 

Management of Intraocular Foreign Bodies

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ABSTRACT

Intraocular foreign body (IOFB) is an ophthalmologic emergency, demanding immediate diagnosis and treatment to prevent blindness and eye loss. These foreign bodies may penetrate via cornea (62%), sclera (25%), or limbus (10%), most IOFB resides in the posterior segment of the eye (58%-88%). Early treatment plays a pivotal role in providing a favorable patient prognosis.

Keywords: Intraocular foreign body, ocular trauma, ophtalmologic emergency.

ABSTRAK

Benda asing intraokular (BAIO) merupakan keadaan gawat darurat oftalmologi yang memerlukan diagnosis dan pengobatan segera untuk mencegah kebutaan atau kehilangan bola mata. Benda asing dapat masuk melalui kornea (62%), sklera (25%), atau limbus (10%), sebagian besar BAIO berada di segmen posterior mata (58%-88%). Pengobatan dini berperan penting dalam memberikan prognosis pasien yang baik. **Ferdy Iskandar, Maria Angelia. Tata Laksana Benda Asing Intraokular**

Kata Kunci: Benda asing intraokular, trauma okular, gawat darurat oftalmologi.

INTRODUCTION

Intraocular foreign body (IOFB) is defined as a foreign body that penetrates the ocular globe wall and is intraocularly retained. This condition represents an urgent ophthalmic emergency that needs immediate diagnosis and treatment to prevent blindness.[1] IOFB accounts for 16%-41% of open-globe injuries.[1] IOFB predominantly occurs in work environments (54%-72%), followed by domestic settings (30%).[2] IOFB incidents are more prevalent among young adult males.[1,3] The average IOFB patient ranges from 29 to 38 years, predominantly between 21 and 40 years of age.[4,5]

IOFB typically penetrates through the cornea (65%), sclera (25%), or limbus (10%). The majority of IOFB lodged in the posterior segment (58%–88%), followed by the anterior chamber (10%–15%), or the lens (2%–8%).[2,4] Kuhn, *et al*, demonstrated that multiple IOFBs may present in 8%–25% cases, with an average size of 2.5 mm (range: 0.5–25 mm).[6] These foreign bodies can be diverse in composition, such as organic material, glass, plastic, or metals such as zinc, nickel, aluminum, mercury, iron, and copper.[2,6]

Manifestations and Mechanisms

Intraocular foreign body (IOFB) injuries exhibit diverse presentation, outcomes, and prognoses.[2,7] Small and sharp IOFBs, like iron chips, typically cause small and linear perforations at the entry site and are relatively straightforward to repair. Conversely, large and irregular projectiles of IOFBs, such as stone particles, cause a large and irregular wound that causes a challenge for repair due to significant tissue damage. This is presumably due to the increased transfer of energy to the eye at the time of impact by the blunt IOFB. Most high-velocity IOFBs often lodge in the posterior eye segment or bounce inside the eye, causing multiple site injuries. Intravitreal IOFBs, for example, may rest in the vitreous following retinal deflection.[2,4,7]

Metallic foreign bodies, notably iron and copper, are the most common types of IOFBs;[7] their reactivity can cause metallosis. They release metallic ions and deposit them in various ocular tissues. Iron deposits lead to siderosis bulbi, characterized by pigmentation and degeneration across ocular tissue such as the cornea, lens, trabecular meshwork, iris, and retina due to chronic retention of iron. Iron deposits in the iris will cause heterochromia, while dilated and fixated pupil. Iron deposits in the trabecular meshwork can cause secondary open-angle glaucoma and cataracts if deposited in the anterior subcapsule. Iron has a toxic effect, causing cell death. Siderosis also damages the retinal pigment epithelium (RPE), which causes retinal degeneration. Histopathologically, iron will give a blue color to Prussian blue staining

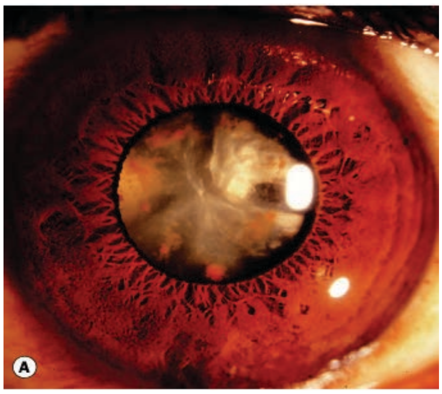

Figure 1. Siderosis bulbi: iron deposit on lens.[8]

