Navigation-guided optic canal decompression for traumatic optic neuropathy: Two case reports

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Two cases of traumatic optic neuropathy presented with profound loss of vision. Both cases received a course of intravenous corticosteroids elsewhere but did not improve. They underwent Navigation guided optic canal decompression via external transcaruncular approach, following which both cases showed visual improvement. Postoperative Visual Evoked Potential and optical coherence technology of Retinal nerve fibre layer showed improvement. These case reports emphasize on the role of stereotactic navigation technology for optic canal decompression in cases of traumatic optic neuropathy.

Key words: Medial transcaruncular approach, navigation-guided surgery, optic canal decompression, traumatic optic neuropathy

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Traumatic optic neuropathy (TON) is a serious complication of craniofacial injury that results in severe visual loss with minimal possibility for recovery. The reported incidence of TON following closed head injury is 0.5%–5.0%.[1] Its association with life-threatening injuries delays the diagnosis and initiation of appropriate management. Moreover, there are no clear guidelines available until date, for the optimum management of TON. The treatment options include observation, intravenous steroids, surgical optic canal decompression (OCD); or a combined approach. However, the role of OCD is not

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established; recent studies have reported improved visual outcome following surgery.[2-4] The goal of OCD is to remove the portion of the bony optic canal thereby releasing the pressure on the nerve. Different surgical techniques have been described for OCD such as intracranial, transethmoidal, transcaruncular, endonasal, and sublabial approaches through endoscopic as well as open surgical technique.[5] The safety of surgical intervention has been examined in numerous studies; reported complications of endoscopic approach include injury to the ophthalmic artery, injury to the carotid artery, cerebrospinal fluid leak, meningitis, and intraorbital infections.[6]

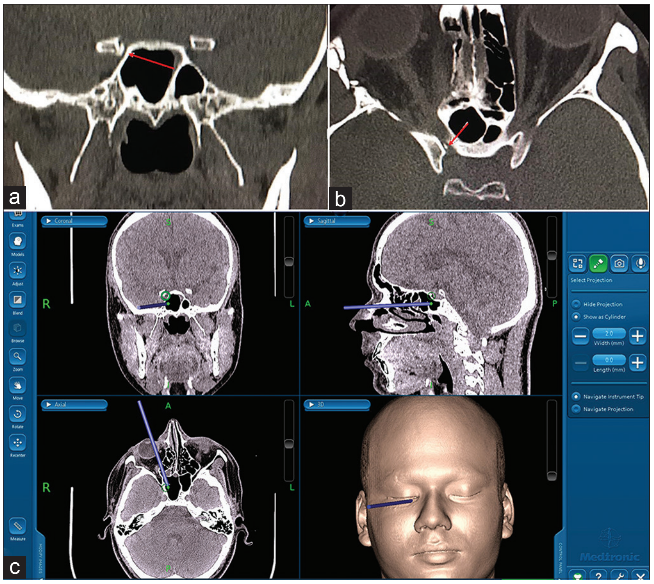

Figure 1: (a and b) Computed tomography scan showing a bone impinging optic nerve in the distal part of the optic canal (red arrow) (c) intraoperative confirmation of target area in the 3 planes of computed tomography scans

Stereotactic navigation guidance has spurred a technical evolution of enhanced safety and precision during most of the minimally invasive surgeries by providing intraoperative positional and spatial orientation.[7,8] With limited literature available, regarding the use of navigation guidance in deep orbital surgery, we report two cases of TON managed by external (orbital route) navigation-guided OCD (NGOCD) surgery using StealthStation™ S7 (Medtronic, Minneapolis, USA) in the electromagnetic mode (AxiEM technology). To the best of the authors' knowledge, this appears to be the first such case report. Approval from the Institutional Ethics Committee was obtained and written informed consents were taken.

