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ORIGINAL ARTICLE

Clinical outcomes and epidemiology of intraocular foreign body injuries in Cork University Hospital, Ireland: an 11-year review

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Abstract

Background/aims To describe the epidemiology, outcomes, and prognostic factors of intraocular foreign body (IOFB) injuries at a tertiary ophthalmic referral centre in Cork University Hospital, Ireland.

Methods A retrospective review of 23 eyes with IOFB that presented to Cork University Hospital (CUH) from January 2009 to December 2019 was performed. The mechanism and characteristics of IOFB injury were all noted. This data was collated and analysed to ascertain the epidemiology of IOFB injury in CUH and to describe the prognostic factors affecting visual outcome following IOFB injury.

Results There was a 100% male prevalence. The mean age was 37.4 years. The majority of IOFBs were metal in nature and were acquired by hammering, often while working and frequently in the absence of personal protective equipment (PPE). The route of entry for the IOFB was via the cornea in 70% of cases. Fifty-two percent of cases were clinically detectable and 43% of cases were only identifiable on CT (computed tomography) imaging. Eighty-seven percent of cases underwent surgery on the same day as presentation. There was no incidence (0%) of endophthalmitis. Seventeen percent of cases developed post-operative retinal detachment (RD). The mean pre-operative VA was 0.79 LogMAR (6/38 Snellen equivalent—SE) compared to a mean VA of 0.58 LogMAR (6/24 SE) following surgery.

Conclusions This review provides important epidemiological data for IOFB injuries in Ireland. It also adds some useful information to the literature in relation to prognostic factors and lens status post IOFB injury.

Keywords Endophthalmitis · Epidemiology · Intraocular foreign body (IOFB) · Personal protective equipment (PPE) · Retinal detachment · Trauma

Introduction

Intraocular foreign bodies (IOFBs) are a major cause of visual morbidity in the working population [1]. While the problem is more significant in the developing world, IOFBs still have a considerable incidence in the developed world [2]. The epidemiology of IOFBs has been well studied in many countries including China and the UK; however, there has been no significant research on the epidemiology of IOFB injury in Ireland to date. This study aims to (1) provide important epidemiological data on the occurrence of IOFB injury in a tertiary centre in Cork, Ireland; (2) identify potential prognostic factors that may have impacted visual outcome; and (3) analyse visual outcomes following surgical intervention. It is hoped that this insight might guide future management, as well as prevention and treatment of IOFBs.

Methods

A retrospective review of all cases of patients presenting to Cork University Hospital (CUH) with an IOFB injury in the past 11 years (January 2009–December 2019) was conducted.

This study was performed in compliance with the principles of the Declaration of Helsinki. The ethics committee decided approval was not necessary for this study as it consisted of retrospective chart review with no additional patient contact and no extra procedures performed.

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IOFB cases were identified through retrospective review of surgical logbook records. These identified cases were then traced and their charts' individually reviewed.

Over the 11-year period, 38 cases in total were labelled as "Intraocular foreign bodies" in the surgical logbooks. A small number of cases had been incorrectly coded as IOFB injuries and were excluded from further analysis. These included eleven paediatric cases of corneal foreign bodies that required general anaesthesia for removal, two cases of scleral foreign bodies in adult patients that did not meet the criteria for classification as IOFBs, one case of secondary intraocular lens exchange, and one case of a foreign body in the socket of a patient who had a previous exenteration. No other cases were excluded, and as such, twenty-three genuine IOFB cases that presented to CUH over the past 11 years are included in this review. All relevant cases were analysed in detail and important demographic and clinical information was collated for further analysis, including age, occupation, initial and final visual acuities (Fig. 1), the entry site and nature of the IOFB, the structures traversed, the final anatomic position of the IOFB within the eye as well as information on the mechanism of injury, surgical interventions, and any post-operative complications. The clinical information retrieved from patient case notes had been recorded by multiple observers over the follow-up period.

