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# Effects of blunt trauma of eye on retinal nerve fibre layer

*Kumar Aalok*[1], *Singh Vipin*[2]

[1]Department of Ophthalmology, Hind Institute of Medical Sciences, Barabanki 225003, India
[2]Department of Ophthalmology, King George Medical University, Lucknow 226003, India
**Correspondence to:** Aalok Kumar. Department of Ophthalmology, Hind Institute of Medical Sciences, Barabanki, Uttar Pradesh 225003, India. dr.aalok01@gmail.com
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## Abstract

● **AIM:** To study the effects of blunt trauma of eye on visual acuity and retinal nerve fiber layer (RNFL).

● **METHODS:** A prospective observational study was done on the patients of a road traffic accident (RTA) having blunt trauma injury of the eye from august 2018 to July 2019 at the Department of Ophthalmology, Hind Institute of Medical Sciences, Barabanki. Patients between the age group of 20 to 65 years undergoing RTA with ocular complaints were included in this study. Colour vision, contrast sensitivity, and best-corrected visual acuity (BCVA) were recorded, RNFL analysis was done through OCT.

● **RESULTS:** A total of 108 patients were enrolled in this study and were grouped as 54 cases and 54 controls. The mean age was 43±2.3 years with 11 (20.37%) females and 43 (79.6%) males in the case group. At initial visit after RTA, the difference between color vision, contrast sensitivity and BCVA between right and left eyes of cases and controls were significant. After a follow up of 3mo only significant difference was noted in contrast sensitivity between cases and control groups. Change in color vision and BCVA after 3mo was insignificant. Similarly, an initial significant difference was noted in mean RNFL thickness between cases and control groups, but after follow up of 3mo mean RNFL thickness difference was significant only in superior and temporal quadrants.

● **CONCLUSION:** RTA or blunt trauma of eye can lead to persistent RNFL thinning and decreased visual function.

● **KEYWORDS:** road traffic accident; retinal nerve fiber; contrast sensitivity; best-corrected visual acuity

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## INTRODUCTION

Blunt trauma of eye can lead to a severe loss of vision which can be permanent at times[1-2]. Blunt trauma of eye occurring in road traffic accident (RTA) may lead to the involvement of orbital walls, periorbital structures, extraocular muscles, eyelids, lacrimal apparatus, conjunctiva, cornea, sclera, and concussion injuries on the retina (Figure 1), optic nerve avulsion[3]. In some cases, there may be globe rupture[4-5], perforation, uveal tissue prolapse, vitreous haemorrhage, endophthalmitis[6], choroidal haemorrhage[7], and traumatic optic neuropathy (TON)[8-10]. TON is one of the most threatening complications of a RTA as it results in thinning of the nerve fiber layer of retina[11-14]. Thinning of the retinal nerve fiber layer can be accessed by optical coherence tomography (OCT). Spectral-domain optical coherence tomography (SD-OCT) is a quick, sensitive, non-invasive, device that provides very high-resolution images of retinal nerve fiber layer (RNFL)[15]. SD-OCT with an axial resolution of 5-7 μm provides clear imaging of RNFL thickness that helps in diagnosing and treating optic nerve disorders[16-18].

## SUBJECTS AND METHODS

**Ethical Approval** This study was a prospective observational study performed at the Department of Ophthalmology, Hind Institute of Medical Sciences, Barabanki, Uttar Pradesh, India, from August 2018 to July 2019. Our study was performed as per the tenets of the Declaration of Helsinki and after being approved by the ethical board of the institute. Written informed consent was obtained from the patients.