Case Reports

Case 1

A 26-year-old male presented with loss of vision in the right eye for 6 weeks following a road traffic accident (RTA). He

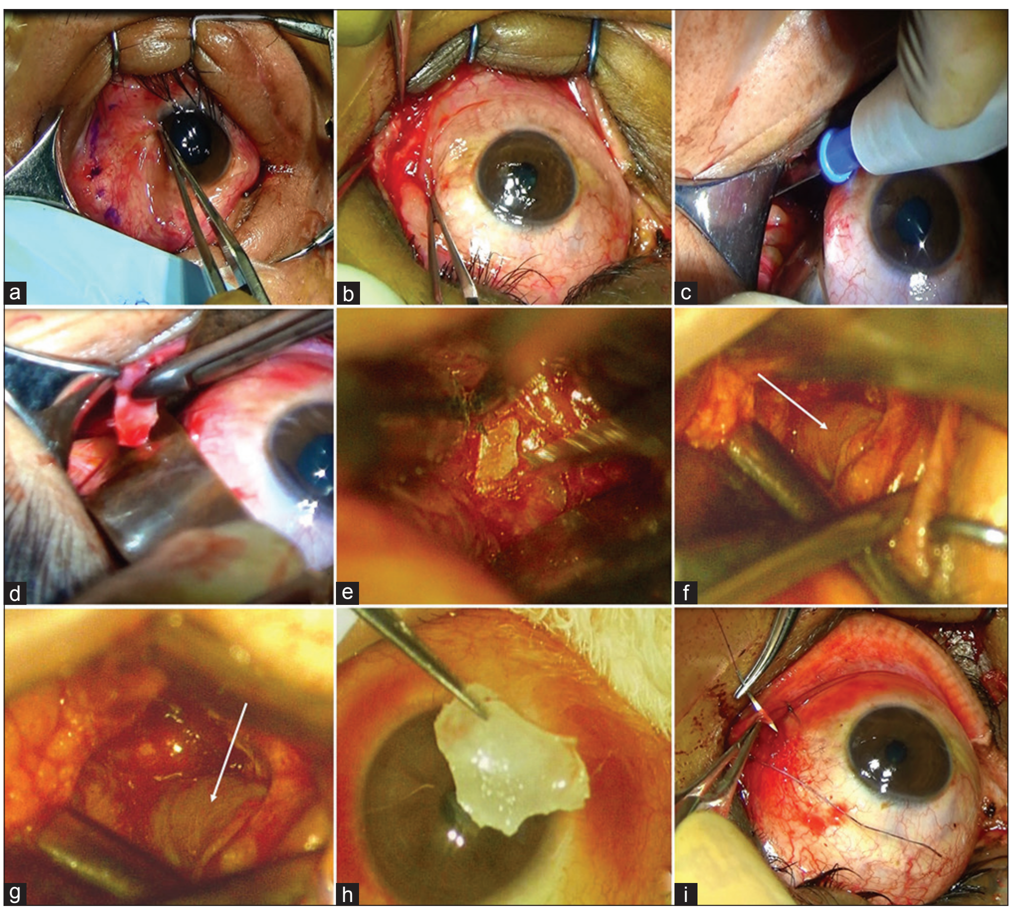

Figure 2: Surgical technique of navigation-guided optic canal decompression. (a) Marking and (b) incision over caruncular area, (c) incision on periosteum of medial orbital wall, (d) removed posterior ethmoid bone fragment, (e) bony fragment impinging the optic nerve, (f and g) optic nerve (white arrow) after optic canal decompression, (h) removed part of optic canal bone, (i) conjunctival closure

received 1 g of intravenous methyl prednisolone (IVMP) for 3 days elsewhere. On examination, he denied perception of light (PL) in the right eye, and the left eye had a best-corrected visual acuity (VA) of 20/20. He had a healed scar on the right eyebrow region, normal extraocular movements, and mid-dilated pupil with Grade IV relative afferent pupillary defect. Fundus showed temporal disc pallor. Computed tomography (CT) scan orbits and optic canal (as per the navigational protocol of contiguous slices of 1-mm thickness and 1-mm slice interval) revealed a bony impingement of right optic nerve in the distal part of optic canal [Fig. 1a and b]. Visual evoked potential (VEP) showed an extinguished waveform response, and retinal nerve fiber layer (RNFL) analysis by optical coherence tomography (OCT) showed decreased thickness in the right eye. Following the diagnosis of direct TON (right eye), he underwent an external NGOCD through the transcaruncular route under general anesthesia [Fig. 2]. After completing the registration process of machine and marking the "target site" in the workstation, medial transcaruncular incision was given and dissection was carried out into subperiosteal space up to the orbital apex, at least 6 mm beyond the posterior ethmoidal foramina. The position of the (anatomically deranged) optic canal was confirmed using the neuronavigation stylet and the small fractured bony fragment compressing the optic nerve was removed to decompress it [Fig. 1c]. Following that, reduction in the pupil size was evident correlating with successful decompression of the nerve [Fig. 2i]. The conjunctiva was closed with 6-0 polyglactin sutures. Postoperatively, he received systemic erythropoietin[9] 10,000 units intravenous daily for 3 days, oral citicoline 500 mg 8 hourly for

