Traumatic intraocular foreign bodies (IOFBs) are a particularly significant and distinct subset of open globe injuries, because of the increased risk for endophthalmitis and toxicity by the IOFB material, as well as the considerations specific to its surgical removal. Because the diagnosis of traumatic IOFB encompasses any foreign material from the environment that is found within the walls of the eye as a consequence of an open globe injury, presentation varies widely. The IOFB may be unaccompanied by any significant intraocular damage outside of its entry-site laceration in the eye wall, or may be associated with massive internal damage in any or all compartments of the eye.

The most common age group affected by IOFB injuries is middle age (20-40 years) which is the most economically productive age group and most injuries occur at work place using various tools with metal striking metal such as hammer and chisel. These particular aspects of IOFBs should alert the ophthalmologist to their medico-legal significance and all efforts must be made to ensure full and detailed documentation of the diagnosis and management.

**Diagnosis**

High clinical suspicion combined with judicious use of radio-diagnostic imaging is essential for prompt and accurate diagnosis of retained IOFBs.

History should elicit how and when the penetrating trauma occurred, and the material that penetrated. Slit lamp examination can locate IOFB in anterior chamber and inside the lens and also helps in picking up other suggestive subtle ocular signs like a self-sealed corneal perforation. Conjunctivo-scleral site of entry may be indicated by localized subconjunctival haemorrhage or chemosis or migration of uveal pigment to the surface. Other signs such as an iris hole, localized cataract or defect in anterior and posterior capsule of lens or a tract through the lens may be visualized, a fibrous strand maybe visualized in the anterior vitreous. Gonioscopy is required to diagnose IOFB in angles. Indirect ophthalmoscopy localizes IOFB in the posterior segment. In the presence of media haze due to hyphaema, total cataract or vitreous haemorrhage, imaging helps in diagnosis and exact localization of IOFB.

**Electrical Induction Methods for Localization of IOFB**

The Berman and Roper-Hall localizers are purely of historic importance. Based on the principle of induction, when the instrument approached a metallic foreign body, a difference in potential is created in the secondary circuit resulting in a flow of current. An audio signal in the form of a continuous sound is heard for an iron foreign body and a discontinuous sound for a nonferrous metallic foreign body.

**Imaging**

**X-Rays**

Radiography is the first-step for metallic foreign body due to its accessibility and low cost.

There are many methods of localization of IOFBs using X-rays.

**Direct Localisation**

Two exposures at right angle (AP and lateral views) are taken (Figure 1). For lateral view the affected side is towards the film with infra-orbital line at right angles to the film. The AP view or nose-chin position allows good view of maxillary region since the bony shadow of petrous temporal bone is excluded.
Methods depending on the Rotation of the globe

The head and the X-ray remain fixed, while the eye moves in different directions, straight gaze, up and down. The position of the IOFB is calculated from the direction and the amount of displacement referred to the center of rotation of the globe.

Methods Using Radio-Opaque Markers

A metallic ring made of either silver or steel of suitable diameter is sutured to the limbus. X-rays are taken in lateral position, in the straight gaze, up and down gaze. An AP view is also taken. The limbal ring is imaged as a straight line corresponding to the limbus. Three such lines will be seen corresponding to the three positions of the eyeball. The position and movement of the IOFB in correspondence to the limbal ring is then used to localize the IOFB.

Other radio opaque markers such as contact lens with 4 radio opaque dots incorporated in it have been used.

However, plain radiography is not considered an adequate modality. In one study, it failed to identify foreign material in 60% of eyes with a known IOFB, it does not show exact localization of IOFB in relation to soft tissues and does not detect non-metallic IOFB. In today’s setting, plain film x-ray has a documentary and medico-legal role.

Ultrasound (USG)

It is the most common screening modality used these days as it is non-invasive, inexpensive and easily performed. It is 98% sensitive in detecting IOFBs in appropriate clinical settings.

Features of IOFB on USG

A scan

- Steeply rising wide echo spike seen. It is noted along the baseline between the initial spike and ocular wall spike.
- The reflectivity of the lesion spike is extremely high (100%) which persists on low gain.
- The distance between the IOFB and the adjacent sclera is accurately measured at lower system sensitivity.
- Sound attenuation is very strong.

B scan

- It appears acoustically opaque contrasting with the acoustically clear vitreous.
- It remains displayed even when the system sensitivity is decreased by 20-30 db.
- Localization of the IOFB in different quadrants can be determined. The proximity to adjacent intraocular tissues is evaluated.
- Mobility of the IOFB can be assessed. Topographic and kinetic echography will show if the FB is adherent to the retina or if it is floating in the vitreous.
- Sound attenuation is very strong. The IOFB causes shadowing of the ocular and orbital tissues behind it as it totally reflects the sound beams preventing its propagation within tissues behind it (Figure 2).
- Associated intraocular damage like vitreous haemorrhage, vitreous bands, fibrosis, retinal detachment, choroidal detachment and even scleral entry wounds can be assessed.

