Endoscopic approaches to orbital lesions: case series and systematic literature review

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OBJECTIVE Surgical treatment of orbital lesions is challenging because complex approaches with a high risk of post-operative sequelae are required. Recently, minimally invasive endoscopic approaches through endonasal (EEA) and transpalpebral (ETP) routes have been proposed. The objective of this study was to assess outcomes of EEA and ETP in the authors' series of patients with orbital lesions.

METHODS Data from all patients who underwent operations for an orbital tumor through an endoscopic approach at the authors' institution from 2002 to 2018 were retrospectively collected. All patients underwent preoperative MRI and ophthalmological evaluation, which was repeated 3 months after surgery and then at regular follow-up intervals. A systematic review of the literature was also performed using Medline, Embase, and Web of Science databases.

RESULTS The series includes 23 patients (14 males); the mean patient age was 48 ± 23.9 years. Most of the lesions were intraconal ($n = 19$, 83%). The more frequent histotype was cavernous hemangioma ($n = 5$, 22%). Exophthalmos was the most common symptom (21 of 23 patients). EEA was performed in 16 cases (70%) and ETP in 7 (30%). The aim of the surgery was achieved in 94% of the cases after an EEA (successful biopsy in 5 of 6 cases and radical resection in all 10 remaining patients), and in 86% after an ETP (successful biopsy in 2 cases and radical tumor resection in 4 of 5 cases). Complications consisted of 3 cases (13%) of transitory diplopia. One recurrence (4%) was observed at follow-up (mean 59 ± 55 months).

CONCLUSIONS The EEA and ETP have demonstrated to be safe and effective for tumors located respectively in medial and lateral quadrants, permitting one to approach orbital lesions endoscopically at 360°. Innovative surgical tools, including intraoperative ultrasonography, may be useful to potentially reduce surgical morbidity. Larger series are needed to validate these preliminary suggestions.

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KEYWORDS orbit; endoscopic transpalpebral approach; endoscopic endonasal approach; cavernous hemangioma; tumor; glioma; intraoperative ultrasonography; surgical technique

TREATMENT of orbital pathologies represents a frontier of skull base surgery, requiring collaboration between different specialists such as ear, nose, and throat surgeons, neurosurgeons, neuroophthalmologists, and maxillofacial surgeons.¹⁰ Because of the rarity of these tumors and the technical difficulties associated with their approach, they have not been extensively considered in the

neurosurgical literature for many years.²² A recent renewal of interest has occurred due to at least three factors: the redefinition of the anatomy of this region, the development of innovative surgical approaches, and the introduction of new operative devices.

In the last decade, several papers have reanalyzed the spatial relationships among the orbital content according

ABBREVIATIONS EEA = endoscopic endonasal approach; ETP = endoscopic transpalpebral approach; GTR = gross-total resection; LOE = level of evidence; WOS = Web of Science.

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to different perspectives, proposing innovative surgical approaches such as the endoscopic endonasal approach (EEA) and endoscopic transpalpebral approach (ETP) routes.^{2,5,9,13–15} Thanks to the versatility, maneuverability, and panoramic view provided by the endoscope, the ethmoidal corridor may be extended toward the orbit, adopting a completely extracranial route and avoiding external scars or brain retraction.^{10,36} However, due to the risk of optic nerve injury, this approach is mainly reserved for tumors located in the medial quadrants.¹⁰ Few authors have proposed that the ETP may allow one to approach lateral lesions, combining the minimal invasiveness provided by the endoscope with the reduced risk of unaesthetic facial scars and surgical complications, but these results need to be confirmed by other consistent patient series.² Moreover, the application of novel imaging technologies and intraoperative devices such as ultrasonography, neuronavigation, and the cryoprobe may further improve the safety and effectiveness of orbital tumor surgery.^{8,27,38}

The aim of this study is to review our surgical experience with EEA and ETP for orbital tumors to analyze their advantages and limits and to display the potentialities of endoscopy and modern technological operative devices in orbital surgery. A pertinent systematic literature review has also been provided.

Methods

Case Series

All cases of orbital lesions operated on through an EEA or ETP from 2002 (corresponding to the first endoscopic orbital surgery performed at the Center for the Diagnosis and Treatment of Hypothalamic-Pituitary Diseases, IRCCS Institute of Neurological Sciences of Bologna) to December 2018 were retrospectively reviewed. Only tumors originating within the orbit were considered, while forms extending into the orbit from other sites were excluded, as well as tumors external to the periorbital, according to Martins et al.²⁹

All patients underwent a preoperative ophthalmological evaluation that included visual acuity measurement, computerized visual field, Hess-Lancaster screen test, measurement of the degree of exophthalmos, and optical coherence tomography for cases operated on after 2016. Patients also underwent contrast-enhanced MRI with dedicated slices for the orbit, as well as CT. Medical history was recorded, with particular attention to previous orbital surgery or other disorders affecting visual function.

The sample of pathological tissue was histologically examined using specific techniques according to the preoperative diagnostic suspicion. Surgical intra- and postoperative complications were recorded.