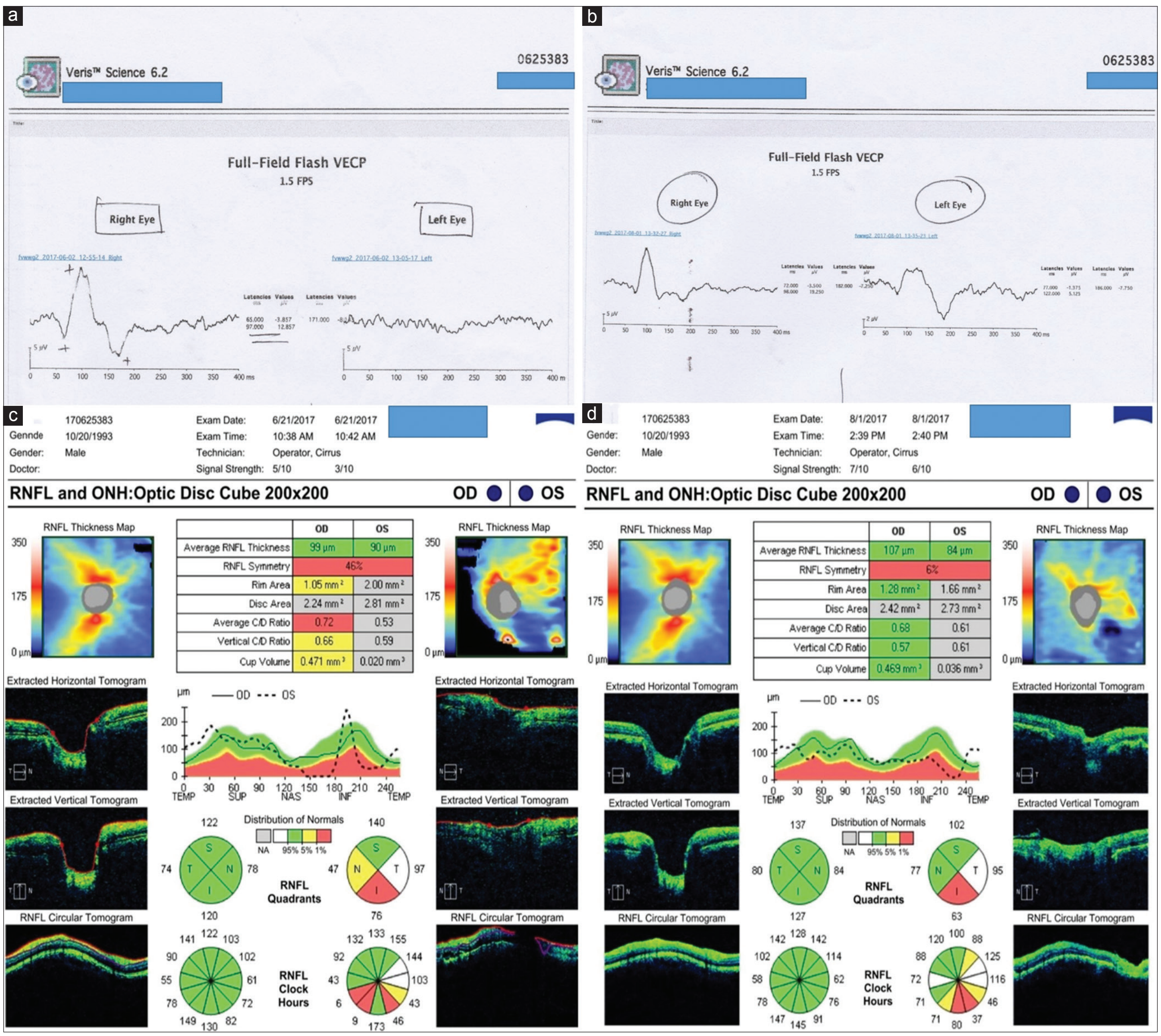

Figure 3: Comparing images before (a and c) and after (b and d) navigation-guided optic canal decompression to illustrate the improvement in visual evoked potential and optical coherence tomography retinal nerve fiber layer of Case 2. (a) Visual evoked potential with extinguished waveform with a prolonged latency. (b) Improved waveform latency and amplitude. (c) Decreased thickness of nerve fibers in the nasal and inferior quadrants (left eye). (d) Increased retinal nerve fiber layer thickness in nasal and temporal quadrant postoperatively

2 months, and oral and topical antibiotics for 7 days. On the 1st postoperative day (POD), VA improved to PL positive. By third POD, VA improved to counting fingers (CF) at 1.5 meters and pupil showed sectoral vermiform movements. On his last follow-up visit (2 months), VA was CF at 3 meters with improvement in the pupillary reaction, VEP, and quadrantic RNFL OCT.

Case 2

A 24-year-old patient presented with PL positive vision in his left eye, 6 days following RTA. He received 1 g/day IVMP for 3 days elsewhere with no improvement. Examination showed Grade IV RAPD (Relative Afferent Pupillary Defect) and normal fundus. The CT scan showed no bony impingement. The VEP was extinguished and RNFL thickness was decreased in OCT [Fig. 3a and c]. Diagnosed as indirect TON (left eye), the patient underwent external NGOCD with above-mentioned protocol. Postoperatively, vision improved to 2 meters on 1st day to 3 meters on 1 month with regained color (blue and red) perception along with improvement in pupillary reaction. Postoperative improvements in VEP and quadrantic RNFL OCT are shown in Fig. 3b and d.

Discussion

With the lack of conclusive evidence in the form of randomized controlled trials evaluating the natural course and optimum management of TON, the current management is tailored according to the stage of presentation. Surgical decompression of the optic nerve has been debatable; however, recently, benefits of surgical OCD in both direct and indirect TON have been reported.