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Long-term follow-up of a patient with partial optic nerve avulsion associated with submacular hemorrhage who underwent pneumatic displacement

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ABSTRACT

Purpose: We report the case of a 16-year-old boy with partial optic nerve avulsion (ONA) and submacular hemorrhage (SMH) resulting from blunt ocular trauma who underwent pneumatic displacement and subsequent monitoring with optical coherence tomography (OCT) and fundus photography.

Observations: Reduced visual acuity was observed in the right eye at presentation (20/2400). Vitreous hemorrhage, partial ONA, and SMH were observed during dilated fundus examination. SMH was managed via pneumatic displacement. Subsequent examination revealed improvement in the visual acuity of the right eye with a substantial reduction in the subfoveal hemorrhage. Further improvement in visual acuity was observed 6 months after the injury (20/150). A smaller optic nerve head excavation defect, foveal atrophy, and reabsorption of SMH were observed during fundus examination. OCT of the optic nerve revealed that glial growth had covered the avulsion excavation. However, atrophy of the outer retinal layer of the fovea was observed during macular OCT.

Conclusions and importance: This case emphasizes the importance of performing multimodal imaging in cases of ONA as it enables the identification of alterations in the retinal layers and optic nerve. The subretinal hemorrhage was displaced from the subfoveal region without any adverse effects.

1. Introduction

Blunt ocular trauma can lead to several pathologic consequences. Optic nerve avulsion (ONA) is the traumatic separation of the optic nerve from the globe at the level of the lamina cribrosa without the rupture of the optic nerve sheath or adjacent sclera. ONA can result in partial or total vision loss in the affected eye. Blunt trauma is considered the mechanism of injury in ONA, where a foreign object intrudes between the globe and the orbital wall.[1] ONA, which is a type of anterior traumatic optic neuropathy, can range from partial to complete avulsion, and its effects on visual function can be devastating.[1,2]

Submacular hemorrhage (SMH) is defined as the collection of blood between the neurosensory retina and retinal pigment epithelium (RPE). SMH can be caused by several conditions, including blunt trauma.[3]

This case report describes a case of ONA associated with SMH secondary to blunt ocular trauma. The patient underwent pneumatic displacement for the treatment of SMH, and the structural changes were monitored via multimodal imaging.

2. Case report

A 16-year-old boy presented with a sudden loss of vision in the right eye after sustaining a closed-globe injury with a bicycle handlebar. At presentation, the best-corrected visual acuity (BCVA) was 20/2400 in the right eye and 20/20 in the left eye. The intraocular pressure (IOP) was within the normal range in both eyes. A relative afferent pupillary defect was noted in the right eye.

A slit-lamp examination of the right eye revealed a 2+ anterior chamber cell reaction without flare. Dilated fundus examination revealed a grade 1 vitreous hemorrhage and excavation of the supero-temporal portion of the optic nerve head, suggesting partial ONA. Peripapillary retinal edema and SMH of approximately four disc diameters were also observed. An examination of the left eye revealed no remarkable findings.

Spectral-domain optical coherence tomography (OCT) revealed a deep cavity in the supero-temporal portion of the optic disc. Macular OCT confirmed that the SMH involved the fovea. B-mode

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ultrasonography of the right posterior pole revealed a hypoechoic focus in the area of optic nerve avulsion (Fig. 1).

Instillation of prednisolone acetate drops every 2 h was initiated, and the patient was urgently referred for a neurological assessment. However, cranio-orbital computed tomography (CT) revealed no signs of brain or eye injury.

SMH was managed via intravitreal injection of 0.6 cc of SF6 gas and 25 μm/0.1 mL of recombinant tissue plasminogen activator (rtPA), and the patient was instructed to maintain the prone position for three days.

The BCVA of the right eye was 20/400 in the subsequent examination three days after presentation. Inferior displacement of the SMH was observed during fundus examination. Macular OCT confirmed a drastic reduction in the subfoveal hemorrhage (Fig. 2A and B).

The BCVA of the right eye was 20/320 at the one-month follow-up after the injury. A glial reaction in the excavated area of the optic nerve, as well as temporal peripapillary and foveal atrophy, were observed during fundus examination. Radial retinal folds located in the macula and remnants of the SMH in the inferior portion of the posterior pole were observed. Macular OCT revealed atrophy of the external retinal layer at the fovea, disruption of the external limiting membrane and ellipsoid zone, and the presence of hyperreflective subretinal material. Optic nerve OCT revealed glial proliferation over the avulsion excavation.

