The Lateral Orbitotomy Approach for Intraorbital Lesions

Ryan P. Lee[1,*] Adham M. Khalafallah[1,*] Abhishek Gami[1] Debraj Mukherjee[1]

[1] Department of Neurosurgery, Johns Hopkins University School of Medicine, Baltimore, Maryland, United States

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Address for correspondence Debraj Mukherjee, MD, MPH, Assistant Professor, Department of Neurosurgery, Johns Hopkins University School of Medicine, 1800 Orleans Street, Baltimore, MD 21287, United States (e-mail: dmukher1@jhmi.edu).

Abstract

The lateral orbitotomy approach (LOA) was first described by Kronlein in 1888 and has since been subject to many modifications and variations. When considering orbital approaches, the location of the pathology is often more important in decision making than the type of pathology. The LOA is best suited for access to intraconal and extraconal lesions lateral to the optic nerve. Pathologies treated via the LOA include primary orbital tumors, extraorbital tumors with local extension into the orbit, and distantly metastatic lesions to the orbit. These all often initially manifest with vision loss, oculomotor deficits, or proptosis. The expertise of a multidisciplinary team is needed to execute safe and effective treatment. Collaboration between many specialties may be required, including ophthalmology, neurosurgery, otolaryngology, plastic surgery, oncology, and anesthesiology.

The modern technique involves either a lateral canthotomy or eyelid crease incision with removal of the lateral orbital wall. It affords many advantages over a pterional craniotomy, primarily a lower approach morbidity and superior cosmetic outcomes. Reconstruction is fairly simple and the rate of complications—vision loss and extraocular muscle palsy—are low and infrequently permanent. Deep orbital apex location and intracranial extension have traditionally been considered limitations of this approach. However, with increased surgeon comfort, modern technique, and the adoption of endoscopy, these limits have expanded to even include primarily intracranial pathologies. This review details the LOA, including the general technique, its indications and limitations, reconstruction considerations, complications, and recent data from case series. The focus is on microscopic access to intraorbital lesions.

Keywords
- lateral orbitotomy
- lateral orbital approach
- orbital tumor
- sphenoorbital meningioma
- endoscopic lateral orbitotomy
- orbital surgery

Introduction

The lateral orbitotomy approach was first described by Kronlein in 1888.[1] Kronlein used a curved skin incision that extended over the temporal fossa toward the ear and removed the lateral orbital wall to gain access to retrobulbar lesions. Though the approach represented a significant advance in the treatment of orbital tumors, it was technically challenging, resulted in suboptimal cosmetic results, and only allowed a restricted exposure. Various modifications have since been made to the procedure. In 1953, Berke modified Kronlein's skin incision to a transverse incision that extended 30 to 35 mm from the lateral canthus.[2] In 1976, Maroon and Kennerdell advocated the use of a surgical microscope and designed special microinstrumentation and a self-retaining orbital retractor to access intraorbital tumors superior, lateral, and inferior to the optic nerve.[3,4]

Further variations of the classical lateral orbitotomy have been proposed since the 1990s to enhance exposure while also improving cosmetic outcomes. Harris and Logani described an eyelid crease incision in the superolateral half of the orbit with removal of the lateral orbit.[5] A canthus-sparing approach has

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* *Indicates co-first authorship*

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also been proposed to access the medial aspect of the lateral orbit to avoid trauma to the canthus.[6] Nemet and Martin described an upper eyelid skin crease incision joining with a skin incision from the lateral canthal angle to create a triangular skin muscle flap that provides exposure to both the lateral and superolateral orbital wall.[7] The LOA can also be performed without osteotomy of the lateral orbital wall.[8] This allows for access to pathologies both outside and within the cone, including optic nerve tumors, though only relatively small lesions can be gross totally resected.

With advances in technique, use of image-guidance, and improved cosmetic outcomes, the lateral orbitotomy has begun to replace transcranial approaches for some complex orbital lesions. In part, this is due to the adaptation of endoscopy, allowing for better magnification and visualization. Sphenoid wing lesions and the middle fossa are also increasingly accessed via modifications of the lateral orbitotomy with good outcomes, avoiding the morbidity of large transcranial access.

