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Review Paper

Optic Nerve Decompression in Traumatic Optic Neuropathy: Surgical Approaches, Timing and Outcomes

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ABSTRACT

Traumatic optic neuropathy (TON) is a rare that causes severe visual impairment usually results from cranial or ocular trauma. TON manifests directly and indirectly, which is more common. The incidence rate ranges from 0.7% to 2.5%. Clinical indicators of TON include the presence of an afferent pupillary defect after trauma, decreased vision acuity and intact ocular structure. Surgical decompression appears to be a feasible option in cases with direct bone compression on the optic nerve or progressive vision impairment in indirect TON. However, the evidence supporting treatment efficacy for improvement in vision is still ambiguous. This review will examine surgical techniques for decompressing the optic canal.

Keywords: Neurosurgical procedures, Nervus opticus, Traumatic optic neuropathy, Secondary cranial nerve injuries

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Highlights

• In Traumatic optic neuropathy (TON), indications for surgery include progressive vision loss, lack of response to steroids, and optic nerve compression by bony fragments or hematoma.

• The surgical techniques highlight the endoscopic endonasal approach for its less invasiveness and superior exposure to the optic canal.

• The endoscopic endonasal surgery results in 51%-58% visual acuity improvement, with complications occurring at a rate of 9.1%.

Introduction

Facial trauma-related visual impairment may result from damage to vital components of vision, such as the orbit and brain regions. The main culprits are damage to the optic nerve or optic canal. Direct traumatic optic neuropathy (TON) frequently causes significant visual loss and has worse recovery outcomes than indirect TON [1]. Direct TON usually results from structural disruption due to contusion or concussion or by laceration of the optic nerve by bone fragments [2, 3]. On the other hand, indirect TON typically occurs after blunt head or ocular trauma. It causes varied vision loss by passing on force to the optic nerve via the oculofacial soft tissues and skeleton [1-3]. This type often develops at the intersection of the intraorbital and intracanalicular segments, squeezing and rupturing pial arteries to decrease the blood supply to the optic nerve [4]. Indirect TON is more common, involving 0.5% to 5% of instances of closed head injuries and 2.5% of cases of midfacial fractures. The frequency of TON ranges from 0.7% to 2.5% [2, 4, 5]. In cases of indirect TON, the orbital apex (16.7%) and intracanalicular segment (71.4%) are the most commonly affected [6]. About 11.9% of instances involve both locations. Furthermore, optic nerve injuries are expected near the neighboring intracranial section of the falciform ligament [5]. There is no standard procedure for treatment at the moment; alternatives include surgical optic nerve decompression, high-dose corticosteroid infusion, or a combination of both [1-3].

TON injury mechanisms: Justification for surgical decompression

Direct optic nerve damage, such as contusion, avulsion, and laceration, which are frequently connected to adjacent fractures, causes direct TON. Conversely, indirect trauma results from acute head trauma and causes hematoma formation, shearing of optic nerve fibers, abnormalities in the circulation of cerebrospinal fluid, intraneural edema, and obstructions to the retroaxial transport of growth factors produced from the brain [1, 2]. Measuring optic nerve or optic canal pressure immediately after TON is not feasible. However, optic nerve status can be evaluated indirectly. Following a trauma, there are discernible reductions in optic nerve retinal nerve fiber layer (RNFL) thickness, circumpapillary RNFL and ganglion cell complexes beginning two weeks after the injury, with a notable reduction in macular thickness occurring after four weeks [1, 2].

Optimal timing for surgical decompression

Additional research is required because many studies have examined the best time to intervene, but large-scale prospective investigations are scarce [2, 3]. Researchers frequently depend on the results of particular experiences, emphasizing thorough research's necessity. According to multiple reports, surgery should be done within 24 hours of starting steroid medication, and positive results are noted when the primary surgical decompression is done within 48 hours [7]. Supporters of optic nerve decompression advise surgery to be performed as soon as possible. Still, a recent meta-analysis found that the visual improvement rates of early (within <3 days) and late (>7 days) surgery groups were comparable, indicating that delayed intervention may be a reasonable option if other treatments are not explored [2, 3].

Indications and contraindications for optic nerve decompression surgery

Many researchers have established particular criteria for surgery to decompress the optic nerve [2, 4]. These criteria are as follows: 1) A history of severe head trauma, whether or not the optic canal was involved, 2) Progressive vision loss unconnected to intraocular problems that are not traumatic, 3) There is no proof that an avulsion or injury to the intracranial optic nerve exists, 4) Extended delay or reduced amplitude in visual evoked potential (VEP) scans conducted before surgery, 5) Ineffectiveness of steroid treatment, 6) Hematomas or bone pieces are compressing the optic nerve.

