



Review Article

Endoscopic endonasal intraconal orbit surgery

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Abstract Endoscopic endonasal orbital surgery is evolving. With increasing knowledge, expertise, and technology, the historical limits of the endonasal endoscopic approach to the orbit have been redefined. This review discusses the clinical presentation and etiology, and highlights the pertinent anatomy, and discusses the diagnostic workup and surgical approach to orbital tumors and post-operative care. The role of the multidisciplinary team is not to be underestimated. The introduction of a classification system to ensure standardization of technical difficulty and outcome data will assist with international collaboration and further consolidate our attainment of knowledge in this developing field.

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Introduction

Endoscopic endonasal orbital surgery is evolving. With increasing knowledge, expertise, and technology, the

historical limits of the endonasal endoscopic approach to the orbit have been redefined. Utilizing the maxillary, ethmoid, and sphenoid sinuses as a working corridor to the sino-orbital interface permits better illumination and visualization of the operative field and reduces the need for globe retraction. In the past five years, significant developments have been made in this field. This manuscript will focus on advances in anatomical knowledge, and current surgical techniques and approaches.

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Clinical presentation/Etiology

The extraocular muscles divide the orbit into intraconal and extraconal compartments. Early vision loss and late onset proptosis is more likely to occur with intraconal lesions as

compared to extraconal lesions that have earlier proptosis and late-onset of vision loss. Lesions in both areas can cause impaired extraocular muscle motility.¹ Orbital tumors are uncommon, occurring 3–5 times yearly per 1 million people.² Orbital cavernous hemangiomas (OCH) represent the most common benign orbital tumor in adults, constituting 5%–15% of all orbital masses, compared to infantile hemangioma in the pediatric population.³ Non-Hodgkin's lymphoma, represent the most common malignant orbital lesion in adults occurring in 8% of cases. Orbital metastases and orbital involvement from paranasal sinus tumors are also a consideration. Rhabdomyosarcoma is the most common pediatric malignant primary orbital tumor. Other benign lesions include pseudotumor, schwannoma, glioma, meningioma in adults, as well as dermoids and lymphangiomas in children (Table 1).²

Anatomy

Orbital anatomy is complex. Within the compact space, there are critical neurovascular structures and important considerations regarding the management and treatment of orbital pathologies. An endoscopic understanding of the medial orbital anatomy is essential. Several advances have recently been made in this area. The concept of the orbital anatomical compartmentalization for the endoscopic surgeon has previously been described elsewhere, it forms a foundation of standardized communication and allows preparation and planning of anticipated technical difficulties and localization of tumors.⁴

The medial orbit is separated from the sinus content by the lamina papyracea. The orbit is a cone-shaped cavity, encased by the periorbita and bounded anteriorly by the bony orbital margins and posteriorly by the orbital apex, with the optic canal and superior orbital fissure. It consists of the globe, extraocular muscles, and neurovascular structures within a fat-filled space. Arising from the annulus of Zinn at the orbital apex are the four rectus muscles (inferior, medial, superior, and lateral), which divide the orbital contents into intraconal and extraconal spaces. From an endonasal perspective, the medial extraconal compartment consists of orbital fat, and the lateral limit is the medial rectus muscles. This compartment is devoid of critical neurovascular structures other than the ethmoidal neurovasculature located superiorly above the medial rectus muscle and the medial ophthalmic vein.⁴

