Contralateral supraorbital keyhole approach to medial optic nerve lesions: an anatomoclinical study

Harminder Singh, MD; Walid I. Essayed, MD; Ajit Jada, MD; Nelson Moussazadeh, MD; Sivashanmugam Dhandapani, MD; Sarang Rote, MCh; and Theodore H. Schwartz, MD

OBJECTIVE The authors describe the supraorbital keyhole approach to the contralateral medial optic nerve and tract, both in a series of cadaveric dissections and in 2 patients. They also discuss the indications and contraindications for this procedure.

METHODS In 3 cadaver heads, bilateral supraorbital keyhole minicraniotomies were performed to expose the ipsilateral and contralateral optic nerves. The extent of exposure of the medial optic nerve was assessed. In 2 patients, a contralateral supraorbital keyhole approach was used to remove pathology of the contralateral medial optic nerve and tract.

RESULTS The supraorbital keyhole craniotomy provided better exposure of the contralateral superomedial nerve than it did of the same portion of the ipsilateral nerve. In both patients gross-total resections of the pathology was achieved.

CONCLUSIONS The authors demonstrate the suitability of the contralateral supraorbital keyhole approach for lesions involving the superomedial optic nerve.

https://thejns.org/doi/abs/10.3171/2016.3.JNS1634

KEY WORDS contralateral supraorbital keyhole approach; craniotomy; optic nerve decompression; medial optic nerve lesion; minimally invasive; anatomy

TRANSCRANIAL decompression of the ipsilateral optic nerve is a well-described surgical step during surgeries for pathologies involving the optic canals. These approaches are best suited to reaching the superolateral optic nerve given the superolateral approach angle. Recently a minimally invasive supraorbital keyhole craniotomy approach to the optic nerve has been demonstrated in a cadaver, again to reach the ipsilateral nerve with exposure primarily of the superolateral aspect of the nerve and canal. The medial optic canal, nerve, and tract, on the other hand, are more challenging areas to approach because of the overlying bone, arteries, and nerves and because of the available angles of visualization. Several approaches to the medial nerve, canal, and tract have been described using a transcranial, transorbital or endonasal route but primarily to expose the ipsilateral nerve. Use of a contralateral approach to the ophthalmic segment of the internal carotid artery has been described, mainly in the management of vascular pathology such as aneurysms. To the best of our knowledge, the contralateral approach to the medial optic nerve for tumors has not been reported. In this article, we describe the supraorbital keyhole approach to the contralateral medial optic nerve and tract, both in a series of cadaver dissections and in 2 patients. Indications and contraindications are discussed.

Methods

Cadaveric Dissection

Bilateral supraorbital keyhole craniotomies were performed through an eyebrow incision in 3 preserved latex-injected heads to evaluate the extent of contralateral medial optic nerve visualization and decompression on each side, for a total of 6 optic nerves. We used standard neurosurgical equipment and instrumentation (NC-4 System, Carl Zeiss Meditec AG; Anspach eMax 2 Plus high-speed drill; and modified Mayfield skull clamp).

We first performed a supraorbital keyhole craniotomy on the left side. Following durotomy, the frontal lobe was retracted to
expose the bilateral optic nerves and the chiasm (Fig. 1A). Next, the medial optic canals were decompressed using a high-speed drill, microcurettes, and rongeurs. A 1-cm portion of the orbital roof was removed bilaterally (Fig. 1B).

The second step was to perform a supraorbital keyhole craniotomy on the right side in the same cadaver. The optic nerves and the chiasm were now visualized from the contralateral (right) side. The extent of medial optic nerve decompression was noted on both sides (Fig. 1C). Next, an extended medial decompression of the left optic nerve was carried out from the contralateral (right) side (Fig. 1D).

**Surgical Technique**

In each patient the positioning and approach was as follows: The head was rotated 15°–20° toward the contralateral side (making the operative eyebrow the highest point in the surgical field) and then fixed in 15°–20° of extension. Using frameless stereotactic navigation, a minimally invasive eyebrow incision was used to turn a 2 × 3-cm craniotomy flap, with a single bur hole placed at the keyhole. The orbital rim was also removed. The dura was gently elevated from the orbit. Extradural drilling of the orbital roof was performed under microscopic visualization. The dura was then opened in a C-shaped fashion and draped over the orbit. Progressive dissection and retraction of the frontal lobe allowed identification of the ipsilateral optic nerve. Dissection was then performed contralaterally to expose the contralateral medical optic nerve and chiasm. The medial optic canal was drilled out, as needed, to reach the pathology in one patient (Case 1), and in the other (Case 2), the lamina terminalis was opened to reach the medial contralateral optic tract.

Once the pathology was resected, watertight dural closure was performed using 4-0 Nurolon suture. The orbital bar and the craniotomy bone flap were affixed to the cranium using a low-profile plating system. Bone cement was used to smooth out any protuberances and fill in the defects between the bones. The scalp was approximated with 3-0 Vicryl sutures, and a 5.0 Prolene suture was used to close the skin. The Prolene suture was removed 1 week postsurgery.

