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ORIGINAL ARTICLE

Endoscopic Optic Nerve Decompression for Direct Traumatic Optic Neuropathy : Our 10 Years Experience

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Abstract

Traumatic optic neuropathy (TON) can be classified into direct or indirect types. Direct optic injury usually results from optic nerve avulsion ,laceration or compression by fracture, fracture segment impingement or a resultant hematoma. Indirect optic injury is caused by increased intracanalicular pressure resulting in ischemia and disruption of neurofeedback channels. The prognosis of TON is usually quite poor. To date, no standardized treatment protocol has been developed for TON. In this study we are assessing the visual improvement in patients with direct TON who underwent endoscopic optic nerve decompression in the last 10 years. A retrospective study of 32 cases of optic nerve decompression for direct TON in the last 10 years. Preoperative and postoperative visual assessment were done and followed up for 3 months. There was complete improvement in vision in 17% of patients when optic nerve decompression was done within 72 h of trauma; whereas 31% cases had only partial improvement when done between 3 and 7 days. And there was no improvement when done after 7 days. Endoscopic optic nerve decompression is a minimally invasive surgery for direct traumatic optic neuropathy; with minimal or no complications when done by an experienced ENT surgeon. Other important prognostic factors include timing of surgery and preoperative visual status.

Keywords Endoscopic optic nerve decompression (EOND) · Traumatic optic neuropathy (TON) · Timing of surgery · Visual outcome

Highlights

Traumatic optic neuropathy (TON); mainly classified into direct and indirect types, do not have a well established treatment protocol till now.

Direct type of optic neuropathy is caused by injury to optic nerve, by fracture lines or segments.

TON not resolving with medical decompression is taken up for endoscopic optic nerve decompression as early as possible; preferably within 72 h.

Pre operative visual status is one of the main prognostic factor along with timing of surgery; patients with at least perception of light fared way better than those with no perception of light.

Patients in whom EOND was done within 72 h had better visual improvement than those in whom intervention was done after 72 h.

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Introduction

Traumatic optic neuropathy (TON) is most frequently encountered in road traffic accidents in which it is seen in 2.5% of midface fractures and 10% of craniofacial fractures [1, 2]. It can be classified into direct and indirect types. As the name implies, direct type occurs when there is avulsion or tear of optic nerve inflicted by fracture of orbit/ bony optic canal or fracture segments impinging on the optic nerve,contusion, concussion, intraneural/extraneural hematoma. Whereas indirect traumatic optic neuropathy occurs when there is edema, ischemia, microvascular thrombosis, interruption of neurofeedback mechanism or infarction which results from trauma [3, 4]. Optic nerve is known for its inability to regenerate as it is a derivative of the central nervous system ;developing as an outpouching of diencephalon. Hence when medical or surgical treatment is planned, it has to be done at the earliest to restore the vision. When there is direct traumatic optic neuropathy, surgical decompression is warranted due to obvious reasons. However, TON may be initially treated with high dose corticosteroids making it rightly called as medical decompression. If there is no visual improvement with medical management, the pressure on the nerve has to be relieved with optic nerve decompression as early as possible, preferably within 72 h. but there are multiple factors which hinders such an early intervention. Firstly, traumatic optic neuropathy is never an isolated pathology as the majority of such patients have associated life threatening conditions / head injury to be attended as part of the inflicted trauma. Secondly patient may not be aware of vision loss immediately after trauma due to coexisting brain damage.

There is still no established consensus on treatment protocol for TON. For decades, direct TON was not usually surgically managed as the available intracranial and pterional approaches were associated with marked morbidity. But with advent of endoscopes and advanced endoscopic techniques, this previously “difficult to access” area became easily accessible. Endoscopic optic nerve decompression (EOND) can be done with minimal or no added morbidity when done by an experienced ENT surgeon. However, the results can vary in each case based on the degree of trauma, vision at the time of presentation as well as the time of intervention. In this article, they have described how they evolved the treatment protocol for TON, graded the visual outcome after EOND and thus have evaluated the validity of EOND for TON in the past 10 years and ; for individual cases during this time period.