Patients who presented with presumed or confirmed IOFB received helical non-contrast orbital CT imaging with 0.625-mm bone acquisitions and 2-mm soft tissue reconstructions (bone windows W: 2000, L: 350 and soft tissue windows W: 300, L: 35) as per the radiology department protocol. VA was measured using Snellen acuity charts. For the purposes of this review, good final visual outcome is defined as VA ≥ to 6/19 (0.5 LogMAR equivalent). The good final visual outcome score was decided upon based on the World Health Organization's classification of visual impairment [3].

Results

Of the 23 IOFB cases that presented to CUH over the last 11 years, there was a 100% male prevalence (Table 1). The mean age of the cases was 37.4 years (range 8–69 years). Eighty-seven percent of cases were related to manual labour and 61% of patients had not been wearing personal protective equipment (PPE) when the injury was acquired.

Fifty-seven percent of cases were related to the left eye and 43% to the right. The route of entry for the IOFB was via the cornea in 70% of cases and via the sclera in 30% of cases. Seventy-four percent of the IOFBs were located in the posterior chamber, while the remaining 26% of IOFBs were found in the anterior chamber. Fifty-two percent of cases were clinically detectable and 43% of cases were identifiable on CT imaging only (see Figs. 2 and 3). One case, an organic IOFB, was not detected clinically or on CT image. This patient had a self-sealing corneal perforation and a vitreous haemorrhage and based on their history were brought to surgery that day for an exploration where the IOFB was found.

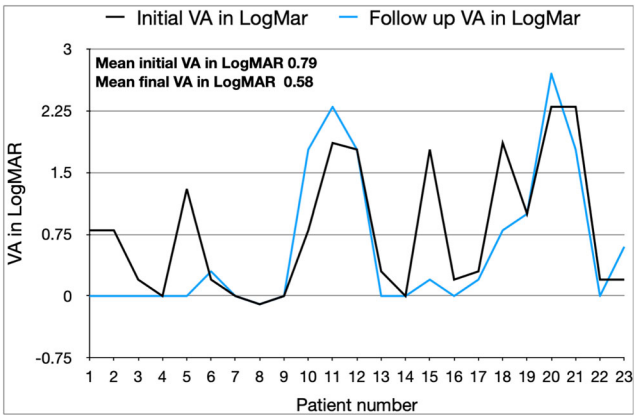

Fig. 1 Initial and final visual acuities for each patient displayed in line chart form. Mean initial VA of 0.79 LogMAR and mean final VA of 0.58 LogMAR

Eighty-seven percent of cases underwent surgery on the same day that they presented to the hospital. Thirty percent of cases (7 patients) did not present to the hospital on the same day that the injury was acquired (Table 2). Five of these patients obtained good final visual acuity ≥ 6/19 Snellen (0.5 LogMAR). Delay in presenting to hospital (> 24 h following the incident) may have an impact on outcome. A delay in presentation in one case (3 days after incident) may have contributed to a poorer final visual outcome. This patient's final visual acuity was 2.3 LogMAR (HMs). However, other patients with longer delays in presentation (5 days following incident in one case and 10 days following incident in another case) achieved good final visual acuity (both 6/6 Snellen, 0 LogMAR).

An external magnet was used in 17% of cases and had a 25% success rate at removing the IOFB when used. There was no incidence (0%) of endophthalmitis. Seventeen percent of cases developed post-operative retinal detachment (RD).

Table 1 Epidemiological data and IOFB material

Sex	100% male
Age	37.4 years (mean)
Occupation	Farmer (21.7%)
	Mechanic (17.4%)
	Carpenter (13%)
	Student (13%)
	Construction (8.7%)
	Other (26.2%)
Material of IOFB	Metal (82.6%)
	Steel (13.1)
	Wood (4.3%)

Fig. 2 Axial CT image with visible intraocular foreign body in the antero-medial aspect of the right globe

There were no cases of siderosis bulbi or chalcosis oculi noted in the intraocular foreign bodies with a ferrous component. Thirty percent of patients were phakic at most recent follow-up. One patient was pseudophakic prior to IOFB injury (4%). Sixty-one percent of patients ended up pseudophakic at most recent follow-up, with one patient awaiting cataract extraction (4%).