The sample size was taken as 108, 54 cases, and 54 controls. This study aimed to study clinical profile, visual functions [visual acuity, color vision (CV), contrast sensitivity (CS)], and RNFL thickness (by SD-OCT) of patients presenting with ocular complaints after RTAs, to a tertiary care referral center. The inclusion criteria comprised of all consenting adult patients (20-65 years) with visual complaints post-RTA. These patients had a normal systemic examination and were free from any disability restricting slit-lamp examination. We excluded patients with media opacity, rupture of the globe, a diagnosed case of glaucoma, pre-existing neurological illness (*e.g.* cerebrovascular accident, brain tumor, patients on nerve

supplements/antioxidants). A detailed history and clinical examination of all cases were done. Epidemiological details (age and gender), color vision (Ishihara color vision chart), and Contrast Sensitivity (Pelli-Robson chart) were noted. Fundus was examined by direct ophthalmoscope and indirect ophthalmoscope (Figure 2). An analysis of RNFL was done by SD-OCT. All RTA patients attending or referred to the department of ophthalmology, outpatient department (OPD), and trauma center were assessed and divided into two groups: RTA patients presenting within the 1st week and RTA patients presenting between 2-4wk. Controls were individuals of similar age and sex attending ophthalmology OPD for refraction. The follow up was done after 3mo, and at that time, best-corrected visual acuity (BCVA), and posterior segment evaluation was done. OCT RNFL of both eyes was analyzed again, and the average thickness of RNFL was taken for analysis.

Continuous variables were presented as mean and standard deviation. Categorical variables were presented in number and percentage (%). Quantitative variables were compared using unpaired *t*-test, ANOVA, and paired *t*-test. The qualitative variable was compared using a Chi-square test/Fisher's exact test. *P*-value<0.05 was considered statistically significant. The data was entered and the analysis was done using Statistical Package for Social Sciences.

## RESULTS

A total of 108 patients were enrolled in the study. The mean age was 43±2.3 years in cases and 41±1.8 years in controls. There were 11 (20.37%) females and 43 (79.6%) males in the case group and 12 (22.22%) females and 42 (77.77%) males in the control group. No statistically significant difference was found (*P*>0.05) between the average age group of cases and controls (Table 1).

The mean BCVA at the time of presentation was 0.28±0.22 and 0.22±0.28 for the right eye and left eye, respectively. The mean CS was 1.25±0.27 and 1.21±0.23 for the right eye and left eye, respectively. Mean CV was 0.81±0.14 and 0.80±0.13, respectively. The mean RNFL thickness of the right eye and left eye was 93.21±9.21 and 94.12±11.8, respectively. Statistically, an insignificant difference was found in visual function between both the eyes of the case group at the first visit (Table 2).

A significant difference was seen in mean RNFL in the right and left eye of cases and controls (*P*≤0.001, *P*≤0.001, respectively). RNFL thinning was found in the nasal and temporal quadrant of both right and left eyes (*P*=0.001 of each, respectively). A significant difference was also found in BCVA, contrast sensitivity, and color vision (*P*<0.05) (Table 3).

In BCVA and color vision the change found after 3mo follow up in both right and left eyes were insignificant (*P*>0.05). A significant change was found in contrast sensitivity in both right and left eyes (*P*<0.05). There was insignificant change in the mean RNFL thickness of both eyes, but the superior quadrant of both eyes and temporal quadrant of the left eye had a significant change in mean RNFL thickness (*P*<0.05; Table 4).

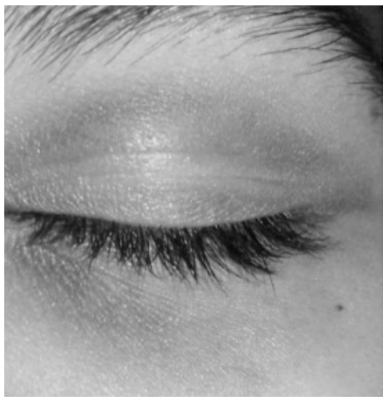

**Figure 1 Black eye.**

**Figure 2 Indirect ophthalmoscopy.**

**Table 1 The demographic data of the patients**

| Parameters | Case group | Control group | *P* |
|---|---|---|---|
| Patients, *n* | 54 | 54 | - |
| Age, y | 43±2.3 | 41±1.8 | >0.05 |
| Sex | | | |
| M | 43 (79.63%) | 42 (77.77%) | >0.05 |
| F | 11 (20.37%) | 12 (22.22%) | >0.05 |