Methods

This is a retrospective study where they analyzed all cases of direct type TON in whom EOND decompression during the time period of September 2009- August 2019. Electronic medical records of these patients were examined for the radiological evaluation, progress notes, timing of surgery, surgical notes, preoperative and postoperative visual assessment. They had the opportunity to perform EOND in 31 patients of which 1 patient had bilateral direct TON. So in total EOND was done in 32 eyes. All patients were males between the ages of 19 and 63 years. In all patients, TON was inflicted as part of road traffic accidents. This study was approved by the institutional review board (PIMSRC/E1/245A/70/2019). Informed written consent was obtained from all the patients.

Table I Tiers of visual assessment

6/6	Snellen chart assessment
5/6	
4/6	
3/6	
2/6	
1/6	
FC	Finger counting
HM	Hand movements
LP with projection(PR)	Light perception with Projection (Projection of rays)
LP without projection(LP)	Light perception without projection
NO LP	No light perception

Pre operative assessment

All patients were admitted in neurosurgery ICU as all of them had sustained head injuries also and when TON was suspected, as part of institutional protocol high dose corticosteroids (1 g methylprednisolone once daily) was started. Ophthalmological evaluations were routinely done in such patients which included visual assessment [5] as well as fundoscopic examination. Visual assessment was done with Snellen chart and if the patient could not read at 1/6 as in Snellen chart; finger counting, projection and perception of light were looked upon (Table I). Fundoscopic examination is of paramount importance because of the following reasons. Firstly, fundoscopic examination is needed to rule out any preexisting optic nerve damage with optic nerve atrophy as performing EOND in such patients is a futile attempt. Secondly fundoscopic examination rules out other causes of diminished vision following trauma like vitreous hemorrhage, choroidal rupture, retinal detachment and retinal edema [6]. Cross reference to our department is usually placed at least 24 h after the patient gets admitted. As the patients were already started on high dose corticosteroids, this time period gives them the time to assess outcomes of medical management or subjective visual improvement ,if any. If there is progressive visual deterioration/ no visual improvement and evidence of fracture segment impingement on optic nerve or any obvious fracture of bony optic

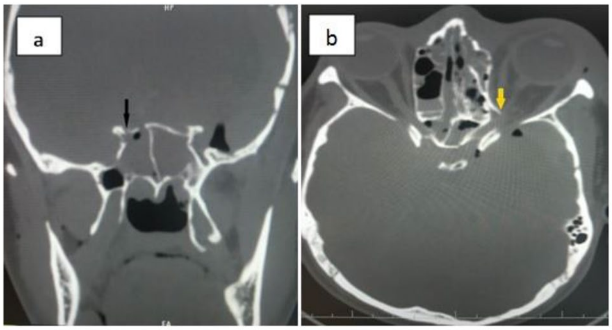

Fig. 1 CT scans of patient with bilateral traumatic optic neuropathy: 1a) Black arrow showing a fracture involving right bony optic canal in the sphenoid sinus.1b) Yellow arrow showing fracture segment impinging on intraorbital portion of the left optic nerve

canal as in Fig. 1a and b, patients were given the option of EOND within 72 h of trauma. Patients with other life threatening situations were taken up only after their general condition was stabilized. In the initial period of our study, they found that there was no visual improvement in patients when EOND was done after 7 days of trauma. Hence in later periods of our study EOND in such patients were deferred.

