Surgery around the Orbit: How to Select an Approach

Davide Locatelli[1] Iacopo Dallan[2] Paolo Castelnuovo[3]

[1] Division of Neurosurgery, Department of Biotechnology and Life Sciences, "Ospedale di Circolo e Fondazione Macchi," University of Insubria, Varese, Italy
[2] Department of Otorhinolaryngology Azienda Ospedaliera Universitaria, Pisa, Italy
[3] Division of Otorhinolaryngology, Department of Biotechnology and Life Sciences, "Ospedale di Circolo e Fondazione Macchi," University of Insubria, Varese, Italy

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Address for correspondence Davide Locatelli, MD, Division of Neurosurgery, Department of Biotechnology and Life Sciences, "Ospedale di Circolo e Fondazione Macchi," University of Insubria, Varese, Italy (e-mail: davide1.locatelli@uninsubria.it).

Abstract

Orbital region pathologies may be safely and effectively treated through a various number of approaches. As the concept of "outcome" and minimally invasive surgery keeps gaining popularity in neurosurgery, these approaches—each with specific indications and limitations—together provide the best surgical options.

Keywords
- orbital surgery
- assisted endoscopic surgery
- endoscopy
- orbital tumors
- superior eyelid approach
- inferior eyelid approach
- endonasal orbital approach

Introduction

The orbit can harbor more than 100 different clinical pathologies, both benign and malignant in nature, in a different relationship with local structures. To manage such a wide variety of lesions, various surgical approaches have been described. In the last few years, endoscopic transnasal and transorbital surgical techniques have been developed and are commonly used to ensure effective, minimally invasive, and safe management of these types of lesions.[1–3]

The orbital region represents a complex anatomical which can be defined as a target of local diseases or as a corridor to the anterior and middle cranial fossae.[4] In this article, we will discuss these two anatomical and surgical nuances in detail, focusing on the various pathologies that can be reached via transorbital neuroendoscopic approaches.

Pearls and Tips

- Preserve orbital capsule.
- Do not apply excessive and continuous compression to avoid damage of optical nerve.
- CSF-leakage repair from eyelid superior approach requires standard techniques, that is, fascia lata and fat free grafts.

Intraorbital Lesions

Orbital lesions can be divided into intraconal and extraconal lesions based on their location within the orbit.

Intraconal Lesions

More than 60% of intraconal diseases are inflammatory: one of the most common is Grave's disease, which is related

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to a dysthyroid condition. Surgical decompression is recommended, especially in case of ophthalmoplegia or neuropathy.[5]

The majority of neoplastic lesions are B-cells lymphomas, while fewer are low-grade non-Hodgkin's lymphomas or mucosa-associated lymphoid tissue diseases. They are common among patients older than 50 years and present with painless unilateral proptosis, loss of visual accuracy, and inconstant motility disturbances. Solid tumors account for approximately 4% of orbital intraconal diseases and are represented by schwannomas or neurofibromas. They arise from cranial nerves branches, as well as sympathetic or parasympathetic nerves.[6]

Cavernous hemangiomas are the most common vascular disease.[7] They are ectatic venous spaces surrounded by a fibrous capsule and predominantly develop in the intraconal space. They are rounded, well-defined lesions with calcifications on computed tomography scans, while on magnetic resonance imaging, they appear hypointense on T1-weighted images with delayed contrast enhancement, hyperintense on T2-weighted images, with various hemorrhagic deposits on susceptibility-weighted imaging. Venous lymphatic malformations are uncommon vascular lesions of unknown origin. For their intrinsic nature, they are prone to bleed acutely with sudden onset of proptosis, periorbital swelling, and reduced eye mobility. They share similar radiological characteristics to cavernous hemangiomas, but they do not enhance after contrast injection.

Extraconal Lesions

The extraconal space can host inflammatory lesions, infectious diseases, mucopyoceles, and tumors. Infections happen in children, as complications of rhinosinusitis which may extend into the orbit as well as intracranially, in the form of epidural abscesses. Mucoceles arise from paranasal sinuses and commonly result from obstruction of the sinus ostium. The obstruction may derive from posttraumatic, postoperative, or neoplastic conditions (secondary mucocele).

The extraconal space is often the first compartment involved in periorbital tumors. The most common and highly malignant tumor of this location is rhabdomyosarcoma. It is frequent in infancy and presents itself with visual loss, exophthalmos, and motility disturbances.

Rarer lesions that can involve the extraconal space are hemangiopericytomas, esthesioneuroblastomas, sinonasal carcinomas, and Langerhans cells histiocytosis.

The lacrimal gland can be reached easily via transorbital neuroendoscopic approaches, as will be explained later. Lacrimal gland lesions mainly present as nonspecific enlargement of the gland and can be divided into epithelial and nonepithelial, congenital or acquired, inflammatory, and neoplastic lesions. The most common congenital disease is dermoid cyst, which arises from the epithelial remnants of embryonal tissue. Pleomorphic adenoma is the most frequent benign lesion, typical of middle-aged patients harboring from the inner lacrimal gland lobe. Adenoid cystic carcinomas represent up to 29% of all epithelial lacrimal gland tumors.

Orbit as Corridor

The transorbital approach is the preferred approach for treatment of spheno-orbital meningiomas.[8] Those extra-axial tumors arise from the sphenoid ridge and may extend laterally into the temporal bone, medially into the cavernous sinus, and anteriorly to the orbit. They can also invade the dura of the fronto-orbital and temporo-sphenoidal region, and are responsible for various degrees of hyperostosis. These lesions have two components: (1) a meningeal “en plaque” component and (2) a hyperostotic bone component involving the orbital walls.[9] For this reason, they usually present with unilateral exophthalmos, vision or visual field deficits, extraocular movement palsy, and cosmetic deformities. For years, traditional fronto-temporal, fronto-temporo-orbital, and supraorbital craniotomies were the only approaches to treat spheno-orbital meningiomas. In the past few years, endoscopic endonasal and transorbital approaches to remove these tumors have been successfully performed.

Other possible indications can be the repair of skull base defects, the treatment of skull base fractures, the drainage of epidural abscess, or hematoma.[2]

Anatomic Location

Endoscopic transorbital and transnasal corridors are among the most recent and interesting advances in all of skull base surgery. They can be considered effective and safe surgical approaches dealing with both medial and lateral intraorbital diseases, and should therefore be considered valid alternatives to more conventional external procedures.[3] Moreover, if we consider the orbit as a corridor, the transorbital route represents a versatile approach to reach the anterior and middle cranial fossae. In selected cases, a modular, combined, and multiportal approach could overcome the boundaries of a single approach.[10]

The choice of the right approach depends on several aspects, such as lesion localization, the relationship with near neurovascular structures, the suspected histological nature of the lesion, skull base team expertise, and various factors related to the patient (i.e., age and comorbidities).

Patient positioning is common for every described approach, as in a standard endoscopic surgical procedure. The head is frameless if an extradural approach is planned and is fixed only if intracranial dissection is required. We recommend using neuronavigation (image guidance) in every case, in particular in intraconal, orbital apex, and intracranial procedures.