All patients underwent contrast-enhanced MRI 3 months after surgery to assess the degree of tumor removal. Gross-total resection (GTR) was defined as the complete excision of the mass on MRI. For those cases in which the aim of surgery was only a biopsy, surgery was considered effective when the collected tissue was sufficient to achieve histological diagnosis. In cases of malignant lesions, further therapies were performed according to the histological type and grade, based on international

guidelines. Follow-up MRI was repeated every 6–12 months depending on the nature of the lesion, as well as ophthalmological controls to assess functional surgical results. Tumor recurrence and its treatment were evaluated, based on medical records.

EEA: Surgical Technique

In the EEA, patients are placed supine, with the thorax slightly elevated at 20° and the head moderately rotated toward the first surgeon (Video 1).

VIDEO 1. Clip showing endoscopic endonasal resection of an intra-orbital intraconal hemangioma. Copyright Matteo Zoli. Published with permission. Click here to view.

Surgery is performed under general anesthesia with orotracheal intubation. Surgeries are conducted using 0° and 30° endoscopes (Karl Storz) with a high-definition 2D/3D camera. The neuronavigation system (StealthStation S7, Medtronic) was implemented in all cases, adopting the preoperative CT scan merged with MRI as the referral examination. This process was performed with StealthMerge Software (Medtronic).

Surgery begins with a middle turbinectomy and ethmoidectomy on the side of the lesion, followed by anterior sphenoidotomy. We prefer a one-nostril approach to reduce nasal morbidity, but a posterior septal window can be useful in selected cases to provide a two-nostril corridor.

The lamina papyracea is opened from posterior to anterior, starting at the apex. We have usually found removal of the posterior third of the medial orbit wall to be sufficient, but this opening may be tailored according to the location of the tumor (Fig. 1). For lesions located in the inferior quadrants, the opening of the lamina papyracea may be enlarged, removing the medial portion of the floor of the orbit through a medial maxillectomy.

For intraconal lesions, after incision of the periorbital, the medial rectus muscle can be identified. Two corridors can be adopted, one passing above and one below this structure. For every case we chose the shorter and more direct route to expose the tumor. Once macroscopically identified, the lesion is progressively dissected by the surrounding anatomical structures and orbital fat (Fig. 1). Sharp instruments should not be used to avoid direct muscle or nerve damage; we also avoid detaching the medial rectus muscle.^{24,40} In particular cases, an external approach may be combined with the EEA to mobilize the tumor and favor its removal through the endonasal approach. To reduce the risk of losing orientation or misinterpreting the pathological tissue, we have adopted intraoperative ultrasonography to localize the tumor, avoiding the limitations of neuronavigation due to the shift of the orbital structures after incising the periorbital.

At the end of tumor removal, the surgical cavity can be inspected to verify complete tumor resection. Hemostasis is usually spontaneous, or it can be performed with hemostatic agents. The use of bipolar forceps should be limited to avoid direct or indirect injury to muscles or nerves. After tumor removal, we avoided performing any medial wall reconstruction, even if some authors suggest covering the surgical field with a mucoperiosteum graft placed over the periorbital.^{3,4,10,33} Nasal fossae were packed with ab-

FIG. 1. MRI and intraoperative endoscopic images (0° endoscope). Endoscopic endonasal resection of an intraorbital intraconal neurofibroma in the inferomedial and inferolateral quadrants medially displacing the optic nerve. **A:** Axial T2-weighted (*upper*) and T1-weighted gadolinium-enhanced (*lower*) MR images showing the tumor and the medial optic nerve displacement. **B:** Access for this tumor is performed by opening the roof of the right maxillary sinus, medially to the infraorbital nerve, and the inferior portion of the lamina papyracea. **C:** Through this inferomedial window the tumor is dissected from surrounding structures, such as the inferior rectus muscle, and then removed. **D:** Postoperative axial T1-weighted image with gadolinium demonstrating the radical resection of the tumor. Figure is available in color online only.

sorbable gelatin sponges (GelFoam, Pfizer, Inc.) and with 8 cm of nasal packing (Merocel, Merocel Corp.).

ETP: Surgical Technique

Our technique of ETP has already been described (Video 2).⁴⁴

VIDEO 2. Clip showing the endoscopic transpalpebral resection of an intraorbital intraconal solitary fibrous tumor. Copyright Matteo Zoli. Published with permission. Click here to view.

Briefly, the patient is placed in the same position described for EEA and under the same general conditions. The skin incision is performed under exoscopic assistance (Karl Storz Endoscopy-America, Inc.).

We prefer to incise the skin in the lateral third of the eyelid to avoid any damage to the levator palpebrae muscle, which runs medially (Fig. 2). The fibers of the orbicular oculis muscles are dissected to expose the bone margins of the orbital rim up to the lateral canthus (Fig. 2). At that point, under the visualization given by a 0° en-

doscope, the periorbita is progressively dissected by the lateral wall (Fig. 2). With the help of neuronavigation, ultrasonography, or a combination of these imaging modalities, it is possible to locate the mass and the surrounding anatomical structures. After incision of the periorbita, the tumor resection is performed with the same technique already reported for the EEA (Fig. 2).

Closure requires suturing of the skin incision. Corticosteroid therapy is routinely administered for the following 7–10 days to avoid postoperative palpebral edema.

