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Review Article

Ophthalmological Complications During Endoscopic Sinus Surgery: A Comprehensive Review

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Abstract

Endoscopic sinus surgery (ESS) is a commonly performed procedure for the management of chronic rhinosinusitis and various sinonasal pathologies. While ESS offers significant benefits regarding improved sinonasal ventilation and reduced disease burden, it has risks. Ophthalmological complications during ESS are relatively rare but can have severe consequences. This review aims to provide a comprehensive overview of the ophthalmological complications associated with ESS, their pathophysiology, clinical manifestations, risk factors, prevention strategies, and management options. Though rare, ophthalmological complications during endoscopic sinus surgery can lead to significant morbidity if not promptly recognized and managed. Surgeons should be aware of the potential risks and strive to minimize them through meticulous surgical technique, preoperative evaluation, and appropriate postoperative care. Continued research and technological advancements are essential to enhance patient safety further and optimize ESS outcomes.

Keywords: endoscopic sinus surgery; ophthalmological complications; optic nerve injury

Introduction

Endoscopic sinus surgery (ESS) is a surgical procedure that has revolutionized the management of chronic rhinosinusitis and various sinonasal pathologies. It involves using a nasal endoscope, which allows surgeons to visualize and access the sinuses through the natural openings of the nose, thus avoiding the need for external incisions. ESS aims to restore normal sinus ventilation, promote drainage, and remove diseased tissue, thereby improving symptoms and reducing the recurrence of sinus disease [1]. Indications for ESS encompass a wide range of sinonasal conditions, including chronic rhinosinusitis refractory to medical management, nasal polyps, sinus mucoceles, fungal sinusitis, and benign sinonasal tumors. The decision to proceed with ESS is typically made after an otolaryngologist's thorough evaluation, considering the disease's severity and chronicity, patient symptoms, and response to conservative treatments [2,3]. While ESS has proven to be a safe and effective procedure for most patients, it is not entirely without risks. Ophthalmological complications during ESS are relatively rare but can have significant consequences. These complications can arise due to the complex anatomical relationships between the paranasal sinuses and the orbit and the proximity of vital structures such as the optic nerve and the ophthalmic artery [4-6]. The prevalence of ophthalmological complications during ESS varies in the literature, with reported rates ranging from 0.1% to 2.4%. Although these complications occur infrequently, their potential severity and impact on visual function make them a cause for concern. Ophthalmological complications can range from transient visual disturbances to permanent vision loss, depending on the nature and extent of the injury [6,7]. The significance of ophthalmological complications lies in their potential impact on the patient's quality of life and visual function. Visual impairment, diplopia (double vision), and other ocular symptoms can lead to functional limitations, decreased productivity, and psychological distress. Prompt recognition, appropriate management, and preventive strategies are crucial in minimizing the occurrence and mitigating the impact of these complications [5,8]. ESS is a valuable surgical approach for managing various sinonasal pathologies. However, it is important to recognize the potential ophthalmological complications associated with the procedure [9]. This review aims to comprehensively understand these complications, including their prevalence, pathophysiology, clinical manifestations, risk factors, prevention strategies, and management options. By enhancing our knowledge of ophthalmological complications, we can improve patient safety, optimize outcomes, and ensure the continued success of endoscopic sinus surgery.

2. Anatomy and Pathophysiology

Sinonasal Anatomy Relevant to Ophthalmological Complications:

To understand the ophthalmological complications that can occur during (ESS, it is important to know the sinonasal anatomy and its relationship with

the orbit. The paranasal sinuses are air-filled cavities located within the facial bones surrounding the nasal cavity. They include the frontal, ethmoid, sphenoid, and maxillary sinuses [10]. The ethmoid sinuses, in particular, are of significance due to their proximity to the orbit. The ethmoid bone forms the medial wall of the orbit, and the lamina papyracea, a thin bony plate, separates the ethmoid sinuses from the orbit. The anterior ethmoid cells are closest to the orbit, followed by the middle and posterior ethmoid cells. The optic nerve, ophthalmic artery, and other vital structures pass through the optic canal and superior orbital fissure, which are adjacent to the ethmoid sinuses [11,12].

Mechanisms Underlying Ophthalmological Complications during ESS:

Ophthalmological complications during ESS can occur due to various mechanisms, including direct trauma, injury to blood vessels, infection, and pressure changes.