Ideal Anatomic Location

When conceptualizing orbital approaches using the "round-the-clock" paradigm (viewing the right orbit from anteriorly), the lateral orbitotomy is best suited for lesions between the 8 and 10 o'clock positions relative to the optic nerve.[9] This approach provides access to the entire lacrimal gland and both intraconal and extraconal retrobulbar lesions lateral to the optic nerve. If there is a significant inferolateral component (6–8 o'clock), then a concurrent zygomatic osteotomy is often necessary. If there is a significant superolateral component, then often a pterional craniotomy with orbital osteotomies is the preferred approach. However, in many cases, a supraorbital craniotomy can be combined with a lateral orbitotomy by extending the incision into the eyelid or eyebrow. Traditionally, intracranial extension and deep apex locations were contraindications to lateral orbitotomy. With increased surgeon experience, refined technique, improved intraoperative technology, and implementation of endoscopy, deeper lesions and intracranial compartments are increasingly considered safely accessible. The focus of this report is on the application of the lateral orbitotomy approach to intraorbital lesions.

Typical Pathologies Treated

The pathologies treated via the lateral orbitotomy approach include primary tumors of the orbit, extraorbital tumors with local extension into the orbit, and distantly metastatic lesions to the orbit. Primary orbital tumors are rare and most commonly include meningioma, hemangioma, neurofibroma, glioma, lymphoid tumors, lacrimal gland tumors, and dermoids.[10,11] The most common secondary tumors that extend into the orbit are meningiomas and sinonasal carcinomas. When determining an optimal operative approach, location may be a more important consideration than pathology. The specific pathology, though, does often determine the availability of nonsurgical treatments or adjuncts, dictate the necessary aggressiveness of resection, and guide techniques of resection. Pathology may also aid in predicting rates of complication. For instance, optic nerve sheath meningiomas share blood supply with the optic nerve and surgical resection carries highly significant risk of blindness due to devascularization.[12] Surgery is generally no longer recommended for these lesions.

Pearls and Tips

- The lateral orbitotomy approach is traditionally best suited for lesions lateral to the optic nerve.
- Lateral canthotomy and eyelid crease incisions are commonly used with good cosmetic results.
- The posterolateral extent of the incision should be limited to no more than 2.4-cm lateral to the lateral canthus to avoid injuring the frontalis branch of the facial nerve.
- Small anterolateral lesions can be accessed without removal of the lateral orbital wall, whereas larger and deeper lesions require its removal.
- The rim of the bony orbit should be reconstructed whenever possible for improved cosmesis.
- Deep orbital apex location and intracranial extension have traditionally been considered limitations of this approach, but these limits can be expanded with a multidisciplinary team.
- Transcranial approaches may offer improved visualization but may carry higher approach morbidity.
- Retraction should be minimized to avoid ischemia to the optic nerve; fixed retraction should be relaxed periodically.

Specialties Involved

The lateral orbitotomy approach is typically performed as a collaboration between a skull base neurosurgeon and an ophthalmologist with oculoplastics expertise. An otolaryngologist with facial plastics or skull base training may also be involved, depending on the case, extent of tumor involvement, planned operative exposure, and institutional norms. An oculoplastic or facial plastic surgeon from a plastic surgery background may sometimes collaborate as well. The anesthesiologist should be familiar with and prepared for autonomic responses secondary to manipulation of the globe and orbital neurovascular structures. The anesthesia team should also be attuned to maintaining perfusion of the optic nerve, particularly if there is preexisting compression.

Generally, intraconal lesions manifest with early vision loss and oculomotor deficits, whereas extraconal lesions present early with proptosis and later with vision loss. These patients will typically present to an ophthalmologist who will make the initial diagnosis. Patients with a prior oncologic diagnosis may have a lesion discovered on screening imaging. In other cases, intracranial extension of an orbital tumor or orbital extension of an intracranial tumor may be initially diagnosed by a neurologist or neurosurgeon. In any of these situations, the expertise of a multidisciplinary team is needed to plan and execute safe and effective treatment. In addition to the above, endocrinologists and oncologists (medical and radiation) may also be integral and involved.

General Technique

The patient is positioned supine and the head is immobilized with rigid pin fixation. The head is rotated 15 to 30 degrees contralateral to the side of the pathology, with slight extension. Stereotactic image guidance may be used for tumor localization, depending on the pathology. The cornea may be covered with a lubricating ophthalmic ointment and a protective lens. A tarsorrhaphy is generally not performed as it restricts retraction and exposure. There are several options for incision. A lateral canthotomy can be extended posterolaterally in a line that would be covered by eyeglasses; many argue this incision leaves the best cosmetic result. The incision can also originate in the lateral eyebrow or eyelid crease and curve down and posterolaterally along this same line (►**Fig. 1**). Originating the incision more superiorly, such as in the eyebrow or eyelid crease, allows easier access to more superolateral pathologies. For any of these incisions, the posterolateral extent should be limited to no more than 2.4-cm lateral to the lateral commissure so as to avoid injuring the frontalis branch of the facial nerve.[13] The course of the nerve can be mapped out before incision with a stimulator.[14]