Intraoperative Ultrasound Imaging

The ultrasound imaging (Ultraneuronav, Esaote) can be performed directly by the surgeon him-/herself or by an assistant and it can be used both for the EEA and ETP. We perform an orbital transpalpebral ultrasonography procedure before starting surgery to identify the lesion and the surrounding anatomical structures (Fig. 3). We prefer to fuse real-time B-scan ultrasound imaging with previ-

FIG. 2. Intraoperative exoscopic and endoscopic images (0° endoscope). ETP for a cavernous hemangioma. **A:** In our technique, the skin incision is performed at the lateral edge of the superior eyelid under exoscopic visualization, with a curved shape around the lateral palpebral commissure, to dissect the lateral canthus more directly and safely, significantly reducing the risk of injury to the levator palpebrae muscle. **B:** The periorbital is progressively dissected from the lateral orbit wall under endoscopic visualization, and then incised to gain access to the intraorbital space. **C and D:** The tumor is progressively dissected from the orbital structures such as the superior rectus muscle using a microsurgical two-hand technique and avoiding blind maneuvers and sharp instruments. m. = muscle. Figure is available in color online only.

ously acquired DICOM volume data sets such as MRI or CT normally used for the standard neuronavigation, to be sure to correctly interpret the ultrasound imaging and to increase the accuracy of tumor identification in the early phases of surgery (before the shift of orbital structures) or in cases of extraconal pathologies (Fig. 4). Tumor location is dynamically reassessed through transpalpebral ultrasonography (performed under sterile conditions) at each stage of its resection, directly confirming the safety of each maneuver. Moreover, with adequate angulation of the probe, ultrasonography permits the identification of the tip of the instruments, therefore allowing one to assess the distance between the surgeon and the tumor (Fig. 3). At the end of tumor removal, intraoperative ultrasonography permits one to control the complete tumor removal or to identify potential tumor remnants, especially in cases of non-en bloc resection of the mass (Fig. 3).

For some lesions the identification of the tumor or of its remnants may be improved by the application of contrast-enhanced ultrasonography (Fig. 4). Utilizing the color Doppler mode, tumor vascular supply can be assessed

before starting its resection, permitting its early devascularization, which could speed up surgery and increase its safety (Fig. 3). With this technique it is also possible to control the sparing of the ophthalmic artery main trunk and branches (i.e., central retinal artery) during each phase of surgery to reduce the risk of vascular damage to the optic nerve.

Literature Review

Search Strategy

A systematic literature review was performed in accordance with the PRISMA statement guidelines.³² Medline, Embase, and Web of Science (WOS) Core Collection (SCI-Expanded, SSCI, A&HCI, CPCI-S, CPCI-SSH, and ESCI) databases were queried using individual keywords and MeSH terms. A purposely defined search string for a MEDLINE search was: (“endoscopy”[MeSH Terms] OR “endoscopy”[All Fields]) AND (“orbit”[MeSH Terms] OR “orbit”[All Fields]) OR “Endoscopy”[Majr] AND (“Orbit/pathology”[Mesh] OR “Orbit/surgery”[Mesh] OR “Orbit/

FIG. 3. Transpalpebral ultrasound imaging. Ultrasound imaging may be adopted to guide the surgeon in real time in the resection of a tumor, reducing the risk of surgeon disorientation or lack of identification of the anatomical orbital structures. Under sterile conditions and with minimum pressure, the surgeon performs ultrasound to the closed eye, using a linear probe. We prefer performing a first ultrasound imaging before starting the surgery when the patient is under general anesthesia to assess the location of the tumor and the possibilities of satisfactorily identifying it. **A:** The cavernous hemangioma can be recognized in the lateral portion of the right orbit as an echogenic mass, laterally and posteriorly to the eye. The eye and the optic nerve are clearly visible on the ultrasound as round hypoechoic (gray-black) and hypoechoic linear structures, respectively. **B:** The color Doppler ultrasound may allow one to verify the blood supply of the tumor. In this case, the tumor presents a poor vascularization with tiny blood vessels (blue and red). **C:** After skin incision for the ETP, ultrasound imaging is repeated to localize the tumor and tailor the periorbital incision, directing the surgical approach toward the tumor. **D and E:** During the surgery, it is possible to verify that the mass under surgical vision corresponds to the target lesion, controlling the position of the surgical instruments. Highly attenuating structures such as the metallic surgical instruments cause posterior shadowing, a particular kind of artifact that allows one to recognize their location on the ultrasound. **F:** At the end of tumor removal, ultrasound permits the surgeon to determine that the tumor is radically removed and that no visible remnants are present in the surgical field. Figure is available in color online only.

therapy"[Mesh]) OR conal[tiab] AND endoscopic[tiab]; for EMBASE it was: (endoscopic OR endoscopy) AND ('orbit'/exp OR orbit) AND 'conal':ti,ab,kw; for WOS it was: TOPIC: (endoscopy or endoscopic) AND TOPIC: (orbit) AND ALL FIELDS: (intraorbital). The results were then limited to the English language, human subjects, and endoscopic approaches. After duplicate removal, titles and abstracts were first screened, and for the papers deemed appropriate, the full text was obtained and reviewed for appropriateness and extraction of data. The articles' reference lists were examined to identify any other relevant studies.