All these surgical procedures are performed using a three- or four-hand technique, without using an endoscope holder. Following the surgical preferences, the first surgeon may hold the endoscope and another instrument, while the other surgeon takes care of a second instrument and suction/irrigation. As an alternative, the first surgeon may work bimanually while the second one holds the scope.[11] During surgery, we commonly interrupt the operation and the associated retraction of the orbital contents several times to avoid excessive pressure and for eye relaxation.

At the end of the intervention, meticulous hemostasis must be performed. In case of intradural pathology as Dallan et al suggest,[4] dura reconstruction is not needed as the orbit contents may act as a natural seal, minimizing the risk of a postoperative cerebrospinal fluid (CSF) leak. At the end of the procedure, the wound is reapproximated and closed with a buried 6–0 fast-absorbing gut suture at the apex and the superior and inferior limbs of the incision, providing excellent functional and cosmetic results. In case of endoscopic endonasal approaches, no external incisions are required.

Superior Eyelid Approach

Transorbital corridors are usually employed to manage extra and intraconal superior and laterally located lesions. If a transdural approach is planned, the transorbital route has its main indication in treating lesions localized lateral to the most lateral limit of the endoscopic endonasal approach to skull base, meaning the lateral portion of the superior orbital fissure, the lateral portion of cavernous sinus, and the retroorbital region of the great wing of sphenoid bone.[12] In combination with transnasal approaches, it gives origin to a multiportal procedure.

After an upper eyelid incision is made, the orbicularis oculi muscle is identified. It is opened in line with its fibers, and dissection is performed in a superolateral direction up to the zygoma and to the frontozygomatic suture laterally. At this point, a skin-muscle flap is raised mostly supero-laterally until the bony orbital rim is found. Once exposed, the periorbita can be incised or saved based on the primary goal of surgery.[4] Generally, in the corridor approach, it is spared while in the orbital approach, it is cut. If an opening is created, orbital fat will protrude into the operative field and should be managed with retractors. Once enough room is available, a 0-degree endoscope (Karl Storz, Tuttlingen, Germany) is introduced, and next steps are performed under complete endoscopic control.

In an anterior cranial fossa approach, the craniectomy involves the drilling of the orbital roof in the lateral basal frontal bone. The osteotomy comprises the excision of frontal bone, together with lesser wing, leaving the greater wing intact. Di Somma et al suggest that the removal of the zygoma body gives more room for dissection.[12] The boundaries of this approach are superiorly the orbital rim; inferiorly the lesser sphenoid wing; laterally the pterion; and medially the lateral aspect of the superior orbital fissure hemostasis can be obtained with continued hot water irrigation, using a diamond burr, cautious topical application of hemostatic matrix, and compression. After performing the craniectomy, the dura mater of the frontolateral convexity comes in view. Dura mater is divided according to individual requirements, and the basal frontal lobe with orbital gyri is exposed.

In the middle cranial fossa approach, the dissection proceeds from the orbital rim in a subperiosteal fashion until inferior and superior orbital fissures are reached, and the greater wing of the sphenoid and the lateral aspect of the upper orbit are fully exposed. Several bridging vessels are seen during this dissection, which should be coagulated and cut. To protect the orbital contents during infero-medial retraction of the orbital contents, we adopt a thin malleable retractor or a soft Silastic sheet (Dow Corning, Midland, Michigan, United States). The supero-medial limit of the approach is the superior orbital fissure, while the lateral boundary is delineated by the temporalis muscle. In case of an intracranial approach, the dura is opened and the anterior part of the temporal lobe of the brain is reached following the subsequent steps. The craniectomy to reach to the middle cranial fossa is performed through the greater wing of the sphenoid, limited medially by the lateral aspect of the superior orbital fissure and laterally by the temporal is muscle. If more room is needed, the bone window can be enlarged inferiorly to include the floor of the middle cranial fossa, and superiorly the approach can be partially extended to the lesser wing of the sphenoid. Removal of the greater wing of the sphenoid allows exposure of the dura mater of the middle cranial base right in front of the temporal pole.[10] The dura is divided, and the intracranial exploration can be done. Superiorly, this approach can be extended to the anterior clinoid process and to the floor of the middle cranial fossa, gasserian ganglion, intracranial tract of trigeminal nerve branches, and the lateral wall of the cavernous sinus. Chen et al have even proved in a cadaveric study, the feasibility of an endoscopic amygdalohippocampectomy adopting this corridor.[13]

Regarding intraorbital pathologies, no craniotomy or craniectomy is required. After having obtained sufficient working space and separating the orbital content from the bony walls, the endoscope is inserted in the surgical cavity and the procedure is performed under endoscopic guidance. The orbital contents are entered with an incision that is taken on the periorbital layer at the approximate depth of the lesion according to image guidance. The periorbital incision reveals the extraconal fat, which is more distinct in an anterior direction, where the lacrimal gland can be seen. To proceed safely with the intervention, several anatomical structures should be identified. The lateral rectus muscle is the first reference point that needs to be identified to guide further steps. Above the lateral rectus muscle, the next structure encountered is the lacrimal neurovascular "bundle," formed by the nerve, artery, and vein, overlying the superior surface of the lateral rectus before it inserts onto the capsule of the lacrimal gland.[4] The orbital branch of the middle meningeal artery can enter the orbit through the superior orbital fissure and usually, it joins the lacrimal artery. It can be spared or coagulated as required. Near the superior orbital fissure, posteriorly, the superior branch of the third cranial nerve is visible. Moreover, the superior ophthalmic vein can be identified more posteriorly right above the optic nerve and below the superior rectus muscle. Posteriorly, toward the apex and superior orbital fissure, the inferior division of the third cranial nerve can be seen deep. Once the lesion is identified, gentle dissection with blunt and sharp instruments is performed all around. The crucial point, in case of high-vascularized lesions, is to identify the feeding arteries and coagulate them with bipolar forceps. The identified lesion is gently removed and the surgeon performs a meticulous hemostasis in the surgical field, respecting all the critical neurovascular structures.

Inferior Eyelid Approach

The main indications for the inferior eyelid approach are lesions located in the inferior intraconal space. It can also be used for dealing with orbital floor decompression and to repair orbital floor fractures as well as select intraconal lesions. If a multiportal approach is planned, it can be combined with an endoscopic transnasal corridor.

The inferior eyelid approach starts with a subciliary or subtarsal incision, generally performed 3 to 5 mm below the free margin of the lower eyelid.[2] The subtarsal incision is preferred and in this case, dissection is carried below the orbicularis and a skin-muscle flap is elevated. Further dissection should be performed in the preseptal plane until the orbital rim is reached. The next step is the identification of the bony orbital rim, where the periosteum is visualized and incised.

At this point, the dissection is performed in a subperiosteal fashion until the inferior orbital fissure (IOF) is clearly recognized. This creates enough space for the following steps. The contents of IOF can be transected from antero-lateral to postero-medial direction, to facilitate exposure of the orbital floor as far as the orbital apex.[2] In this way, the anterior maxilla and orbital floor can be fully exposed.

This kind of approach allows a direct exposure of the floor of the middle cranial fossa, with the possibility of transdural approaches directed at the temporal lobe. Moreover, just inferior to the horizontal aspect of the sphenoid greater wing, the infratemporal fossa is found, with the possibility to reach the intra- and extracranial segments of the maxillary and mandibular nerves.