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in the area of epithelial structures, trabecular meshwork, and retina.[4,6–8]

Copper can be deposited on the cornea, Descemet's membrane, lens capsule, and retina, causing an inflammatory reaction known as chalcosis. The clinical manifestations depend on the levels of copper content. If the copper content is >85%, it generally causes endophthalmitis and extensive copper deposits; if the copper content is <85%, the manifestations are local deposits or chalcosis bulbi. Copper deposits will be stained with rhodanine, rubeanic acid, and alizarin blue.[5,7]

Organic IOFBs, such as contaminated animal hairs, insects, or thorns, produce a severe tissue reaction and risk of contamination, which can cause fulminant endophthalmitis. Conversely, inert IOFBs such as glass and plastic are generally more tolerated and do not cause significant reactions.[5,7]

The mechanism of injury and the nature of the foreign body material are essential for accurate diagnosis. The patient often presents with conjunctival congestion or blurring of vision; however, they might be asymptomatic or report a sensation of something entering the eye without obvious external changes.[5,7] Ocular and adnexal examinations include visual acuity assessment, pupillary reaction, intraocular pressure, and evaluation of media clarity. External injuries, conjunctival laceration, conjunctival hemorrhage, and the entry site of IOFB should also be assessed. Conjunctival pigmentation may indicate uveal prolapse or entry site. If the cornea is the entry site of IOFB, discontinuation of the smooth surface and corneal edema may be seen. If corneal perforation is suspected, a Seidel test should be performed.[2,4–6,8] The Seidel test involves applying topical fluorescein to the upper conjunctival fornix. A positive test occurs when the fluorescein is diluted or turns green, indicating a potential full-thickness corneal injury.[9] Iris transillumination defect may also be a sign of perforating injury. If globe rupture is present or suspected, special care should be taken since pressure on the globe may cause the expulsion of ocular contents.[2,4–6,8]

Gonioscopy serves as a valuable tool for observing angles if there's suspicion of IOFB in the anterior angle chamber. Dilated fundus examination helps to visualize IOFB in the posterior segment, although it becomes challenging in the presence of hyphema or vitreous hemorrhage. Scleral depression examination generally is not recommended if IOFB is suspected and the wound is not self-healing. The peripheral retinal examination should be conducted to detect any IOFB presence. Applanation tonometry, gonioscopy, and scleral depression are not recommended until the entry wound is sealed.[4,5]

IMAGING

X-ray imaging, ultrasonography, CT, and MRI are commonly utilized as ocular imaging tools. The selection of diagnostic tools depends on the suspected composition and location of the IOFB.

X-ray imaging is effective in detecting radio-opaque IOFBs like metals but fails to identify radiolucent IOFBs such as wood or glass. The standard "foreign body x-ray series," which including Water's, Caldwell's, and lateral views, will notify the presence rather than the precise localization of IOFBs.[2,5] The Sweet method for IOFBs localization technique involves frontal and lateral projections. The X-ray photo in the primary position is followed by another image as the patient looks either left or right. If the foreign body moves in the same direction as the eye, it indicates an anterior segment IOFB. Conversely, if the IOFB moves in the opposite direction, the foreign body suggests a posterior segment IOFB.[5]

The X-ray detection rate for metallic IOFBs ranges from 69%-90%; bottle glass, aluminum, windshield glass, and slate produce radiopaque images but are difficult to distinguish between different objects. **(Figure 2)**. Wood and plastic cannot be detected with an X-ray. While X-rays could detect 87% of IOFB cases that clinically could not be seen, CT exhibits a superior sensitivity rate, particularly for smaller objects. The X-ray detection threshold size is 0.12 mm^3, whereas for CT, it ranges from 0.048–0.07 mm^3. CT sensitivity does not reach 100% if the object size is below 0.06 mm^3.[10,11]