1. Direct Trauma: During surgical manipulation of the sinonasal structures, inadvertent direct trauma to the orbit or its contents can occur. This can lead to orbital fractures, disruption of the orbital walls, or damage to the ocular structures such as the optic nerve, extraocular muscles, or the globe itself [12,13].

2. Injury to Blood Vessels: The ophthalmic artery, a major blood supply to the orbit and its contents, runs in close proximity to the ethmoid sinuses. Injuries to the ophthalmic artery or its branches can result in retrobulbar hemorrhage or orbital hematoma, causing increased intraorbital pressure and compromising blood flow to the optic nerve and other ocular structures [15,16].

3. Infection: Sinonasal infections can extend into the orbit, resulting in orbital cellulitis or abscess formation. The infection may spread through the ethmoid sinuses with thin bony partitions separating them from the orbit. The proximity of the orbit to the ethmoid air cells facilitates the spread of infection, leading to inflammation and subsequent ophthalmological complications [17,18].

4. Pressure Changes: Manipulation of the sinonasal structures during ESS can result in pressure changes within the sinuses and the orbit. Increased intraorbital pressure can compress the optic nerve, leading to ischemia and subsequent vision loss. Additionally, rapid decompression of sinuses can cause air or gas to enter the orbit, resulting in orbital emphysema, which can lead to proptosis (protrusion of the eyeball) and impaired ocular mobility [19-22].

Understanding the anatomical relationships and mechanisms underlying ophthalmological complications during ESS is crucial for their prevention, early recognition, and appropriate management. Surgeons must exercise caution, employ precise surgical techniques, and have a thorough knowledge of the sinonasal anatomy to minimize the risk of complications and ensure patient safety [15-23].

3. Ophthalmological Complications During Endoscopic Sinus Surgery

3.1 Orbital Hemorrhage:

Orbital hemorrhage is a potentially serious complication that can occur during endoscopic sinus surgery (ESS). It involves bleeding into the orbit, which can lead to increased intraorbital pressure, compression of ocular structures, and potential visual impairment [22-24].

Etiology and Risk Factors:

Orbital hemorrhage during ESS can result from several factors, including:

- Injury to the ophthalmic artery or its branches during surgical manipulation

- Disruption of blood vessels within the orbit due to direct trauma or inadvertent damage

- Anticoagulant or antiplatelet medication use, which can increase the risk of bleeding

- Presence of vascular anomalies or abnormalities in the orbital vasculature

Clinical Presentation and Diagnosis:

Patients with orbital hemorrhage may present with the following signs and symptoms:

- Proptosis (forward displacement of the eyeball)

- Periorbital swelling and ecchymosis (bruising)

- Pain and restricted eye movements

- Visual disturbances, including decreased visual acuity or visual field defects

Diagnosis of orbital hemorrhage is primarily clinical, based on the characteristic signs and symptoms. Imaging studies, such as computed tomography (CT) or magnetic resonance imaging (MRI), may be performed to confirm the diagnosis, assess the extent of hemorrhage, and evaluate the involvement of adjacent structures [24-27].

Management Strategies:

The management of orbital hemorrhage during ESS involves a multidisciplinary approach, including ophthalmologists and otolaryngologists. The main goals of management are to relieve orbital pressure, preserve visual function, and control bleeding. Strategies may include:

- Immediate medical intervention: This may involve applying ice packs to reduce swelling, elevating the head of the patient's bed, and administering systemic corticosteroids to reduce inflammation [28,29].

- Surgical intervention: In severe cases with significant visual impairment or uncontrolled bleeding, surgical decompression of the orbit may be necessary. This can involve lateral canthotomy (incision of the outer corner of the eye) and cantholysis (release of the eyelid tendon) to alleviate pressure [30,31].

- Hemostasis and control of bleeding: Surgical techniques, such as cauterization, ligature, or packing, may be employed to achieve hemostasis and control active bleeding.

- Postoperative monitoring and follow-up: Close observation and regular ophthalmological examinations are essential to assess visual function, monitor for signs of orbital compartment syndrome, and manage any associated complications.

Prompt recognition and timely intervention are crucial in managing orbital hemorrhage during ESS to prevent long-term visual sequelae and optimize outcomes [30-32].

3.2 Orbital Cellulitis and Abscess:

Orbital cellulitis and abscess are infectious complications that can occur as a result of the spread of sinonasal infections into the orbit during or after endoscopic sinus surgery (ESS) [33-35].

