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Major review

Intraocular foreign bodies: A review

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ABSTRACT

Intraocular foreign body injuries may result in a wide range of intraocular pathology and visual outcomes based on the mechanism of injury, type of foreign body, and subsequent complications. We have reviewed the literature to describe the epidemiology and mechanisms of such injuries; types of foreign bodies; imaging tools for diagnosis; current trends in management, presurgical, and surgical interventions; as well as visual prognosis and potential complications. The purpose of this review is to familiarize clinicians with the recent advances in diagnosis and management of such injuries.

1. Introduction

Open-globe injury (OGI) often can result in serious visual loss and imposes a significant economic burden on the patient and society. Intraocular foreign bodies (IOFBs) account for 18%–41% of all OGIs.[99,138,141] Most post-traumatic IOFBs (58%–88%) reside in the posterior segment.[15,99,120,136,141] The extent of ocular injury and visual prognosis depends on the IOFB size, the zone of the injury, and the ensuing complications.[36,39,53,59,136] For open-globe perforating injuries, the zone is described by the most posterior defect, as opposed to the "site" of injury (typically entrance site). Here, we review the diagnosis, medical and surgical management, and outcomes of IOFB-associated OGI.

2. Epidemiology

Among an estimated 2.4 million eye injuries occurring each year in the USA, between 20,000 and 68,000 are serious vision-

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threatening injuries.[98] According to the US eye injury database, the places of injury include as follows: home (43%), industrial premises (20%), recreation and sport (13%), street and highway (15%), school (3%), farm (3%), and public buildings (3%). The causes of injury include: various blunt objects (34%), various sharp objects (26%), motor vehicle crash (10%), gunshot (6%), BB and pellet gun (6%), fall (5%), fireworks (5%), hammering on metal (5%), and explosion (3%).[41]

The incidence of IOFBs among open-globe injuries ranges from 18% to 41%.[47,65,136,141] Young men constitute 92%–100% of the patients presenting with IOFBs.[25,53,55,74] The average age of a patient with an IOFB is 29 to 38 years with a majority (66%) between 21 and 40. The most common place of injury is work (54%–72%) followed by home (30%). Most common causes include hammering (60%–80%), usage of power or machine tools (18%–25%), and weapon-related injuries (19%).[47,53,55,65,136] Approximately 25% of the US military service members seen by the Walter Reed Army Medical Center Ophthalmology Service for combat-related ocular injury in Afghanistan and Iraq since 2003 had intraocular foreign bodies.[28] One series in Turkey showed that 45 of 47 eyes suffering OGI related to military activities had IOFB.[49] Less common causes of an IOFB-related injury include assault, motor vehicle accidents, lawn mower, and firework injuries.[62,107]

2.1. *Characteristics of IOFBs*

Foreign body–related injuries can be penetrating or perforating. Foreign bodies that lie intraocularly are penetrating and can enter through the cornea (65%), sclera (25%), or at the limbus (10%).[107] These foreign bodies are usually seen in the posterior segment in most (58%–88%) cases, with most others in the anterior chamber (10%–15%) or the lens (2%–8%).[53,55,128,141]

A literature review conducted by Kuhn and colleagues has shown that, in penetrating injuries, multiple IOFBs can be found in 8%–25% of eyes, with an average size of an IOFB of 3.5 mm (range: 0.5–25 mm).[65] The composition of IOFBs varies from organic material (e.g., insect parts and animal hairs), glass, plastic, or metals such as zinc, nickel, aluminum, mercury, iron, and copper.[128] By far, most IOFBs are metallic in nature.[42,136,141] Imaging modalities used in diagnosis may differ depending on the composition of the IOFB and are described in the following sections.

3. Pathophysiology

3.1. *Direct mechanical damage*

Intraocular foreign bodies can cause direct mechanical damage along their path of entry into the eye. Their path is not always linear, as they can ricochet and cause additional intraocular damage. For example, intravitreal IOFBs can come to rest in the vitreous after rebounding off the retina.[74] In 1 study of 64 eyes with ferrous IOFBs in the posterior segment, there was a 66% probability of the metal causing 1 retinal lesion and a 20% probability of causing 2 or more retinal lesions.[85]

The extent of intraocular damage caused by IOFBs depends on several factors. Wound length can be used to predict the risk of retinal injury. A shorter wound means that less of the IOFBs energy is dissipated during penetration and may travel much further inside the eye, allowing it to reach and injure the retina. Foreign bodies entering the eye through the sclera are more likely to cause intraocular damage than those entering though the cornea.[65] Object shape can also be predictive of intraocular damage. Sharp IOFBs cause less damage than blunt ones of the same size.[65] This is presumably due to the increased transfer of energy to the eye at the time of impact by blunt IOFBs as opposed to sharp IOFBs,[103] which often enter through a smaller linear laceration. Retained IOFBs can exhibit long-term toxicity as described in the following.

3.2. *Metallosis*

3.2.1. *Siderosis bulbi*

A retained IOFB containing iron can lead to siderosis bulbi, which can occur in as short as 18 days after ocular injury.[95] Iron deposition in the eye results in ocular siderosis, which includes iris heterochromia, pupillary mydriasis, cataract formation, secondary glaucoma, and retinal pigmentary degeneration.[84,122,143] Characteristic ERG changes of siderosis bulbi are an increased “a” wave followed by a continual reduction of the “b” wave.[65]

Ocular damage can be caused by the deposition of released iron from the IOFB as ferritin throughout the cytoplasm of ocular cells especially in the form of siderosomes.[122] Chao and coworkers created experimental siderosis by administering an iron particle, $FeSO_4$ in eyes of Wistar rats. This experimental siderosis system resulted in the disorganization of the retina with loss of photoreceptor outer segments and cholinergic amacrine cells. Chao and coworkers suggest that retinal damage occurs possibly due to oxidative stress combined with excessive glutamate release and increased calcium influx.[19]

3.2.2. *Chalcosis*

An IOFB containing copper can cause another vision-threatening disease called chalcosis. The pathogenesis of chalcosis is not clear, but one possible mechanism may be free radical attack.[112] In the presence of copper, reactive free hydroxyl radicals can be generated from hydrogen peroxide,[112] which is a product generated from the reaction between superoxide dismutase and superoxide free radicals.[106] Some clinical signs of chalcosis include Kayser-Fleischer ring (green-blue perilimbal ring in the cornea at the level of Descemet membrane), tiny refractile copper particles in the anterior chamber or iris, and formation of a sunflower cataract.[74]

A copper foreign body can induce mild reversible retinal toxicity and/or a severe inflammatory reaction, depending on its purity; however, Tokoro and associates have reported a case of a copper foreign body located in the lens for over 15 years without causing a severe inflammatory reaction. One possible explanation could be that the epithelial cells in the lens encapsulated the foreign body, which might reduce the diffusion of the copper ion. Alternatively, the formation of water-insoluble copper oxide on the surface of the foreign body may have reduced copper ionization. Although visual