Original Article

A Modified Surgical Procedure for Endoscopic Optic Nerve Decompression for the Treatment of Traumatic Optic Neuropathy

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Abstract

Background: Although the endoscopic anterior-to-posterior technique offers many advantages, the long-term effects of the iatrogenic trauma (removal of the uncinate process and anterior ethmoidal sinus) resulting from the complete ethmoidectomy procedure used to gain full access to the optic nerve canal is unknown, and sequelae such as nasal synechia and sinusitis should not be ignored. **Aims:** The aim of our study is to develop a less invasive procedure for endoscopic optic nerve decompression. **Materials and Methods:** We proposed a modified trans-sphenoidal surgical procedure for endoscopic optic nerve decompression in five patients with traumatic optic neuropathy (TON), all with high sphenoidal pneumatisation and without Onodi cellulae. **Results:** After performing a direct sphenoidotomy through the natural ostium of the sphenoid sinus rather than a complete ethmo-sphnoidectomy, we found that the modified approach provided adequate access to the optic nerve canal and the apex using a 45° angled endoscope. Successful decompression of the canal optic nerve was performed trans-sphenoidally in all five TON patients using an angled endoscope. No surgical complications occurred, and none of the patients suffered from anterior ethmoidal sinus or skull base damage. **Conclusions:** The modified trans-sphenoidal approach is a feasible, safe, effective, and minimally invasive approach for TON patients with high sphenoidal pneumatisation and without supersphenoid-ethmoid cellulae.

Keywords: Endoscopic technique, Optic nerve decompression, Traumatic optic neuropathy

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Introduction

Traumatic optic neuropathy (TON) is an impact injury to the optic nerve, usually secondary to blunt head trauma, resulting in partial or complete loss of vision. The choice of treatment for TON is controversial. A meta-analysis reported that both steroid administration and surgical decompression improved the prognosis of patients with TON.[1] After consideration of a lateral or medial orbitotomy, as well as transcranial approaches to the orbital apex and optic nerve canal, an endonasal transethmoidal-sphenoidal approach represents an alternative strategy for the treatment of TON.[2] The endoscopic anterior-to-posterior technique offers many advantages, including decreased morbidity, preservation of olfaction, rapid recovery time, more acceptable cosmetic results without external scars and no risk of injury to developing teeth in children.[3] However, despite its safety, effectiveness, and minimal invasiveness, the long-term effects of the iatrogenic trauma (removal of uncinate process and anterior ethmoidal sinus) resulting from the complete ethmoidectomy procedure used to gain full access to the optic nerve canal is unknown, and sequelae such as nasal synechia and sinusitis should not be ignored.[4]

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Anatomically, the optic canal is just superolateral to the sphenoid sinus as a part of the lesser sphenoid wing. The canal is wide with thin walls proximally toward

the optic chiasm, and narrow with thick walls distally at the optic tubercle. The optic tubercle is the thick bulge of the medial aspect of the bone surrounding the optic foramen. Depending on the degree of pneumatisation or the presence of supersphenо-ethmoid (Onodi) cellulae, the optic tubercle can be visualized within the sphenoid sinus or at the junction of the sphenoid and posterior ethmoid sinuses.[5,6] In the case of high sphenoidal pneumatisation, the use of an angled endoscope allows clear visualisation of the lateral sphenoidal wall and the orbit apex. This raises the possibility that optic nerve decompression can be performed through a single trans-sphenoidal approach rather than using complete ethmoidectomy.

Herein, we report five cases of TON in which a modified surgical procedure for endoscopic optic nerve decompression was performed, using a 45° endoscope. We include discussion of the operative events, along with the apparent advantages and limitations.

Materials and Methods

Subjects

Five patients with TON, all of whom were unresponsive to high-dose methylprednisolone (500 mg/day) for more than 7 days, were enrolled to undergo modified endoscopic optic nerve decompression. The patient demographics are displayed in Table 1. Only patients with high sphenoidal pneumatisation and without Onodi cellulae identified by preoperative fine-cut computed tomography (CT) scan [Figure 1] were included. This study was approved by the Ethical Committee of our hospital, and a written informed consent was obtained from each subject.

Surgical procedure

The surgical procedure was modified from what we have previously described.[3] Briefly, patients were prepared in the routine manner for endoscopic sinus surgery under general anesthesia. Cotton pledgets soaked in epinephrine solution were placed in the nasal cavity to ensure vasoconstriction. In contrast to the standard endoscopic ethmoidectomy procedure, we located the ostium of the sphenoid sinus by removing the superior turbinate [Figure 2a]. When the sphenoid sinus was opened and the ostium was enlarged to the lateral wall, the optic nerve canal was clearly identified using a 0° or 45° endoscope [Figure 2b]. In two cases, the posterior ethmoids were slightly opened retrograde from the sphenoid to improve the exposure of the optic nerve canal.

