Review Article

Multimodality Imaging in Mechanical Orbital Trauma

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Abstract

Orbital trauma is commonly associated with trauma to head and face and the radiologist plays a key role in assessing these injuries. Common forms of orbital injury include bony fractures, anterior chamber injuries, injuries to lens, open-globe injuries, ocular detachments, intra-orbital foreign bodies, carotico-cavernous fistula and optic nerve injuries with orbital fractures being the commonest. Radiographic examination has low sensitivity for soft tissue injuries and is rarely performed. Ultrasound (USG) can be used to evaluate intraocular injuries and foreign bodies, however has poor sensitivity for evaluating the bone and retrobulbar area. It is contraindicated in open globe injuries. Computed tomography (CT) is the modality of choice for initial imaging in orbital trauma owing to its easy availability, high sensitivity for detection of orbital fractures, and improved sensitivity for evaluation of soft tissue injury and entrapment. Magnetic resonance imaging (MRI) may be difficult to perform in an emergency setting, has limited role in evaluating bony injuries and is contraindicated in cases of suspected intra-orbital metallic foreign body. However, owing to its higher soft tissue contrast resolution, it is indicated in optic nerve injuries, ocular detachments, carotico-cavernous fistula and particularly when contrast cannot be administered due to deranged renal function.

This article provides a comprehensive account of the role of various imaging modalities in the evaluation of trauma to the orbit and ocular globe with their imaging features and clinical relevance.

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***Keywords:** Orbital Trauma, Imaging, Computed Tomography, Blow Out Fracture, Open Globe Injury, Intraocular Foreign Body*

Introduction

In the recent era of liberal expansion of automobile usage, motor vehicle accidents and industrial injuries remain the common causes of orbital trauma. In fact, eyes are one of the most protected organs in the body, encased within the bony orbit. Yet, they are not spared from injury. The World Health Organization estimates that trauma to the eye results in blindness in about 1.6 million people and unilateral blindness or decreased vision in 19 million people annually.[1] In North India, 82.3% of the ocular trauma is associated with non-occupational causes with sports related injury and road traffic accidents accounting for 23.9% and 23.6% of the cases respectively.[2] Among patients with head injury, 84% have associated orbital injury.[3]

General Principles Of Imaging In Orbital Trauma

Role of imaging in mechanical orbital trauma is crucial in the diagnosis, evaluation of the extent, classification and in planning management strategies. Computed tomography (CT) is the imaging modality of choice for evaluation of orbital trauma.

In the setting of acute trauma, CT imaging has the following advantages:

- Wide availability
- Shorter imaging time and with the advent of helical multidetector CT, imaging time has further reduced to a few seconds with enhanced image resolution
- Multiplanar reconstruction
- High sensitivity for detection of orbital fractures
- Improved sensitivity for soft tissue injury and entrapment

Generally in all trauma centers, non-contrast CT imaging is routinely done for patients with head injury and orbital imaging sequences can be acquired in the same sitting if and when indicated. Most patients with severe head injury have altered sensorium and lack the ability to convey any ocular or visual complaints. Hence, it is recommended that in patients with severe trauma to the head with anterior cranial vault fracture, a low-dose protocol for orbital imaging should be performed to look for orbital trauma which would help the radiologist make an accurate diagnosis while limiting radiation exposure to the lens.

Plain radiographs generally aid in the detection of orbital fractures and radio-opaque intra-orbital foreign bodies. However, they have a high degree of false negatives in detecting fractures. Ultrasonography (USG) being a non-invasive, bed side tool can be used for evaluation of ocular globe injury particularly in the presence of opaque media but is insensitive to fractures and carries a risk of acute ocular decompensation when performed on patients with globe rupture. Magnetic resonance imaging (MRI) has superior soft tissue resolution but is not recommended in an acute setting and is contraindicated in patients with suspicion of metallic foreign body. The indications for use of various imaging modalities are listed in (Table 1).

Birmingham Eye Trauma Terminology System

Birmingham Eye Trauma Terminology (BETT) system[4] is a standardized system of terminology used to define and classify orbital trauma.

The classification is depicted in Figure 1.
According to BETT system, the term Eye wall refers only to the external two layers, sclera and cornea.

Closed globe injury: This is an intraocular injury without full thickness involvement of the eye wall. It is of two types-

A) **Contusion:** This is usually consequent to blunt trauma and can result in impact at the site of injury (eg. Choroidal rupture) or change in the shape of one globe (eg. Angle recession).

B) **Lamellar laceration:** Partial thickness involvement of the eye wall usually following sharp trauma.