Pathogenesis and Predisposing Factors:

Orbital cellulitis and abscess typically arise due to the spread of bacteria from the sinuses into the orbit. The ethmoid sinuses, which are in close proximity to the orbit, are often involved. Predisposing factors for orbital cellulitis and abscess include:

- Sinonasal infection: Acute or chronic bacterial rhinosinusitis, sinusitis, or nasal polyposis can serve as a source of infection.

- Inadequate surgical drainage: Incomplete removal of infected material or inadequate drainage during ESS can contribute to the development of orbital complications.

- Immunocompromised status: Patients with compromised immune systems, such as those with diabetes, immunodeficiency disorders, or systemic illnesses, may be more susceptible to orbital infections.

3.3 Orbital Emphysema:

Orbital emphysema is a rare but potential complication of endoscopic sinus surgery (ESS). It occurs when air or gas enters the orbit and becomes trapped within the soft tissues, leading to swelling and proptosis of the eye [36-39].

Mechanism and Contributing Factors:

The mechanism of orbital emphysema during ESS involves the introduction of air or gas into the orbit through breaches in the sinus walls or inadvertent communication between the sinus and the orbit. Contributing factors include:

- Inadvertent creation of a communication between the sinuses and the orbit during surgery

- Sinus wall fractures or disruption of the lamina papyracea, which separates the ethmoid sinuses from the orbit

- Excessive air insufflation during endoscopy, leading to increased intrasinus pressure and subsequent escape of air into the orbit

Signs, Symptoms, and Diagnostic Evaluation:

Patients with orbital emphysema may present with the following signs and symptoms:

- Rapid onset of proptosis (bulging of the eye)

- Subcutaneous emphysema, palpable as crepitus (crackling sensation) around the eye or face

- Swelling and edema of the eyelids

- Restricted eye movements

- Decreased visual acuity or diplopia (double vision)

The diagnosis of orbital emphysema is usually clinical, based on the characteristic signs and symptoms. Imaging studies, such as CT or plain radiographs, can help confirm the diagnosis and assess the extent of emphysema [38-40].

C**onservative and Surgical Management Approaches:**

The management of orbital emphysema during ESS depends on the severity of symptoms and potential complications. Conservative management may include:

- Observation and monitoring: In mild cases with minimal symptoms, close observation and monitoring for any progression or associated complications may be sufficient.

- Topical decongestants: Nasal decongestants may be used to reduce mucosal edema and promote the natural resorption of trapped air.

- Warm compresses: The application of warm compresses can help alleviate discomfort and facilitate the resorption of air.

- Avoidance of valsalva maneuver: Patients should be instructed to avoid activities that increase intranasal pressure, such as forceful blowing of the nose or straining.

Surgical intervention may be necessary in more severe cases or if complications arise. Surgical approaches may include:

- Decompression: In cases of significant proptosis or compromised visual function, surgical orbit decompression may be performed. This can involve lateral canthotomy and cantholysis to relieve pressure.

- Repair of sinus wall defects: If there are breaches in the sinus walls contributing to orbital emphysema, repair of these defects may be necessary to prevent further air entry and facilitate resolution.

Management decisions should be made in consultation with ophthalmologists and otolaryngologists, considering the individual patient's symptoms, emphysema severity, and associated complications.

Overall, prompt recognition and appropriate management of orbital emphysema during ESS are crucial to minimize discomfort, prevent visual complications, and optimize patient outcomes [40-42].

3.4 Optic Nerve Injury (during ESS):

Optic nerve injury is a rare but potentially devastating complication that can occur during endoscopic sinus surgery (ESS). Injury to the optic nerve can lead to significant visual impairment or even permanent vision loss [43-47].

Pathophysiology and Mechanisms:

Optic nerve injury during ESS can result from various mechanisms, including:

- Direct trauma: Direct mechanical injury to the optic nerve or its sheath during surgical manipulation can cause nerve compression, ischemia, or transection.

- Vascular compromise: Disruption or compression of the blood supply to the optic nerve, such as the posterior ciliary arteries, can result in ischemic optic neuropathy.

- Pressure-related injury: Increased intraorbital pressure or compression due to orbital hemorrhage, edema, or compartment syndrome can compromise the blood flow to the optic nerve.