The preferred initial diagnostic tool for

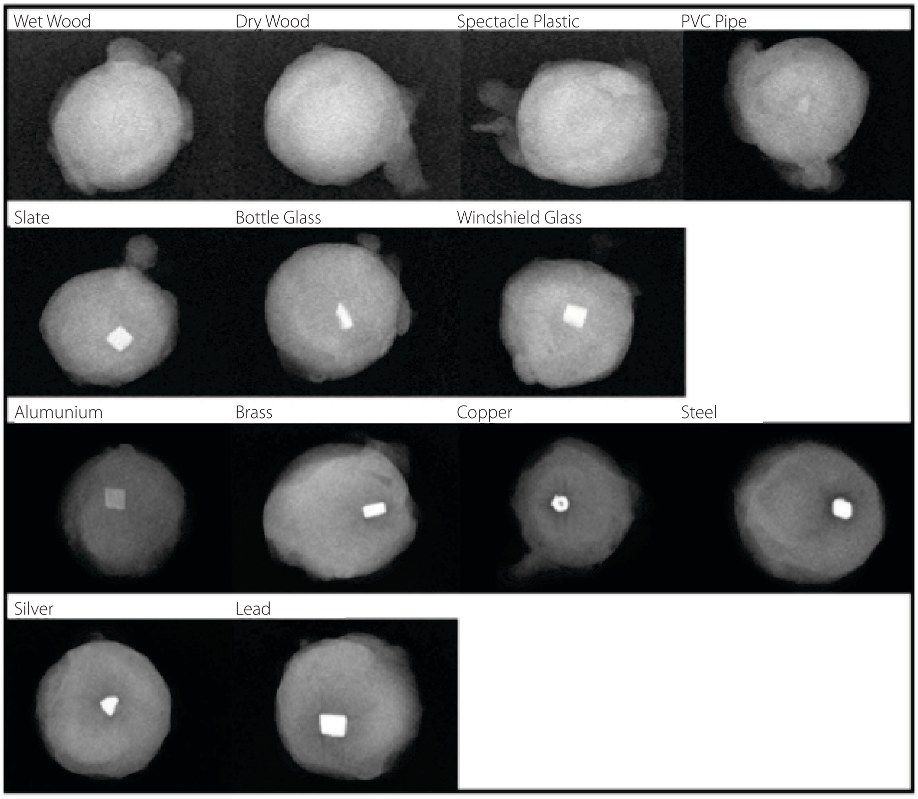


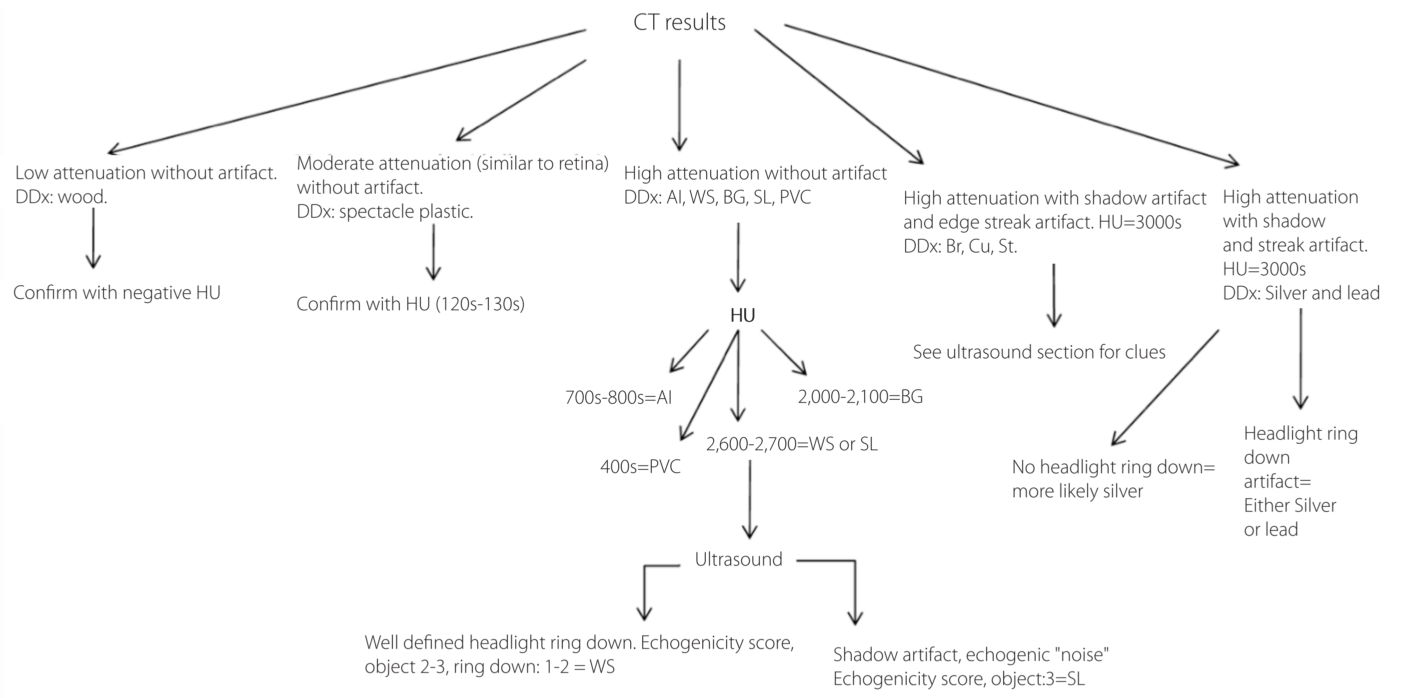
Figure 2. Plain film depicts IOFBs. Wet wood, dry wood, and spectacle plastic are not visualized. Polyvinyl chloride (PVC) is minimally radiopaque. Aluminum is moderately radiopaque. Slate, bottle glass, windshield glass, brass, copper, steel, silver, and lead are strong radiopaque.[11]


