Although several surgical approaches have been historically described for optic nerve decompression, the endoscopic endonasal technique is gaining popularity in the skull base surgeon’s armamentarium. This technique definitely provides excellent exposure of the optic canal and orbital apex in a minimally invasive fashion. While decompression in traumatic optic neuropathy has been widely investigated, indeed with debatable results, decompression for nontraumatic optic neuropathies (NONs) is still insufficiently studied.

We hypothesize that the minimally invasive endoscopic endonasal approach will be more widely used in decompressions for nontraumatic pathologies of the orbital apex. We present our preliminary series of 11 optic nerve decompressions performed for NONs. The surgical technique is detailed and potential indications are discussed.

Key Words • skull base surgery • minimally invasive neurosurgery • endoscopic endonasal surgery • optic nerve decompression • orbital tumors • optic neuropathy

Abbreviations used in this paper: NON = nontraumatic optic neuropathy; TOF = time-of-flight.
Methods

Patient Cohort

We reviewed the medical records of all patients who had undergone endoscopic endonasal decompression for NONs at the Lyon University Neurosurgical Hospital in the period from January 2012 to March 2014. Data were collected from preoperative and postoperative ophthalmological examinations, operative reports, and hospital records.

Surgical Management

Preoperative orbital MR images and thin-slice bone CT scans were reviewed to determine the most appropriate surgical approach and precise anatomy of the sphenoid-tumoral complex (the Onodi cells, septa, bone thickness, and so forth). The surgical procedure was standardized, involving advanced endoscopic techniques derived from pituitary surgery and intraoperative navigation systems coupling CT and MRI data.

Data Collection

For all cases, clinical and imaging data on the underlying pathology and the patient, including demographics, pre- and postoperative ophthalmological assessment results, symptom duration, operative details with video debriefing, as well as the immediate and delayed postoperative course, were collected from the medical records. The ophthalmological assessment included visual acuity testing according to the decimal scale of Monoyer, a funduscopic examination, and computerized visual field testing.

Literature Review

An exhaustive and systematic review of the literature was performed using large biomedical databases (PubMed, Google Scholar, ScienceDirect, and Scopus) and the key words “optic nerve,” “orbital apex,” “decompression,” “optic neuropathy,” “endoscopic endonasal,” and “minimally invasive neurosurgery.”

Results

Patient Characteristics

Eleven patients underwent endoscopic endonasal decompression for NON in the multidisciplinary skull base surgery unit of the Lyon University Neurosurgical Hospital during the 27-month study period (Table 1). The mean patient age was 53.4 years, and there was a clear female predominance (8 females and 3 males). Among the underlying pathologies were 4 sphenoorbital meningiomas (36%), 3 optic nerve meningiomas (27%), and 1 each of trigeminal neuroma (9%), orbital apex meningioma (9%), ossifying fibroma (9%), and inflammatory pseudotumor of the orbit (9%).

Surgical Technique

Of the 11 patients, 4 underwent a secondary surgical procedure for the underlying pathology between 3 and 6 months after the optic nerve decompression: One orbital meningioma was secondarily totally resected through an intracranial subfrontal craniotomy, and 3 sphenoorbital meningiomas were resected in a classic frontotemporal manner. Two patients did benefit from a single procedure: one with a trigeminal neuroma removed through an anteromedial corridor to Meckel’s cave and one with an ossifying fibroma of the medial orbital apex.

Visual Outcome

Fifty-four percent of the patients had improved visual acuity at the 6-month follow-up. Only 1 patient (9%) whose sphenoorbital meningioma had been treated at the optic nerve atrophy stage continued to worsen despite surgical decompression. The 2 patients presenting with preoperative papilledema totally recovered. Four patients (36.4%) remained stable or improved slightly (< 2/10 of an increase on the visual acuity scale).

Postoperative Complications

One patient presented with a moderate epistaxis on the 3rd postoperative day, requiring a compressive inflatable balloon for 48 hours. A second patient experienced swelling of the orbit by air insufflated during sneezing on the 2nd postoperative day, which spontaneously resolved within 1 week.