Clinical Signs and Diagnostic Methods:

The clinical signs of optic nerve injury during or after ESS may include:

- Acute or subacute vision loss, ranging from mild blurring to complete loss of vision

- Visual field defects, such as central or peripheral scotomas (blind spots)

- Color vision abnormalities

- Relative afferent pupillary defect (Marcus Gunn pupil) in unilateral cases

- Optic disc edema or atrophy on ophthalmoscopic examination

Diagnostic methods to assess optic nerve injury may include:

- Visual acuity testing: Measurement of visual acuity using a Snellen chart or other standardized methods to assess the extent of vision loss.

- Visual field testing: Perimetry techniques, such as automated or manual visual field testing, to evaluate any visual field defects

- Fundus examination: Ophthalmoscopic optic disc examination to assess for optic disc edema or atrophy.

- Optical coherence tomography (OCT): This imaging technique can provide detailed inform

ation about the thickness and integrity of the retinal nerve fiber layer, which can aid in diagnosing and monitoring optic nerve injury.

Treatment Options and Visual Outcomes:

The management of optic nerve injury during ESS depends on the severity and extent of the injury. Treatment options may include:

- Conservative management: In cases of mild or transient optic nerve injury, conservative measures such as observation, systemic corticosteroids, and neuroprotective agents may be considered.

- Surgical intervention: In cases of severe or progressive optic nerve injury, surgical optic nerve decompression may be performed. This involves relieving the pressure on the optic nerve, which can be achieved by removing bone or tissue causing compression.

- Rehabilitation and visual support: Visual rehabilitation strategies, including low vision aids, vision therapy, or referral to low vision specialists, may be beneficial in optimizing functional vision.

The visual outcomes following optic nerve injury during ESS vary depending on the severity and duration of the damage. While some cases may experience partial or complete recovery of vision, others may have permanent visual impairment or blindness.

Early recognition of optic nerve injury, prompt referral to ophthalmologists, and appropriate management are crucial in optimizing visual outcomes and preventing further damage to the optic nerve. A multidisciplinary approach involving otolaryngologists and ophthalmologists is essential for the comprehensive care of patients with optic nerve injury during ESS [48,49].

4. Risk Factors and Prevention Strategies

Ophthalmological complications during endoscopic sinus surgery (ESS) can have significant consequences on visual function. Understanding the risk factors associated with these complications and implementing appropriate prevention strategies is crucial in ensuring patient safety. Risk factors can be categorized into anatomical variations and surgical factors, patient-related factors, and perioperative precautions [50].

Anatomical Variations and Surgical Factors:

1. Ethmoid sinus anatomy: Anatomical variations in the ethmoid sinuses, such as the lamina papyracea's thinning or the orbit's proximity to the ethmoid air cells, can increase the risk of orbital complications during ESS. Surgeons should be aware of these anatomical variations and exercise caution during surgical manipulation to avoid injury to the orbital structures.

2. Surgical technique and experience: Surgeon experience, expertise, and adherence to proper surgical technique significantly minimize the risk of ophthalmological complications. Familiarity with the anatomy, meticulous dissection, and gentle tissue handling can reduce the likelihood of inadvertent trauma to the orbit or its contents [51,52].

Patient-Related Risk Factors:

1. Prior orbital surgery or trauma: Patients with a history of prior orbital surgery or trauma may have altered orbital anatomy, scarring, or compromised blood supply, increasing susceptibility to ophthalmological complications during ESS.

2. Pre-existing ocular conditions: Patients with pre-existing ocular conditions, such as glaucoma, optic neuropathy, or significant visual impairment, may be at higher risk for complications and should be evaluated and managed accordingly [53].

5. Management Approaches (for Ophthalmological Complications during ESS):

Ophthalmological complications during endoscopic sinus surgery (ESS) require prompt recognition and appropriate management to minimize morbidity and optimize outcomes. The management approaches depend on the specific complication and its severity. Here, we discuss the general management strategies for ophthalmological complications during ESS, including immediate management of acute complications, medical interventions, surgical interventions, and rehabilitation with long-term follow-up [54].

Immediate Management of Acute Complications:

In cases of acute ophthalmological complications during or immediately after ESS, prompt intervention is crucial to prevent further damage and preserve visual function. The immediate management may involve:

1. Stabilization: Ensure patient stability, secure the airway if necessary, and address any life-threatening conditions or systemic complications.