**Results**

In comparing the left versus the right supraorbital approach, the medial portion of the optic nerve was much better visualized from the contralateral side in all cadavers (Fig. 1A and C).

While we were able to perform bilateral medial optic nerve decompression of up to 1 cm from a unilateral craniotomy, the risk of retraction-induced injury to the ipsilateral optic nerve was higher than it was for the contralateral side, where no retraction was required. Similarly, the risk of iatrogenic vasa nervorum injury from the drill and curettes was significantly higher when decompressing the medial aspect of the optic nerve from the ipsilateral side compared with from the contralateral side. Figure

**FIG. 1.** Cadaveric dissection demonstrating a supraorbital keyhole craniotomy: The left optic nerve (black A) and right optic nerve (black B) are shown in each image (A–D). A: Supraorbital left-sided keyhole approach with the dura opened and frontal lobe retracted to expose bilateral optic nerves and the optic chiasm. B: A high-speed drill and an assortment of microcurettes and rongeurs were used to decompress the medial optic canal on both sides, and 1 cm of the orbital roof was removed bilaterally. Note the injury to the left optic nerve from retraction and the absence of the vasa nervorum, compared with the right side. C: Supraorbital keyhole craniotomy on the right side in the same cadaver. The optic nerves and the chiasm are now visualized from the contralateral (right) side. Again, note the absence of the vasa nervorum on the left side (A). D: Extended medial decompression of the left optic nerve was performed from the contralateral (right) side. Note the circumferential decompression of the left optic nerve (A) and the extent of medial optic nerve decompression. An additional 5 mm of decompression was achieved using the contralateral approach.
IC shows the medial decompression of a nerve (Nerve A) when performed from the ipsilateral side—note the absence of the vasa nervorum. Figure 1B shows the medial decompression of another nerve (Nerve B) when performed from the contralateral side—note the presence of the vasa nervorum.

The ipsilateral approach to the optic nerve allowed for proximal superomedial decompression. However, avoiding any injury to the optic nerve itself or to its vasculature—the vasa nervorum—was difficult to achieve from this route. As the decompression was carried away distally and inferiorly, the tangential view of the optic nerve prohibited further safe dissection and drilling. When approached contralaterally, the previous decompression was revealed to be circumferentially and longitudinally incomplete in all specimens (Fig. IC, Nerve A). The extensive medial view of the contralateral optic nerve enabled us to extend the previous decompression by approximately 5 mm in all specimens (Fig. 1D, Nerve A). The depth of the surgical field was increased during contralateral procedures but did not significantly impede microsurgical maneuverability.

**Clinical Case Examples**

We present 2 clinical examples in which a contralateral supraorbital keyhole approach was used to treat a lesion medial to the optic nerve and tract, a prechiasmatic lesion in Cases 1 and a postchiasmatic lesion in Case 2.

**Case 1**

A 62-year-old woman presented with progressive visual deterioration 7 years after undergoing a pterional approach for the resection of a left sphenoid wing meningioma. She had noticed a visual deterioration in her left eye over the course of a year, which prompted her primary care physician to request an MRI scan. Contrast-enhanced MRI revealed a recurrence of the meningioma, which compressed the medial aspect of the optic nerve on the left side, anterior to the chiasm, compressing the nerve. Gadolinium-enhanced MR images demonstrating the recurrent meningioma on the medial aspect of the optic nerve on the left side, anterior to the chiasm, compressing the nerve. C: Intraoperative photograph revealing the meningioma on the medial aspect of the left optic nerve prior to its entering the optic canal on the left side. D: Intraoperative photograph after safely removing the lesion from the left optic nerve. E and F: Postoperative coronal and axial Gd-enhanced MR images showing gross-total resection of the lesion.

A contralateral (right-side) supraorbital keyhole craniotomy was performed. The lesion was seen on the medial aspect of the left optic nerve, prior to its entry into the optic canal (Fig. 2C). The lesion was safely removed (Fig. 2D) using microsurgical technique, preserving the integrity of the optic nerve and not injuring the left ophthalmic artery, which was adherent to the residual tumor on the medial aspect of the nerve. The roof of the optic canal was also drilled away to further decompress the nerve as it entered the orbit. Postoperative MRI showed a gross-total resection (Fig. 2E and F). Her vision stabilized after surgery. Three months after surgery, visual field testing in the left eye showed a mean deviation score of −16.62 dB, with a superior arcuate defect and blind spot enlargement. This indicated stability compared with her preoperative examination. She had no radiographic recurrence at the 3-month follow-up.

**Case 2**

A 53-year-old man had undergone an expanded endonasal resection of a craniopharyngioma that was performed by the senior author (T.H.S.) 3 months prior to current presentation. The patient did well postoperatively, with his vision markedly improved. However, 2 months after this surgery, he developed progressively worsening vision in his left eye. Visual field testing showed the following: right eye, mean deviation score of −11.01 dB with a temporal hemianopia; left eye, mean deviation score of −10.85 dB with a dense central scotoma. MRI revealed interval development of a small hemorrhagic cyst (with a fluid level) compressing the chiasm and left optic tract (Fig. 3A and B), which was not present on the postoperative MRI.