Within the medial and inferior intraconal space, the medial rectus and inferior rectus muscles serve as the inferior and lateral boundaries. Within this region, there exists a complex and compact neurovascular system and rich vascular arcade within orbital fat, which can make this area a challenge to navigate endoscopically (Fig. 1A). The lateral boundary consists of the optic nerve the ophthalmic artery, nasociliary nerve, and the long ciliary artery and nerve. It is essential to appreciate that the oculomotor nerve enters the superior orbital fissure and branches almost immediately into the inferior and superior rami (Fig. 1B). A branch of the inferior ramus inserts along the posterior third of the lateral surface of the medial rectus muscle. The ophthalmic artery enters the orbital apex via the optic canal and is positioned initially lateral to the optic nerve. At approximately 1 cm anterior to the sphenoid face, an inferiomedial muscular trunk (IMT) arises from the ophthalmic artery and sends an arcade of arterioles to supply the medial rectus (Fig. 1C). The IMT serves as a crucial landmark and can be used to divide the intraconal space into 3 compartments that can be associated with increasing technical difficulty. Zones A and B are anterior to the IMT, and represent the upper and lower halves of an imaginary line referenced from the medial rectus muscle. Zone A is situated inferiorly and therefore is considered to be easier to dissect compared to the superior Zone B. Zone C is situated posterior to the IMT and represents the most technically challenging, due to the close proximity of the optic nerve (Fig. 2). The ophthalmic artery can pass inferiorly to the optic nerve in 16%–33% of cases, and as a result, the artery is even closer to the dissection space in Zone C lesions.⁵

Diagnostic workup

Orbital tumors involve a multi-disciplinary team approach, including an oculoplastic surgeon, and otolaryngologist. In some cases, the inclusion of a neurosurgeon is required. It is crucial to appreciate that a team approach is vital to ensure optimal outcomes. An ophthalmological exam is conducted and includes visual field testing, and may include retinography if clinically indicated. Nasal endoscopy should be performed during the otolaryngology exam to note anatomy, septal deviation, and the presence of any concurrent pathology that will affect decision - making at the time of surgical intervention. Neurosurgical consultation should be

Table 1 Benign and malignant orbital tumors.

	Benign	Malignant
Adult	Orbital cavernous hemangioma Inflammatory pseudotumor Schwannoma Glioma Meningioma	Non-Hodgkin's lymphoma Paranasal tumors with orbital extension Orbital metastases
Pediatric	Infantile hemangioma Dermoids Lymphangiomas Histiocytic tumors	Rhabdomyosarcoma

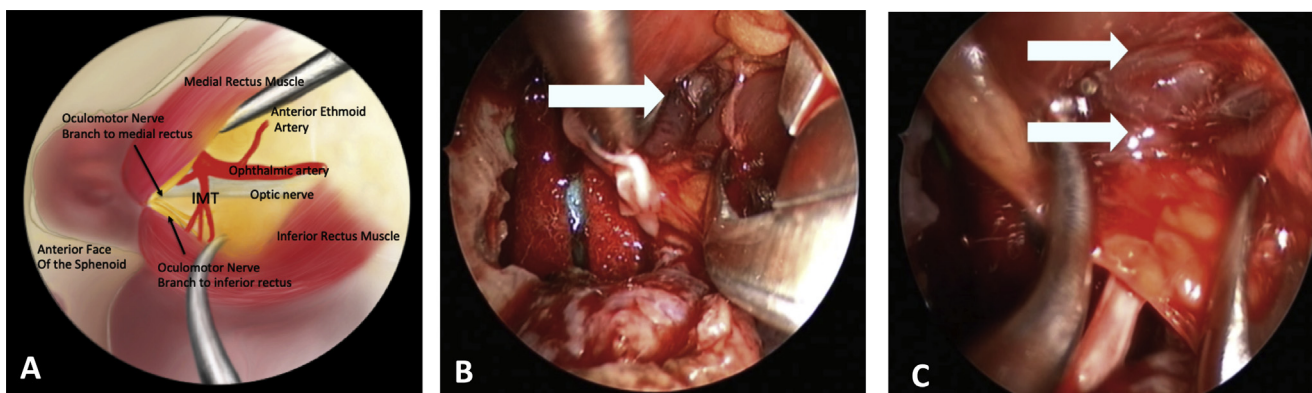


Fig. 1 Endoscopic approach to the left medial intraconal Space. A: Illustration demonstrates removal of the extraconal fat. The medial and inferior rectus muscles are retracted to highlight the critical anatomy. B: Oculomotor nerve positioned lateral to the medial rectus muscle. The ophthalmic artery enters the orbital apex via the optic canal and is positioned initially lateral to the optic nerve. At approximately 1 cm anterior to the sphenoid face, an inferiomedial muscular trunk (IMT) arises from the ophthalmic artery and sends an arcade of arterioles to supply the medial rectus. C: Arterial branches of the IMT.