Endoscopic Transnasal Transorbital Approaches

The transnasal transorbital corridor represents a valuable solution to manage both intraconal and extraconal medial orbital lesions, avoiding external medial approaches which often require one or more orbitotomy and muscle detachment. Other indications may include orbital and optic canal decompression, and repair of medial and inferomedial wall fractures.[14] Even in this case, in combination with a superior and inferior eyelid approach, it can give rise to a multiportal procedure for selected anterior and middle cranial fossa lesions.

After maxillary antrostomy and a standard spheno-ethmoidectomy, the lamina papyracea is removed and the periorbita is opened in the most suitable area to dominate the lesion.

Extraconal lesions located medially usually come into direct view after the opening of the periorbita, or after minimal dissection into the periorbital fat.[15] In intraconal lesions, the orbital fat is reduced via bipolar cautery and the medial muscular wall is identified. For lesions located inferomedially, the corridor is represented by an inferior window located between the medial and inferior rectus muscles, while in the more infrequent cases of supero-medial lesion, the working space is obtained between the medial rectus and the superior oblique muscles.

When curative surgery is planned, dissection is performed until the capsule of the lesion is reached, which can be hard and time consuming because of the extreme mobility of the orbital structures. In this regard, the help of devices like cryo-probes can ease the process.[16,17]

For intraorbital neoplasms located lateral to the optic nerve, the transorbital endoscopic approach represents the less invasive route to perform biopsies, debulking or complete removal of the lesions. As most lesions are located superolaterally, the access is usually provided via a superior palpebral incision, followed by dissection to expose of the superior orbital rim. The dissection is continued in a subperiosteal plane on the superolateral wall of the orbit until the superior and IOFs are exposed. The periorbita is finally opened, and the lesion is dissected from orbital fat and extraocular muscles. As not all the lesions are completely accessible with one of the two approaches described, a combined approach is sometimes necessary, using both transnasal and transorbital corridors.

Specialties Involved

Orbital pathologies are very complex and delicate. Therefore, choosing the right approach represents the key point in a multidisciplinary curative strategy. For this reason, before performing this type of surgery, a careful study of the case with the various specialists involved is mandatory.[18]

A skull base team focused on orbital pathology should include specialists such as otolaryngologists, neurosurgeons, and ophthalmologists. They have a fundamental role which is not limited to the operating theater but crucial during the pre- and postoperative evaluation and also for nonsurgical therapy. Other specialists must be consulted in case of malignant or systemic diseases where surgery of the orbital lesion constitutes the first step of a complex multidisciplinary treatment. In this sense, the creation of tumor boards in every hospital is fundamental in a medical perspective built around the patient's well-being.

Last but not least, we believe that this type of surgery should not be undertaken without an excellent knowledge of the anatomy of the orbit and without mastering both conventional and endoscopic techniques. The latter specifically require long learning curves, with hours of training in the dissection laboratories; if we are speaking about saving patient's vision, the stakes are very high.

Reconstruction Options

The reconstruction of the anatomical continuity after transorbital surgery is a subject of debate and depends on numerous factors.

In the endoscopic transnasal transorbital approach, reconstruction of the medial orbital wall is not necessary,[19] as reported by Karligkiotis et al, even in the case of wide removal of the periorbit and extensive intraorbital dissection. In fact, Nicolai et al[20] demonstrated that removal of the lamina papyracea or even the medial wall of the orbit does not affect the eyeball position or its movements if the periorbita is preserved. Moreover, Castelnuovo et al suggested that orbital stability is related more to the intraorbital septa than to the periorbit itself.[21] The same authors reported that even if the only periorbital layer is removed and an intraconal dissection is performed with interruptions of the connective septa, postoperative scar tissue is enough to restore the orbital continence.[14,21] For this reason, we usually do not perform a medial orbital reconstruction, and we place of a thick silastic sheet in an inverted U-shape in the nasal cavity. This is sufficient to ensure spontaneous reconstruction of the medial orbital wall together with its reepithelization.[19]

In the lateral transorbital approach, a distinction must be made. In case of intraorbital lesions, both intra- and extraconal, reconstruction in not needed. We suggest filling the orbital empty space with fat to reduce the risk of postoperative enophthalmos.[9]

If the orbital corridor is utilized to reach the anterior or middle cranial fossa with a dural opening, the risk of postsurgical CSF leakage theoretically exists. Dallan et al suggested[4] that this risk is remote because the orbit contents may act itself as a natural seal. Many authors, however, described the need for skull base repair according to a standard multilayer reconstruction technique. Alqahtani et al described a multilayer technique for skull base reconstruction during transorbital transnasal endoscopic combined approach to the anterior and middle skull base.[19] They put an intracranial intradural layer with synthetic graft, followed by muco-periosteal septal graft that was used in overlay fashion to cover the superior orbital wall defect. In another publication,[10] the skull base reconstruction was performed in a multilayer fashion, using such autologous materials as iliotibial tract and fat tissue harvested from the right thigh of the patient. Even in case of spheno-orbital meningiomas, many authors performed a multilayer skull base reconstruction.[9] Bony reconstruction of the lateral orbit wall is not necessary, and usually, drilling of the hyperostotic bone is done to reduce proptosis and reestablishing of the normal orbital cosmetic appearance.

Intraoperative Neurophysiology

During surgery of intra- or periorbital lesions affecting visual pathway, we do not use routinely intraoperative visual evoked potential (VEPs) monitoring.

However, intraoperative monitoring of visual pathway (VP) has been studied in the last years for the possible application during transorbital procedures. From the beginning of the 70s, some authors proposed VEPs for intraoperative monitoring of VP in patients affected by Graves' disease or lesions involving the orbital, sellar, and parasellar region.[22] VEPs are usually performed by scalp electrodes on the occipital area because subcortical recording is often not available for the operative positioning and also because the idea of an occipital craniotomy is not easily acceptable for the patient. Since these first reports in orbital surgery, much interest was posed in studying the different waveforms in the monitoring of VEPs during various kind of surgeries, although a strong correlation between intraoperative modification of VEPs during surgical manipulation and the visual outcome has not been proven.[23,24]

In the last decade, some authors executed the possibility to use such neurophysiological assessments also during transorbital surgeries for anterior cranial base and orbit masses. In 2012, Chung et al published a work where their experience in intraoperative VEPs monitoring during endoscopic transsphenoidal surgeries for sellar or perisellar lesions was presented. In that series, they collected data from patients affected by different types of lesions (craniopharyngiomas, pituitary adenomas, Rathke's cleft cyst, etc.) who underwent continuous intraoperative monitoring of VEPs during surgery. Pre- and postoperative assessment of VEPs and visual status was recorded to evaluate visual outcome in according to intraoperative VEPs' waveform alterations. No complication directly related to the monitoring occurred, and although well reproducible waveforms were obtained, they did not find any statistically significant correlation between intraoperative decreasing of VEPs and the postoperative visual outcome of the patients.

Anyway, some tricks may rationally be taken into consideration when performing transorbital neuroendoscopic surgery. For example, we suggest relieving often, during surgery, the pressure on bulbar, vascular, and nervous structures to avoid microvascular injuries or optic nerve stretching and possible ischemia. Moreover, care should be taken—especially in long procedures—to prevent eye opening and possible dryness, avoiding corneal ulcerations. However, in more than 120 orbital surgeries performed in more than 10 years, we did not experience orbital complications directly related to neurovascular or bulbar manipulation.