Selection Criteria

Only studies assessing outcomes of endoscopic procedures for biopsy/resection of nontraumatic lesions primarily originating within the orbital space were included (Fig. 5). Articles were excluded if they involved combined nonendoscopic approaches and endoscopy-assisted procedures or fewer than 3 reported cases. Studies involving various surgical procedures or patient populations were included only if sufficient individual data on endoscopic removal of orbital pathology could be obtained to meet the inclusion criteria. Nonhuman, cadaveric and anatomical, technical, radiological, and review studies, as well as

FIG. 4. Image fusion (ultrasound and CT) for interventional planning. Ultrasound imaging may be coupled with neuronavigation to increase its accuracy in the early phases of surgery or for an extraconal tumor, with a limited shift of the orbital content, as in the presented case. **A:** An intraorbital extraconal lipoma in the lateral portion of the orbit is visible as an echogenic mass lateral to the eye on the ultrasound imaging and as a hypodense mass on the CT scan. **B and C:** For image fusion the CT scan is color-coded and superimposed onto the fundamental B-scan. This advanced real-time ultrasound image fusion technique increases surgical accuracy, and permits the surgeon to better identify small portions of the tumor that would otherwise be difficult to identify, as well as the normal anatomical structures. **D:** A contrast agent may be adopted to increase the accuracy of the ultrasound and allow evaluation of the perfusion of the mass. In the presented case of an intraorbital lipoma, the tumor corresponds to the hypoechoic (gray-black) area after contrast administration. Figure is available in color online only.

papers with insufficient data, were excluded. In cases of aggregate (nonindividual), missing, and unreported data, the authors of each eligible study were contacted to obtain additional information.

Data Extraction

Data from the included studies were extracted, organized, and analyzed using Microsoft Excel 2019 (Microsoft Corp). Collected variables included first author, publication year, level of evidence (LOE; according to the Oxford Centre for Evidence-Based Medicine), intraorbital sample size, tumor histopathology, location, employed endoscopic approach, extent of resection, and complications.

Results

Twenty-three patients for a total of 24 endoscopic surgeries were included (1 patient underwent reoperation for

a recurrence). The male/female ratio was 14:9. The mean age at surgery was 48 ± 23.9 years (range 1–76 years; Table 1). In 9 cases (39%) the lesion was in the right eye and in 14 (61%) in the left eye. The mean hospital stay was 2 ± 1.6 days after surgery for adults and 19 ± 11 days for pediatric patients; the longer time for children was due to the differences between the two populations, and also because our center is a referral center for pediatric pathologies, collecting patients coming from distant regions of the country.

Patients were naïve for orbital surgery except for a 6-year-old boy with an orbital germinoma, previously biopsied in its extraorbital component and then treated with neoadjuvant chemotherapy. Twenty-one patients (91.5%) presented with exophthalmos, in 10 cases (43.5%) with a proptosis > 20 mm. Nine (39%) presented with a reduction of visual acuity, with residual acuity $> 5/10$ in 5 and $< 5/10$ in 3, while 1 patient was blind. Eleven patients (47.8%) also presented with diplopia.

In 19 cases (83%) the tumor was completely intraconal

FIG. 5. Flowchart of the systematic literature review. Figure is available in color online only.

or with a major intraconal extension. EEA was adopted in 16 cases (70%). In the first 2 cases of the series, an external superolateral approach was prepared to favor the endoscopic endonasal resection of the tumor. The EEA was also preferred for a tumor located in the inferolateral quadrant because the lesion was in strict contiguity with the maxillary sinus roof and could be resected through a transethmoidal-transmaxillary endoscopic approach. In the other 7 cases (30%) involving the lateral quadrants, an ETP was chosen.

The aim of surgery was achieved in all cases but two (15 of 16 cases [94%] treated with an EEA and 6 of 7 cases [86%] treated with an ETP). In 8 cases (6 treated with an EEA and 2 with an EPT) surgery was limited to biopsy or debulking to achieve a diagnosis for inflammatory and infiltrative lesions, i.e., pseudotumor orbitae, lymphoma, or optic pilocytic astrocytoma. The collected tissue was sufficient to formulate a diagnosis in 7 of 8 cases (87.5%). In 1 patient (case 8, Table 1) biopsy was performed on an infiltrative tumor not clearly identifiable at the endoscopic endonasal exploration, and the sample was not diagnostic. A subsequent transcranial approach was needed to diagnose an orbital lymphoma. In the case of the child with a germinoma (case 18), due to the infiltrative nature of the tumor, the aim of surgery was to debulk the lesion to support the subsequent oncological treatment. Conversely,

complete excision was considered the goal for the other histotypes (10 treated with EEA and 5 with ETP), and it was achieved in 14 of 15 cases (93.3%). In 1 patient (case 21, Table 1) the aim of ETP was GTR. However, for the friable consistency of the mass, an en bloc resection was not possible and the postoperative MRI showed a tumor remnant. Ultrasonography was adopted in the last 4 cases of the series. Complications consisted of 3 cases (13%) of transitory diplopia occurring after EEA and spontaneously regressing within 3 months after surgery (Table 1). Exophthalmos completely normalized in 11 cases (52%) and improved in 7 (33%), while it remained stable in 3 (14%). Exophthalmos normalization or improvement was observed in 13 (81.2%) and 5 (71.4%) cases, respectively, after EEA and ETP. Of the 3 cases with severe preoperative deficit of visual acuity (< 5/10), 1 normalized while the other 2 remained unchanged after surgery. Of the 5 cases with moderate preoperative deficit of visual acuity (> 5/10), normalization was achieved in 2 patients, improvement in another, while 2 remained stable.