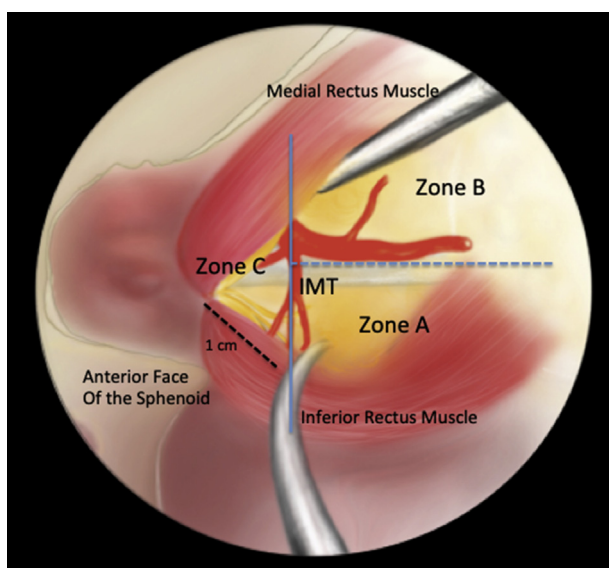


Fig. 2 The anatomical zones of the left orbit. The upper and lower halves of an imaginary line referenced from the medial rectus muscle denote Zone A and Zone B (blue dashed line - not shown in this picture as the medial rectus has been retracted). Zone C is situated posterior to the IMT and represents the most technically challenging, due to the close proximity of the optic nerve and is located approximately 1 cm anterior to the face of the sphenoid.

obtained when there is a concern for potential cerebrospinal fluid leaks, intracranial extension, or if lesions involve the proximal optic tract, or if there is the need for craniotomy.

High resolution computed tomography (CT) scans is essential to examine the underlying anatomy and pathology. Bone and soft tissue windows can provide pertinent information and can be formatted for intraoperative image guidance. Magnetic resonance imaging (MRI) assists in defining the neurovascular structures as well as soft tissue and fat planes. The relationship between the lesion, the

ophthalmic artery, and the optic nerve is of particular importance as this can be variable in up to one-third of patients and result in the potential for morbidity. Using three dimensional (3D) reconstruction based on the CT and MRI, the relationship between the tumor and optic nerve can help estimate tumor volume, and assist with spatial confirmation of anatomic lesion relative to other vital structures (Fig. 3).⁶ Angiography, is not typically required, however it can be a useful adjunct in cases of vascular anomalies and lesions that are located within the optic canal. In order to standardize outcomes in reporting on orbital tumors, a multi-disciplinary international group of expert panelists developed the International Cavernous Hemangioma Exclusively Endonasal Resection (CHEER) staging system.⁷ The staging system provides a universal standardized language for outcome reporting and collaboration, and allows stratification of potential difficult OCHs based on their location within the orbit. The staging system is based on differentiating extraconal or intraconal lesions. Key anatomic landmarks then further divide the intraconal lesions are centered on the relationship of the IMT, the ophthalmic artery, horizontal axis of the medial rectus, as well as extension to optic canal, inferior orbital fissure, or superior orbital fissure (Fig. 4).

The surgical technique

The endoscopic approach begins with adequate exposure of the lamina papyracea by creating a working space with a wide opening of the maxilla, ethmoid and sphenoid sinuses. The decision to open the frontal sinus can depend on the location of the orbital lesion and if there is any concurrent sinus pathology that needs to be addressed. The middle turbinate may be resected to increase access and visibility. The location of the orbital lesion within the orbit relative to the optic nerve dictates the choice of the approach. Pathology located with an epicenter medial to the optic nerve or below a "plane of resectability" (POR), which represents a plane subtended by the contralateral nostril and the long axis of the optic nerve, are amenable to the exclusively