Illustrative Cases

Case 3

A 64-year-old man, whose medical history included chronic leukemia treated with chemotherapy, was admitted for 6 months of progressive visual decline in the left eye and left frontoorbital dysesthesia. Visual assessment revealed deficient left visual acuity (counts fingers at 50 cm), decreased color vision, and an afferent pupillary defect. Fundoscopy revealed left papillary pallor. Three-dimensional time-of-flight (TOF) MRI (Fig. 1A) showed an enhancing lesion of the left orbital apex following the trajectory of the superior orbital fissure. Because of the facial dysesthesia, a diagnosis of trigeminal neuroma was discussed, even though a metastatic lesion due to the chronic leukemia could not be eliminated in this context. With the patient under general anesthesia and the aid of image guidance, we approached the lesion via a left sphenoethmoidal approach. After performing a wide opening of the left posterior ethmoidal cells, including the Onodi cell, we identified the left optic canal, as well as the anteromedial wall of the left Meckel’s cave lateral to the left internal carotid artery (Fig. 1B). The left lamina papryacea was then easily outfractured using a blunt microspatula, and the optic canal was drilled from lateral to medial under thorough saline irrigation. The thin eggshell bone remaining on the optic nerve was removed at approximately 270° until pulsations of the optic nerve sheath were observed (Fig. 1C and D). The tumor was subsequently removed through the anteromedial wall of Meckel’s cave. Histopathological examination confirmed the diagnosis of trigeminal neuroma. The postoperative course was uneventful, and visual acuity was stable. At the 6-month follow-up, a slight left facial dysesthesia remained, left visual acuity improved to 6/10, and no tumor recurrence was noted.
Case 9

A 27-year-old man without any remarkable medical history presented with progressive left proptosis and slight visual decline in the left eye. Visual acuity reached 10/10 in the right eye and 7/10 in the left, with no anomalies on fundoscopic examination and visual field testing. Imaging revealed a calcified nonenhancing tumor of the left medial orbital wall and optic canal, suggesting an ossifying fibroma (Fig. 2A). An endoscopic endonasal approach via the left nostril (Fig. 2B) was performed, allowing subtotal removal of a crumbly osseous tumor using a piecemeal technique along with irrigated ultrasonic drilling. The medial orbital wall and apex were drilled until the periorbital layer was reached. The left optic canal was consequently opened from lateral to medial (Fig. 2C). The postoperative course was uneventful. The diagnosis of benign ossifying fibroma was definitively established. Follow-up evaluation at 6 months after treatment confirmed an improvement in left visual acuity that reached 8/10 and a reduction in the proptosis. Computed tomography scanning showed good decompression of the orbital apex and optic canal (Fig. 2D), as well as an anterior medial remnant, which is being monitored yearly in the absence of any symptoms except a slight proptosis.

Discussion

Optic nerve decompression has been thoroughly described for traumatic optic neuropathy. Nontraumatic optic neuropathy is a rare condition that can be caused by a variety of disorders, including tumors, endocrine orbitopathy, idiopathic intracranial hypertension, bone dysplasia, or infectious processes (Table 2). Therefore, surgical decompression of the optic nerve may be either part of the treatment for the primary compressive process (for example, an orbital apex tumor) or a preliminary step before treating the underlying cause via an intracranial route (for example, sphenoorbital meningioma).

Various surgical approaches have been described for decompression of the optic nerve: a medial approach by external ethmoidectomy, an inferomedial approach via a transantral transethmoidal route, a supraorbital transcranial approach, and the endoscopic endonasal transsphenoidal approach. This latter approach affords excellent visualization of the optic canal and medial orbital apex with minimal morbidity and no brain retraction or scarring. Nevertheless, the optimal timing and the visual benefits are still questioned in the absence of a prospective study.

Surgical Anatomy

Considered as an extension of the brain, each optic nerve is enveloped by 3 meningeal layers (Figs. 3–6). Each measures about 50 mm in length. Four anatomical segments can be described: intraocular (1 mm), intraorbital (25–30 mm), intracanalicular (10 mm), which is the most vulnerable to compression, and intracranial (10 mm). It is the intracanalicular segment that is addressed in endoscopic endonasal decompression. In this segment the optic nerve is fixed by the fibrous annulus of Zinn. From...
the endoscopic endonasal view, the optic nerve is covered by a thin bone of about one-half millimeter in the majority of patients and is uncovered in 4% of patients. In comparison, the carotid artery is uncovered in the sphenoid sinus in about 8% of patients. These conditions are of paramount importance during drilling of the optic canal.