2. Control of hemorrhage: In cases of orbital hemorrhage, achieving hemostasis is essential to relieve pressure on ocular structures and restore blood flow. Surgical interventions may be required to control active bleeding, such as ligature, packing, or cauterization.

3. Decompression: Surgical decompression may be necessary in situations where increased intraorbital pressure is compromising ocular structures. Lateral canthotomy (incision of the outer corner of the eye) and cantholysis (release of the eyelid tendon) can provide immediate relief by reducing pressure within the orbit [54-56].

Medical Interventions:

Medical interventions aim to manage inflammation, prevent infection, and preserve visual function. These interventions may include:

1. Systemic corticosteroids: The administration of systemic corticosteroids can help reduce inflammation and edema, particularly in cases of orbital cellulitis, abscess, or optic nerve injury. The dosage and duration of corticosteroid therapy should be tailored to the individual patient's condition [57].

2. Antibiotics: In the presence of orbital cellulitis or infection, appropriate broad-spectrum antibiotics should be initiated promptly to control the infection and prevent its spread. The choice of antibiotics should be guided by the suspected or identified pathogens.

Surgical Interventions:

Surgical interventions may be required for complications that cannot be managed conservatively or those that necessitate direct intervention. These interventions may include:

1. Orbital surgery: In cases of severe orbital trauma or extensive injury, surgical repair or reconstruction may be necessary to restore normal orbital anatomy and preserve visual function.

2. Optic nerve decompression: Surgical decompression of the optic nerve may be considered in cases of optic nerve injury or optic neuropathy that does not improve with medical management. The goal is to relieve pressure on the optic nerve and restore blood flow [58].

Rehabilitation and Long-term Follow-up:

Rehabilitation and long-term follow-up are crucial for optimizing visual outcomes and monitoring for any late complications or sequelae. These measures may include:

1. Visual rehabilitation: Patients with permanent visual impairment may benefit from low vision aids, vision therapy, or referral to low vision specialists to maximize functional vision and quality of life.

2. Ophthalmological follow-up: Regular ophthalmological examinations and visual assessments are essential to monitor for any changes in visual

function, assess ocular health, and manage any ongoing complications or sequelae.

3. Patient counseling and support: Patients should receive appropriate counseling and support regarding their visual status, expected outcomes, and available resources for coping with any visual impairment.

The management of ophthalmological complications during ESS requires a multidisciplinary approach involving otolaryngologists, ophthalmologists, and other healthcare professionals. Individualized management plans should be tailored to the specific complication, patient characteristics, and severity of the condition. Close collaboration, timely intervention, and long-term follow-up are essential for optimizing patient outcomes and preserving visual function [50-59].

Conclusion:

Ophthalmological complications during endoscopic sinus surgery (ESS) are relatively rare but can significantly affect visual function. Understanding the prevalence, pathophysiology, clinical manifestations, and management strategies associated with these complications is crucial for ensuring patient safety and optimizing outcomes.The anatomical relationships between the paranasal sinuses and the orbit and the close proximity of vital structures like the optic nerve and ophthalmic artery contribute to the risk of ophthalmological complications during ESS. Orbital hemorrhage, orbital cellulitis and abscess, orbital emphysema, and optic nerve injury are among the potential complications that can occur.Prevention and management of these complications require a comprehensive approach. Surgeons must be mindful of anatomical variations, employ precise surgical techniques, and exercise caution to minimize the risk of direct trauma to ocular structures. Preoperative evaluation, informed consent, and the use of intraoperative imaging techniques can aid in surgical planning and reduce the risk of complications. Postoperative monitoring, early recognition of complications, and prompt intervention are essential for optimizing outcomes and preventing further damage.The management of ophthalmological complications during ESS involves a multidisciplinary approach, with collaboration between otolaryngologists and ophthalmologists. Depending on the specific complication and severity, medical and surgical interventions, and rehabilitation strategies may be employed [60]. By enhancing our knowledge of ophthalmological complications during ESS and implementing appropriate preventive measures and management strategies, we can improve patient safety, optimize outcomes, and ensure the continued success of endoscopic sinus surgery. Continued research, advancements in surgical techniques, and ongoing collaboration between specialties will further enhance our understanding and management of these complications in the future.