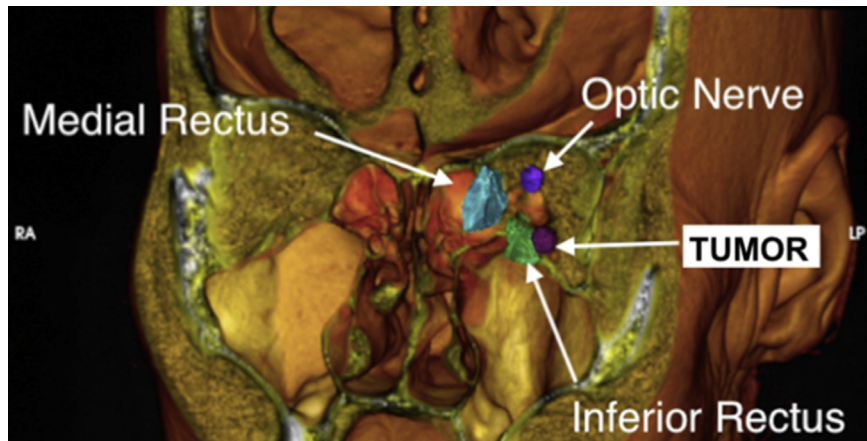


Fig. 3 Using three dimensional (3D) reconstruction based on the CT and MRI, the relationship between the tumor and optic nerve can help estimate tumor volume, and assist with spatial confirmation of anatomic lesion relative to other vital structures.

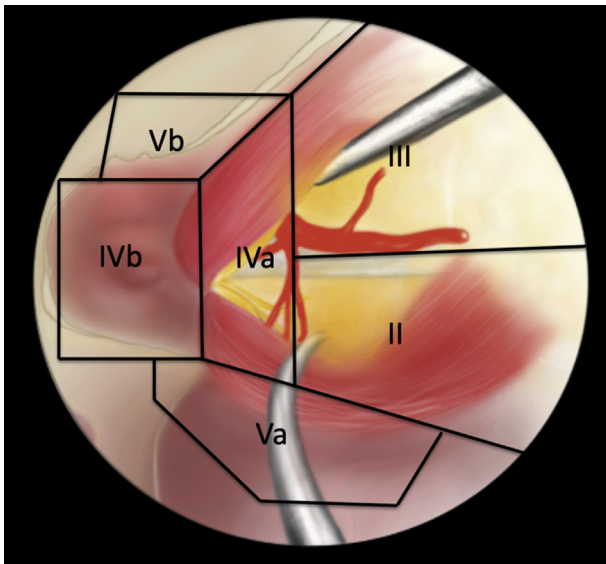


Fig. 4 Cavernous Hemangioma Exclusively Endonasal Resection (CHEER) staging system. Within the intraconal space, the staging system further subdivides based on the relationship to the IMT of the ophthalmic artery, horizontal axis of the medial rectus, as well as extension to optic canal, inferior orbital fissure, or superior orbital fissure.

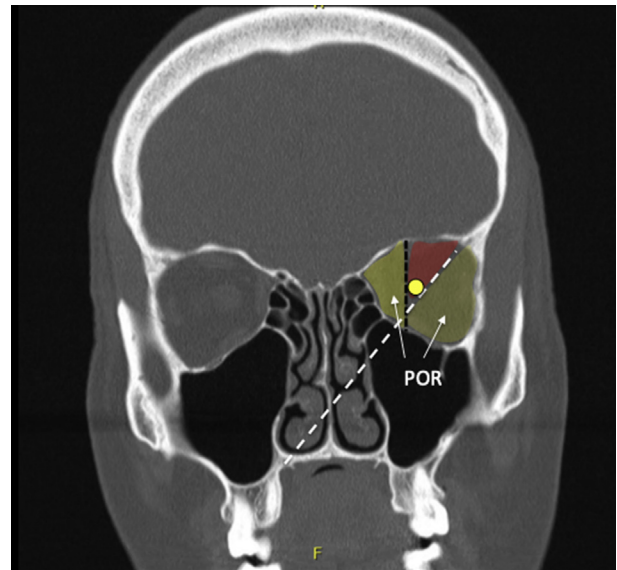


Fig. 5 The location of the orbital lesion within the orbit relative to the optic nerve dictates the choice of the approach. Pathology located with an epicenter medial to the optic nerve or below a "plane of resectability" (POR), which represents a plane subtended by the contralateral nostril and the long axis of the optic nerve, are amenable to the exclusively endoscopic resection (EER). The red shaded area represents the area that is unresectable by the EER.