The optic canal is fashioned from the 2 struts of the lesser wing of the sphenoid bone. It contains the optic nerve and the ophthalmic artery. This canal is approximately 10 mm long and 4–5 mm wide. It is thinner and wider proximally and thicker and narrower distally. At this point, the dura mater and the periosteal layer of the

![Figure 1](image.jpg)

**Fig. 1.** Case 3.  
A: Axial 3D TOF high-resolution T1-weighted MR sequence with Gd showing trigeminal neuroma (yellow arrows) of the left orbital apex.  
B: Endoscopic view through the left nostril after sphenoidotomy and posterior ethmoidectomy. Asterisk indicates the anteromedial corridor to the left Meckel’s cave.  
Black and yellow dotted lines mark the borders of the structure indicated.  
C: View after a lateral to medial decompression of the left orbital apex and optic nerve, before trigeminal neuroma removal. Asterisk indicates the anteromedial corridor to the left Meckel’s cave.  
Black and yellow dotted lines mark the borders of the structure indicated.  
D: Postoperative CT scan showing the extent of left optic canal and orbital apex decompression (dotted and solid yellow lines). CA = internal carotid artery; CR = clival recess; OA = orbital apex; ON = left optic nerve within its canal; S = sella turcica; Tbc = tuberculum sellae.

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>No. of Patients</th>
<th>Mean Age (yrs)</th>
<th>Underlying Pathology</th>
<th>Complication</th>
<th>% w/ Good Visual Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lund &amp; Rose, 2006</td>
<td>12</td>
<td>42.6</td>
<td>sphenoid wing meningioma</td>
<td>no</td>
<td>58.3</td>
</tr>
<tr>
<td>Pletcher &amp; Metson,</td>
<td>7 (10 decompressions)</td>
<td>49</td>
<td>meningioma, lymphangioma, mucocele, fibrous dysplasia, Graves’ orbitopathy</td>
<td>postop hyponatremia, corneal abrasions</td>
<td>70</td>
</tr>
<tr>
<td>Attia et al., 2012</td>
<td>8</td>
<td>NA</td>
<td>suprasellar meningioma</td>
<td>no</td>
<td>37.5</td>
</tr>
<tr>
<td>Sencer et al., 2014</td>
<td>10</td>
<td>34.1</td>
<td>idiopathic intracranial hypertension</td>
<td>no</td>
<td>80</td>
</tr>
<tr>
<td>current study</td>
<td>11</td>
<td>53.4</td>
<td>sphenoorbital meningioma, optic nerve meningioma, orbital meningioma, inflammatory pseudotumor, ossifying fibroma, trigeminal neuroma</td>
<td>epistaxis, pneumo-orbit</td>
<td>54.5</td>
</tr>
</tbody>
</table>

* Series dealing with traumatic optic neuropathy or including fewer than 3 patients were excluded. NA = not available.
Endoscopic endonasal optic nerve decompression

optic canal fuse to form the periorbita. Typically, the ophthalmic artery lies inferolateral to the optic nerve, but a more medial trajectory is possible and hence should be considered during decompression. The central retinal artery leaves the ophthalmic artery 10 mm behind the globe.

As seen from below, the optic canal is in direct contact with the lateral sphenoid recess and the most posterior ethmoidal cells. Among these cells are some sphenoethmoidal cells, also known as Onodi cells, which may directly cover the optic canal and must be opened to expose the optic nerve.

Pathophysiology

From a pathophysiological perspective, function of the optic nerve may be altered by a combination of CSF circulation dysfunction, ischemia from arterial injury (ophthalmic artery and central retinal artery), and a direct axoplasmic transport interruption (conduction block, demyelination, degeneration). Edema and hemorrhage inside the nerve are also possible, especially in acute traumatic optic neuropathy. While decompression in acute traumatic optic neuropathy is useful exclusively in the first 3–6 hours, the timing of decompression in chronic optic neuropathy is debatable. Moreover, there is no evidence that

Fig. 2. Case 9. A: Preoperative CT scan demonstrating an ossifying fibroma of the medial orbital apex and left optic canal. B: View after sphenoidotomy and posterior ethmoidectomy via an endoscopic endonasal approach through the left nostril. CA = right carotid artery; CR = clival recess; ON = right optic nerve (contralateral nerve); ST = sella turcica. Double asterisks indicate tumor of the left orbital apex covering the left optic canal. C: View after tumor drilling and decompression via an endoscopic endonasal approach through the left nostril. CR = clival recess; ICA = left carotid artery; ION = left optic nerve; OA = left orbital apex; rCA = right carotid artery; rON = right optic nerve. D: Postoperative CT scan demonstrating sufficient decompression of the left optic nerve and medial orbital apex (dotted yellow line). Note the remnant on the most anterior medial wall (yellow arrows) requiring regular follow-up.