Preoperative diplopia regressed in 7 (63%) of 11 patients, 5 of 8 after EEA and 2 of 3 after ETP; in the remaining cases, it was stable or slightly improved. One patient affected by pilocytic astrocytoma of the optic nerve (case 6, Table 1) presented with postoperative diplopia after tumor resection using a transcranial approach.

TABLE 1. Primary patient characteristics

Case No.	Age (yrs), Sex	Exop (mm)	VA	Diplopia	Conal Localization	Eye Quadrant	Surgical Approach	Histology	Surgical Outcome	Complication	Further Tx	Follow-Up	
												Exop	VA
1	63, M	>20	<5/10	No	Intra	Sup/med	EEA	Pseudotumor	Biopsy	None	Medical therapy	No	Normal
2	51, M	>20	10/10	Yes	Intra	Sup/med	EEA	Fibrous osseous lesion	GTR	TD	None	No	Normal
3	68, M	<20	10/10	Yes	Intra	Sup/med	EEA	SFT/HP	GTR	TD	None	No	Normal
4	50, M	<20	10/10	No	Extra	Sup/med	EEA	SFT/HP	GTR	None	None	Improved	Normal
5	31, F	<20	10/10	Yes	Intra	Sup/med	EEA	Osteoma	GTR	None	None	No	Normal
6	1, F	<20	<5/10	No	Intra	Sup/med	EEA	Pilocytic optic astrocytoma	Biopsy	None	Craniotomy	Stable	Yes
7	6, M	<20	10/10	No	Extra	Sup/med	EEA	AVM	GTR	None	EEA for recurrence after 8 yrs	No	Normal
8	30, M	<20	10/10	No	Intra	Inf/med	EEA	Nondiagnostic (lymphoma)	Biopsy	None	Craniotomy	Stable	Normal
9	66, F	>20	0/10	No	Intra	Inf/med	EEA	Pseudotumor	Biopsy	None	Lat orbitotomy	Improved	Stable
10	76, F	None	10/10	Yes	Intra	Sup/med	EEA	Lymphangioma	Biopsy	None	Medical therapy	Stable	Normal
11	47, M	>20	>5/10	No	Intra	Inf/lat	EEA	Neurofibroma	GTR	None	None	No	Normal
12	53, M	>20	10/10	Yes	Intra	Inf/med	EEA	CH	GTR	None	None	No	Normal
13	19, F	<20	10/10	No	Intra	Inf/med	EEA	CH	GTR	None	None	No	Normal
14	58, F	>20	>5/10	Yes	Intra	Inf/lat	ETP	Lymphoma	Biopsy	None	Medical therapy	Stable	Stable
15	65, M	None	10/10	No	Extra	Sup/med	EEA	Lymphangioma	GTR	None	None	Stable	Normal
16	85, F	<20	>5/10	No	Intra	Sup/med	EEA	CH	GTR	TD	None	Improved	Improved
17	75, F	>20	>5/10	No	Intra	Sup/lat	ETP	CH	GTR	None	None	Improved	Normal
18	2, M	>20	10/10	Yes	Intra/extra	Inf/med	EEA	Germinoma	STR	None	Chemo & RT	Improved	Normal
19	47, M	>20	10/10	Yes	Intra	Sup/lat	ETP	CH	GTR	None	None	No	Normal
20	68, M	<20	10/10	Yes	Extra	Sup/lat	ETP	Lipoma	GTR	None	None	No	Normal
21	32, F	>20	>5/10	No	Intra	Sup/lat	ETP	SFT/HP	STR	None	None	Improved	Stable
22	56, M	<20	10/10	Yes	Intra	Inf/lat	ETP	Lipoma	GTR	None	None	No	Normal
23	55, M	<20	<5/10	Yes	Intra	Inf/med	ETP	Amyloidoma	Biopsy	None	Medical therapy	Improved	Stable

AVM = arteriovenous malformation; CH = cavernous hemangioma; chemo = chemotherapy; Exop = exophthalmos; extra = extraconal; inf = inferior; intra = intraconal; lat = lateral; med = medial; RT = radiotherapy; SFT/HP = solitary fibrous tumor/hemangiopericytoma; STR = subtotal resection; sup = superior; TD = transient diplopia; Tx = treatment; VA = visual acuity.