After skin incision, the canthal tendon can be released to create a larger surgical corridor, depending on the location and size of the target lesion, as well as the amount of exposure needed. Soft-tissue dissection is carried deep to reach the underlying lateral orbital bone, and the skin is undermined laterally. Traction sutures can be placed in the upper and lower canthal tissue to improve exposure. A vertical incision is made using needle-tip monopolar cautery in the periosteum on the apex of the lateral orbital wall. A subperiosteal dissection is then performed medially along the inner wall of the orbit and laterally to dissect the temporalis muscle off the orbital wall posteriorly. The temporalis can be dissected posteriorly to the inferior orbital fissure and freed at the superior temporal line. The periosteum is also dissected superiorly and inferiorly to fully expose the lateral orbital rim. Many anterolateral orbital pathologies (e.g., lymphoma and cavernous hemangioma) can be visualized and accessed at this point without bony removal. However, for larger and posterior lesions (e.g., sphenoorbital meningioma), often involving neurosurgeons, the lateral orbital wall is removed.

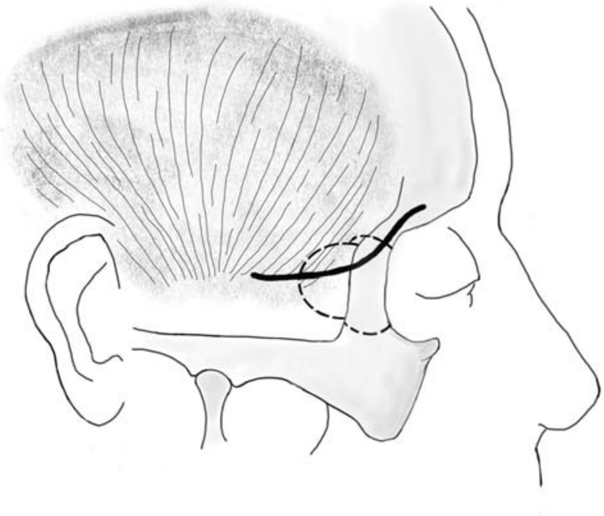

Fig. 1 General technique: the incision (solid line) originates in the lateral eyebrow or eyelid crease and curves down and posterolaterally. It can also originate in the lateral canthus and extend in a straight line posterolaterally. The posterolateral extent is limited by the location of the frontalis branch of the facial nerve. The typical osteotomy of the lateral orbital wall is depicted by the dashed line.

To remove the lateral orbital wall, a sagittal or reciprocating saw may be used to make two axially oriented cuts in the lateral orbital bone. The superior cut should be made just above the zygomaticofrontal suture and the inferior cut should be made just above the take-off of the zygomatic arch. The cuts are often made in a "**V**" shape to aid in reconstruction. The orbital contents should be protected and retracted medially. Generous irrigation is used during drilling to avoid transmission of heat to the globe and optic nerve. The posterior extent of these cuts should correspond roughly to the zygomaticosphenoid suture. After the superior and inferior cuts are made, the bone can typically be outfractured and removed. If there is hyperostosis from a meningioma, for example, the posterior extent of the osteotomy can be thinned from the lateral aspect of the orbital wall before outfracturing. After removal of the lateral orbital wall and temporalis dissection, the sphenoid wing becomes visible. Depending on the particular case, additional bone can be removed from the sphenoid wing posteriorly using a high-speed drill or rongeurs up to the orbital apex. The superior orbital fissure and frontal and temporal dura can be further exposed as needed.

With these maneuvers, the lateral periorbita becomes visible and can be incised parallel to the lateral rectus muscle. The decision to incise the periorbita above or below the lateral rectus depends upon the location of the pathology. The muscle is best identified anteriorly at its attachment to the globe, where a suture or vessel loop can be used for retraction and manipulation. Intraconally, above the lateral rectus, one may encounter the lacrimal artery and lacrimal nerve traveling to the gland. Also at risk above the lateral rectus muscle are the posterolateral ciliary artery, short ciliary nerves, and the superior branch of the oculomotor nerve with branches to the superior rectus and levator palpebrae superioris. Below the lateral rectus, one may encounter the ciliary artery, ciliary nerves, and the inferior division of the oculomotor nerve, which supplies branches to the inferior rectus and inferior oblique muscles. Orbital fat can be carefully reduced with cautery and/or retracted. Retraction should be periodically relaxed to allow perfusion of the optic nerve and globe. For large tumors, centrally debulking can allow for identification of surrounding dissection planes.