Table 1: Indications for various imaging modalities

Radiograph	USG	CT	MRI
• Suspected case of orbital floor or roof fracture (if facilty for CT imaging is out of reach) • Detection of radioopaque intraocular foreign bodies	• Traumatic hyphema • Traumatic cataract • Suspected trauma to the lens for detection of lens subluxation, dislocation or capsular rupture • Trauma involving angle of anterior chamber to rule out iridodialysis/ cyclodialysis • Vitreous hemorrhage • Ocular detachment (Choroid/ retina) • Retinal tears	• Traumatic hyphema • Traumatic cataract • Suspected trauma to the lens for detection of lens subluxation, dislocation or capsular rupture • Trauma involving angle of anterior chamber to rule out iridodialysis/ cyclodialysis • Vitreous hemorrhage • Ocular detachment (Choroid/ retina) • Retinal tears	• Suspected trauma to optic nerve to rule out transection/ avulsion • Traumatic optic neuropathy • Ocular detachment • Intraocular organic foreign body • Detection of subperiosteal hematoma

Open globe injury: This is associated with full thickness involvement of the eye wall. It is also of two types-

A) **Rupture:** Full thickness eye wall injury following blunt trauma causing brief increase in intraocular pressure. Injury is produced by an inside-out mechanism and the eye wall gives way at its weakest point.

B) **Laceration:** Full thickness eye wall injury produced by an outside-in injury mechanism following sharp object trauma, seen at the site of impact.

i) **Penetrating injury:** Single laceration involving full thickness of the eye wall i.e no exit wound. If there are multiple, each must have been as a result of different impacts.

ii) **Intraocular foreign body:** Penetrating laceration with retained foreign body inside the globe. It is classified separately due to difference in clinical implication.

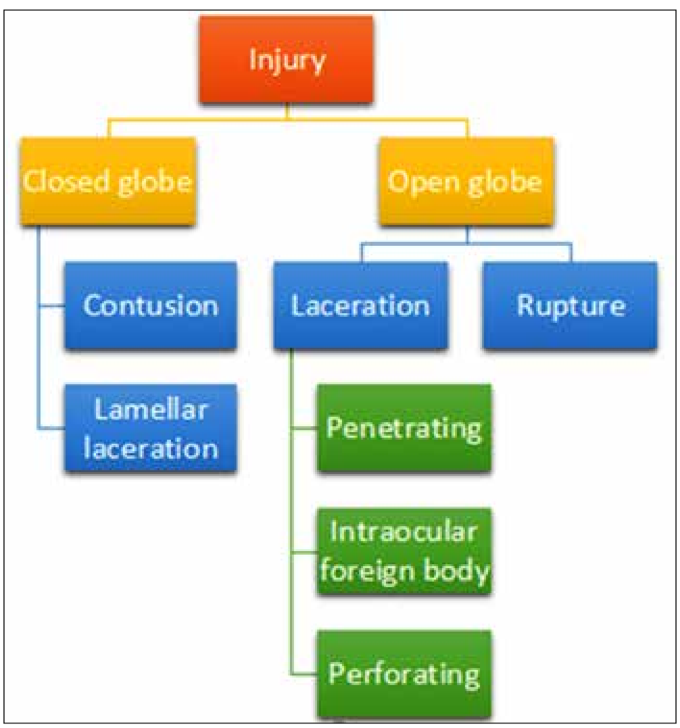

Figure 1: *Classification of orbital trauma based on Birmingham Eye Trauma Terminology (BETT) system*

iii) **Perforating injury:** Through and through involvement is seen with perforating injury. Two lacerations (entry and exit wounds) caused by the same agent are seen involving the entire thickness of the eye wall.

Orbital Fractures

Orbital fractures are usually associated with facial or cranial vault fractures. Isolated orbital fractures are uncommon. Most orbital fractures are undisplaced and do not require any surgical intervention. Surgical intervention is required if there is displacement of fracture fragment with associated extraocular muscle entrapment or in cases where there is intraorbital hypertension and vision loss secondary to intraorbital hematoma compressing the optic nerve. Evidence of potential damage to the globe or optic nerve impingement indicate surgical emergency and should be conveyed to the Ophthalmologist at the earliest.