Complications

Endoscopic Transorbital Approach

In the transnasal approach to target orbital pathologies, complications considerably differ according to the location, since managing the intraconal space rather than the orbital apex region presents a greater degree of surgical difficulty with consequent greater risk of intraoperative and postoperative complications.

Extraconal Neoplasms

Most of the literature[14,15,25–29] agrees with the efficacy and safety of the endonasal approach to address extraconal neoplasm. Intraoperative or postoperative complications are rarely encountered in these cases, as no critical neurovascular structures are encountered during the dissection. The main concern in this case is with regard to the manipulation of extraconal periorbital fat and the need for reconstruction of the medial orbital wall, a topic that has already been addressed. Nowadays, it is common opinion that the removal of intraorbital fat should be performed very cautiously only if really needed, the main concern being postoperative enophthalmos. Extraconal orbital fat is mobilized with saline-soaked cottonoids (Neuro Patties) to get access to the neoplasm, and it can be shrunk with judicious use of bipolar electrocautery to improve visualization. In contrast, the removal of intraconal fat is to be avoided whenever possible due to possible trauma to the delicate inferomedial branches of the ophthalmic artery that supply the belly of the medial rectus muscle as well as branches of the third cranial nerve.[30] If these surgical hints are followed carefully, the complications are in terms of new diplopia or new enophthalmos is rarely encountered, generally in <15% of the cases.[27]

Intraconal Neoplasms

Surgical Intermuscular Windows and Postoperative Diplopia

As already mentioned, intraconal dissection can be performed through the inferior window between medial and inferior rectus muscle, and through a superior window between medial rectus and superior oblique muscles. Different methods for enlarging the surgical window to dissect inside the intraconal space have been described: detachment of the muscle, external traction from insertion point through a transconjunctival route,[31] transchoanal,[32] and transeptal retraction,[33] use of specific muscular divaricator.[34] All of these methods provide a certain degree of medial rectus muscle displacement, which improves surgical exposition at the expense of a variable degree of muscular impairment, with subsequent diplopia.

Nowadays, it is possible to operate in the intraconal space without resorting to such muscular retraction, performing only a blunt dissection in the previously described "windows" between the muscles. This is done either superiorly or inferiorly to the medial rectus muscle, which still represents the main anatomical barrier that hinders most of the intraconal region. The main factor in the decision to use the approach is to be used is the location of the neoplasm. In the authors' opinion, whenever possible it is preferable to use the inferior window to access the lesion, the reason being the paucity of major arterial and venous vessels in this intraconal orbital region (see below).

Critical Neurovascular Orbital Structures

The medial intraconal space is a narrow region rich in critical neurovascular structures (e.g., branches of third cranial nerve to the extraocular muscles, anterior ethmoidal artery and branches, long and short ciliary nerves, optic nerve). They all must be preserved anatomically and functionally intact to prevent intraoperative and postoperative complication. Possible complications resulting from inadvertent damage of these structures include bleeding, diplopia, weakening or loss of pupillary reflex, and visual impairment. With regard to bleeding, the most useful techniques to manage eventual bleeding into the orbit is cautious use of bipolar with frequent saline irrigation, which both enhances the hemostatic effect of bipolar cautery and protects surrounding structure from thermal damage. The use of bipolar cautery must be limited to a minimum and always under direct vision, avoiding to blindly coagulate in the intraorbital region due to the possible damage to important neurovascular structures. However, the critical factor in limiting the possibility of orbital complications is to perform a safe intraconal dissection. As already mentioned, this is done by using saline-soaked neurosurgical patties until adequate access to the malformation is achieved. In case the aim of the surgical intervention is the removal of the malformation, the dissection is to be performed into the nasal fossa space, limiting intraorbital dissection to a minimum. This is achieved by traction of the lesion outside the orbital region into the nasal fossa, so that the dissection can be performed under direct vision, thus preventing damage to intraorbital structures due to inadequate visualization. Traction of the lesion is mainly achieved with grasping forceps, even though this might be challenging in some cases and cause the inadvertent rupture of the malformation, which must be avoided in any case. The use of cryoprobes is effective and safe in this regard, and it does not compromise microscopic examination of the specimen.[16,17]

When approaching intraconal neoplasms, the surgeon must be aware that critical areas due to the presence of vessels and nerves are the superior portion of the orbit and the orbital apex. As already mentioned, it is preferable to perform intraconal dissection through the inferior window between the medial and inferior rectus muscle whenever possible due to the paucity of important neurovascular structures in this area. In case of a supero-medial location of the lesion, a superior window approach might be the most appropriate, but in this case, prophylactic coagulation and cut of anterior ethmoidal artery are advisable to prevent intraorbital stripping of a bleeding artery which might be critical to control. In case of a posteriorly located intraconal lesion, critical sites are represented by the region posterior to the inferomedial muscular trunk of the ophthalmic artery of the extension toward or into the optic canal. [27] Anterior to the inferomedial trunk of the ophthalmic artery, the inferior orbit is free of important neurovascular structures and dissection is safe. In posterior cases, a working knowledge of the endonasal anatomy of the orbital apex is a prerequisite to perform this surgery.[14,35]

In particular, the course of the oculomotor nerve along the medial aspect of the medial rectus muscle is of paramount importance to prevent possible damage: the nerve divides into superior and inferior branches before entering the orbital region and these nerves penetrate the muscular bellies at approximately one-third of the distance from the annulus of Zinn to their insertion on the globe.[36]

Transpalpebral Approach

Some critical aspects need to be mentioned when considering transorbital endoscopic approaches for both orbital and skull base pathologies. The transpalpebral corridor represents a minimally invasive approach in term of skin incisions and need for bony work, since a small cutaneous access is realized, using a preexisting skin crease of the superior tarsus in most of the case. However, even if rarely encountered nowadays in clinical practice provided that proper asepsis is respected, surgical site infections, postoperative edema, diastasis of the cutaneous suture still represent minor complications that need to be mentioned.

Subcutaneous dissection represents a crucial step for the surgical procedure, as it carries the risk of damaging the elevator palpebrae muscle, with consequent palpebral ptosis. With appropriate training in performing the access, this complication is very unlikely to be observed, but nonetheless it should be discussed preoperatively with all patients.

With regard to intraorbital endoscopic dissection, a possible concern is related to orbital compression during the procedure. In this regard, the surgeon should provide an opportunity for relaxation of the orbital contents during the surgical procedure to prevent a persistently elevated intraocular pressure, which might produce ischemic damage to the optic nerve. Provided this technical hint, safety of this kind of surgery has been confirmed by many experiences, dealing with both orbital pathologies[3,18] and skull base lesions.[2]

No cases of postoperative visual deficit related to persistently elevated intraorbital pressure have been reported.

With regards to intraorbital dissection through a transpalpebral approach, the same considerations provided in the preceding paragraph regarding transnasal intraorbital dissection can be applied. A profound anatomical knowledge and high endoscopic skills are necessary to perform this kind of surgery, as potential complications deriving from improper maneuvers performed in the intraorbital space can be devastating. The same can be affirmed for skull base and intracranial steps of the surgery. Endoscopic visualization provides magnification and angled view, which permit an adequate identification of the main anatomical structures, thus allowing a delicate and precise surgery. Nonetheless, a precise knowledge of the skull base and intracranial surgical anatomy as visualized from this perspective is crucial to overcome damage of important neurovascular structures.

