascular management by vascular teams or interventional radiology (IR).^[69]

Conclusion

During the last decades, endonasal endoscopic sinus surgery has significantly developed. Moreover, further progress has been carried out especially in improvement procedures and also developing endoscopic rhino-neurosurgery. Consequently, adequate provisions in the procedure of patients' management, the quality of process

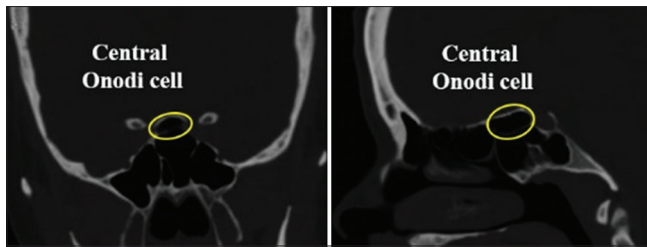


Figure 2: Taking CT scan images in the sagittal and coronal planes which showing a posterior Onodi cell. Derived in accordance with^[66] Left:) Coronal plane computed tomography scan of the paranasal sinuses demonstrating the central Onodi cell. Right:) Sagittal plane computed tomography scan demonstrating the central Onodi cell positioned anterior to the superior side of the sella turcica and superior to the sphenoid sinus

and structure of patient's management in addition to more skillful physician training has been increased recently.

Applying functional endoscopic sinus surgery, approximately in more than 80% of patients result in adequate positive outcomes without any recurrence and also lower rates of morbidity. The functional endoscopic sinus surgery procedure should be capable of precise and adequate identifying and tolerating possible complications, in addition with approximating to more complexed cases of subsequent cases of functional endoscopic sinus surgery and revisions.

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Conflicts of interest

There are no conflicts of interest.

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