Quantitative echography

The reflectivity of foreign body echo spikes is extremely high. This special technique allows a comparison with the scleral signal. A horizontal marker line is displayed at a definite height. This line is kept in the same position through out the procedure. The maximal lesion spike is identified. The system sensitivity is then decreased until the peak of the lesion spike just touches the horizontal marker line without exceeding it. This is called ‘lesion sensitivity’. The maximal scleral spike is displayed. The beam has to bypass the IOFB to avoid shadowing. The system sensitivity is then decreased until the peak of the scleral spike just touches the horizontal marker line without exceeding it.
This is called ‘scleral sensitivity’. The sensitivity of the two systems is in decibels and their difference is also expressed in decibels. A difference of 6 dB is characteristic of an IOFB signal, no biological interface in the posterior segment of the eye produces as strong a signal as the sclera.

Disadvantages

- If the IOFB is close to the ocular coats, it cannot be made out well.
- It cannot be performed in an open globe.
- It is operator dependent.

Ultrasound Biomicroscopy (UBM)

It is an imaging technique that uses high frequency (50 MHz) sound waves to produce high resolution, cross-sectional images of anterior segment to a depth of around 5 mm. It can also visualize angle recession, cyclodialysis, hyphema, scleral laceration, and lenticular foreign bodies. High frequency (50 MHz) ultrasound shows appearance of foreign body, surrounding tissue, exact location, size and the nature of IOFB much better than conventional low frequency (10 MHz) ultrasound. UBM is useful for detection and localization of small superficial non-metallic foreign bodies that are usually missed on CT and conventional USG (Figure 3).

Anterior Segment Optical Coherence Tomography

It has been used in identification of IOFBs along internal lining of cornea, angle and iris.

Computerised Tomography (CT)

Conventional CT is regarded as the state-of-the-art method for the detection and localization of metallic intraocular foreign bodies, providing cross-sectional images with a sensitivity and specificity that is superior to plain film radiography and echography. CT is useful in severely traumatized patients or open globe injuries.

Advantages

- CT with 1 mm sections (and no contrast) can detect almost 100% of metallic IOFBs greater than 0.05 mm, although sensitivity may be lower for non-metallic material.
- An exact localization of the foreign bodies is possible due to cross-referencing of the multiple planes as volume scanning allows reconstruction of images at any position within the scanned volume in an overlapping fashion.
- Delineation from surrounding soft tissues and determination of shape in case of the metal foreign body is improved as imaging artifacts are reduced in the reconstructed coronal and sagittal planes.
- Localization with respect to sclera, lens and optic nerve are well documented on CT in metallic, glass and plastic foreign bodies, although some report the difficulties of locating glass foreign bodies located near the crystalline lens as the radio-densities are similar.
Diagnostics

• Multiple foreign bodies can be detected and their location with respect to each other determined.

• Estimation of the composition of the foreign body on CT is possible, metallic foreign bodies are seen as hyperdense structures with pronounced streak artifacts; glass foreign bodies appear as oval-shaped structure of similar density as that of cortical bone, without streak artifacts. In contrast to both the metal and glass foreign bodies, the density of the plastic foreign body is lower than that of cortical bone.

• Evaluation of size by distance measurement in CT leads to overestimation when performed on soft tissue window displays and improves when performed on bone window displays in both the helical and conventional CT studies.

• CT is not operator dependent like ultrasonography.

• In patients with visual loss after injury, CT may help determine the potential for reversibility. If the optic nerve is partially or completely avulsed, aggressive measures are not indicated (Figure 4).

Disadvantages

• Patient cooperation is required.

• It is an expensive procedure.

• Radiation exposure is greater than in other imaging techniques.

• Motion artefacts due to long scanning times and repositioning that was required to image in more than one plane.

• CT has low sensitivity when used for organic IOFBs. For example, wood has density similar to air and fat on CT and can be difficult to distinguish from surrounding soft tissue.

• CT is inferior to USG in the assessment of associated vitreoretinal damage.

However, Spiral or Helical CT that has now replaced conventional CT, the entire scan volume is imaged continuously in one imaging plane (usually axial sections) without a time gap in slice/image acquisition. This provides short total scanning times and hence reduced patient cooperation is required, minimized motion artifacts, reduced radiation exposure and better multiplanar reconstruction capability.

MRI

It is not a general screening tool for retained IOFBs.

Advantages

• Wood and plastic are almost always detected. T1-weighted images demonstrated wood better than T2-weighted images and required less scanning time than either proton density or T2-weighted images. MRI shows well-delineated, low intensity lesions in these cases.

Disadvantages

• MRI employs strong magnetic forces hence torsional forces are applied to ferromagnetic substances, which can lead to sudden movements in metallic foreign bodies leading to further destruction of ocular structures and is therefore only used once metallic foreign bodies have been ruled out on CT.

• Severe artifacts prevent diagnosis of iron, glass and graphite on MRI.

Even in the cases where IOFBs are well visualized clinically, appropriate imaging must be done to rule out multiple IOFBs and for medico-legal documentation. Estimation of size and nature of IOFB along with exact localization will also help in planning the surgical approach employed in removal of IOFB. In cases of severely traumatized open globe, CT scan must be done to confirm the presence or absence of foreign bodies, their anatomic location and integrity of orbital and ocular structures to allow an appropriate surgical approach. Judicious and well planned out use of the various radio-diagnostic modalities at our disposal is essential for optimal management of IOFBs.

References