The BCVA was 20/150 at the two-month follow-up. Increased glial proliferation in the excavated area of the optic nerve head was observed during fundus examination. Furthermore, peripapillary temporal pigmentation and persistent radial retinal folds were observed in the macula. A reduction in the subretinal hemorrhage in the lower portion of the macula, which was in the process of resolving, was also observed. Optic nerve OCT revealed increased glial proliferation during avulsion excavation (Fig. 2C and D).

Thinning of the temporal, supero-temporal, and supero-nasal retinal nerve fiber layer (RNFL), with an average thickness of 46, 91, and 60 μm, respectively, was noted. Fluorescein angiography revealed non-perfusion of the supero-temporal vein branch occlusion distribution, with secondary microvascular restructural changes in the affected vessel territory. (Fig. 3).

The BCVA of the left eye was 20/150 at the final examination 6 months after the injury. A smaller excavation defect due to the contraction of the glial tissue, partial resolution of the macular radial folds, persistent foveal atrophy, and near-complete reabsorption of the SMH was observed during fundus examination (Fig. 2E and F). Optic nerve OCT revealed that the avulsion excavation had been covered by glial growth (Fig. 4).

3. Discussion

The optic nerve is susceptible to avulsion at three locations: the optic disc, orbital apex, and optic chiasma. ONA is a frequent sequela of road traffic accidents, sporting injuries, and falls.[4] Buchwald et al. reported that the cause of ONA was a small blunt object or finger in 49% of patients.[1,5] In our patient, a bicycle handlebar was the causative agent.

Cirovic et al. reported in their computer modeling study that the point at which the optic nerve inserts into the sclera, i.e., the point on the opposite side of the finger impact, appears to be under the most significant strain. Direct trauma, rotation of the optic nerve relative to the globe, and sudden increase in IOP arising from the deformation of the globe are considered to be the principal mechanisms of injury. The maximum recorded value of IOP was approximately 300 mmHg, and this increase may be a result of the direct pressure applied to the eye.[6] A previous study reported that using an intraocular gas bubble causes a substantially lower increase in IOP, averaging 29 mmHg.[7] Thus, it is unlikely to exacerbate the lesion through this procedure.

Avulsion can be diagnosed clinically if the media is clear. Optic nerve head examination shows a cavity where the optic disc retracts into its dural sheath, as in the patient described herein. Although ONA may be associated with other globe and orbital injuries, it can also occur as an isolated lesion.[8] Vitreous and peripapillary hemorrhages are usually associated with nerve avulsion; however, SMH associated with ONA has also been reported.

The early identification of subretinal hemorrhages in individuals with blunt ocular trauma should prompt further investigation for the presence of a choroidal rupture. A choroidal rupture, characterized by a break in the choroid, Bruch's membrane, and the RPE, occurs in approximately 5–10% of cases of blunt ocular trauma.[3] In the current case, analysis of macular OCT raster images did not definitively reveal any disruption in the RPE or Bruch's membrane, potentially allowing for the migration of hemorrhage into the subretinal space. However, based on the anatomical location, it is likely that the SMH in this patient originated from this anatomical site.

Ultrasonography or imaging can be used to establish a diagnosis if the disc area is obscured by a vitreous hemorrhage. CT may demonstrate optic nerve head avulsion, as evidenced by hypodensity where the nerve inserts into the globe. A B-scan may also demonstrate a hypoechoic focus correlated with the area of the avulsed optic nerve.[8]

ONA does not compromise retinal vasculature in all cases; however, it can disrupt retinal perfusion as a result of changes in the peripapillary vasculature after trauma.[2] In the present case, fluorescein angiography revealed venous branch occlusion and associated microvascular changes resulting from the previous trauma. We hypothesized that these changes occurred at the level of the emergence of the supero-temporal vein on