endoscopic approach.⁶ The feasibility and safety of this approach has been consistently demonstrated in the literature.^{3,8–16} Lesions that have tumor volume lateral and inferior to the plane of resectability can be resected, however lesions lateral and superior to the POR, are not candidates for purely endoscopic approach (Fig. 5).

The decision to perform a uninarial or binaral approach depends on the location and size of the tumor as well as the preference of the surgical team. Extraconal lesions are more likely to involve a uninarial approach. A binaral, four-handed trans-septal approach is more commonly used in intraconal resections. This technique requires a posterior septectomy or septal window to permit cross table work within a confined space, assisting with maneuvering of

endoscopes and instruments. The dynamic retraction of the medial rectus muscle and retraction of the prolapsed orbital fat, and the trajectory of the surgical instruments via the trans-septal route facilitates easier dissection of the lateral aspect of the orbital lesion. This is associated with minimal morbidity, and may be incorporated into the elevation of a nasoseptal flap for medial wall reconstruction.¹⁶ A nasoseptal flap can be raised from the contralateral side prior to the posterior septectomy. The size of the nasoseptal flap is based on the location of the lesion, and degree of dissection required and therefore is tailored to each individual case. Removal of the orbital process of the

palatine bone can provide an additional $0.36 \pm 0.42 \text{ cm}^3$ of exposure in the inferolateral vector.¹⁷ If required the optic strut may be drilled to permit safe removal of the thick bone overlying the optic nerve. The lamina papyracea is then removed with blunt dissection to expose the underlying periorbital. The periorbital is incised in a reverse hockey stick fashion just anterior to the tumor border, this is to prevent unnecessary orbital fat prolapsing into the anterior field. The intraconal dissection corridor is bounded by the medial rectus above and inferior rectus below. A periorbital window is created between the medial and inferior rectus and allows for identification of the extraconal fat and muscles. A blunt dissector, such as a penfield or lusk probe, is then used to dissect between the medial and inferior rectus and to visualize the intraconal space. The medial rectus serves as a landmark of the medial orbit and is retracted to access intraconal orbital lesions. The medial rectus is retracted with care using a right-angled instrument under the inferior border of the muscle and gently and dynamically retracting the muscle in a superio-medial direction to prevent post-operative diplopia.

Monopolar cautery is relatively contraindicated when operating within the orbit due to a significant risk of thermal conduction to vital neural structures.³ Bipolar cautery can be used in a judicious and precise manner has been reported however if possible other hemostatic techniques such as saline soaked cottonoid pledgets, and warm water irrigation have all been documented to be relatively safe for use.³

The herniation of orbital fat into the nasal corridor can limit visualization and add unnecessary complexity to the operation. Preserving the extraconal fat not only helps to preserve orbital volume,¹² but also minimizes the risk of medial rectus scarring and entrapment. Extraconal fat removal can be avoided by correct placement of the peri-orbital incision.^{8,15} The use of cottonoid pledgets, to separate and retract the orbital fat can assist with visualization and assist with keeping the intraconal corridor open.