The orbital apex was then dissected to expose the lateral wall of the sphenoid sinus. Under endoscopic observation, a long-hand microdrill with a diamond burr was used to remove the medial wall of the bony optic canal. To avoid thermal injury to the optic nerve, frequent irrigation was required. Using this technique, the optic nerve canal was drilled 180° medially from the optic tubercle to near the optic chiasm until the bony canal became very thin. A special instrument was then used to elevate the thin bony canal from its position over the optic nerve. Extreme care was taken to not exert pressure on the optic nerve with the elevator [Figure 2c].

We modified the routine procedure for endoscopic optic nerve decompression as follows:

1. We used a endonasal trans-sphenoidal approach instead of a endonasal transethmoidal-sphenoidal approach to keep the anterior ethmoidal sinus and middle meatus intact [Figure 2d]
2. We drilled off the distal bony wall of the optic nerve canal using a 0° endoscope

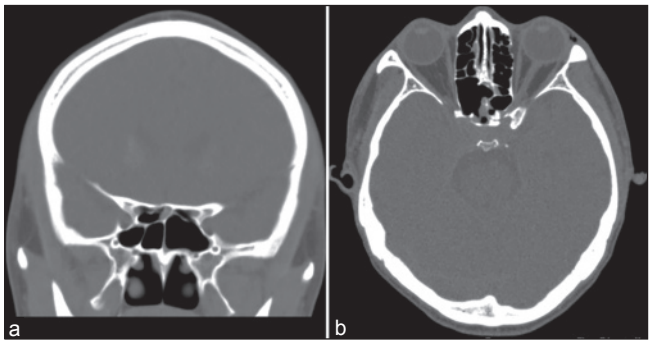

Figure 1: Representative preoperative computed tomograpgy (CT) scan of a traumatic optic neuropathy (TON) patient (a) Coronal view; (b) Horizontal view

Table 1: Demographics of five TON patients performed modified optic nerve decompression

Case no	Sex	Age (yrs)	Affected side	Visual acuity		Surgical complication
				preoperative	postoperative	
1	Male	24	Left	No light perception	No light perception	No
2	Male	18	Left	No light perception	0.1	No
3	Male	37	Left	Light perception	0.2	No
4	Male	31	Right	No light perception	Hand movement	No
5	Male	25	Right	Light perception	Counting fingers	No

TON = Traumatic optic neuropathy

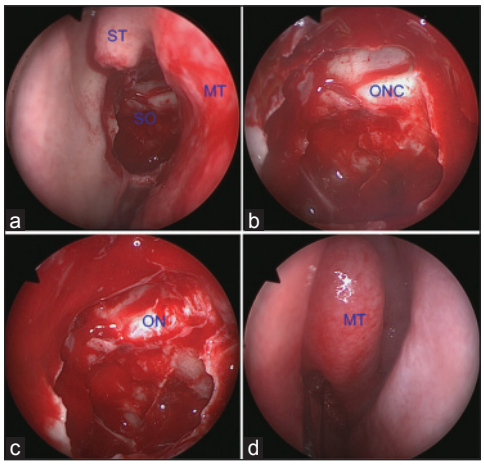

Figure 2: Representative endoscopic view of optic nerve decompression using a modified trans-sphenoidal approach (a) Sphenoidal ostium; (b) Optic nerve canal; (c) Optic nerve; (d) Intact middle meatus SO, Sphenoidal ostium; ST, Superior turbinate; ONC, Optic nerve canal; ON, Optic nerve; MT, middle turbinate

3. We drilled off the proximal bony wall of the orbital apex using a 45° angled endoscope
4. We maintained the integrity of optic nerve without incision of the optic sheath.

Finally, the optic nerve sheath was covered with an absorbable gelatin sponge.

Evaluation of visual acuity

All patients received regular follow-up care including visual acuity and field chart testing 10 days postoperatively. A patient's vision was considered to have improved if they showed any of the following: An improvement from no light perception to light perception or better; an improvement from light perception to hand motion or better; an improvement from hand motion to finger counting or better.

Results

Five patients with TON with high sphenoidal pneumatisation and without Onodi cellulae were enrolled. The cause of TON included motorcycle accidents (4/5) and a fall (1/5). After performing a direct sphenoidotomy through the natural ostium of the sphenoid sinus rather than a complete ethmo-sphnoidectomy, we found that the endonasal trans-sphenoidal approach provided adequate access to the optic nerve canal and the apex using a 45° angled endoscope. Successful decompression of the canal optic nerve was performed trans-sphenoidally in all five patients using an angled endoscope. Four patients showed improved optic vision after decompression surgery [Table 1]. No surgical complications occurred, and none of the patients suffered from anterior ethmoidal sinus or skull base damage.