In the end, one of the main concerns related to the use of a transpalpebral route to approach skull base pathologies is the possible risk of intraorbital CSF leak. In this regard, it is possible not to perform any reconstruction in case of small dural openings with limited intraoperative CSF leaks. Otherwise, several possibilities of skull base transorbital reconstructions exist (see above), with very low risk of postoperative CSF leak, given the critical support offered by the orbit to the skull base reconstruction.[10,37]

Approach Limitations

Orbital and skull base lesions represent a real challenge and their management depends on several factors, including patient's expectations as well as the position, nature, and biological behavior of the lesion.

Endoscopic Transnasal Approach

In the last decades, the transnasal approach has emerged as a valid alternative to the external approaches for lesions located medially and inferiorly to the optic nerve, which represent the only indication for this approach as far as treatment of orbital pathologies is concerned. Therefore, an insoluble limit is represented by the optic nerve, with respect to which the position of the neoplasm to be treated is therefore the main determining factor in the choice of the surgical approach. Provided this, the endoscopic endonasal approach has some intrinsic limitations that need to be mentioned.

One of the main disadvantages advocated for endoscopic surgery is the lack of three-dimensional vision and the need to operate with a single hand. The first disadvantage can be overcome with a deep anatomic knowledge, the active back-and-forth movement of the endoscope that provides some sense of depth, and eventually the use of an intraoperative navigation system.[38]

On the other hand, the use of a single hand in the dissection still remains challenging in some surgical steps, especially for intraorbital dissection. From a retrospective study of techniques for endoscopic orbital cavernous hemangioma (OCH) resection from six centers on three continents,[27] there was general consensus for lesions located in the extraconal space to be sufficiently exposed via a single nostril using two or three hands. Intraconal lesions, in contrast, were approached using a variety of both single-nostril and binarial techniques. Although the majority of intraconal OCH were resected using a three-handed or four-handed approach, total 31.25% were resected using only two hands. Therefore, when performing preoperative planning for tumors located in the medial intraconal space, consideration should be given to provide adequate access for an assisting surgeon, usually via posterior septectomy.[39] This is not an absolute requirement and in authors' experience a two-nostril approach is very seldom used. This is particularly true if cryoprobes are used to displaced the neoplasm to be removed into the nasal fossa,[16] where the dissection is much easier due to the absence of orbital fat and soft structures that make the neoplasm elusive within the orbital cone. Another critical topic for the endoscopic endonasal approach is the limit of the technique to realize a proper medial orbital wall reconstruction. Few reports of transnasal medial orbital wall reconstructions have been reported in text using the same immunocompetent vascularized grafts used for skull base indications.[40–45]

It seems reasonable to perform an immediate reconstruction with vascularized flaps which might limit the attendant morbidity including diplopia and enophthalmos; however, no study specifically addressed the need for a medial orbital wall reconstruction following removal of medially located intraconal lesions, even though the doubt of possible postoperative diplopia due to changes in the extraocular muscle vectors after endonasal orbitotomy still represents a point of concern.[46] The risk of diplopia might be therefore increased as compared with open approaches, but no comparative study exists on the topic. The difficulty to perform a proper medial orbital wall reconstruction through the same transnasal route used for the treatment of the orbital lesion is an intrinsic limitation of the approach, even though proposal for such an immediate or delayed reconstruction already exists.[47]

The last aspects to be taken into consideration are dimensions and location of the neoplasm to be treated. No studies specifically address the dimensional limits of neoplasms removed via transnasal approach, but the bigger the lesion is, the more difficult the dissection results and the higher the probability of postoperative enophthalmos is. Large neoplasms require wide periorbital opening, extensive intraorbital dissection, and high postoperative volume defect, which can therefore determine postoperative enophthalmos or diplopia. With regards to location, the surgeon who decides to perform this surgery must be aware that the apex of the orbit is a critical anatomical area: lesions located here are difficult to reach, expose, and safely remove. As a rule, intraconal dissection in the space 15 mm anterior to the sphenoid face should be done only by very experienced surgeons[28]: the optic nerve is less than 1 mm from the lateral border of the medial rectus muscle, the muscle itself cannot be retracted due to its attachment to the annulus of Zinn, and superior and inferior branches of oculomotor nerve are particularly prone to functional or anatomical damage so that the risk of postoperative complication is higher.[30]

Transpalpebral Approach

Anatomical Limits

With regard to the transpalpebral corridor to approach orbital pathologies, contraindications to this surgical route are represented by lesions located inferomedial to the optic nerve. In these cases, the gold standard approach is represented by the transnasal route (see above). For other sites, the superior eyelid approach for superiorly located lesions and the inferior eyelid approach for inferiorly located neoplasms are effective in providing adequate surgical access to accomplish the surgery. Contraindications related to dimensions or apical location of the lesion are real, but no specific studies have been performed to understand when to revert to open orbitotomy approaches to succeed in the treatment of such lesions. However, when dealing with orbital tumors, the decision to surgically intervene should not imply an obligation for a radical resection at any price: intraoperative finding of some unmanageable attachments should advise modifications in the surgical strategy to preserve vision and function, nevertheless resorting to traditional external orbitotomy or craniotomy approaches rather than interrupting the procedure.

With regard to transorbital approaches performed to reach anterior and middle cranial fossa, absolute contraindications to the endoscopic transpalpebral approach are represented by lesions posteriorly extended toward the squamous portion of the temporal bone or laterally toward the temporal fossa.[2] In such cases, a traditional frontotemporal or pterional craniotomy might represent the best surgical approach to be used.

Endoscopic Technique Limits

Among the possible drawbacks of this approach, we need to mention: unfamiliarity of most skull base surgeons with transorbital procedures and therefore a steep learning curve to get enough skills and the need to work in a two-dimensional endoscopic environment. In this regard, the authors stress the importance of a proper extensive preclinical anatomical training,[48] which is the most important factor preventing the surgeon from being disoriented in such a niche among endoscopic procedures. Moreover, the use of intraoperative navigation systems and recently introduced three-dimensional endoscopy may reduce the impact of such limitations.

To conclude, the surgeon must be aware that the concept of minimal invasiveness does not depend on the entry wound size, but on the limited impact that of the procedure on the patient's quality of life. In this respect, transorbital endoscopic surgery should not be considered as an alternative technique for replacing expanded endoscopic endonasal approaches or traditional external craniotomies but should be proposed as an additional corridor able to improve visualization and maximize the instruments' maneuverability. Traditional external approaches, with different skin or trans-conjunctival incisions, represent an effective and sound surgical option for the management of these kind of lesions.

Case Examples

In the past 15 years, the senior authors (D.L. and P.C.) operated 120 cases of orbital pathologies, including both primary orbital lesions and cranial base lesions spread to the orbital compartment. Epidemiologic data revealed a male to female radio of 1:1.5 with 40% being male patients. Mean age at surgery was 53.6 years (range = 3–89 years). Pathologies treated are reassumed in ►**Table 1**.

In particular, depending on the location of the lesion, pathologies were treated through a superior eyelid transorbital corridor. Benign pathologies represented the great majority of cases (►**Figs. 1**, **2**).