Fig. 3. Endoscopic anatomical view after wide anterior bilateral sphenoidotomy and posterior ethmoidectomy. The sella turcica (S) lies on the midline, limited posteriorly by the clival recess (CR) and anteriorly by the tuberculum sellae (Tbc) and planum sphenoidale (Pla). The sella is bordered laterally by both optic canals (OC) with an anterolateral trajectory going toward the orbital apex (OA) and both internal carotid arteries (CA). OCR = opticocarotid recess; On = Onodi cell.
high-dose corticosteroids, particularly as cell membrane stabilizers, are useful in NON.

**Patient Evaluation**

A detailed ophthalmological assessment should include at least fundoscopic examination, visual acuity evaluation, and computerized visual field testing. As the perception of red is lost first, color vision can also be tested. If the patient is unable to cooperate, monitoring of visually evoked potentials is valuable.

Imaging of the optic canal relies mainly on thin-slice CT scanning. This modality accurately shows in 3 anatomical planes (axial, sagittal, and coronal) the pneumatization and septations of the sphenoid sinus and the ethmoidal cells, as well as any uncovered carotid artery. In sphenoorbital meningiomas or dysplasia, CT scanning reveals bone density and thickness. Magnetic resonance imaging should include not only traditional sequences (T1-weighted with or without Gd, T2-weighted) but also a 3D TOF high-resolution sequence. This latter sequence shows very accurately the relationships between the optic nerve and the underlying pathological compressive lesion as well as the position of the ophthalmic artery.

**Surgical Technique**

Today, the surgical technique is well standardized with very few variants. The approach is very similar to that used for pituitary surgery, therefore, most skull base surgeons are familiar with it. With the
Endoscopic endonasal optic nerve decompression

If a tumor is present, it can be resected or biopsied. The technique allows tissue sampling and/or tumor removal for nontraumatic neuropathies. This minimally invasive technique allows tissue sampling and/or tumor removal if indicated during the same procedure. Optic nerve decompression must be considered early in the course of a disease before the onset of optic nerve atrophy. Nevertheless, given the variety of possible underlying pathologies, it is important to not draw premature conclusions about any recommendation in the absence of randomized studies and more homogeneous series.

**Conclusions**

Our preliminary results confirm the potential benefits of endoscopic endonasal optic nerve decompression for nontraumatic neuropathies. This minimally invasive technique allows tissue sampling and/or tumor removal if indicated during the same procedure. Optic nerve decompression must be considered early in the course of a disease before the onset of optic nerve atrophy. Nevertheless, given the variety of possible underlying pathologies, it is important to not draw premature conclusions about any recommendation in the absence of randomized studies and more homogeneous series.

**TABLE 3: Potential indications for endoscopic endonasal optic nerve and orbital apex decompression**

- optic nerve sheath meningioma
- osteopetrosis
- fibrous dysplasia
- endocrine orbitopathy
- orbital apex tumors
- medial orbital tumors
- mucocele
- idiopathic intracranial hypertension
- cavernous sinus tumors w/ extension to optic canal
- sphenoorbital meningioma
cortico-resistant inflammatory optic &/or orbital disease
29. Li HB, Shi JB, Cheng L, Yun O, Xu G: Salvage optic nerve...

Manuscript submitted June 12, 2014. Accepted July 22, 2014. Please include this information when citing this paper: DOI: 10.3171/2014.7.FOCUS14303. Address correspondence to: Moncef Berhouma, M.D., M.Sc., Skull Base Surgery Unit, Department of Neurosurgery B, Pierre Werthemier Neurological and Neurosurgical Hospital, Hospices Civils de Lyon, 59 Boulevard Pinel, 69394 Lyon Cedex 03, France. email: berhouma.moncef@gmail.com.

Neurosurg Focus / Volume 37 / October 2014