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References:

1. Govindaraj S, Adappa ND, Kennedy DW. (2010). Endoscopic sinus surgery: evolution and technical innovations. *J Laryngol Otol.* Mar;124(3):242-250.
2. Gray ST, Sadow PM, Lin DT, Sedaghat AR. (2016). Endoscopic sinus surgery for chronic rhinosinusitis in patients previously treated for sinonasal malignancy. *Laryngoscope*. 2016 Feb;126(2):304-315.
3. Krings JG, Kallogjeri D, Wineland A, Nepple KG, Piccirillo JF, et al (2014). Complications of primary and revision functional endoscopic sinus surgery for chronic rhinosinusitis. *Laryngoscope.* Apr;124(4):838-845.
4. Wu H, Shen T, Chen J, Yan J. (2016). Long-term therapeutic outcome of ophthalmic complications following endoscopic sinus surgery. *Medicine (Baltimore).* Sep;95(38): e4896.
5. Weber RK, Hosemann W. (2015). Comprehensive review on endonasal endoscopic sinus surgery. GMS Curr Top Otorhinolaryngol Head Neck Surg.
6. Maharshak I, Hoang JK, Bhatti MT. (2013). Complications of vision loss and ophthalmoplegia during endoscopic sinus surgery. *Clin Ophthalmol*.:573-580.
7. Khademi S, Kazemi A, Divanbeigi R, Afzalzadeh M. (2022). A review of the revisions and complications management procedure in sinus surgery. *J Family Med Prim Care.* Mar;11(3):887-895.
8. Al-Mujaini A, Wali U, Alkhabori M. (2009). Functional endoscopic sinus surgery: indications and complications in the ophthalmic field. *Oman Med J*. 2009 Apr;24(2):70-80.
9. M.Tariq Bhatti, James A. (2003). Stankiewicz,Ophthalmic complications of endoscopic sinus surgery,Survey of Ophthalmology,Volume 48, Issue 4,Pages 389-402,
10. Arslan H.(1999). Aydinlioglu A.Bozkurt M.Egeli E,**Anatomic variations of the paranasal sinuses: CT examination for endoscopic sinus surgery.***Auris Nasus Larynx.* **26**: 39-48
11. Salgado-López L, Campos-Leonel LCP, Pinheiro-Neto CD, Peris-Celda M. (2020). Orbital Anatomy: Anatomical Relationships of Surrounding Structures. *J Neurol Surg B Skull Base*. Aug;81(4):333-347.
12. Francies O, Makalanda L, Paraskevopolous D, Adams A. (2018). Imaging review of the anterior skull base. *Acta Radiol Open.*7(5):2058460118776487.
13. Grob S, Yonkers M, Tao J. (2017). Orbital Fracture Repair. *Semin Plast Surg*. 2017 Feb;31(1):31-39.
14. Roth FS, Koshy JC, Goldberg JS, Soparkar CN. (2010). Pearls of orbital trauma management. Semin Plast Surg. 2010 Nov;24(4):398-410.
15. Scientific Session of the 16th World Congress of Endoscopic Surgery, Jointly Hosted by Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) & Canadian Association of General Surgeons (CAGS), Seattle, Washington, USA, 11-14 April 2018: Poster Abstracts. Surg Endosc. 2018 Apr;32(Suppl 1):130-359.
16. Cellina M, Cè M, Marziali S, Irmici G, Gibelli D. et al. (2022). Computed tomography in traumatic orbital emergencies: a pictorial essay-imaging findings, tips, and report flowchart. Insights Imaging.;13(1):4.
17. Presutti L, Lucidi D, Spagnolo F, Molinari G, Piccinini S et al (2021). Surgical multidisciplinary approach of orbital complications of sinonasal inflammatory disorders. *Acta Otorhinolaryngol Ital*. S108-S115.
18. Tadros D, Tomoum MO, Shafik HM. (2022). Orbital Complications of Acute Invasive Fungal Rhinosinusitis: A New Challenge in the COVID-19 Convalescent Patients. *Clin Ophthalmol*. 2022 Dec 7; 16:4011-4019.