Discussion

In this study, we successfully developed a modified endoscopic optic nerve decompression procedure for five patients with TON with severe sphenoidal pneumatisation and without Onodi cellulae. Our results suggest that modified endoscopic optic nerve decompression is a safe, effective, and minimally invasive strategy for specially selected TON patients.

TON is an important cause of severe visual impairment following blunt or penetrating head trauma. Treatment options include steroids, surgical decompression, or both, with no consensus on the optimal protocol. The use of high-dose steroids after optic nerve injury became more common during the 1980s, following the rationale that steroids may reduce post-traumatic edema, contusion necrosis, and vasospasm, and thus aid functional recovery. Previous studies have reported improvement in between 44% and 82% of patients following steroid therapy. However, in other studies, 57% of untreated patients showed improvement in visual acuity, indicating spontaneous remission.[7] The indications for endoscopic optic nerve decompression are also cause for debate. It has been suggested that such surgery should only be performed following failure of high-dose steroid therapy.[8] Some authors suggested that endoscopic optic nerve decompression be performed if vision fails to improve after 72 hours of methylprednisone therapy; or if progressive visual loss during steroid therapy is observed. Additionally, complete blindness with CT evidence of optic nerve compression was also put forth as an indication for surgery.[9]

Despite the lack of evidence showing a clear benefit for either steroids or surgery or combined therapy, patients with TON have a strong desire for endoscopic optic nerve decompression for vision salvage. In this study, we sought to develop a novel, less invasive surgical approach rather than to address the clinical efficacy of and indications for endoscopic optic nerve decompression. Currently, a traditional transethmoidal-sphenoidal approach is generally performed to gain wide access to the optic nerve canal and optic apex by means of a complete endoscopic ethmoidectomy and sphenoidotomy. However, the complete endoscopic ethmoidectomy includes removal of the uncinate process and anterior ethmoidal sinus, and the long-term effects of this trauma are unknown. Additionally, common postoperative sequelae such as nasal synechia and sinusitis[4] should not be ignored. To avoid iatrogenic trauma as much as possible, we developed a modified surgical procedure that leaves the uncinate process,

ethmoidal bulla, and middle meatus intact. In this study, we modified the endonasal transethmoidal-sphenoidal approach by using an endonasal trans-sphenoidal approach to avoid removing the uncinate process and anterior ethmoidal sinus.

In cases of high sphenoidal pneumatisation, we were able to drill off the distal bony wall of the optic nerve canal using a 0° endoscope, and drill off the proximal bony wall of the orbital apex using a 45° angled endoscope. In addition, the modified endonasal trans-sphenoidal approach may be especially appropriate for patients with lamina papyracea bony fragments, in whom the orbital fat herniating into the ethmoidal sinus typically blocks access to the sphenoidal sinus and orbit apex. We successfully conducted trans-sphenoidal decompression of the canal optic nerve in all five patients. The decision to perform nerve sheath incision during optic nerve decompression is also under debate.[2,10] Based on our unpublished data, we found no additional optic vision improvement following incision of the optic sheath. Thus, we made a second modification by maintaining the optic nerve intact without incision of the optic sheath. Consequently, we showed that incision of the optic sheath is not a prerequisite for successful optic nerve decompression.

We acknowledge that this technique has some limitations. First, although the uncinate process and anterior ethmoidal sinus were kept intact, the posterior ethmoids were slightly opened retrograde from the sphenoid to improve the exposure of the optic nerve canal in two of five cases; thus, the minimal trauma of this approach cannot be over-interpretated for some patients. It is also worthwhile to note that all five patients had high sphenoidal pneumatisation without Onodi cellulae (identified by a preoperative fine-cut CT scan), as the optic nerve canal may not be accessible in the case of Onodi cellulae. Additionally, when the ostium of sphenoidal sinus is enlarged to the lateral wall, the optic nerve canal need to be identified using a 45° endoscope to gain appropriate access to the lateral sphenoidal wall and orbit apex, which may increase the technical difficulty of the surgery.

Conclusion

Our study demonstrates that a modified trans-sphenoidal optic nerve decompression is a feasible, safe, effective, and minimally invasive approach for TON patients with high sphenoidal pneumatisation and without supersphenoid-ethmoid cellulae. In cases of high sphenoidal pneumatisation, the use of an angled endoscope allows for easy access to the optic nerve canal and the orbit apex using a trans-sphenoidal approach while keeping the uncinate process and anterior ethmoidal sinus intact.

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