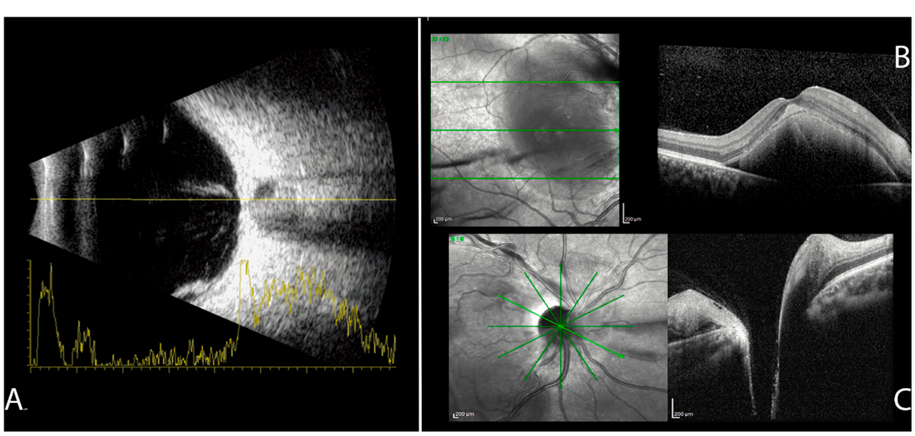

Fig. 1. A. B-mode ultrasound of the right eye showing mild vitreous hemorrhage and hyporeflectivity posterior to the optic nerve head that is consistent with the avulsed area. **B.** Macular OCT showing submacular hemorrhage involving the fovea. **C.** OCT of the optic nerve head scan demonstrates a deep excavation that corresponds with an optic nerve avulsion. OCT, optical coherence tomography.