Surgery

EOND was done under general anesthesia where nasal cavities were decongested with pure adrenaline; 1 mg/ml (Vasocon*). Middle meatal antrostomy, anterior and posterior ethmoidectomy were done. A wide sphenoidotomy was done by removing anterior sphenoid wall superiorly up to skull base, laterally up to lamina papyracea and medially upto nasal septum. Optic nerve, internal carotid artery and lateral optico carotid recess were identified within the sphenoid sinus. Unlike routine endoscopic sinus surgeries, the above said land marks may not be readily identifiable due to anatomical distortion by fracture lines, fracture segments and coexisting mucosal edema. Hence the entire mucosa of the sphenoid sinus is removed to expose the bony landmarks inside. Decompression begins after delineation of the entire lamina papyracea (which in most cases were found to be fractured) upto the orbital apex. Lamina papyracea is removed starting from the midpoint between the posterior wall of maxillary sinus and orbital apex approximately 10-15 mm anterior to the face of the sphenoid. Care was taken not to injure the periorbita and the underlying extra ocular muscles. Periorbita was followed posteriorly to where it converges at the orbital apex. The thick bone between posterior ethmoid and sphenoid sinus at the orbital apex is known as the optic tubercle. The *Annulus of Zinn* is attached to the superior, inferior and medial margins of the orbital junction with the optic canal and can be identified at the level of the optic tubercle. At this point, a diamond burr, with adequate irrigation, was used to remove the optic tubercle, exposing the annulus of Zinn. Decompression was performed on entire length of optic canal within the sphenoid sinus till the point where the nerve curves from an oblique to a transverse direction in its posterior course, indicating that it was nearing the chiasmal region and well posterior to the encasing bony canal (Fig. 2). The optic nerve sheath and the annulus of Zinn were incised with a sickle knife, as these two structures may contribute to pressure on the optic nerve. This step of fenestration was done in our study only in selected cases; (1) when an intrasheath hematoma was suspected (2) when the optic nerve appears grossly edematous or an impression of bulging optic nerve was obtained after decompression [7] (3) when there was a traumatic breach in the nerve sheath inflicted by a fracture segment. The incision was performed in a longitudinal way on the upper-medial part, reducing the risk of damaging the ophthalmic artery, usually situated in the inferior-medial part of the optic nerve/canal (Fig. 3). In cases where the surgeon placed nerve sheath incisions, a mucosal graft was placed to prevent potential CSF leak. Also mucosal grafts from the nasal cavity were placed over traumatic dehiscence of the carotid canal; if any. Nasal packings were avoided as far as possible. But if any coexistent CSF leak was repaired, then packing was done using oxidized regenerated cellulose (Surgicel®) and absorbable gelatin sponge (AbGel®).

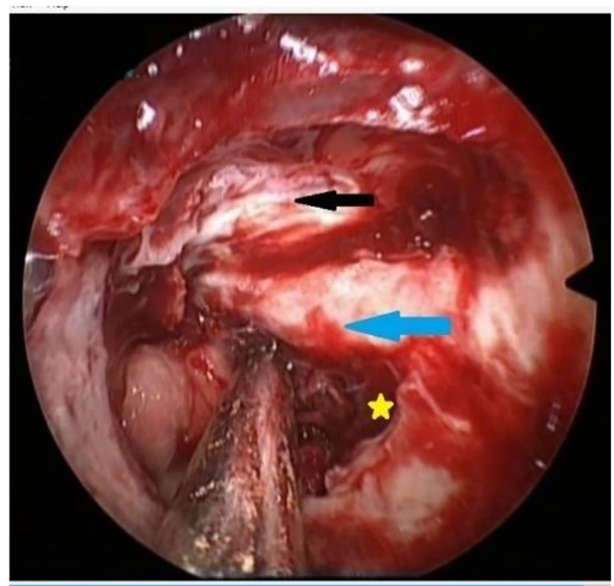

Fig. 2 Decompressed optic nerve (Blue arrow), lateral optic carotid recess (yellow star), and exposed dura (black arrow)

After the surgical procedure, high-dose systemic administration of steroids was maintained every 8 h for 24 h. An ophthalmological assessment was performed 24 h after surgery.