Postoperative clinical outcomes revealed a stability/improved status in around 11% of patients treated, independently from the kind of lesion treated. Surgical complications resulted to be mainly transient, with just 1.7% of patients affected by long-term diplopia or V2 numbness (►**Figs. 3**, **4**).

As outlined in other sections, such pathologies were treated using transorbital endonasal and superior eyelid endoscopic approaches, depending on multiple factors, which will not be discussed further in this section. Here we present three exemplificative cases:

- Extraconal cavernous hemangioma removed with a trans-lamina papyracea transnasal approach (Case 1).
- A spheno-orbital meningioma operated on through a superior eyelid approach (Case 2).

Table 1 Orbital pathologies treated in a 15-year period by the senior authors

Orbital pathologies	*n*	%
Spheno-orbital meningiomas	35	29.2%
Hemangiomas	28	23.3%
Fibrosis/fibrotic tissue	16	13.3%
Lymphomas/lymphoid hyperplasia	9	7.5%
Pleomorphic adenomas	8	6.7%
Abscesses	5	4.2%
Schwannomas	4	3.3%
Inflammatory pseudotumor	4	3.3%
Mucoceles	2	1.7%
Aspergillosis	2	1.7%
Other	7	5.8%
Total cases	120	100%

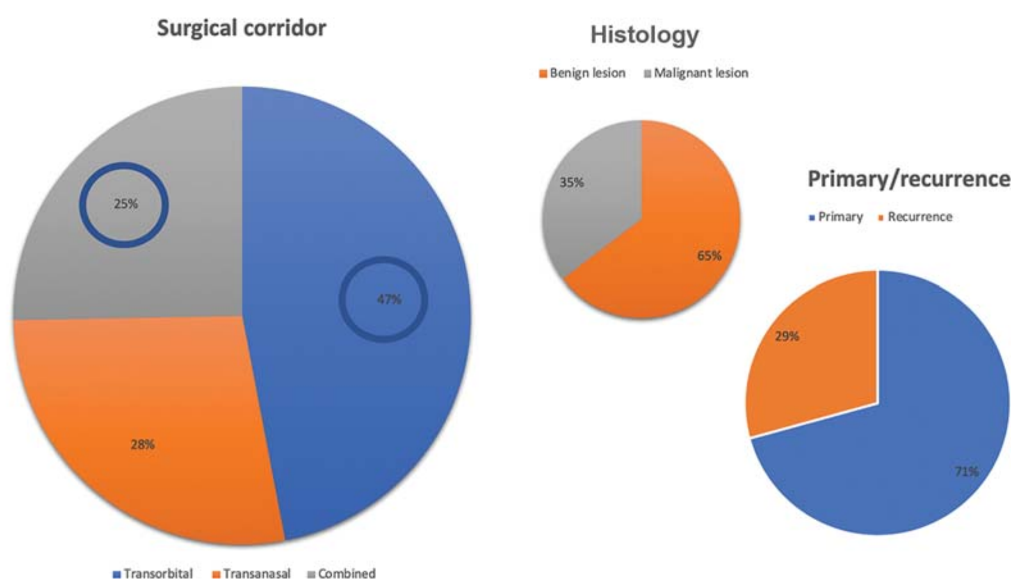

Fig. 1 Characteristics and surgical route for orbital lesions treated.

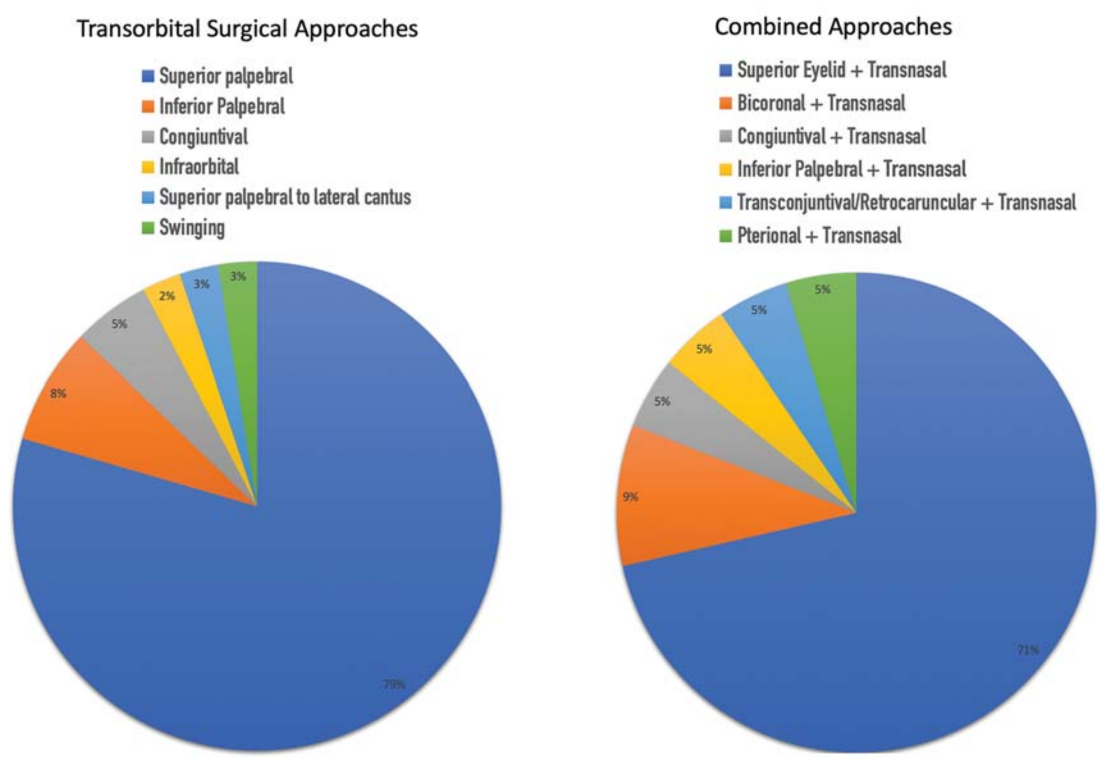

Fig. 2 In depth analysis of surgical corridors used.

- An intraconal hemangioma operated on through superior eyelid approach (Case 3).

Case 1: Extraconal Cavernous Hemangioma Removed with a Translamina Papyracea transnasal Approach

A 63-year-old man was admitted to our department with an incidental finding of a left intraorbital extraconal lesion, characterized by homogeneous strong contrast enhancement, suspicious for cavernous hemangioma (►**Fig. 5A–C**). On neurologic examination, mild proptosis was noted. The patient was offered removal through an endonasal transorbital approach. ►**Fig. 5D–F** shows respectively papyracea drilling, removal, and dissection of the lesion at the endonasal intraorbital stage. Postoperative magnetic resonance demonstrated the complete removal of the lesion without

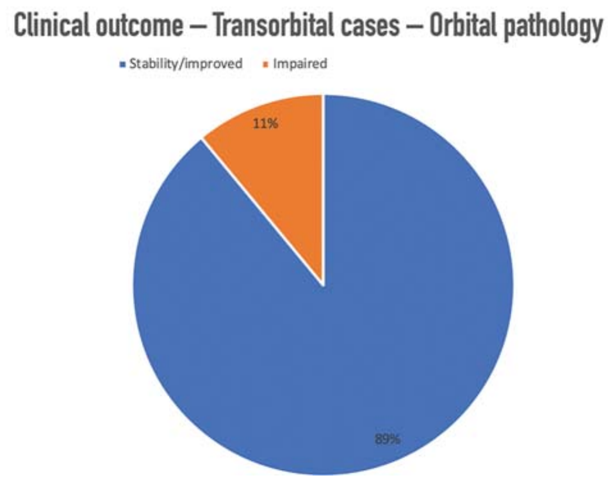

Fig. 3 Clinical (visual) outcomes.

any complication (►**Fig. 5H**). The patient went home on postoperative day 5 in good clinical condition, with complaint of new-onset diplopia that resulted to be totally transient at 3-month follow-up.