19. Kim NR. (2018). Optic nerve changes in chronic sinusitis patients: Correlation with disease severity and relevant sinus location. PLoS One. 2018 Jul 10;13(7): e0199875.
20. Seredyka-Burduk M, Burduk PK, Wierzchowska M, Kaluzny B, Malukiewicz G. Ophthalmic complications of endoscopic sinus surgery. *Braz J Otorhinolaryngol*. 2017 May-Jun;83(3):318-323.
21. Wu H, Shen T, Chen J, Yan J. (2016). Long-term therapeutic outcome of ophthalmic complications following endoscopic sinus surgery. *Medicine (Baltimore)*. 2016 Sep;95(38): e4896.
22. Duvanova ED, Danilov SS, Grusha YO. (2022). Oftal'mologicheskie oslozhneniya endoskopicheskikh operatsii na pridatochnykh pazukhakh nosa [Ophthalmic complications of endoscopic sinus surgery]. *Vestn Oftalmol*. 138(2):108-113. Russian.
23. Bhatti MT, Stankiewicz JA. (2003). Ophthalmic complications of endoscopic sinus surgery. *Surv Ophthalmol*. 2003 Jul-Aug;48(4):389-402.
24. Maharshak I, Hoang JK, Bhatti MT. (2013). Complications of vision loss and ophthalmoplegia during endoscopic sinus surgery. Clin Ophthalmol. 7:573-580.
25. Bailey WK, Kuo PC, Evans LS. (1993). Diagnosis and treatment of retrobulbar hemorrhage. *J Oral Maxillofac Surg*;51(7):780-782.
26. McCallum E, Keren S, Lapira M, Norris JH. (2019). Orbital Compartment Syndrome: An Update with Review of The Literature. *Clin Ophthalmol*; 13:2189-2194.
27. Tarlan B, Kiratli H. (2013). Subconjunctival hemorrhage: risk factors and potential indicators. *Clin Ophthalmol*. 2013; 7:1163-1170.
28. Sharma S, Wilcsek GA, Francis IC, Lee D, Coroneo MT, et al. (2000). Management of acute surgical orbital haemorrhage: an otorhinolaryngological and ophthalmological perspective. *J Laryngol Otol*.
29. Murali S, Davis C, McCrea MJ, Plewa MC. (2021). Orbital compartment syndrome: Pearls and pitfalls for the emergency physician. *J Am Coll Emerg Physicians Open*. 2021 Mar 6;2(2): e12372.
30. Turgut B, Karanfil FC, Turgut FA. (2019). Orbital Compartment Syndrome. *Beyoglu Eye J*. 2019 Feb 12;4(1):1-4.
31. Lima V, Burt B, Leibovitch I, Prabhakaran V, Goldberg RA. (2009). Orbital compartment syndrome: the ophthalmic surgical emergency. *Surv Ophthalmol*. 2009 Jul-Aug;54(4):441-9.
32. McCallum E, Keren S, Lapira M, Norris JH. (2019). Orbital Compartment Syndrome: An Update with Review of The Literature. *Clin Ophthalmol*. 2019 Nov 7; 13:2189-2194.
33. Torretta S, Guastella C, Marchisio P, Marom T, Bosis S, Ibba T. (2019). Sinonasal-Related Orbital Infections in Children: A Clinical and Therapeutic Overview. *J Clin Med*. 2019 Jan 16;8(1):101.
34. Strek P, Zagólski O, Składzień J, Kurzyński M, Oleś K. (2008). Endoskopowe leczenie chorych z powikłaniami oczodołowymi zapaleń zatok przynosowych [Orbital complications of sinusitis treated endoscopically]. *Przegl Lek*.;65(5):221-224. Polish. PMID: 18853645.
35. Presutti L, Lucidi D, Spagnolo F, Molinari G, Piccinini S. (2021). Surgical multidisciplinary approach of orbital complications of sinonasal inflammatory disorders. *Acta Otorhinolaryngol Ital*. Apr;41(Suppl. 1): S108-S115.
36. Çınar E, Yüce B, Fece M, Küçükerdönmez FC. (2019). Periorbital Emphysema After Endoscopic Nasal Polyp Surgery. *Turk J Ophthalmol*.;49(1):47-50.
37. Rene C, Rose GE, Lenthall R, Moseley I. (2001). Major orbital complications of endoscopic sinus surgery. *Br J Ophthalmol*.;85(5):598-603.
38. Bildik F, Baydin A, Doğanay Z, Nural MS, Deniz T. (2007). Minör maksillofasiyal travma sonrasi yüz, boyun ve üst mediastene yayilan cilt alti amfizem olgusu [Subcutaneous emphysema of the face, neck and upper mediastinum following a minor maxillofacial trauma]. *Ulus Travma Acil Cerrahi Derg*;13(3):251-253.
39. Fleischman D, Davis RM, Lee LB. (2014). Subcutaneous and periorbital emphysema following dental procedure. *Ophthalmic Plast Reconstr Surg*.30(2): e43-e45.
40. Gauguet JM, Lindquist PA, Shaffer K. (2015). Orbital Emphysema Following Ocular Trauma and Sneezing. *Radiol Case Rep*. 2015 Nov 6;3(1):124.
41. Mihara, R.; Murai, Y.; Sato, S.; Matano, F.; Morita, A. (2022). Subcutaneous Emphysema of the Orbit after Nose-Blowing. *Reports*, *5*, 21.
42. Bars N, Atlay Y, Tülay E, Tanju G. (2008). Extensive subcutaneous emphysema and pneumomediastinum associated with blowout fracture of the medial orbital wall. *J Trauma*. 2008 May;64(5):1366-1369.
43. Kim JY, Kim HJ, Kim CH, Lee JG, Yoon JH. (2005). Optic nerve injury secondary to endoscopic sinus surgery: an analysis of three cases. *Yonsei Med J*.;46(2):300-304.
44. Stankiewicz JA, Lal D, Connor M, Welch K. (2011). Complications in endoscopic sinus surgery for chronic rhinosinusitis: a 25-year experience. *Laryngoscope*. Dec;121(12):2684-2701.
45. Stankiewicz JA. (1989). Blindness and intranasal endoscopic ethmoidectomy: prevention and management. *Otolaryngol Head Neck Surg*. 1989 Sep;101(3):320-329.
46. Neuhaus RW. (1990). Orbital complications secondary to endoscopic sinus surgery. Ophthalmology;97(11):1512-1518.
47. Corey JP, Bumsted R, Panje W, Namon A. (1993). Orbital complications in functional endoscopic sinus surgery. *Otolaryngol Head Neck Surg*;109(5):814-820.
48. Yu-Wai-Man P. (2015). Traumatic optic neuropathy-Clinical features and management issues. *Taiwan J Ophthalmol*. ;5(1):3-8.
49. Miller NR. (2021). Traumatic Optic Neuropathy. *J Neurol Surg B Skull Base*. 2021 Feb;82(1):107-115.
50. Seredyka-Burduk M, Burduk PK, Wierzchowska M, Kaluzny B, Malukiewicz G. (2017). Ophthalmic complications of endoscopic sinus surgery. *Braz J Otorhinolaryngol*;83(3):318-323.
51. Hui L, Hung KF, Yeung AWK, von Arx T, Leung YY. (2022). Anatomical variations of the ethmoid sinuses and their association with health or pathology of the ethmoid and maxillary sinuses in a Southern Chinese population: An analysis using cone-beam computed tomography. Imaging Sci Dent;52(1):109-115.
52. Reddy UD, Dev B. (2012). Pictorial essay: Anatomical variations of paranasal sinuses on multidetector computed tomography-How does it help FESS surgeons? *Indian J Radiol Imaging*;22(4):317-24.
53. Murray AD. (2015). An Approach to Some Aspects of Strabismus from Ocular and Orbital Trauma. *Middle East Afr J Ophthalmol*. 22(3):312-319.