The mean pre-operative VA was 0.79 LogMAR (6/38 Snellen equivalent—SE) compared to a mean VA of 0.58 LogMAR (6/24 SE) following surgery. An analysis was performed to assess whether a significant relationship between initial visual acuity and final visual acuity existed, but did not reach statistical significance (p value > 0.05, 0.107; paired sample t test). At most recent follow-up, 65% of cases achieved a good final visual outcome, obtaining a post-operative VA score of ≥ LogMAR 0.5 (6/19 SE) and 44% of patients showed an improvement in VA (See Fig. 1).

Of the IOFBs that entered via the cornea, the average pre-operative VA was 0.8 LogMAR (6/38 SE) and this improved to an average of 0.5 LogMAR (6/19 SE) following surgery. As expected, the visual outcomes were not so positive for the scleral entry-site patients, who presented with an average pre-operative VA of 0.7 LogMAR (6/30 SE) and a post-operative average of 0.76 LogMAR (6/34 SE). The average duration of follow-up was 34.6 months.

Fig. 3 Axial CT image with a visible radio-opaque intraocular foreign body in the medial aspect of right globe

Discussion

IOFB injury is a major cause of visual morbidity and blindness worldwide. Some authors have posited that the incidence of IOFB in developed countries is declining due to a combination of factors, such as decreasing manual labour and improvements in health and safety [2]. However, other studies have shown that the use of PPE, for example safety goggles and visors, remains low, ranging from 0.77 to 6% [4, 5]. In Ireland, the use of PPE in the construction industry is mandated under S.I. No. 299/2007—Safety, Health and Welfare at Work (General Application) Regulations 2007. PPE worn should include, but is not limited to, eye and face protection. However, compliance rates with the use of PPE in Irish construction have been reported as sub-optimal; in a review of twenty building sites, only three had complete compliance with PPE requirements [6]. Our data shows that 61% of patients in our study who sustained an IOFB injury were not using PPE.

As is the case in many other studies, hammering was the main mechanism of injury in this study and as a result, metallic IOFBs were the most common. IOFB injury is strongly correlated to manual labour and 87% of our study's cases were work-related. One hundred percent of the patients were male. Our data indicated that 0% of patients developed endophthalmitis. This may be due to the fact that endophthalmitis is more closely linked with organic IOFBs and only 1 patient in our cohort presented with an organic IOFB [7]. Another contributing factor might be the quick turn-around from presentation to surgical intervention, where 87% of surgeries to remove IOFBs in our study were carried out on the same day as initial presentation. This theory would be consistent with other studies which show a significant reduction in post-operative

Table 2 Surgical data

Time to surgery	Same day as presentation (86.9%)
	1 day after presentation (8.8%)
	> 1 day after presentation (4.3%)
Magnet used	No (82.6%)
	Yes—successful (4.3%)
	Yes—unsuccessful (13.1%)
Lens status	Phakic at most recent follow-up (30.4%)
	Pseudophakic prior to IOFB (4.3%)
	Pseudophakic at most recent follow-up (61%)
	Listed for cataract extraction (4.3%)

endophthalmitis where the IOFB is removed within 24 h [5]. Additionally, all of our patients who are admitted with IOFB injuries are commenced on systemic intravenous antibiotics as part of our IOFB protocol. One study listed the presence of an IOFB and delay in primary repair as the main risk factors for developing endophthalmitis in the setting of trauma [8]. Where there has been a delay in removing an IOFB, evidence has shown that immediate injection of intravitreal antibiotics may preserve the eye and assist in restoring visual acuity [8].

Imaging

Plain film x-rays alone may be used as a screening tool for suspected IOFBs, but these are likely to provide an equivocal result when compared to other imaging modalities. One retrospective review found that if an IOFB could be seen on x-ray, then 6-mm CT cuts would be sufficient to detect and localise the IOFB [9].

Two varieties of CT imaging are deployed when dealing with IOFBs: conventional CT and helical/spiral CT. In our centre, helical CT imaging is used and Lakits et al. have shown that helical CT with multiplanar reconstruction enables precise evaluation of intraocular metallic, stone, and glass foreign bodies [10]. Further benefits of using helical CT over the conventional type include reduced examination time, less radiation exposure, superior multiplanar reconstruction ability, and reduced motion artefact [11, 12].