TABLE 2. Systematic literature review on outcomes of endoscopic orbital surgery

Authors & Year	LOE	No. of Pts	Location	Histology	Approach	Tumor Resection	Complication
Sieskiewicz et al., 2008	4	4	Medial quadrants	Pseudotumor (n = 3), plasmacytoma (n = 1)	EEA	Biopsy (n = 4)	None
McKinney et al., 2010	4	6	Medial quadrants	NA	EEA	GTR (n = 4), STR (n = 1), biopsy (n = 1)	None
Tomazic et al., 2011	4	6	Medial quadrants	CH (n = 2), schwannoma (n = 1), melanoma (n = 1), lymphoma (n = 1), optic glioma (n = 1)	EEA	GTR (n = 2), PTR (n = 1), biopsy (n = 3)	Transient CN III palsy (n = 1)
Castelnuovo et al., 2012	4	16	Medial quadrants	CH (n = 6), SFT/HP (n = 2), pseudotumor (n = 2), melanoma (n = 1), abscess (n = 1), lymphoma (n = 1), optic glioma (n = 1), schwannoma (n = 1)	EEA	GTR (n = 8), biopsy (n = 6), PTR (n = 1), drainage (n = 1)	Transient diplopia (n = 2), transient CN III palsy (n = 1), permanent diplopia (n = 1), enophthalmos (n = 1), periorbital edema (n = 1)
Karaki et al., 2012	4	4	Medial quadrants	Hematoma (n = 1), CH (n = 1), vasculitis (n = 1), metastasis (n = 1)	EEA	GTR (n = 2), biopsy (n = 1), drainage (n = 1)	None
Lim et al., 2012	4	6	Medial quadrants (n = 1), superior quadrants (n = 5)	Abscess (n = 6)	Endoscopic pre-caruncular (n = 1), ETP (n = 5)	Drainage (n = 6)	None
Netuka et al., 2013	4	3	Medial quadrants	CH (n = 2), SFT/HP (n = 1)	EEA	GTR (n = 3)	Transient CN VI palsy (n = 1)
Wu et al., 2013	4	12	Medial quadrants	CH (n = 12)	EEA (in 5 w/ MRM detachment)	GTR (n = 12)	Transient diplopia (n = 3, in which there was an MRM detachment)
Chhabra et al., 2014	4	5	Medial quadrants	CH (n = 5)	EEA	GTR (n = 4), STR (n = 1)	Transient diplopia (n = 5), enophthalmos (n = 2), silent sinus syndrome (n = 1)
Lyson et al., 2014	4	12	Medial quadrants (n = 6), superior quadrants (n = 2), inferior quadrants (n = 1), intraconal (n = 3)	Abscess (n = 12)	EEA	Drainage	None
Braddoo et al., 2015	4	4	Lateral quadrants	Abscess (n = 2), tuberculoma (n = 1), pseudotumor (n = 1)	ETP	Biopsy (n = 2), drainage (n = 2)	None
Tan & Prepagaran, 2015	4	4	Medial quadrants	Pseudotumor (n = 2), lymphoma (n = 1), metastasis (n = 1)	EEA	GTR (n = 4)	None
Craig et al., 2015	3a,4	3	Medial quadrants	Schwannoma (n = 2), CH (n = 1), giant cell fibrous osseous tumor (n = 1)	EEA	GTR (n = 2), PTR (n = 1)	None
Arai et al., 2016	4	4	Medial quadrants (n = 2), lateral quadrants (n = 2)	CH (n = 2), AVM (n = 1), SFT/HP (n = 1)	EEA	GTR (n = 2), biopsy (n = 2)	Transient dyschromatopsia & diplopia (n = 1)
Jaiswal, 2017	4	7	Medial quadrants	CH (n = 3), SFT/HP (n = 1), pseudotumor (n = 1), lymphoma (n = 1), epidermoid cyst (n = 1)	EEA	GTR (n = 6), STR (n = 1)	Visual deterioration (n = 1), transient diplopia (n = 1)
Dallan et al., 2016	4	9	Lateral quadrants	Pleomorphic adenoma (n = 2), Warthin's tumor (n = 1), pseudotumor (n = 1), Langerhans cell histiocytosis (n = 1), lymphoma (n = 1), SFT/HP (n = 1), dense connective tissue (n = 1)	ETP	GTR (n = 2), PTR (n = 2), biopsy (n = 5)	Transient eyelid ptosis (n = 1), partial permanent eyelid ptosis (n = 1), damage to conjunctiva (n = 1)

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TABLE 2. Systematic literature review on outcomes of endoscopic orbital surgery

Authors & Year	LOE	No. of Pts	Location	Histology	Approach	Tumor Resection	Complication
Bleier et al., 2014	4	23	Medial quadrants	CH (n = 23)	EEA	GTR (n = 17), PTR (n = 2), biopsy (n = 2), decompression (n = 2)	Transient diplopia (n = 4), permanent diplopia (n = 1), enophthalmos (n = 5)
Montano et al., 2018	4	8	Medial quadrants	CH (n = 4), schwannoma (n = 1), lymphoma (n = 1), melanoma (n = 1)	EEA	GTR (n = 6), PTR (n = 2)	None
Present series, 2019	4	23	Medial quadrants (n = 15), lateral quadrants (n = 8)	CH (n = 5), pseudotumor (n = 2), lymphangioma (n = 2), SFT/HP (n = 3), lipoma (n = 2), AVM (n = 1), germinoma (n = 1), amyloidoma (n = 1), lymphoma (n = 1), fibro-osseous (n = 1), neurofibroma (n = 1), osteoma (n = 1), optic glioma (n = 1), nondiagnostic (n = 1)	EEA (n = 16), ETP (n = 7)	GTR (n = 14), PTR (n = 2), biopsy (n = 7)	Transient diplopia (n = 3)

CN = cranial nerve; MRM = medial rectus muscle; NA = not applicable; PTR = partial tumor removal; Pts = patients.