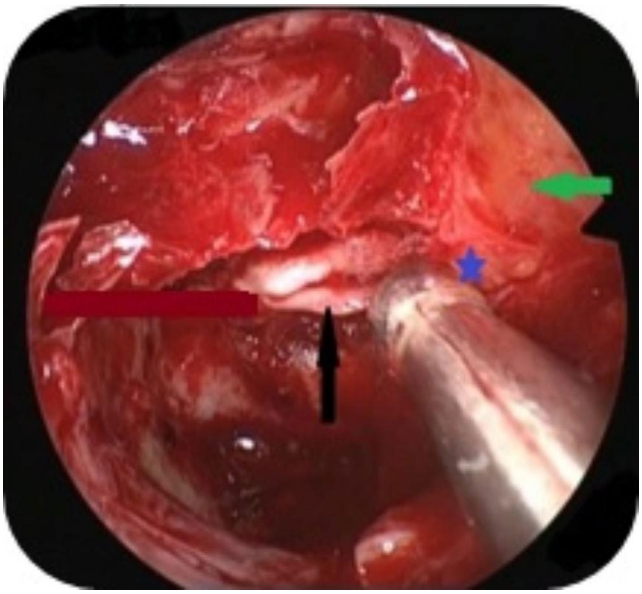

Fig. 3 Nerve sheath incision (black arrow) placed horizontally along the inferomedial aspect of optic nerve, orbital apex (green arrow), annulus of Zinn (blue star)

Table II Time of intervention, visual assessment before & after surgery

Time of intervention	Pre operative Visual assessment	Post operative Visual assessment
Within 72 h (12 cases)	LP	5/6
	LP	4/6
	PR	6/6
	PR	5/6
	LP	4/6
	PR	5/6
	LP	6/6
	LP	1/6
	LP	2/6
	PR	3/6
	No LP	No LP
	No LP	No LP
3 days- 7 days (13cases)	LP	2/6
	PR	1/6
	LP	3/6
	LP	1/6
	9 cases OF LP	LP
More than 7 days	4 eyes - No LP	No LP
	3 eyes - LP	LP

PR = Light perception with projection of rays; LP = Light perception without projection

An institutional assessment of visual improvement was made by the grading system they developed. EOND can be considered successful if the patient is able to gain useful vision. Post operative visual improvement was classified as complete improvement, partial improvement and no improvement irrespective of the preoperative visual status. A patient is said to have complete improvement if his vision improves completely and attains 6/6 vision according to Snellen chart; partial improvement if his vision improves but not beyond 5/6 and no improvement if there is no change in vision post surgery (Table II).

Results

Of the 12 patients who underwent EOND within 72 h of trauma, 2 patients had complete improvement of vision. This implies that 17% cases obtained 6/6 vision when surgical intervention was made within 72 h. 66% cases (8 cases) had partial improvement and 17% (2 cases) had no improvement.

Of the 13 patients, when EOND was done between 3 and 7 days, 31% (4 cases)had partial improvement and 69% (9 cases) had no improvement. None of the cases had complete improvement of vision.

In the initial period of their study, they attempted EOND when the patient presented to them 7 days after trauma. 4 patients had no perception of light and 3 had perception of light. But none of them had any improvement in vision. Hence in later periods of our study such cases were not taken up for EOND.

Post operative visual improvement was observed only in patients with at least perception of light before intervention; those with no perception of light carried poor prognosis with visual improvement.

They encountered intra operative CSF leak in 13 cases during manipulation of bony spicules which were not apparent before surgery. All these were repaired using fascia lata.

Nerve sheath fenestrations were done in 5 selected cases as discussed above of which 2 (40%) patients had partial improvement of vision. There were no associated CSF leaks in cases where fenestration of sheath was done. However a mucosal graft was placed over the site of fenestration to prevent the chances of delayed CSF leaks.

Post operative bed side visual assessment was done daily during the patients stay at the hospital. Earliest signs of improvement in vision were found 72 h after surgery. Visual improvement had continued to occur for up to 8 weeks after surgery in our study.