evaluating globe rupture is non-contrast CT imaging, which provides a thorough evaluation of the orbital and facial bones, the retrobulbar space, and both globes. This approach is preferred due to its high sensitivity, capacity to locate single or multiple IOFBs, minimal patient cooperation requirement, and minimal globe manipulation.[4] Modjtahedi, *et al*, found that CT scan not only could detect all IOFBs but also enabled the classification of their composition. IOFB's composition can be distinguished by their attenuation and surrounding artifacts.[11] **(Scheme)** For instance, bottle glass, windshield glass, PVC, slate, and aluminum exhibit high attenuation without surrounding artifacts. While plastic had moderate attenuation, resembling the surrounding retina and without artifacts. Brass, copper, and steel provide high attenuation and shadow artifacts around objects and scatter artifacts nearby. Lead and silver display high attenuation with both shadow artifacts and significant scatter artifacts. Wet and dry wood demonstrated a low attenuation (negative HU) without scatter artifact.[10,11] The minimum detectable size of IOFB on CT varies depending on its composition: steel and copper are detectable at 0.06 mm^3; aluminum and windshield glass require sizes of 1.5-1.8 mm^3. Wood IOFBs may not be visualized unless coated with lead-containing paint.[4]

MRI modality should only be used if the possibility of metallic IOFB has been ruled out, as MRI can dislodge the metallic ferromagnetic IOFB and cause further intraocular damage. MRI should not be the primary imaging modality. Some metals such as platinum, titanium, and tantalum are MRI-compatible.[4] A rare case report by Ta and Bowman documented ocular injury caused by metallic IOFB shifting up to 10 mm during exposure to MRI.[12] Murphy, *et al*,[13] recommend obtaining plain films before MRI imaging in patients with a known history of IOFB or involvement in high-risk occupational activities such as welding and metalworking.[1,5,10,12,13]

Non-metallic IOFB typically provides a low signal intensity (apparently dark) at T1, T2, and Gradient echo sequences (GRE). **(Figure 3)** A thin, high-intensity rim surrounds all objects on all sequences, with greater prominence at T1, possibly because it contrasts with the vitreous that imparts low intensity. The distinguishing characteristic of these various non-metallic IOFBs is the presence of blooming artifacts, particularly visible on the windshield glass and slate across T1, T2, and GRE. Dry wood gives minimal blooming artifacts on GRE and bottle glass on GRE and T2. Other non-metallic IOFBs don't provide artifacts.[10,11]

Ultrasound serves as a real-time, high-resolution, cost-effective, and valuable imaging modality. Metallic IOFB typically appears as a hyperechoic structure with acoustic shadowing. Plastic IOFBs, on the other hand, produce less echogenic image compared to the surrounding retina/choroid. Metallic IOFBs and windshield glass will provide an overview of the ring-down artifacts. Lead, copper, silver, and windshield glass give headlight ringdown (broad and dense) artifacts, while steel, glass, and aluminum provide flashlight artifacts (focused and narrow). Wood, spectacle plastic, and PVC lacked ring-down artifacts. In addition, ultrasound can also detect retinal detachment, vitreous body bleeding, and exudate in the vitreous body. However, ultrasound is to be avoided in cases of open globe injuries, as the pressure from the probe may exacerbate the injury and lead to discharge of eyeball contents. Another disadvantage of the ultrasound modality is that it is operator-dependent.[4,7,10,11]



Scheme. Proposed diagnostic algorithm for radiologic assessment of IOFBs.[11]
Abbreviations : CT: computerized tomography; DDx: differential diagnosis; HU: hounsfield unit; Al: aluminium; WS: windshield; BG: bottle glass; SL: slate; PVC: polyvinyl chloride; Br: brass; Cu: copper; St: steel.