On the other hand, the following conditions preclude optic nerve decompression surgery: 1) Total disruption of the nerve or chiasm, 2) Total atrophy of the nerves, 3) Fistula carotid-cavernous, 4) Insufficient tolerance to general anesthesia.

Preoperative evaluation

To determine the state of visual function, interdisciplinary teams must conduct a comprehensive ophthalmological assessment. This evaluation encompasses several tests, including fundus inspections, vision assessments, assessments of color vision, evaluations of relative afferent pupillary abnormalities, and visual field examinations. Computed tomography (CT) images are crucial for identifying nearby bone fractures and illustrating the link between the optic nerve and canal. Modern innovations such as three-dimensional reconstructive CT scans improve viewing from the needed angles [2–4]. When determining the extent of damage to nearby blood vessels and soft tissues, magnetic resonance imaging helps identify direct injuries. VEP tests help predict visual results. When taken as a whole, these diagnostic modalities give medical practitioners a thorough grasp of the situation and help them make educated decisions [2–4].

Surgical methodology

Conventional external ethmoidectomy and medial transorbital approach

Traditionally, external ethmoidectomy surgery has been the access to the medial orbit region. This technique successfully reaches the medial orbit wall and the ethmoid sinus. The cut begins at the medial canthus, starting from the medial aspect of the lower eyebrow. After that, lifting the periosteum permits the lacrimal bone and lamina papyracea to be removed, which relieves pressure in the orbital cavity and allows access to the optic canal (OC). However, there are certain disadvantages to the external ethmoidectomy approach, such as noticeable scarring and facial dysmorphia. As a result, its application in optic nerve decompression has decreased recently. A medial transorbital technique with endoscopic assistance has been developed to overcome these difficulties. This substitute technique involves making a transconjunctival incision in the middle and dissecting the subperiosteum toward the back. Drilling is done through the optic foramen, the OC and the medial orbit apex using a diamond burr. The medial OC ring can be accessed by creating bone defects in the posterior region of the medial orbital wall. After that, the orbital contents are moved laterally, and the diamond burr-created, thinned OC ring is removed [1, 2].

Transcranial approach

Neurosurgeons appreciate the transcranial method's wide surgical access and well-known viewpoint. The results of morphometric research indicate that this method decompresses the OC more widely than the endonasal route, achieving a decompression angle of 245.2 degrees. However, compared to the endonasal method, it is recognized for its invasiveness and related cosmetic problems. Serious problems may arise from brain retraction during this surgery [2, 6].

The patient is placed supine during transcranial surgery while under general anesthesia, immobilized with a 3-pin head fixator, and has their head extended 10 to 15 degrees and rotated 5 to 30 degrees contralaterally. Neuro-navigation technologies let surgeons pinpoint anatomical landmarks with accuracy. To gain pterional access to the surgical site, a craniotomy is performed after a curved linear incision. After the sphenoid ridge has been flattened, an extradural anterior clinoidectomy is carried out. Drilling is easier without needing a retractor by lumbar draining for brain relaxation, cisternal opening, and arachnoid dissection. Complete unroofing of the OC and attention to avoiding damage to the periorbita are essential during anterior clinoidectomy. To prevent heat damage to the optic nerve, great care is also taken when piercing the upper surface of the OC. Saline irrigation is used in this process. When the anterior clinoid process (ACP) is small, tiny rongeurs are used to remove it carefully. However, if the optic strut and ACP are thicker, drilling must remove them partially. After a dural incision, the optic nerve sheath, annular ligament, and falciform ligament are divided to decompose the optic nerve [2, 6].

The endonasal approach

There are various benefits to using an endoscopic approach to the base of the skull. This less invasive procedure offers excellent exposure to the orbital apex and the OC compared to conventional transcranial techniques. Similar procedures to the outlined endoscopic endonasal technique are followed while the patient is under general anesthesia for preparation. Following the use of cotton soaked with epinephrine to decongest the nasal mucosa, a 4-mm, 0-degree rigid endoscope is placed via the nose. The posterior ethmoidectomy and intermediate turbinectomy are among the procedures. Sphenoidotomy and posterior septectomy result from confirmation of the sphenoid ostium. Enough room is provided for the optic nerve and internal carotid artery (ICA) by a wide lateral sphenoidotomy. It is essential to identify anatomic features such as the thin lamina papyracea excision, posterior ethmoidal artery, OC, ICA and optic carotid recess [2, 8, 9].