54. Ulualp SO. (2008). Complications of endoscopic sinus surgery: appropriate management of complications. *Curr Opin Otolaryngol Head Neck Surg*. 2008 Jun;16(3):252-9. PMID: 18475081.
55. Cicinelli MV, Marmamula S, Khanna RC. (2020). Comprehensive eye care - Issues, challenges, and way forward. *Indian J Ophthalmol*;68(2):316-323.
56. Lau OC, Montfort JM, Sim BW, Lim CH, Chen TS. (2014). Acute intraoperative rock-hard eye syndrome and its management. *J Cataract Refract Surg*;40(5):799-804.
57. Kim BY, Bae JH. (2021). Role of systemic corticosteroids in orbital cellulitis: a meta-analysis and literature review. *Braz J Otorhinolaryngol*.88(2):257-262.
58. Boyette JR, Pemberton JD, Bonilla-Velez J. (2015). Management of orbital fractures: challenges and solutions. Clin Ophthalmol; 9:2127-137.
59. Agarwal R, Tripathi A. (2021). Current Modalities for Low Vision Rehabilitation. Cureus;13(7): e16561.
60. Ghosh D, Khanna S, Baruah DK. (2013). Ophthalmological Manifestations of ENT Diseases: An Overview. *Indian J Otolaryngol Head Neck Surg*;65(3):197-202.