A contralateral (right-sided) supraorbital keyhole craniotomy was performed. The lesion was seen on the superomedial aspect of the left optic tract, inferior to the lamina terminalis and posterior to the chiasm (Fig. 3C). The lamina terminalis was opened posterior to the chiasm and the lesion resected, decompressing the left optic tract (Fig. 3D).

Postoperative MRI showed a gross-total resection of the lesion (Fig. 3E and F). Postoperative visual field testing showed a remarkable improvement in vision: right eye, mean deviation score of −4.16 dB with a temporal hemianopia; left eye, mean deviation score of −1.5 dB and resolution of central scotoma.

**Discussion**

Optic nerve decompression is a crucial step for visual function outcome when treating various patholo-
gies,5,9–11,18,19,22 whether it is done through a transcranial, transorbital, or endoscopic endonasal route.1,3,13,14,20,23

Transcranial ipsilateral optic nerve decompression is a well-described microsurgical step, particularly used during middle fossa tumor surgery.10,13,13,18,19,21,22

Cheng et al. have reported quantitative data demonstrating that the supraorbital keyhole approach was equivalent to the larger pterional and supraorbital approaches for parasellar exposure.6 This relationship was true for ipsilateral as well as contralateral exposures. Our study demonstrates that, for optic canal approaches, the contralateral keyhole exposure provides better visualization of the medial optic canal, while the ipsilateral corridor offers only a tangential and partially obstructed view (Fig. 4).

Recent advances in endoscopic endonasal surgery have increased the neurosurgeon’s ability to safely approach a wider range of anterior and middle fossa structures. Of note is the medial optic canal, where successful endoscopic decompression has been performed for traumatic, infectious, and neoplastic optic lesions.3,20 The endoscopic endonasal approach is not only safe for medial orbital wall decompression in optic nerve injuries, but it also serves as a useful therapeutic tool during the management of more diffuse compressions as seen in sphenoorbital meningiomas.5,7,10,11,13,18,21,22

This approach, however, is best suited for inferomedial dural-extradural pathologies, while the contralateral supraorbital keyhole approach better addresses intradural superomedial compressive lesions. In addition, if the lesion extends lateral to the anterior clinoid, it will not be amenable to resection through the endonasal route, while the contralateral keyhole approach will still be applicable. The risk of a CSF leak with the endoscopic endonasal approach is also much higher (3%–5% of cases) than with the contralateral keyhole approach, where the risk of CSF leak is minimal as long as the sphenoid sinus is not entered while drilling the canal.

If the goal were to expose the medial aspect of both optic nerves, then a subfrontal approach would be appropriate. However, if the goal is to approach only the medial aspect of one nerve, then the contralateral keyhole approach is more suitable. There are 3 major limitations of the subfrontal approach: 1) risk of loss of olfaction due to bilateral frontal lobe retraction, 2) sacrifice of anterior superior sagittal sinus, which, in some cases, can lead to brain edema, and 3) exenteration of the frontal sinus, which can increase the risk of infection and CSF leak rates. If one endorses the keyhole concept of minimally invasive neurosurgery—that patients will fare better with smaller openings and less brain retraction—then the subfrontal approach is overly aggressive for unilateral medial optic nerve pathology.

In our experience, 15°–20° of head rotation allows optimal contralateral exposure and obviation of any need for frontal retraction. The direct exposure of the medial wall of the optic canal through the contralateral approach also eliminates the need for anterior clinoid process drilling, as it is often the case during ipsilateral approaches.5 Moreover the use of an endoscope can further enhance the field of view provided by the microscope should additional visualization be required.

Careful patient selection is mandatory. Evaluation should include assessment of the anterior communicating...
artery complex and the position of the optic chiasm.\textsuperscript{2,8,12,15}
As with aneurysm surgery, a prefixed chiasm and short interoptic distances represent limitations for the contralateral approach, increasing the risk for visual complications.\textsuperscript{2,8,12,15}
In addition, the presence of a prominent tuberculum sellae may considerately restrict contralateral access.\textsuperscript{16}

In our Case 1 we were also able to avoid going through the prior craniotomy incision on the left side and instead accessed the lesion via a virgin approach from the right (contralateral) side.

Conclusions
In selected cases, a contralateral supraorbital keyhole approach can be used to safely and effectively decompress the superior and medial optic canal and should be the preferred surgical approach.

Acknowledgments
We thank Cindy H. Samos for manuscript editing.

References

Disclosures
Dr. Schwartz owns stock in VisionSense and has received fellowship funding from Karl Storz.

Author Contributions
Conception and design: Schwartz, Singh, Moussazadeh. Acquisition of data: Singh, Essayed, Jada, Moussazadeh, Dhandapani, Rote. Analysis and interpretation of data: Schwartz, Singh, Rote. Drafting the article: Schwartz, Singh. Critically revising the article: Singh. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Schwartz.

Correspondence
Theodore H. Schwartz, Department of Neurosurgery, Weill Cornell Medical College, New York-Presbyterian Hospital, 525 East 68th St., Box 99, New York, NY 10065. email: schwahr@med.cornell.edu.