**Table 2 The RNFL thickness and visual acuity of cases at the first visit**

| Parameters | Right eye (case group) | Left eye (case group) | *P* |
|---|---|---|---|
| BCVA | 0.28±0.22 | 0.22±0.28 | 0.06 |
| Contrast sensitivity | 1.25±0.27 | 1.21±0.23 | 0.16 |
| Colour vision | 0.81±0.14 | 0.80±0.15 | 0.09 |
| Mean RNFL thickness | 93.21±9.21 | 94.12±11.8 | 0.15 |
| Superior quadrant | 122.10±14.25 | 116.28±13.58 | 0.30 |
| Inferior quadrant | 111.21±21.01 | 111.02±19.12 | 0.71 |
| Nasal quadrant | 58.98±7.25 | 66.92±9.08 | 0.16 |
| Temporal quadrant | 70.96±11.23 | 61.51±6.30 | 0.07 |

**Table 3 The comparison of BCVA, CV, CS, and RNFL thickness between cases and controls at the initial visit**

| Parameters | R/E cases | R/E controls | *P* | L/E cases | L/E controls | *P* |
|---|---|---|---|---|---|---|
| BCVA | 0.22±0.21 | 0.01±0.03 | <0.001 | 0.18±0.21 | 0.01±0.03 | <0.001 |
| Contrast sensitivity | 1.24±0.23 | 1.35±1.18 | <0.001 | 1.24±0.27 | 1.37±1.8 | <0.001 |
| Colour vision | 0.81±0.22 | 0.93±0.04 | <0.001 | 0.78±0.10 | 0.93±0.04 | <0.001 |
| Mean RNFL thickness | 91.28±9.31 | 98.48±4.5 | <0.001 | 93.01±9.8 | 99.12±6.7 | <0.001 |
| Superior RNFL | 120.97±19.60 | 122.38±31.71 | 0.63 | 114.97±18.04 | 120.93±21.28 | 0.027 |
| Inferior RNFL | 109.98±22.84 | 123.05±20.23 | <0.001 | 109.98±20.83 | 112.94±24.0 | <0.28 |
| Nasal RNFL | 57.97±7.23 | 66.98±9.80 | <0.001 | 65.67±9.8 | 74.86±8.34 | <0.001 |
| Temporal RNFL | 69.93±11.98 | 77.67±12.98 | <0.001 | 59.93±7.98 | 64.97±8.8 | <0.001 |

**Table 4 Changes in visual function and RNFL thickness on follow up after 3mo in the case group**

| Parameters | R/E cases (0d) | R/E cases (90d) | *P* | L/E cases (0d) | L/E cases (90d) | *P* |
|---|---|---|---|---|---|---|
| BCVA | 0.25±0.31 | 0.22±0.39 | 0.55 | 0.19±0.21 | 0.21±0.39 | 0.65 |
| Contrast sensitivity | 1.18±0.29 | 1.01±0.18 | 0.05 | 1.31±0.22 | 1.13±0.19 | 0.04 |
| Colour vision | 0.78±0.11 | 0.77±0.12 | 0.08 | 0.75±0.11 | 0.76±0.02 | 0.13 |
| Mean RNFL thickness | 90.28±10.97 | 89.21±10.96 | 0.06 | 92.18±9.8 | 90.82±13.9 | 0.08 |
| Superior RNFL | 122.92±19.68 | 113.97±18.38 | 0.001 | 116.28±18.13 | 109.38±18.10 | 0.009 |
| Inferior RNFL | 110.97±21.23 | 112.23±19.96 | 0.56 | 111.22±18.60 | 107.98±20.18 | 0.19 |
| Nasal RNFL | 58.13±7.9 | 56.35±6.97 | 0.13 | 66.18±11.01 | 68.37±11.12 | 0.1 |
| Temporal RNFL | 68.23±11.67 | 69.94±14.11 | 0.36 | 61.05±7.4 | 58.21±9.01 | 0.049 |