To avoid heat injury, OC decompression should be done carefully with a diamond drill and continuous irrigation. The opticocarotid recess is identified by moving proximally toward the distal, reducing the danger of ICA and dura injury. The OC's covering bone is meticulously thinned to resemble an eggshell [8, 9]. The optic nerve sheath is cut using a sickle knife, ideally on the superomedial side, to prevent injury to the ophthalmic arteries following inferomedial OC decompression. The impact of optic nerve sheath opening on visual outcomes is controversial [2, 8]. There have been reports of surgical procedures using a 45-degree endoscope without middle turbinectomy or posterior ethmoidectomy. However, proficiency with the endoscope is essential to prevent restrictions in the surgical field. Although the average OC decompression achieved by this approach is 168 degrees, it has some limitations in the superolateral aspect. Research on attaining entire circumferential decompression via the combined transorbital technique is ongoing to overcome these restrictions [2, 8, 9].

To identify the orbicularis oculi muscle, a 2.5 cm incision is made along the line where the eyelid wrinkles. The superior and inferior orbital fissures are confirmed by dissection, which also displays the orbital rim's superolateral border. The cranio-orbital foramen allows for the visualization of the recurrent meningeal artery. When possible, peeling off the periorbita makes surgery easier. Orbital contents are displaced inferomedially using elastic sheets. Drilling from the greater wing of the sphenoid bone to the lesser wing allows for precise bony decompression of the OC. According to morphometric analysis, this combination method may be feasible for 360 degree OC decompression; nevertheless, additional clinical trials are required for validation [2, 8, 9].

Lateral wall orbitotomy

Under general anesthesia, the lateral orbital wall orbitotomy surgery was carried out. The skin was incised in the shape of a lazy S, running posteriorly along the upper margin of the zygomatic arch for about 35 to 40 mm from the outer corner of the eye and curving towards the eyebrow. This incision style was chosen to prevent damage to the frontal branches of the facial nerve. The lateral orbital bone was exposed by subperiosteal dissection and posterior retraction of the temporal muscle, which were made possible by the incision of the fascia covering the temporal muscle after the skin incision. The intraorbital and cerebral areas communicated using a bone window created at the pterion by a pneumatic cranial perforator. Following periosteum dissection at the orbital rim, the aperture was carefully widened using a 2-mm Kerrison rongeur. The periorbita was then removed from the lateral orbital wall's inner surface. The OC became unroofed after removing the lateral orbital wall [10].

The outcome of OC decompression

Different OC decompression techniques have various results depending on the method used. About 30% to 70% of individuals with TON report improved eyesight after using the transcranial optic nerve decompression technique. On the other hand, although there are differences in the timing of treatment, the endoscopic endonasal technique improves visual acuity in 51% to 58% of TON cases. Furthermore, patients with higher levels of visual acuity before surgery typically had better results than those who were completely blind. Patients receiving endoscopic endonasal surgery have reaction rates of 41%, 89%, 93% and 84% for no light perception, light perception, hand motion and finger count, respectively, among individuals with varied degrees of visual impairment. Moreover, compared to medical treatment alone, surgical intervention and medication, such as steroid therapy, do not produce improved results [2, 11–14]. According to reports, the endoscopic endonasal technique has an overall complication rate of 9.1%, of which 3.1% are considered severe. Severe consequences are iatrogenic damage to the carotid and ocular arteries, cerebrospinal fluid leakage, worsening vision and infections [2, 11, 12].

Conclusion

As was previously said, optic nerve decompression comprises a variety of strategies and tactics, but the best one is still up for debate. Considering each strategy's benefits and drawbacks, a comprehensive evaluation of possibilities customized to the patient's particular situation and requirements is necessary. To ensure the greatest outcomes, personalized evaluation is essential for choosing the optimal course of action.

Ethical Considerations

Compliance with ethical guidelines

All study procedures were in compliance with the ethical guidelines of the 2013 Declaration of Helsinki.

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Authors contributions

Supervision and resources I Wayan Niryana; Writing the original draft: All authors; Conceptualization, investigation, review and editing: I Wayan Niryana, Anak Agung Ngurah Agung Harawikrama Adityawarma and Christopher Lauren.

Conflict of interest

The authors declared no conflict of interest.

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