Case 2: Spheno-Orbital Meningioma Treated through an Endoscopic Superior Eyelid Approach

A 53-year-old woman presented to our department complaining of left eye proptosis, without any visual deficits. Imaging disclosed a spheno-orbital meningioma, characterized by extensive bony invasion without any soft component, intracranial or intraorbital. Such lesion extended to the roof and lateral wall of left orbit and to pterional area. After discussion of the various therapeutic options with the

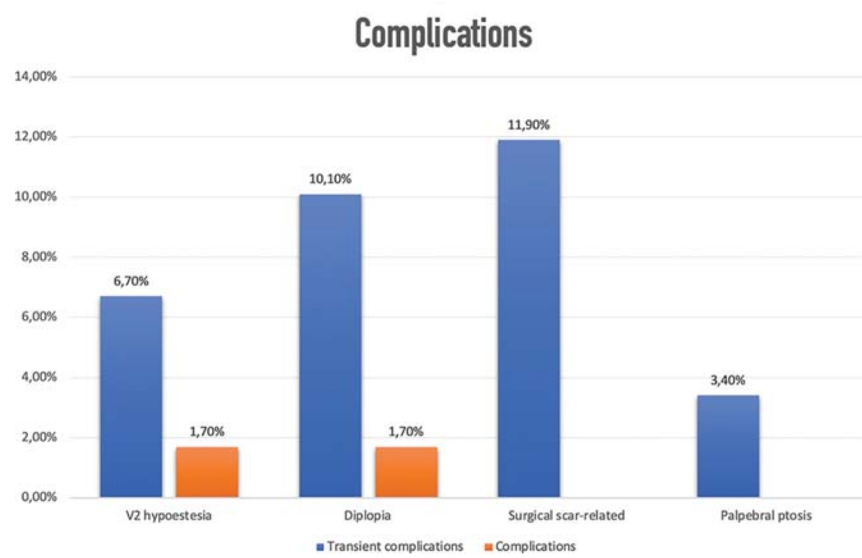

Fig. 4 Surgery-related complications.

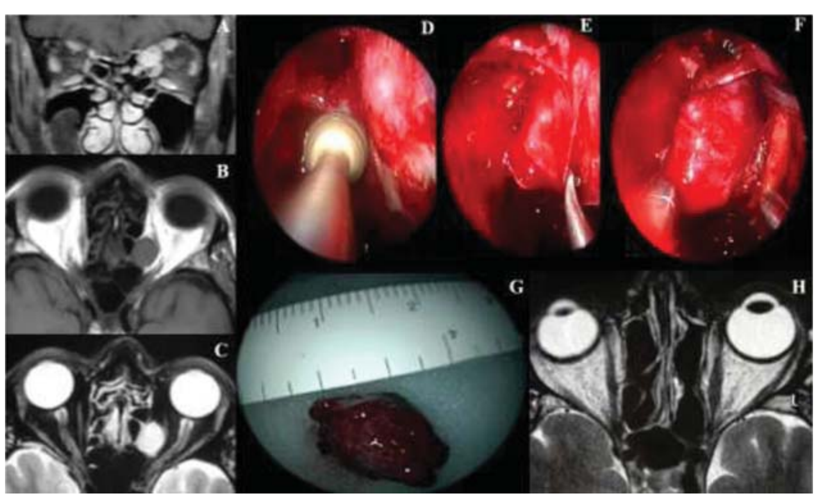

Fig. 5 Transnasal Resection of Extraconal Cavernous Hemangioma. (**A**) Coronal T1 MRI with contrast demonstrating left extraconal cavernous hemangioma. (**B, C**) Axial T1 and T2 MRIs demonstrating lesion with lateral compression of the medial rectus muscle. (**D**) Endoscopic view of high speed drill removal of lamina. (**E, F**) Incision of periorbita with dissection of cavernous hemangioma. (**G**) Final pathologic specimen following removal. (**H**) Postoperative T2 axial MRI demonstrating complete resection of the lesion.