A lateral orbitotomy was performed after endoscopic endonasal medial decompression and diagnostic biopsy for pseudotumor orbitae in a blind patient with a severe painful exophthalmos to increase the orbital decompression. Patients with inflammatory disease or infiltrative nonresectable tumor underwent specific medical or radiation treatments. In 1 case, a cavernous hemangioma recurred 8 years after primary surgery and was removed by EEA. The mean length of patient follow-up was 59 ± 55 months (range 3–210 months).

Discussion

The recent development of endoscopic approaches has led us to consider their application for orbital tumors.^{4,9,10,14,21,26,43} In our study, we analyzed the potentialities of such routes for medial and lateral orbital lesions at 360°. Although the adoption of an EEA for orbital tumors had already been described in the 1990s by Herman et al., it has been frequently adopted only recently, after the technical refinements of the technique and the redefinition of the anatomy of this region from this different perspective.^{3,4,6,9–12,14,16,17,19,23,27,30,33,34,38,40–42} Conversely, in the last few years the ETP has been proposed by Dallan et al. as a further option besides the transcranial, anterior transconjunctival, and lateral approaches, as the lateral orbitotomy for tumors in the lateral quadrants.^{2,14} It consists of an endoscopic approach directed to the intraorbital lesion, which is similar to other minimally invasive neuroendoscopic transorbital routes, such as the lateral retrocanthal described by Moe et al. as part of Transorbital Neuroendoscopic Surgery (TONES).^{23,31,37} Indeed, other endoscopic approaches such as the transcuteaneous approach proposed by Bradoo et al., and the superior eyelid crease or the lateral retrocanthal approach included in the description of TONES, have been described in the last decade to expand the possibilities of endoscopic removal of orbital tumors, overwhelming the limitation of the EEA.^{6,31,34,37} We have observed that these approaches allowed us to reach the planned surgical goal (radical tumor removal or biopsy, according to the preoperative diagnostic suspect) in 91% of our 23 cases. One exception was represented by one of the early cases of our series, possibly because we were at the beginning of our learning curve and not all the modern intraoperative devices were available at that time. The adoption of these extracranial routes led to prompt patient recovery, reducing postoperative hospital stay (2 days on average for adults) and permitting us to start adjuvant treatments earlier, when needed.^{9,31,34}

In the literature, 18 endoscopic studies have already been reported for an overall total of 159 cases, including the present series (Table 2).^{3,4,6,9,11,12,14,17,19,22,23,27,30,33,38,40–42} Specifically, EEA has been performed in 133 (83.7%) cases (130 of them were located in the medial quadrants and 23 in the lateral), ETP was preferred in 25 lateral tumors (15.7%), and in 1 case an endoscopic precaruncular approach was adopted. The aim of surgery in cases operated on using the EEA was tumor removal in 92 cases (69%), biopsy in 25 (19%), and decompression/drainage in 16 (12%). For those undergoing an ETP, the goal of treatment was tumor removal in 9 patients (35%), biopsy in 9 (35%),

FIG. 6. Results from the systematic literature review. **A:** Distribution of histotypes of orbital tumor operated on using an endoscopic approach as reported in the literature. CH = cavernous hemangioma; SFT/HP = solitary fibrous tumor/hemangiopericytoma; NA = not available. **B:** Aim of surgery as reported in the studies in the literature review. Bx = biopsy; D/D = decompression/drainage; TR = tumor removal. **C:** Morbidity rate of orbital tumor surgery conducted using an endoscopic approach, as reported in the literature. PM = permanent morbidity; TM = transient morbidity. Figure is available in color online only.

and decompression/drainage in 8 (30%; Fig. 6). GTR was achieved in 88 (87.1%) of 101 cases, including 82 (89.1%) of 92 after EEA and 6 (67%) of 9 after ETP.

In our experience, the EEA has allowed us to combine a satisfactory surgical outcome with a reduced approach-related morbidity rate (represented in the literature by a case of silent sinus syndrome [0.7%]).^{9,31,34} Conversely, in most cases transcranial approaches to the orbit require frontal lobe retraction with consequent possible complications, including cerebral edema, stroke, seizures, and brain injury.^{34,35} Moreover, the EEA could allow one to minimize the risk of CSF leakage, which is present in other external approaches in cases of accidental dural opening, and avoid any injury to the frontal branch of facial nerve, minimizing the chances of poor aesthetic results.^{34,35} In the literature, a relevant complication of EEA is represented by the risk of postoperative enophthalmos (5.9% of cases in the analyzed series). It derives from an excessive medial decompression, with consequent silent or symptomatic posterior eye retraction. We suggest tailoring the opening of the lamina papyracea on tumor extension, limiting

this opening to its posterior third whenever possible, and placing abdominal fat covered by mucoperiosteum in the intraorbital space for cases of large tumors or for patients without preoperative exophthalmos needing larger boneperiosteal opening.