Using helical CT's multiplanar reconstruction capability, one can acquire helpful sagittal and coronal views without additional imaging. This feature is particularly favourable to elderly patients and patients with neck injuries, who cannot be adequately positioned for conventional CT coronal view. Helical CT has also been shown to be more accurate than axial CT, magnetic resonance imaging (MRI), and ultrasonography in detecting glass IOFBs [13].

Reports indicate the minimum detectable size of IOFB on CT depends on its composition: steel and copper particles can be detected as small as 0.06 mm^3; in the case of aluminium and glass, the minimal detectable size is about 1.5–1.8 mm^3; and wood, if small, likely cannot be visualised (unless coated with paint containing lead) [14].

MRI is contraindicated in the detection of suspected metallic IOFBs because the electromagnetic field created may lead to foreign body migration, potentially damaging or further damaging ocular tissues.

Wooden IOFBs may look similar to air on CT, appearing hypodense. However, the shape of the IOFB (elongated/oblong) may facilitate in the diagnosis and differentiate it from air [15].

Complications of IOFB

In terms of lens status, 30% of patients were phakic at most recent follow-up. One patient was pseudophakic prior to IOFB injury (4%). Sixty-one percent of patients ended up pseudophakic at most recent follow-up, with one patient awaiting cataract extraction (4%). This is important data to have in counselling patients at the time of injury and does not seem to have been evaluated extensively in previous studies. In our patient cohort, no patients attended with pre-operative RD. Pre-operative RD is associated with posterior segment IOFBs, endophthalmitis, and posterior entry wounds. One study reported pre-operative RDs in 6% of their cases [16].

The rate of post-operative RD ranges from 6 to 40% [17–19]. In our case series, we report a post-operative RD rate of 17%. Post-operative RDs are associated with posterior segment IOFBs and endophthalmitis. Additionally, eyes with IOFB impact sites on the retina are at an increased risk of post-operative RD [20].

In our study, 35% of patients were noted to have vitreous haemorrhage on presentation and 26% were noted to have cataracts. Thirteen percent were noted to have a hyphaema and 9% were noted to have retinal haemorrhages, indicating possible impact sites of the IOFB.

Apart from the main complications like retinal detachment, vitreous haemorrhage, cataract and endophthalmitis, further complications like metallosis and sympathetic ophthalmia may occur.

Metallic IOFBs with a high iron or copper content can cause chalcosis or siderosis, respectively. No cases were commented on or reported in our study, and this is likely due to the fact that there was an overall quick time to surgery from presentation. It is reported that siderosis may occur as soon as eighteen days after ocular injury with iron IOFBs [21].

Siderosis bulbi occurs when ferrous IOFBs undergo dissociation with deposition of iron in neuroepithelial tissues such as the corneal endothelium, iris and ciliary body, lens epithelium, and sensory retina [22].

If removing the foreign body could cause significant damage to an eye that otherwise presents with reasonable visual acuity and no evidence of endophthalmitis, then regular follow-up using visual acuity, slit lamp, and serial electroretinograms (ERGs) is an acceptable option [23].

Chalcosis is seen when IOFBs with a significant copper content deposit copper in basement membrane tissues, like Descemet's membrane [24]. Although chalcosis reactions are usually less severe and less sight threatening than siderosis, IOFBs with a high copper content (> 90%) may cause a violent endophthalmitis-like picture [25].

Prognosis

Our data showed that good final visual outcome was obtained in 65% of cases. Our study has identified some factors that contributed to poorer final visual outcomes: (1) poor initial visual acuity; (2) patients who developed post-operative

complications; and (3) patients with scleral entrance wounds (on average this cohort achieved a final LogMAR of 0.76 vs the corneal average of 0.5 LogMAR).

The Ocular trauma classification group (OTCG) have defined the zone of IOFB injury based on entry zone location: zone 1 (the whole cornea, including corneoscleral limbus), zone 2 (corneoscleral limbus to a point 5 mm posterior into the sclera), and zone 3 (posterior to the anterior 5 mm of the sclera) [26]. Due to the retrospective nature of this study and incomplete data on whether the scleral wounds were within the anterior 5 mm or not, we were unable to further classify our scleral entry wound sites into zone 2 or 3 injuries based on this classification system.