Approach Limitations

The lateral orbitotomy approach is best suited for extraconal and intraconal tumors lateral to the optic nerve. More specifically, this approach is the best for lesions in the 8 to 10 o'clock positions relative to the optic nerve when viewing the right orbit from anteriorly.[9] If there is an inferolateral component (6–8 o'clock), then a zygomatic osteotomy is often necessary. With an intracranial component involving superolateral extension (10–1 o'clock), or with involvement of the deep orbital apex, a transcranial approach has traditionally been considered necessary. However, with improved techniques and greater surgeon comfort, the limits of what can be accomplished through the lateral orbitotomy are expanding.[13,15–19] At least some of this progress may be related to use of endoscopy over traditional microscopy.

Role of Endoscopy

Given the small and tapering corridor of the orbit, visualization can be difficult, particularly when close to the apex. To address the limitations of a microscopic lateral orbitotomy approach, including potential restricted visualization and insufficient illumination, endoscopic techniques have been increasingly applied. With improved surgeon comfort and instrumentation refinements led by its popularity in the endonasal corridor, endoscopy has been increasingly adapted for many extranasal skull base approaches, including the lateral orbitotomy. Benefits include increased magnification and illumination. Endoscopy also allows for the use of angled endoscopes, further expanding surgeons' visualization.

Expanding the Approach to Intracranial Pathologies

While the traditional teaching has been that intracranial extension of orbital pathology precludes a lateral orbitotomy approach, this boundary has been increasingly expanded. While transcranial approaches are more familiar to most neurosurgeons, they are not without substantial risk and cosmetic disadvantage. With both microscopy and endoscopy, bony and dural based tumors of the periorbital sphenoid wing are successfully approached via lateral orbitotomy. This has been extended to intracranial pathology of the lateral cavernous sinus and floor of the middle cranial fossa, with an argument for lower morbidity and a esthetic advantage over larger traditional transcranial approaches.[20,21] The use of lateral orbitotomy for pathology outside of the orbit is further discussed in a separate article in this series. (reference pending)

Intraoperative Neurophysiology

When planning the incision for this approach, the posterior lateral extent is usually no more than 2.4 cm from the lateral canthus. Adhering to this boundary helps to prevent injury to the frontalis branch of the facial nerve. The frontalis nerve can be localized by stimulating in this region with a Kartush probe.[14,22] The facial nerve is typically stimulated at 30Hz at 0.05 to 5.0 mA. Aside from this upfront localization, there is typically no intraoperative neuromonitoring necessary for a simple lateral orbitotomy approach. If there is planned dural or intracranial dissection, then global neurophysiologic monitoring, including somatosensory-evoked potentials (SSEP), electroencephalography (EEG), and transcranial motor-evoked potentials (MEPs), can be used. Intraoperatively, the pupil can be evaluated periodically for size and reactivity.

Reconstruction

If the intracranial compartment is entered, care should be taken to prevent unintentional durotomy. If there is a small unintentional durotomy, it should be closed primarily if possible. Dural resections, such as in the case of meningioma, should be repaired with a dural graft; this can be supplemented with a fat graft and/or fibrin glue. A lumbar drain may also be useful perioperatively if there is concern for a high-flow cerebrospinal fluid (CSF) leak. If entered, the periorbita does not need to be approximated. In cases of severe bony deformity, the lateral orbital wall is not always reconstructed; in such instances, a thick allograft over the lateral periorbita may provide some structural support in the absence of bone. Whenever possible, the lateral orbital rim should be reconstructed for improved cosmesis. This is typically performed by using a low-profile craniofacial plating system to reattach the removed bone. Sutures and biodegradable plating systems have also been used and described elsewhere.[2,8,11,23]

The initial lateral orbitotomy approach, described by Kronlein in 1888, required a crescent-shaped incision that began at the lateral orbital rim and extended to the temporal fossa over the ear. This approach was a major advance in surgical approaches to orbital pathologies but resulted in significant scarring.[5,8] The approach has undergone many modifications to improve cosmetic outcomes, and today the eyelid crease and lateral canthotomy incisions are routinely used. The lateral canthotomy incision is thought to provide the most cosmetic outcome. The skin can be closed with absorbable subcuticular, absorbable simple running, or nonabsorbable simple running suture.