Discussion

Optic nerve is incapable of regeneration; hence, if not “rescued” at the earliest, it can result in irreversible blindness. The influence of the interval between trauma and surgery is controversial. Theoretically, improvement in vision following surgery would be better when the patient undergoes surgery as early as possible (within 72 h). However, in a study, Dhaliwal et al. found vision improvement of 57% in patients undergoing surgery within 3 days post-trauma, 58% in patients who underwent surgery between 3 and 7 days after the trauma, and 51% in the group who underwent surgery more than 7 days after the trauma [8]. According to pathophysiological principles, increased pressure on the optic nerve leads to ischemia and to deterioration in visual acuity that might be irreversible after 24–48 h [9, 10]

Di Somma et al. [11] investigated the amount of bony canal removal that could be achieved via an endonasal, transcranial, or transorbital pathway. In their study they found that an open pterional transcranial approach allowed the greatest area of surgical freedom with the widest optic canal decompression compared with the endonasal routes. In another study they found that the endoscopic endonasal route permitted exposure and removal of the most inferomedial portion of the nerve canal (168° on average), whereas the transorbital approach provided good control of the superolateral part of the canal (192° on average) [12]. Hence, although different approaches are available for optic nerve decompression, choosing the ideal approach depends on the location of optic canal fracture. A fracture on the lateral wall of optic canal requires a pterional approach whereas a medially placed fracture; which is more common; requires endonasal approach. Obviously, there is significant heterogeneity in the literature considering visual improvement following EOND for traumatic optic neuropathy as reviewed by Wang et al.; [13] .There is no quantitative assessment of visual improvement following decompression in the literature. Surgery can be considered beneficial only if the patient regains useful vision. Hence they have devised a method of quantifying the visual improvement irrespective of pre operative visual status; as follows: Complete improvement, partial improvement and no improvement. A patient is said to have complete improvement if his vision improves completely up to 6/6, according to Snellen chart after surgery; partial improvement if his vision improves but not greater than 5/6 and no improvement if there is no change in vision post surgery (Table I).

The possible complications of optic nerve decompression are bleeding of the sphenopalatine artery, ethmoidal arteries, ophthalmic artery, internal carotid artery, injury to the optic nerve and / or chiasm, medial rectus muscle, CSF leak, pneumocephalus or death.

Finally, unlike facial nerve, optic nerve cannot be repaired. Optic nerve which develops from the central nerve system as out-pouching of the diencephalon (optic stalks) is incapable of regeneration. Whereas facial nerve is a mixed nerve which develops from the second pharyngeal arch. Facial nerve injuries are initially treated with decompression and if it fails, various other surgical options like direct facial- facial nerve suture, facial nerve interposition graft, hypoglossal- facial jump-nerve anastomosis, dynamic muscle transfer and sling plasties; are available [14]. But the optic nerve once atrophied cannot be repaired. Hence it is always advisable to surgically intervene as early as possible to salvage the vision in clinically indicated, properly selected patients. And it is justified to state that "Time lost is vision lost".

Conclusion

Traumatic optic neuropathy (TON) denotes an acute injury to the optic nerve (ON) secondary to direct or indirect trauma. Direct trauma occurs usually due to penetrating injury causing shearing or hematoma of the optic nerve. Indirect TON is usually due to blunt head trauma and is caused by increased intracanalicular pressure from the injury with vascular ischemia and interruption of neurofeedback mechanisms leading to blindness [15, 16]. To date no standard treatment protocol has been developed regarding traumatic optic neuropathy. However, their study shows that the timing is the most important prognostic factor in traumatic optic neuropathy. Best results are obtained when decompression is done within 72 h. Since most of these patients have associated head injury, which needs neurosurgical intervention; it is suggestible to perform optic nerve decompression at the same sitting to ensure better prognosis. Degree of vascular compromise is another determining factor for visual restoration. Unfortunately there is no tool to assess the degree of optic nerve ischemia.

Also proper selection of patients for decompression plays a vital role. The overall condition/ prognosis of the patient as well as the extent of head injury of the patient has to be considered before doing a "heroic" attempt to restore the vision. Our study did not show any added benefits with nerve sheath incision routinely. Patients with at least light perception seem to benefit more from the surgery than patients with no perception of light.

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