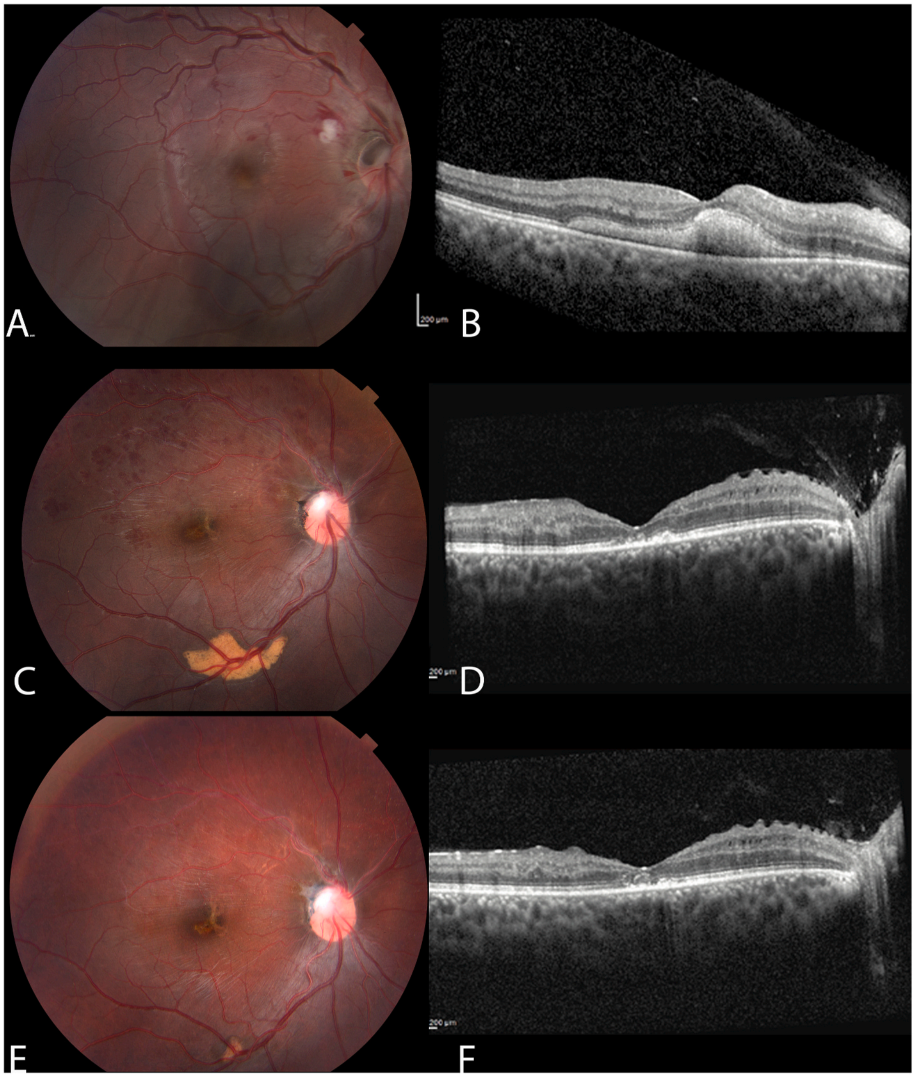

Fig. 2. A. Fundus photograph of the right eye obtained 3 days after pneumatic displacement. The optic nerve head shows a supero-temporal excavation and an inferior displacement of the submacular hemorrhage. **B.** Macular OCT showing the presence of subfoveal hemorrhage. **C.** Fundus photograph obtained after 1 month. The optic nerve head shows glial tissue at the level of the avulsion excavation, foveal atrophy, and remnants of vitreous hemorrhage in the lower portion of the macula. **D.** Macular OCT showing disruption of the outer hyperreflective lines and the presence of scarce subretinal hyperreflective material. **E.** Fundus photograph obtained after 6 months. The optic nerve head shows glial tissue contraction, foveal atrophy, and resolution of the subretinal hemorrhage. **F.** Macular OCT showing foveal atrophy at the expense of the external layers. OCT, optical coherence tomography.

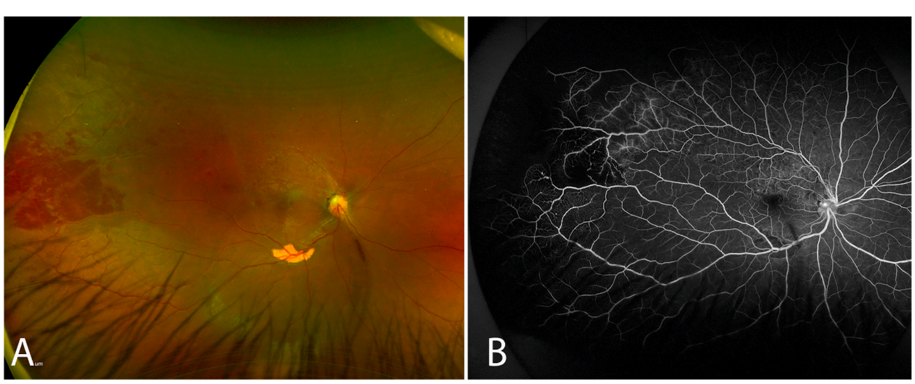

Fig. 3. A. Ultra-wide field fundus photograph of the right eye showing glial growth at the optic disc, in addition to vascular attenuation in the supero-temporal vein branch accompanied by blot hemorrhages and a peripheral intraretinal hemorrhage. **B.** Fluorescein angiography showing signs of vascular incompetence and microvascular remodeling in the territory of the supero-temporal vein branch, as well as peripheral non-perfusion. OCT, optical coherence tomography.