Certain prognostic models have been described to predict the visual outcome of patients after ocular trauma and may be useful in counselling patients and in management decision-making. In 2002, Kuhn et al. developed one of these prognostic models, the ocular trauma score (OTS) [27]. The OTS is calculated by assigning numerical points to six variables: initial visual acuity, globe rupture, endophthalmitis, perforating injury, retinal detachment, and a relative afferent pupillary defect (RAPD). A more recent model was proposed by Schmidt et al. in 2008 called the classification and regression tree (CART) [28]. They attempted to predict visual outcome after open globe injury. In their classification tree, poor initial visual acuity and the presence of an RAPD were most predictive of visual loss, while the presence of lid laceration and posterior wound location also predicted poor visual outcome. A comparison of the two models and their accuracy was carried out by a centre in the UK and published in 2009 [29]. They found that the OTS had a superior prognostic accuracy compared to the CART model to predict correctly (1) visual survival (PL or better) vs no vision (NPL or enucleation), and (2) minimal to severe visual loss (3/60 or better) vs profound visual loss (worse than 3/60). The OTS score can be calculated easily and templates are widely available online.

Conclusions

Limitations of this research include the fact that it is a retrospective study, with a relatively small sample size. However, this review provides important epidemiological data for IOFB injuries in Ireland. We also provide information on the lens status of patients who have had IOFB injuries, and this may prove beneficial to clinicians in counselling patients on their prospective lens status on their initial presentation to the ophthalmic department. We have shown that IOFB injury remains a significant complication of work-related injuries in Ireland. While no incidences of endophthalmitis and the favourable visual outcomes are positive, as is the early removal of IOFBs obtained in the majority of cases, the uptake of PPE in patients with IOFB in our locality appears to remain somewhat low [6]. This points to the further work that needs to be done in promoting PPE in order to reduce visual morbidity and blindness from this preventable condition. The retrospective nature of this study means data was not readily available to classify injuries into their respective OTCG zones. Going forward we recommend documentation of zone scores according to the OTCG and completion of OTS documentation to be filled out on IOFB presentation.

Data availability Not applicable.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

Ethics approval This study was performed in compliance with the principles of the Declaration of Helsinki. The ethics committee decided approval was not necessary for this study as it consisted of retrospective chart review with no additional patient contact and no extra procedures performed.

Code availability Not applicable.

References

1. Nicoară S, Irimescu I, Călinici T, Cristian C (2015) Intraocular foreign bodies extracted by pars plana vitrectomy: clinical characteristics, management, outcomes and prognostic factors. BMC Ophthalmol 15:151. https://doi.org/10.1186/s12886-015-0128-6
2. Imrie F, Cox A, Foot B, MacEwen C (2007) Surveillance of intraocular foreign bodies in the UK. Eye (Lond). 22(9):1141–1147
3. List of Official ICD-10 Updates Ratified October 2006. Geneva (Rep.). (2006). Retrieved from World Health Organization (WHO); website: http://www.who.int/classifications/icd/2006Updates.pdf. Accessed 2 July 2020
4. Woodcock M, Scott R, Huntbach J, Kirkby G (2006) Mass and shape as factors in intraocular foreign body injuries. Ophthalmology. 113(12):2262–2269
5. Liu C, Tong J, Li P, Li K (2016) Epidemiology and clinical outcome of intraocular foreign bodies in Hong Kong: a 13-year review. Int Ophthalmol 37(1):55–61
6. McEvoy P (2004) Safety performance on 20 construction sites in Dublin. Masters dissertation. Technological University Dublin. https://doi.org/10.21427/D7KP58
7. Duan F, Yuan Z, Liao J, Zheng Y, Yang Y, Lin X (2018) Incidence and risk factors of intraocular foreign body-related endophthalmitis in Southern China. J Ophthalmol 2018:1–5
8. Knox F, Best R, Kinsella F, Mirza K, Sharkey J, Mulholland D et al (2004) Management of endophthalmitis with retained intraocular foreign body. Eye (Lond). 18(2):179–182
9. Etherington R, Hourihan M (1989) Localisation of intraocular and intraorbital foreign bodies using computed tomography. Clin Radiol 40(6):610–614
10. Lakits A, Prokesch R, Scholda C, Bankier A (1999) Orbital helical computed tomography in the diagnosis and management of eye trauma. Ophthalmology. 106(12):2330–2335
11. Lakits A (1998) Multiplanar imaging in the preoperative assessment of metallic intraocular foreign bodies helical computed