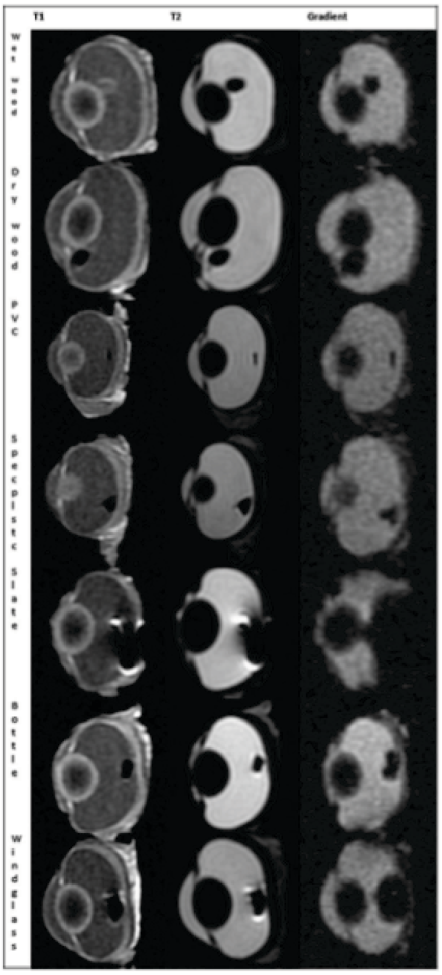


Figure 3. Magnetic resonance imaging of IOFBs.[11]

MANAGEMENT

The management of IOFB involves cleaning the contaminated area and administering broad-spectrum topical and systemic antibiotics as soon as possible. Cultures should be obtained, and tetanus vaccination status should be assessed and updated, if necessary, given the increased risk of endophthalmitis associated with IOFB presence.[1,2,4,7] Traumatized eyes must be protected with a rigid shield to prevent pressure on the eyeball. Examination of the eye must be carried out with great care, and external pressure must be avoided as it can dislodge the contents of the eyeball.[1,7]

The timing of IOFB extraction surgery depends upon various factors, including the patient's general condition, the nature of the injury (heat-sterilized missiles are probably less likely to induce infectious endophthalmitis, whereas farm injuries with contaminated IOFBs are more likely to cause endophthalmitis), composition, location of IOFB, and resource availability.[1,4,5] Immediate IOFB removal offers advantages such as decreased risk of endophthalmitis and proliferative vitreoretinopathy (PVR) rates, as well as a single procedure in patients.[14] Instability of the patient's hemodynamics is an indication to delay the IOFB removal; however, primary globe closure and administration of antibiotics can be done as primary resucitation.[1,4,5]

However, delayed removal may allow for better control of inflammation, further assessment of intraocular structures, and potential spontaneous posterior vitreous detachment (PVD) facilitating easier posterior hyaloid excision.[15] Nonetheless, delaying removal carries a heightened risk for endophthalmitis due to potential IOFB contamination.[4]

Surgical approaches for IOFB extraction depend on factors such as material, location, size of the IOFB, and accompanying ocular abnormalities.[1,2] Common instruments include external electromagnets, intraocular forceps, and intraocular magnets.[2,4] Small metallic IOFBs (<1 mm) can be removed with an intraocular magnet, while the non-metallic

Table 1. Prognosis of IOFB.[5]

Favorable Visual Prognosis	Unfavorable Visual Prognosis
Intact lens	Poor initial visual acuity
No lens damage	Presence of afferent pupillary defect
Shorter wound length	Longer wound length
Anterior chamber IOFBs	Posterior chamber IOFB
Advance age	Younger age
Utilization of PPV over magnets for posterior chamber IOFB	Absence of PPV for posterior IOFB
Absence of retinal detachment	Presence of retinal detachment
Absence of endophthalmitis	Presence of endophthalmitis, PVR, vitreous haemorrhage, hyphema
	Culture of non-virulent organism
	Metal-on-metal mechanism of injury