Complications

When planning the incision for a lateral canthotomy, the posterolateral extent is limited by the location of the facial nerve. Stimulation with a Kartush probe can aid in localizing the nerve to prevent injury.[14] The incision should not continue more than 2-cm posterior to the bony lateral orbital rim; some use 2.4-cm lateral to the lateral canthus as a posterior limit of the incision. Generous irrigation should be applied while drilling bone, so as to avoid transmission of heat to sensitive structures, including the optic nerve. The optic nerve is perhaps the most important structure for which to be mindful during orbital approaches. When using self-retaining retractors, they should be loosened periodically (e.g., every 10–15 minutes) to allow for perfusion of the eye. The patient's blood pressure should be maintained at or above their normal physiology to prevent hypoperfusion injury to the nerve. Patients with significant lesional compression are particularly susceptible to such injury, especially during the induction phase of anesthesia. Placement of a preinduction arterial line may help ensure that mean arterial pressure (MAP) does not drop significantly during intubation in patients with significant baseline vision loss.

Opening the periorbita should be done parallel to the lateral rectus muscle to avoid transection. The lateral rectus muscle is best identified anteriorly where a suture or vessel loop can be used to retract or manipulate it. Dural openings should be repaired primarily if possible or with a dumbbell of fat to prevent persistent CSF leak and lessen secondary risk of meningitis. A lumbar drain should be considered for patients at high risk for persistent leak. Retroorbital hematomas are rare complication and may be avoided through upfront meticulous hemostasis. Postoperative periorbital edema is common and frequently causes transient diplopia. As long as care is taken not to transect or damage the encountered extraocular muscles, permanent diplopia is rare. Caution should be exercised during reconstruction so as not to entrap the extraocular muscles, which would cause permanent deficits if not detected and addressed expeditiously.

The size, location, and type of tumor are important factors in predicting complications. Large tumors are often best centrally debulked upfront to allow for identification of surrounding dissection planes, thus permitting safe preservation of adjacent structures. Tumors within the periorbita require its opening and increase risk of damage to intraorbital structures. Meticulous microsurgical technique is essential for complication avoidance. In some cases, such as optic nerve sheath meningiomas, resection is not possible without devascularizing the nerve and secondarily causing blindness. Other tumors, such as hemangiomas, are well encapsulated, physically separate from the optic nerve, and are often able to be safely resected completely.

Case Series and Examples

Several case reports and series have been published on this approach. Literature from the past 10 years was reviewed for this manuscript. Okay et al published a series of 10 patients who were treated for intraorbital tumors via lateral orbitotomy with low morbidity despite the more limited exposure.[24] This series included nine extraconal and one intraconal lesion with varied pathologies (pleomorphic adenoma, dermoid cyst, inflammatory granuloma, malignant epithelial tumor, arachnoid cyst, cholesterol granuloma, and cavernoma). Seven patients had excellent outcomes, one patient developed a transient fourth nerve palsy, one patient developed a transient conjunctival chemosis, and one patient developed a CSF fistula that resolved with lumbar drainage.

Hamed-Azzam et al reported 18 cases of diverse intra- and extraconal pathologies that were successfully surgically accessed through lateral orbitotomy.[8] This included lymphoma, inflammatory lesions, optic nerve glioma and meningioma, cavernous hemangioma, and metastatic adenocarcinoma. In this series, no patients actually required bony removal and the lateral canthal ligament was only minimally disrupted. While this technique allowed for access to pathologies both outside and within the cone, including optic nerve tumors, only relatively small lesions could be gross totally resected. In this series, there were no permanent complications from this approach. Of note, starting with this restricted approach does not preclude conversion to a larger, true lateral orbitotomy approach, including bony removal and cantholysis, if a wider corridor is needed.

Overall, the lateral orbitotomy is still a relatively uncommon approach to intraorbital tumors. Montano et al published a recent series of 70 orbital tumors treated surgically.[25] Only one tumor was resected via lateral orbitotomy and overall transcranial approaches were used much more frequently than transorbital. However, this article provided no direct comparison of transcranial versus lateral orbitotomy approaches for laterally situated tumors, and the approach frequency is likely a representation of surgeons' preferences, which the authors acknowledge in their discussion. The authors conceded the likely increased risk of morbidity associated with larger transcranial exposures, while noting the trade-off of improved exposure and possible less morbidity during tumor resection.