tomography versus conventional computed tomography Historical image. Ophthalmology. 105(9):1679–1685
12. Lakits A, Prokesch R, Scholda C, Nowotny R, Kaider A, Bankier A (2000) Helical and conventional CT in the imaging of metallic foreign bodies in the orbit. Acta Ophthalmol Scand 78(1):79–83
13. Gor D, Kirsch C, Leen J, Turbin R, Von Hagen S (2001) Radiologic differentiation of intraocular glass. AJR Am J Roentgenol 177(5): 1199–1203
14. Tate E, Cupples H (1981) Detection of orbital foreign bodies with computed tomography: current limits. AJR Am J Roentgenol 137(3):493–495
15. Ho VT, McGuckin JF Jr, Smergel EM (1996) Intraorbital wooden foreign body: CT and MR appearance. AJNR Am J Neuroradiol 17(1):134–136
16. Parke D, Pathengay A, Flynn H, Albini T, Schwartz S (2012) Risk factors for endophthalmitis and retinal detachment with retained intraocular foreign bodies. J Ophthalmol 2012:1–6
17. Chiquet C, Zech J, Gain P, Adeleine P, Trepsat C (1998) Visual outcome and prognostic factors after magnetic extraction of posterior segment foreign bodies in 40 cases. Br J Ophthalmol 82(7): 801–806
18. Chow D, Garretson B, Kuczynski B, Williams G, Margherio R, Cox M et al (2000) External versus internal approach to the removal of metallic intraocular foreign bodies. Ophthalmol Retina 20(4): 364–369
19. Wani V, Al-Ajmi M, Thalib L, Azad R, Abul M, Al-Ghanim M et al (2003) Vitrectomy for posterior segment intraocular foreign bodies. Ophthalmol Retina. 23(5):654–660
20. Zhang Y, Zhang M, Jiang C, Qiu H (2011) Intraocular foreign bodies in China: clinical characteristics, prognostic factors, and visual outcomes in 1421 eyes. Am J Ophthalmol 152(1):66–73.e1
21. O'Duffy D, Salmon J (1999) Siderosis bulbi resulting from an intralenticular foreign body. Am J Ophthalmol 127(2):218–219
22. Terai N, Sandner D, Kissner A, Pillunat L (2010) Siderosis bulbi nach intraokularem Metallfremdkörper. Ophthalmologe. 108(1): 60–63
23. Zhu L, Shen P, Lu H, Du C, Shen J, Gu Y (2015) Ocular trauma score in siderosis bulbi with retained intraocular foreign body. Medicine (Baltimore) 94(39):e1533
24. Rosenthal A, Appleton B (1975) Histochemical localization of intraocular copper foreign bodies. Am J Ophthalmol 79(4):613–625
25. Ravani R, Kumar V, Kumar A, Kumar P, Chawla S, Ghosh S (2018) Fleck-like deposits and swept source optical coherence tomography characteristics in a case of confirmed ocular chalcosis. Indian J Ophthalmol 66(11):1640–1642
26. Pieramici D, Sternberg P, Aaberg T, Bridges W, Capone A, Cardillo J et al (1997) A system for classifying mechanical injuries of the eye (globe). Am J Ophthalmol 123(6):820–831
27. Kuhn F, Maisiak R, Mann L, Mester V, Morris R, Witherspoon C (2002) The ocular trauma score (OTS). Ophthalmol Clin N Am 15(2):163–165
28. Schmidt G, Broman A, Hindman H, Grant M (2008) Vision survival after open globe injury predicted by classification and regression tree analysis. Ophthalmology. 115(1):202–209
29. Man C, Steel D (2009) Visual outcome after open globe injury: a comparison of two prognostic models—the Ocular Trauma Score and the Classification and Regression Tree. Eye (Lond) 24(1):84–89