Abbreviations: IOFB: intraocular foreign body ; PPV: pars plana vitrectomy; PVR: proliferative vitreoretinopathy

Table 2. Ocular trauma score variables and raw points.[2,4]

Variable	Raw Points
A. Initial raw score based on initial visual acuity	
No light perception	60
Light perception	70
1/200-19/200	80
20/200-20/50	90
≥20/40	100
B. Rupture	-23
C. Endophthalmitis	-17
D. Perforating injury	-14
E. Retinal detachment	-11
F. Afferent pupillary defect	-10

Table 3. Ocular trauma score (OTS) category and predicted final visual acuity.[2,4]

Sum of Raw Points	OTS	No Light Perception	Light Perception/ Hand Motion	1/200-19/200	20/200-20/50	≥20/40
0-44	1	74%	15%	7%	3%	1%
45-65	2	27%	26%	18%	15%	15%
66-80	3	2%	11%	15%	31%	41%
81-91	4	1%	2%	3%	22%	73%
92-100	5	0%	1%	1%	5%	94%

IOFBs may require a vitreous cutter. Medium-sized IOFBs (1-3 mm) can be extracted using forceps, while large-sized (3-5 mm) or glass IOFBs may necessitate diamond-coated forceps.[1] Anterior chamber IOFB removal through the entry wound is generally discouraged, except in specific cases such as a very large foreign body or gaping corneal wound. The anterior chamber IOFB usually does not require a pars plana vitrectomy and often can be removed through a secondary limbal incision.[4] The surgical approach aims to minimize further injury and preserve ocular structure.

Post-operative care involves monitoring for complications such as endophthalmitis, retinal detachment, and PVR. Topical antibiotics are typically prescribed, such as gatifloxacin and moxifloxacin, demonstrating efficacy against gram-positive bacteria.[4,14,16]

Post-operative endophthalmitis occurs in a rage of 2.1% to 17% of patients, with higher incidents observed in cases involving organic IOFBs. Various risk factors contribute to the development of endophthalmitis, including delayed IOFB removal, posterior open globe injury, exposure to contaminated environment, a large wound, delayed administration of antibiotics, and injury to the lens capsule.[5,17] Andreoli, *et al*, conducted a study of 558 cases of open globe injury with a minimum follow-up period of 30 days. These patients were managed using a standardized treatment approach, which was intravenous vancomycin and ceftazidime upon admission, discontinued after 48 hours. Post-surgery, patients received topical antibiotics, corticosteroids, and cycloplegics. Endophthalmitis occurred in 0.9% cases (n = 5), a notably low rate attributed to the presence of a good eye trauma service equipped with a standardized protocol and the administration of intravenous antibiotics for 48 hours. The presence of an IOFB and primary IOL (intraocular lens) placement were identified as statistically significant risk factors for the development of endophthalmitis. Delayed surgery, delay in presentation, prolapse of uveal tissue, and vitrectomy were not found as significant risk factors for endophthalmitis.[17]

Other potential complications include sympathetic ophthalmia (SO), optic neuropathy, and anterior segment injuries including corneal scarring, traumatic cataracts, or hyphema, which may occur in up to 60–75% of IOFB cases.[4,5]

PROGNOSIS

Prognosis is largely depends upon multiple factors **(Table 1).**

The ocular trauma score system (OTS) was introduced by Kuhn, *et al*, in the early 2000s to offer a simple method with minimal variables to estimate the visual prognosis of an injured eye. To calculate the raw score, sum up values A through F (**Table 2**). The conversion of these raw points into the OTS enables the prediction of the probability of final visual outcomes categorized as per the chart (**Table 3**).[2,6]

The OTS employs minimal variables that could be assessed during the initial evaluation or surgical interventions, coupled with simple mathematical calculations. This approach affords ophthalmologists a 77% probability of accurately predicting the eventual functional outcome after the eye injury. Access to early prognostic data facilitates effective patients counselling and assists in making informed decision regarding triage and management.[6]

CONCLUSION

IOFB injuries vary in presentation, outcome, and prognosis. A comprehensive evaluation includes the injury mechanism, examination, and ocular imaging. The choice of imaging modality depends on factors such as the size and composition of IOFBs, as well as the extent of tissue damage. The optimal timing for surgery should be based on weighing the advantages and disadvantages of intervention. Postoperative measures focus on preventing and addressing potential complications. Early intervention is crucial for achieving a favorable prognosis for the patient.

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