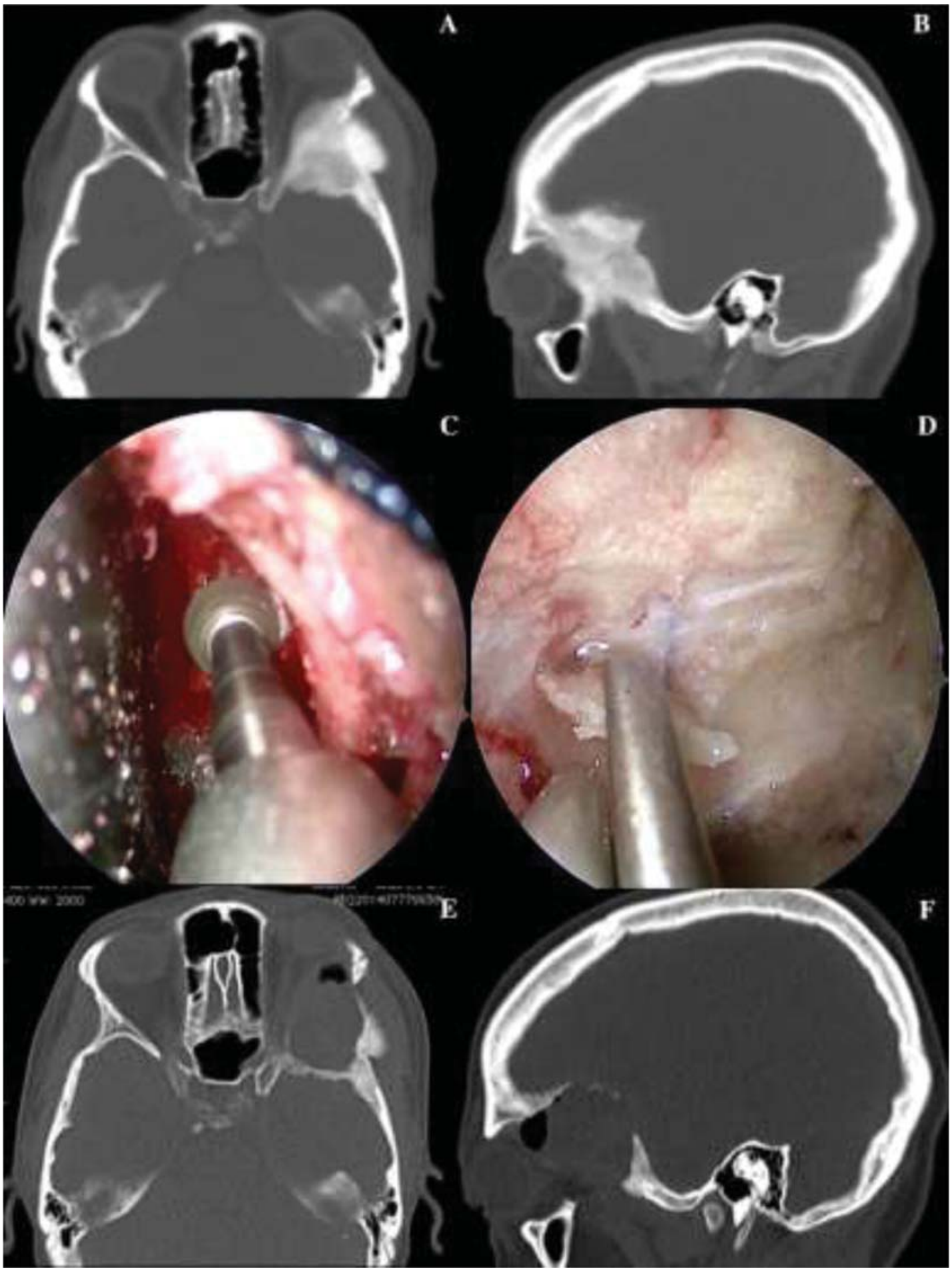

Fig. 6 Endoscopic superior eyelid approach to a left spheno-orbital meningioma. (**A, B**) Axial and Sagittal CT scans demonstrating hyperostotic growth. (**C, D**) Trans-superior eyelid endoscopic views of drilling and resection of the meningioma. (**E, F**) Postoperative axial and sagittal CT scans.

patient—given the predominant hyperostotic behavior of the mass—without any intracranial involvement, patient decided to undergo a superior eyelid removal of the lesion (►**Fig. 6C, D**). Postoperative imaging demonstrated a subtotal resection of the tumor, with pterional hyperostosis left untouched. Patient was sent home on postoperative day 5 without clinical complications. Proptosis totally resolved in 1 year, and her remnant pterional hyperostosis is stable until now.

Case 3. Intraconal Hemangioma Operated on through Superior Eyelid Approach

A 66-year-old woman presented to our department with an incidental finding of a left intraorbital intraconal lesion, involving the orbital apex. The patient complained of vision loss and diplopia with a visual field examination confirming a campimetric deficit (►**Fig. 7A, B**). The rest of neurologic examination was unremarkable. After careful

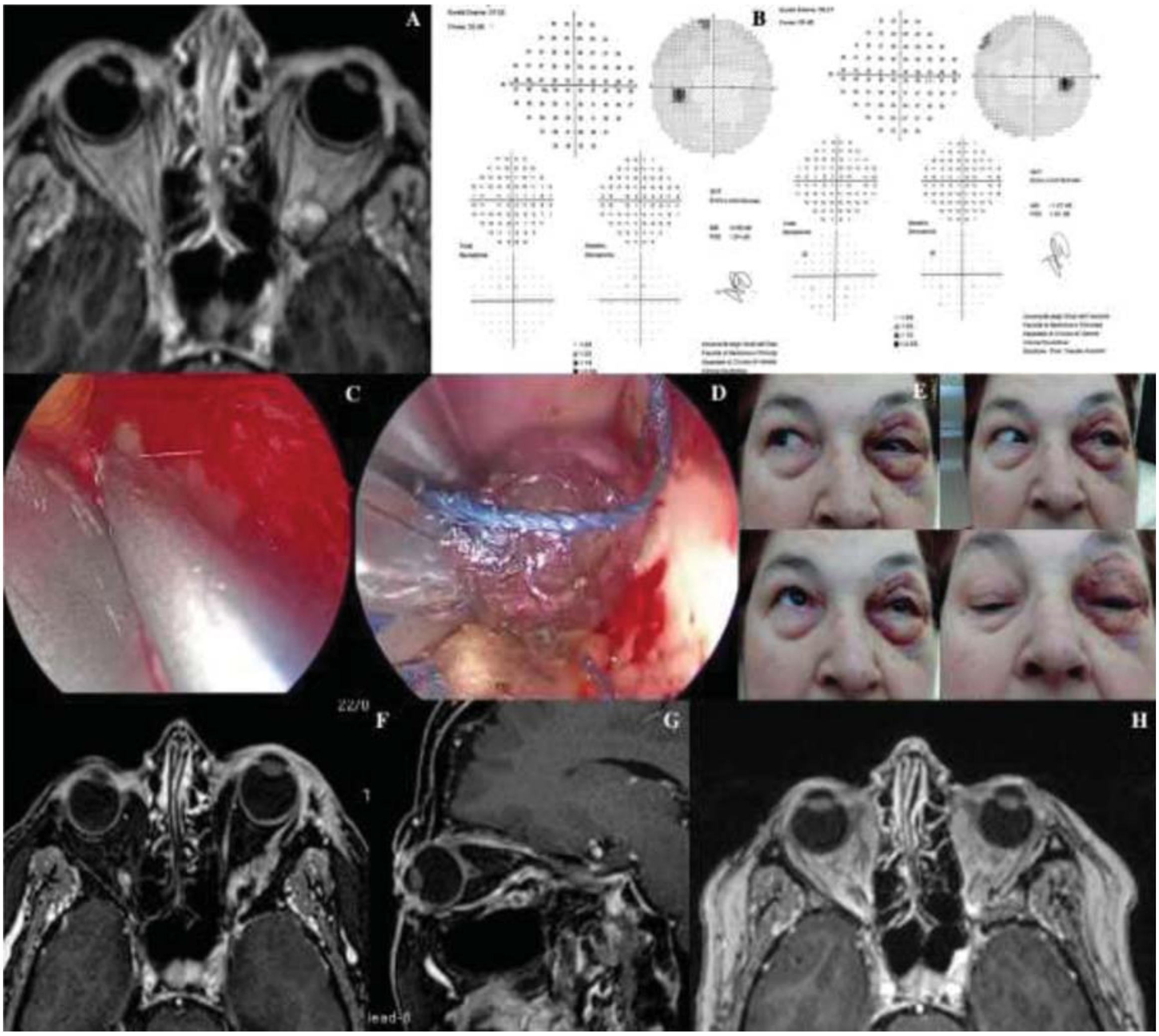

Fig. 7 Superior eyelid approach to intraconal cavernous hemangioma. (**A, B**) Axial T1 post-contrast MRI demonstrating a cavernous hemangioma within the left orbital apex with associated visual field impairment. (**C, D**) Endoscopic trans-superior eyelid approach for resection of the lesion with post-operative external swelling and mild diplopia. (**F-H**) Postoperative MRI images demonstrating complete removal of the lesion.

discussion with the patient of possible therapeutic and conservative options, she underwent a superior eyelid removal of the hemangioma (►**Fig. 7C, D**). Postoperative imaging showed the complete removal of the lesion, without deficit (►**Fig. 7F–H**). Early postoperative clinical conditions were optimal, with mild transient diplopia and inferior rectus muscle deficit. Diplopia resolved at follow-up at 3 month, while the inferior rectus muscle deficit was improving but still not totally resolved at 6 months.

Conflict of Interest
None declared.

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