The resection of tumors is dependent on whether or not a tumor capsule is present. The most common primary benign tumor of the orbit is an OCH, and they are characterized by a fibrous capsule and do not typically infiltrate into the surrounding tissue. In most case series involving

OCH the literature describe a process of gentle traction, cottonoids, and blunt dissection.^{8,18} Other tumors may require the use of sharp cutting instruments to dissect out the lesion, which can increase the risk of bleeding from inadvertent arteriolar injury.^{8,19} Incomplete resection is acceptable for a benign lesion and has been documented in cases where the lesion was adherent to the optic nerve, however, long-term follow up remains unknown.¹⁰

Reconstruction of the medial orbital wall

Preservation of orbital volume is a key reason to consider reconstruction of the medial orbital wall, and it should be considered when intraconal or large extraconal lesions are being resected. Deliberate placement of orbital fat over the extraocular exposed muscles to prevent scarring has been described.^{8,20} The current consensus on the best reconstruction options remains unknown, however it is agreed that immediate rigid reconstruction does place the orbit at risk for compartment syndrome due to edema and postoperative bleeding. The pedicled nasoseptal flap technique is preferred by the authors as it provides the opportunity for a delayed contraction thereby reducing the risk of diplopia and enophthalmos (Fig. 6A and B).²⁰

The role of nasal packing

Despite no consensus on whether to use nasal packing is necessary it is widely accepted that nasal packs should not be placed in a position which could risk exerting direct pressure on the exposed orbit.²⁰ Alternatively, absorbable hemostatic packing has been reported. Placement of a polyvinyl acetate sponge placed innasal cavity to assist with adherence and positioning of a nasoseptal flap for 7 days has been documented.²¹

Post operative care

Post operatively, all patients routinely undergo vision assessment in the recovery room. Routine serial assessment of vision is then continued. Signs of hemorrhage or peri-orbital swelling that is beyond anticipated routine post

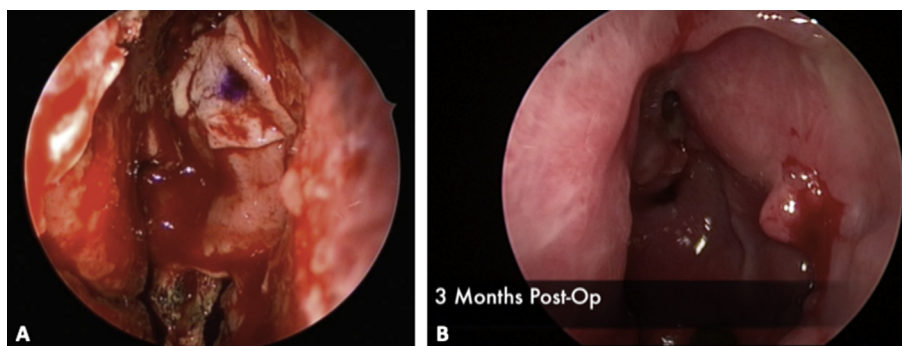


Fig. 6 A: Reconstruction of the left medial orbital wall using a right pedicled nasoseptal flap from the contralateral side and positioned over the left extraocular exposed muscles to prevent scarring, reduce delayed contraction and subsequently diplopia and enophthalmos. B: At 3 months post op the nasoseptal flap is well healed and there is a patent sphenoid sinus.

surgical changes requires further assessment and a low threshold for re-exploration in the operating room in the setting of ongoing hemorrhage, proptosis and swelling. Corticosteroids can be utilized post operatively, and are advocated by some institutions, to reduce edema and theoretically reduce the risk of optic nerve compression. Saline irrigation sprays can be used for patient comfort, but the use of saline irrigations is withheld for at least 2 weeks post recovery, to allowing adequate healing and prevent saline irrigation entering through the orbitotomy. Post operative debridement at the first one week visit is to important maintain the inferior nasal airway and check on the status of the nasal airway and flap position, however usually the debridement at the following clinic appointment at week 3 is more extensive.

Conclusions

Endoscopic endonasal orbital surgery continues to evolve utilizing the sinuses as a working corridor to the sino-orbital interface is a natural extension of endoscopic skull base surgery. The role of the multidisciplinary team is not to be underestimated. Understanding the anatomy is critical, the introduction of a classification system to ensure standardization of technical difficulty and outcome data will assist with international collaboration and further consolidate our attainment of knowledge in this developing field.

Conflicts of interest/Financial disclosures

N/A.

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