## DISCUSSION

Out of 54 cases enrolled in study 41 came for follow up. Thirteen patients lost to follow up. The RTA was more common in adults with a mean age of 43±2.3 years[19]. Ezegwui had reported the peak age between 16 and 30 years in his study[1]. Armstrong *et al*[20] and Arora *et al*[21] have also reported similar results. In our study, male patients were 79.6% and female patients were 20.37%. Males were more commonly involved in RTAs[22-23]. The male to female ratio was 4:1 in our study. At the time of presentation, the visual acuity after trauma ranged from 6/5 to PL (perception of light). Most of the patients had visual acuity ranging from 6/9 to 6/24, who had sustained ocular adnexal injury. A decrease in visual acuity occurred due to corneal abrasion, intraocular hemorrhage, and retro-orbital hemorrhage. In our study, there was a significant decrease in visual acuity as compared to controls. A similar decrease was also found in contrast sensitivity and color vision. In our study, 30 (55.5%) patients had periorbital ecchymosis, edema, and subconjunctival hemorrhage. It was the most common form of injury. 8 (14.8%) patients had isolated subconjunctival hemorrhage were the second-most common form of injury. 2 (0.03%) patients had lid tear. Closed globe injury was more common than open globe injury[24], similar to reported by Mittal *et al*[24] and Arora *et al*[21]. Several studies have reported that retinal layer thickness decrease following optic nerve injury[13-14,25]. Kanamori *et al*[12] reported a decrease in thickness of the entire retina, cp RNFL, and retinal ganglion cell (RGC) complex at 2, 3, 4, and 20wk after trauma in four patients. Cunha *et al*[16] also investigated that there was a progressive decrease in macular and cp RNFL thickness over the first 12wk following TON in three patients. However, most studies had small sample sizes and did not evaluate the morphological changes in the retina and visual function in patients with TON. No studies have evaluated all RTA patients. Therefore, we conducted this study on RTA patients and subsequent follow up was done to find out the change in visual function and circumpapillary RNFL thickness measurement using SD-OCT. We demonstrated that there was significant peripapillary RNFL thinning in both eyes of RTA patients when compared with the eyes of healthy individuals. The inpatient of trauma, damage of nerve fiber occurred. Therefore, we evaluated the nerve fiber layer thickness to assess all possible changes in RTA patients[16]. Sarkies *et al*[10] found out a strong correlation between RGC density and retinal layer thickness, and reported an exponential decline in the number of ganglion cells and thinning of RNFL thickness on SD-OCT which was significant following injury to the optic nerve in mice[26-28]. These morphological changes detected by SD-OCT have also been reported in humans. Kanamori et al. reported that cp RNFL and GCL thicknesses remain stable within 1wk after the trauma

but start to decrease thereafter. Cunha *et al*[16] reported a 12% reduction in macular thickness over 5wk in patients of TON. With time, morphological changes in the retina occur. The optic disc becomes progressively pale and atrophic 3-5wk after trauma. Timely intervention may regain the vision loss[29-30]. At the timing of the first visit, we did not detect any significant change in optic nerve head on the fundus examination or the disc SD-OCT. We detected a tendency for mean cp RNFL thickness to decrease as compared to controls at the time of presentation. Whereas there was a marked reduction in RNFL thickness that occurred in the outer nasal and temporal quadrant of both eyes and outer superior quadrant of left eyes and temporal quadrant of right eyes. This neurodegenerative progression observed in early TON may occur due to early loss of RGC soma[31]. Munguba *et al*[32] reported that RGC soma count decreases initially faster than the NFL *in vivo* as an overall measurable change following optic nerve injury in animals. In our study, we also found that a significant decrease in visual function such as BCVA, CV, and CS occurred that can be correlated to the structural damage to the retina. A similar study was also done by Lee *et al*[14] and demonstrated similar changes in RNFL thickness and visual function. When we did the RNFL thickness measurement after follow up found that the mean RNFL thickness decreased as compared to controls, but these decreases were not statistically significant. We also found that significant change in RNFL changes occurred in the superior quadrant in both the eyes and temporal quadrant of the left eye. These losses were likely to that of occurred in glaucomatous damage in which large damage occurred in superior and temporal areas as compared to other areas[33-35]. In glaucoma, the arcuate fiber passing through the superior and inferior portion of lamina cribrosa is generally known as the most vulnerable zone due to less connective tissue support[36-37]. On follow up, there was a decreased in visual acuity, CV, and CS, but statistically, the insignificant difference was observed in visual acuity and color vision. Decrease in visual function occurs following RTA. Furthermore, RNFL thinning occurs which remains persistently thin thereafter[38].

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