A) Medial wall fractures

These are usually seen as a posterior extension of naso-orbito-ethmoid fractures or as a component of Le Fort II/ III complex. Medial orbital wall is the thinnest of the bones in the body and is more susceptible to injury. Lamina papyracea (posteromedial wall of orbit) shows a convex lateral contour and bulges into the orbit. This posteromedial bulge is lost in case of medial orbital wall fracture (Figure 2). Medial orbital wall fractures can be associated with medial rectus entrapment. Focal discontinuity of medial wall can often be missed, but loss of convex contour, presence of ethmoid hemosinus and intraorbital emphysema should raise a suspicion of medial wall fracture. Associated entrapment of the medial rectus muscle should be always ruled out. Clinically, patients present with pseudo- Duane retraction syndrome characterized by diplopia, restricted axial ocular movements and enophthalmos. [5,6]

Associated involvement of the lacrimal bone and frontal process of the maxilla (known as inferomedial orbital sturt) should be looked for. Lacrimal fossa and frontal process of maxilla provide a site of attachment for medial canthal tendons. Fracture involving the medial canthus is usually associated with disruption of the medial canthal tendons which require medial canthoplasty. If medial canthal anatomy is not restored, patients develop telecanthus and globe malposition.[5]

Injury to the nasofrontal duct if not attended to, can predispose to mucocele formation.[7]

Figure 2: Fracture of medial orbital wall

Axial non- contrast bone window CT image in a 21 year old with history of road traffic accident shows fracture of the right medial orbital wall (blue arrow), ethmoid hemosinus and intraorbital emphysema due to extravasation of air from the adjacent ethmoid air cells

B) Orbital floor fractures

Floor of the orbit akin to the medial wall is thin and fractures involving the floor are frequent. Entrapment of the inferior rectus and resultant restriction of vertical ocular movement and diplopia are usual associations. Inferior orbital wall should be evaluated in coronal and sagittal reformats. The shape and position of inferior rectus should be carefully evaluated (Figure 3). A rounded contour with inferiorly displaced inferior rectus indicates involvement of the fascial sling[5] and might require surgical reconstruction. If the inferior wall defect is large, there can be associated enophthalmos due to herniation of periorbital soft tissue and inferior rectus into the maxillary sinus along its roof.[8]

Due care should be given while evaluating inferior wall fractures in the pediatric population owing to the 'trapdoor' phenomenon. Inferior orbital wall in children is pliable so that the fractured bone can spring back and result in a normal radiological appearance except for inferior rectus and periorbita entrapment.[5,7] The radiologist has to carefully observe for such injuries because these injuries if not corrected within 24-72 hours might lead to permanent ocular motility impairment.[9]

Involvement of infraorbital canal (Figure 4) results in sensory loss over the cheek, ala of nose and upper lip due to infraorbital nerve injury which might require surgical attention.[6,10]

C) Orbital roof fractures

Isolated orbital roof fractures are uncommon and are usually seen as an extension of anterior cranial vault fracture (Figure 5). Surgical repair is not indicated unless there is gross displacement. Presence of associated pneumocephalus, intracranial hemorrhage, CSF leak and dural tear that require neurosurgical attention should be ruled out.[7] Direct impact over the superior orbital rim can result in isolated fracture of the orbital roof with caudal displacement and resultant exophthalmos.[5]

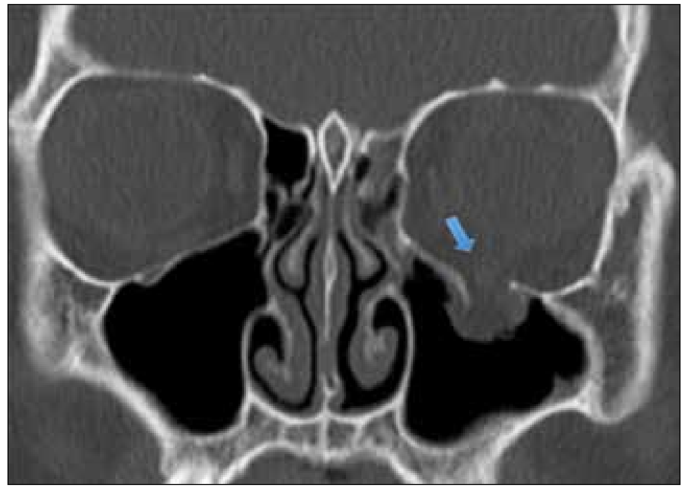

Figure 3: Blow out fracture of orbital floor

Coronal reformated non-contrast CT bone window image in a 35 year old female who sustained a road traffic accident shows blow out fracture of the floor of left orbit (blue arrow) associated outward displacement of the inferior rectus and periorbita into the maxillary sinus. The normal elliptical contour of the inferior rectus seen on the contralateral side is lost

D) Lateral wall and apex fractures

Lateral wall and apex fractures are usually associated with complex zygomaticomaxillary fractures (Figure 6). Degree of displacement, presence of intraorbital displacement of fracture fragment and its relationship with the optic nerve should be described. Orbital apex fractures can be associated with intracanalicular optic nerve compression with resultant sudden loss of vision which might need surgical correction.[5]