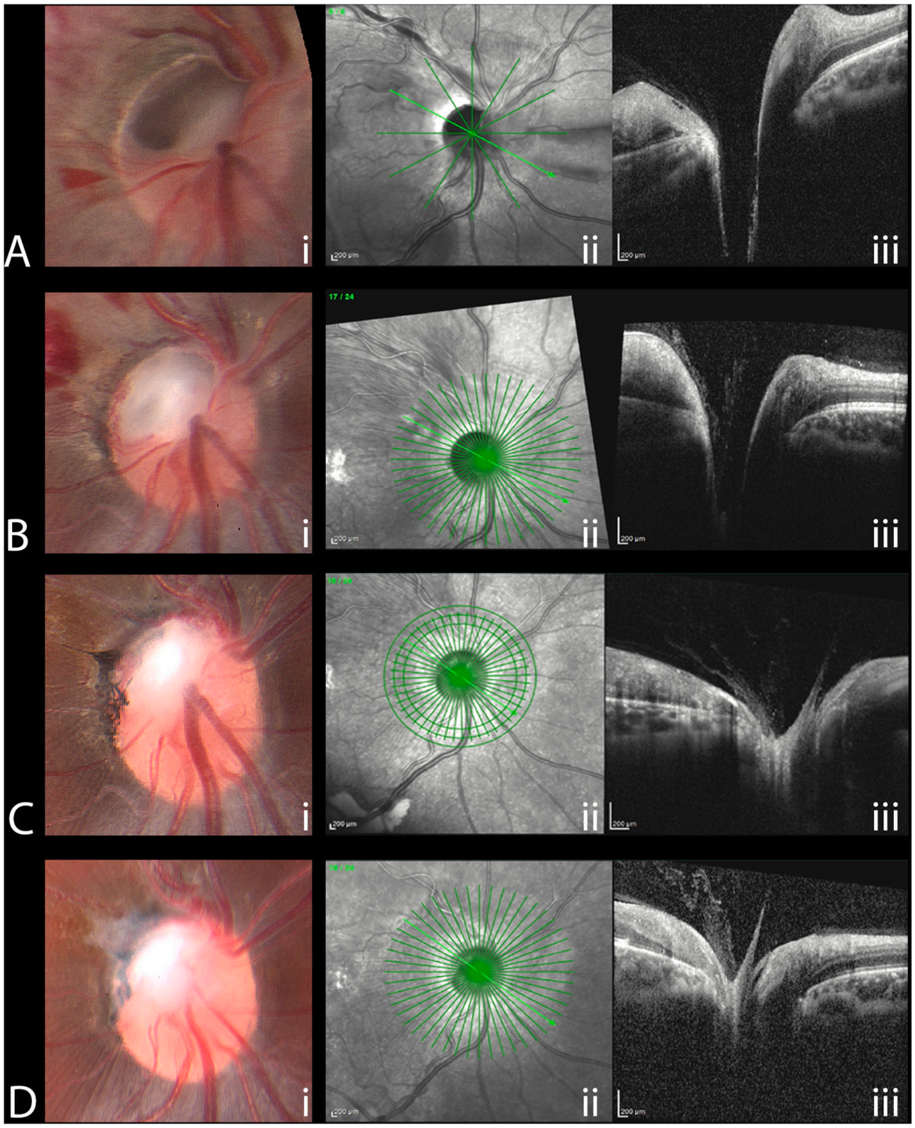

Fig. 4. Close-up images of the avulsed right optic nerve head **(i),** infrared images **(ii),** radial OCT scans **(iii),** post-pneumatic displacement at day 3 **(A)**, one month **(B)**, two months **(C)**, and six months **(D)**. OCT, optical coherence tomography.

the edge of the optic nerve adjacent to the area of the avulsion, which is considered to be the point of the most significant impact.

OCT is remarkably useful in cases with clear media as it can document changes in the optic nerve head and macular area. It can also reveal changes in the macular ganglion cell and peripapillary RNFL regions and correlate the defects with visual field loss in partial ONA.[2]

There is no established treatment for ONA. Recent studies have failed to demonstrate the benefit of using high-dose intravenous corticosteroids and suggest a considerable risk of harm.[9,10]

The natural history of SMH is variable and spontaneous resorption is possible; however, it generally has unfavorable visual outcomes. Although there is no consensus on the optimal clinical management, several procedures have been investigated with mixed results. One such technique is intravitreal gas injection, with or without intravitreal rtPA. Gas tamponade with prone positioning aims to displace the SMH, and rtPA is used to facilitate the liquefaction of the clot. Multiple studies using this approach have reported stable or improved visual acuity.[3]

OCT was performed sequentially at the optic nerve head in the present case such that the glial reaction was documented at partial ONA excavation. The changes in the macular area were monitored over time following pneumatic displacement (Fig. 2).

Thinning of the RNFL corresponding to partial ONA was recorded at the structural and functional levels using OCT, and scotoma in the visual fields was also observed.

4. Conclusion

This case emphasizes the importance of using multimodal imaging for assessing changes in the eye due to blunt trauma, both immediately after the event and during follow-up. The subretinal hemorrhage was successfully displaced from the subfoveal region using pneumatic displacement without any adverse effects.

Consent to publish statement

The patient provided written informed consent for the publication of the details of their medical case and any accompanying images according to the Declaration of Helsinki.

Authorship

All authors attest that they meet the current ICMJE criteria for

Authorship.

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CRediT authorship contribution statement

Mauricio Bayram-Suverza: Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Conceptualization. **Mauricio Rosano-Barragán:** Investigation, Conceptualization. **Juan Abel Ramírez-Estudillo:** Writing – review & editing, Writing – original draft, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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