[2,4] In Case 1, because of the displaced bony fragment and fibrosis in the tissue surrounding the optic nerve, confident localization of the bony fragments in the distal part of optic canal may have been difficult without navigation guidance. However, with the aid of navigation system, we could precisely trace the desired anatomical location, avoid injury to the surrounding vital structures (ophthalmic artery), and decompress the canal effectively that possibly contributed to a positive visual outcome. Postoperatively, both the cases showed not only visual recovery but also significant improvement in pupillary reaction and objective improvement in VEP waveforms and RNFL thickness in the affected quadrants, suggesting the recovery of optic nerve function to certain extent. We hypothesize that these improvements in our cases are signs suggestive of possible reversal of optic nerve function due to reestablishment of axoplasmic flow/perfusion. Studies have reported that RNFL thickness following TON decreases sequentially until 6 months, mainly within first 6 weeks of injury;[10] however, in our cases, pre- and post-operative (6 weeks) OCT RNFL shows significant improvement in the affected quadrant. This suggests that decompressing the optic canal may restore the RNFL thickness possibly due to axoplasmic flow restoration. Furthermore, Yan *et al*. reported surgical efficacy of OCD is 78.4% for patients with optic canal fracture (OCF) and 87.6% for patients without OCF, suggesting the role of the OCD in both types of TON.[2] The proposed mechanism of erythropoietin in TON is antiapoptotic activity on retinal ganglionic cells, antioxidant and anti-inflammatory properties, and regeneration of axonal nerve fibers.[9]

Conclusion

The present report aims to highlight the promising role of navigation technology in external transcaruncular OCD, which provides precise intraoperative localization of the optic canal region (as trauma deforms the anatomy), with favorable postoperative visual outcome. Encouraging results of our cases suggest that randomized control study can be planned to evaluate the role of navigation in external OCD. Although much is not known about the possible mechanism of recovery of optic nerve function, these case reports certainly strengthen the fact that vision recovery is possible even after complete loss of vision (PL negative) in direct as well as indirect TON.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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