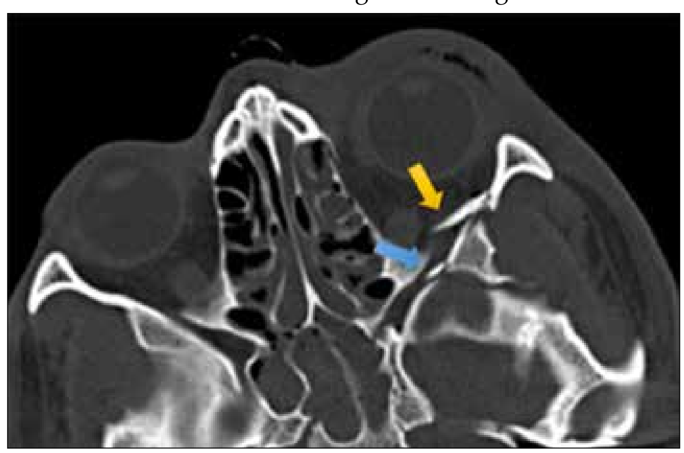

Figure 4: Fracture of the inferior orbital fissure

Axial bone window image in a 17 year old male who presented with complaints of epistaxis and numbness over the left cheek with history of fall two days back shows fracture of the left inferior orbital fissure with inwardly displaced fracture fragment (blue arrow). Blow in fracture of the lateral wall of left orbit (yellow arrow) is also seen.

Blow-Up, Blow-In And Blow-Out Fractures

Orbital fractures can be classified based on the direction of fracture as blow-up, blow-in and blow-out fractures.

Blow-up fractures involve the orbital roof, sparing the orbital rim. Fractured bone fragments are displaced superiorly into the cranial fossa. Associated dural tear or intracranial hemorrhage can be present.

Blow-in fractures involve the orbital floor with intraorbital displacement of fracture fragments and might require

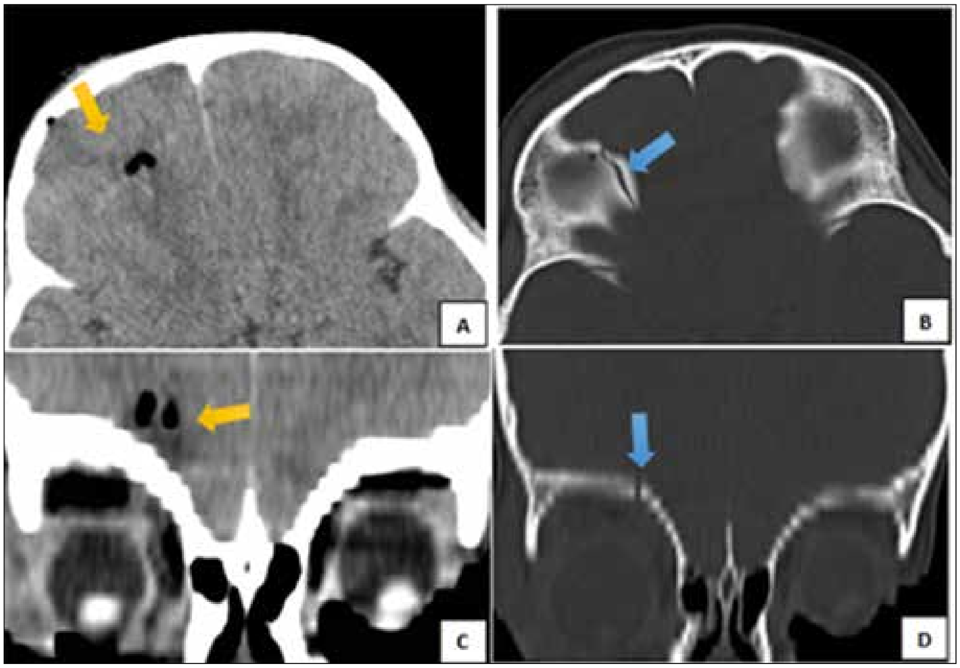

Figure 5: Fracture of roof of orbit

Axial soft tissue (A) and bone window (B) and coronal reformatted soft tissue (C) and bone window (D) images in a 40 year old female following motor vehicle accident show fracture of the roof of right orbit (blue arrow) and inracranial intraaxial pneumocephalus (yellow arrow). Few tiny foci of intraparenchymal hemorrhage are also seen in the vicinity.

surgical decompression if associated with intraorbital hematoma causing enophthalmos.