In our initial experience, ETP has allowed us to reach the surgical goal (tumor resection or biopsy) in 86% of cases with no relevant morbidity, supporting the potential satisfactory outcome associated with this approach.¹⁴ In our literature review, the main complications consisted of one transient (4%) and one permanent eyelid ptosis (4%), and one conjunctive injury (4%). This approach has given the surgeon a sufficient working space with a straight angle and a short distance from the incision to the target, combining a favorable cosmetic result (thanks to the minimal eyelid incision, barely visible some few weeks/months after surgery) with the excellent view of the orbital structures (provided by the endoscope).¹⁴ In our technique, we prefer to perform the skin incision in the lateral third of the eyebrow to reduce the risk of eyelid ptosis, which has been reported in 2 cases (one permanent and one

transient) by Dallan et al.^{14,44} The retraction of the eyelid usually leads to transient edema, which in our experience regressed spontaneously in a few days or weeks. However, this approach is limited by the need for adequate training in endoscopic surgery and should be reserved for selected centers.

Besides the morbidity related to the approach, orbital surgery is considered challenging and risky because it requires careful dissection of the delicate structures contained in the orbital space and because of the lack of anatomical reference points, thus with potential loss of orientation.^{9,30,34} Although endoscopic approaches could present some advantages, these potential surgical pitfalls remain.^{7,9,18,20,25,28,30,34} In our literature review we have found a rate of 17.9% for postoperative diplopia (16.4% transient and 1.5% permanent), 0.7% for periorbital edema, 0.7% for visual deterioration, and 0.7% for transient dyschromatopsia after endoscopic endonasal surgery.^{7,9,18,20,26,28,30,34} The application of a dedicated intraoperative imaging technique and advanced instrumentation for orbital surgery may further reduce this morbidity as they help the surgeon to identify the tumor early, reducing the invasiveness of the approach and minimizing the manipulation or retraction of the orbital structures.^{8,24,27,38,39} Based on our preliminary experience, intraoperative B-scan ultrasonography is safe, noninvasive, and free of radiation, which gives the surgeon useful dynamic information, providing a real-time visualization of the tumor and surrounding structures.²⁷ Its adoption was proposed by Lyson et al. to localize orbital abscesses, and by Alexandre et al. to cannulate the superior or inferior ophthalmic vein for carotid-cavernous fistula embolization, but it can be extended to all lesions of the region, overcoming the limitations associated with neuronavigation after the opening of the periorbital due to the shift of orbital content.^{1,27} Moreover, it does not require one to stop the surgery or prepare the patient for intraoperative CT or MRI.²⁷ Recently, Castelnovo et al. proposed the adoption of an Optikon Cryo-line probe to limit the excessive tumor dissection or the adoption of sharp instruments that may cause direct injury to orbital structures.⁸

The main limitations of our study are the retrospective design, the inclusion of a variety of lesions with different natures and histotypes, and the small number of patients treated. Particularly for the ETP, the results, derived from the limited cohorts reported in the literature, should be considered as preliminary, requiring further confirmation by more extensive studies. Moreover, our experience with ultrasonography is too limited to extensively discuss all its possible advantages or limitations.

Conclusions

Orbital surgery has been reconsidered in the last few years thanks to the development of innovative intraoperative instrumentations and surgical approaches. Tumors in the medial quadrants may be effectively and safely managed through an EEA, which has been proven to allow good results with reduced morbidity rates. The main limitation of this approach is represented by the optic nerve, which should not be crossed to avoid the risk of dramatic postoperative consequences. The recent development of an

ETP may compensate for this EEA limitation, allowing one to treat orbital tumors at 360° with endoscopic approaches. In our experience, this route combines the good visualization of the endoscope with a minimally invasive technique, avoiding brain retraction and extensive bone opening or facial scars, with promising surgical results. The intraoperative application of new technologies and tools (such as ultrasonography) may be useful in reducing the manipulation of the orbital structures, and therefore further reducing surgical morbidity. Larger series are needed to validate these preliminary suggestions.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Zoli. Acquisition of data: Sollini, Milanese, La Corte, Rustici, Ascoli. Analysis and interpretation of data: Zoli, Sollini, Milanese, La Corte, Rustici. Drafting the article: Zoli, Sollini, Milanese, La Corte, Rustici, Guaraldi. Critically revising the article: Zoli, Guaraldi, Ascoli, Cirillo, Pasquini. Reviewed submitted version of manuscript: Zoli, Guaraldi, Ascoli, Cirillo, Pasquini, Mazzatenta. Approved the final version of the manuscript on behalf of all authors: Zoli. Statistical analysis: Mazzatenta. Study supervision: Pasquini, Mazzatenta.

Supplemental Information

Videos

Video 1. <https://vimeo.com/369295637>.

Video 2. <https://vimeo.com/369295627>.

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