Other authors have expanded the limits of this approach. Mariniello et al published a series of 18 patients with sphenoorbital meningiomas who were treated via lateral orbitotomy.[16] Patients in their series were included based on tumor location in the lateral or superolateral orbit. Sixty-seven percent (12/18) of patients had intracranial extension into the anterior middle cranial fossa, but cases were excluded if there was extension to the anterior clinoid process, superior orbital fissure, or surrounding the optic canal. Reported outcomes were excellent in this series, with transient diplopia developing in only three patients (17%). Seventy-two percent (13/18) achieved Simpson's grade-I resection, while the remainder achieved a Simpson's grade-II resection. Eighty-three percent (15/18) of patients had no growth or recurrence after follow-up (mean follow-up was 9.7 years). An eyelid crease incision was used and postsurgical cosmetic outcomes were reported as excellent or good in all cases.

Saeed et al detailed the surgical management of 66 patients with sphenoorbital meningioma.[21] Eleven of these patients were treated with extended lateral orbitotomy, including five cases with infiltration of the ocular muscles. There was no significant difference in postoperative vision or reduction in proptosis between craniotomy and lateral orbitotomy cases. The authors argue that lateral orbitotomy is effective for this pathology and avoids many of the risks of craniotomy. Partial orbital roof removal was performed in 5 of the 11 extended lateral orbitotomy cases to gain greater superior surgical access. They also used a coronal incision (as opposed to lid crease or lateral canthotomy) in a subset of these lateral orbitotomy cases that is not quantified. For these two reasons, it is difficult to apply the outcomes of this series to the standard lateral orbitotomy approach.

Amirjamshidi et al reported a series of 88 patients who underwent surgery for resection of hyperostosing enplaque sphenoid wing meningiomas.[20] Twelve (14%) patients in their series underwent a standard pterional craniotomy, and 76 (86%) patients underwent a modified lateral orbitotomy. Patients with anterior clinoid process or cavernous sinus involvement were excluded. Of those who underwent lateral orbitotomy, the recurrence rate after a 11.4-year mean follow-up was 11% (8/76). In fact, the recurrence rate was significantly less in the lateral orbitotomy cohort compared with the transcranial cohort. However, the preoperative extent of invasion was greater in the craniotomy group, potentially accounting for this difference. The rate of neurologic deficit after lateral orbitotomy was lower than after craniotomy.

Two recent series have been published focusing on orbital cavernous venous malformations, the most common primary orbital lesions in adults. Kim et al reported 18 patients with intraconal lesions, 8 of whom underwent lateral orbitotomy, while the remainder underwent anterior orbitotomy.[26] Both approaches were used for lesions lateral to the optic nerve, but lateral orbitotomy was favored if the lesion was located near the orbital apex, large in size (>3 cm), or attached to the orbital wall or tissues. Four of eight patients (50%) who underwent lateral orbitotomy were reported to have a complication, although further granular detail was not provided. The authors reported that surgical approach was not a factor in complication rate but no definitive statistics were given and the series was relatively small.

Clarós et al published a larger series of 76 patients with orbital cavernous venous malformations, where 72 of 76 patients were treated using a lateral orbitotomy and the remainder underwent anterior orbitotomy.[27] The authors reported improvement in visual acuity in 75% of patients with no change in vision in the remaining 25% of patients. Postoperative complications occurred at an overall rate of 23.7%, including superior palpebral swelling, chemosis, and lateral rectus trauma; these were reported as mild and transient complications. There was no comparison of complication rate between techniques.

Several cases have now been described adapting the endoscope to this approach.[18,28] Zhou et al presented a 10 patient series of 8 cavernous hemangiomas and 2 schwannomas at the lateral orbital apex who were resected via an endoscopic lateral orbitotomy.[17] These were mostly small tumors (range: 10–18 mm) but all were completely resected. Neuronavigation was used in all cases and there were no major complications. Five of the seven (71%) patients who had preoperative visual acuity loss improved after surgery, and the other two patients remained stable. Visual fields improved in all patients. Four patients had transient abduction paresis.

Conclusion

The lateral orbitotomy is ideal for intraconal and extraconal tumors lateral to the optic nerve, including sphenoorbital meningiomas. A wide range of pathologies can be treated in this location, with many available modifications depending on the particular case. Cosmetic outcomes can be excellent, and this minimally invasive approach may spare morbidities associated with a transcranial approach. Through the adoption of new technology, including intraoperative navigation and endoscopy, the limits of what are possible via lateral orbitotomy continue to expand.

Conflict of Interest
None declared.

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