Blow-out fractures are associated with outward displacement of fracture fragments and usually involve the floor and rarely involve the roof. Blow-out fracture of the floor is associated with inferior rectus entrapment. Muscle entrapment can often be overlooked or maybe less conspicuous in the presence of fat stranding or hematoma. Hence, the radiological findings should be correlated with a bedside forced duction test.[11] Any fracture involving the orbital floor with an area of more than one sq.cm or more than 50% of the surface area is an indication for surgical repair.[12,13]

Anterior Chamber Injury

The portion of the globe between the cornea and the lens is called anterior chamber. Anterior chamber injuries usually present with hyphema. USG is not advocated in patients presenting with hyphema as there can be associated open globe injury.[14] CT can demonstrate blood-fluid level with dependent hyperattenuating contents within the anterior chamber. Possibility of associated corneal laceration has to be ruled out. CT imaging can show iris prolapse and shallow anterior chamber compared to the normal side.[15] Reduced anterior chamber volume can also be seen in case of anterior lens subluxation. So, the position of lens should be evaluated before considering the possibility of corneal laceration.

Injury To Ocular Lens

Lens is a biconvex structure that is suspended from the ciliary bodies by radially oriented zonular fibres. In blunt ocular trauma, the wave of impact causes transient deformation and equatorial expansion of the globe, displacing the cornea and anterior sclera posteriorly. This results in stretching of zonular fibres with resultant partial or complete disruption.

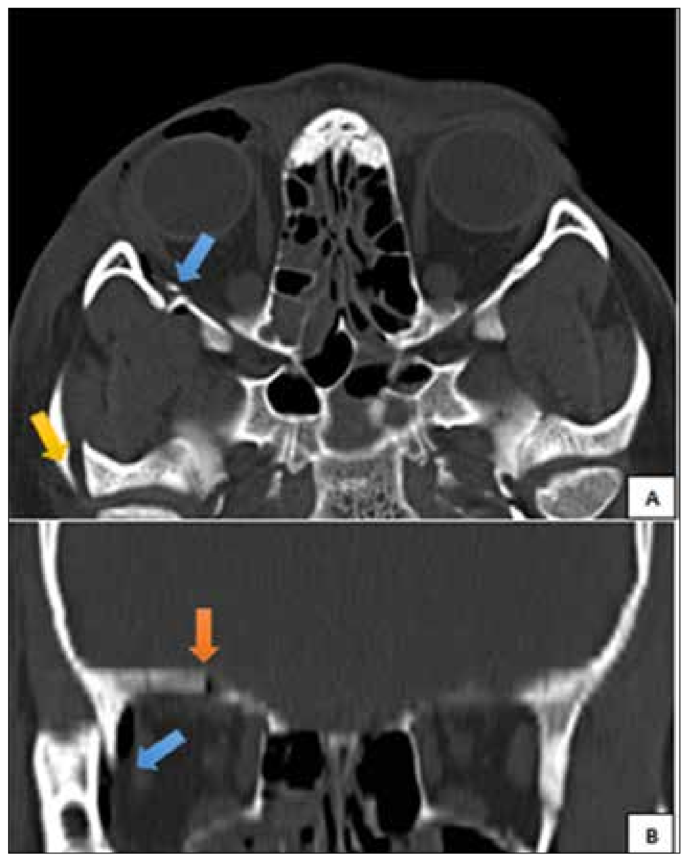

Figure 6: Blow in fracture of lateral wall and orbital roof of right orbit

CT orbit axial (A) and coronal reformatted (B) bone window images in a 42 year old male with history of fall from height show fracture of the lateral wall of the right orbit (blue arrow). There is also fracture of the zygomatic process of the right temporal bone (yellow arrow) and fracture of roof of right orbit (orange arrow).

In partial zonular disruption or tear, there is tear of fibres along one margin of the lens while fibres along the other half are intact. As a result, there is dependent displacement of the torn portion of the lens, projecting into the vitreous. In case of complete zonular disruption, there is tear of the zonular fibres throughout the lenticular margins with total lens displacement. Usually, complete tear is associated with posterior lens dislocation where the lens can be seen lying in the dependent portion of the posterior segment on imaging because the iris impedes anterior subluxation of lens. Sometimes, in patients with conditions like Marfan's syndrome, Ehler-Danlos syndrome, lens dislocation can be an incidental finding that is not associated with trauma. Lens dislocation can be diagnosed on ophthalmoscopy and on imaging.

Disruption of the lens capsule can result in lenticular edema and calcification that eventually result in cataract formation. In the initial stages, affected lens appears hypoattenuating compared to the normal lens and appears hyperattenuating or calcified on maturation.[16]

Posterior Segment Injury

Portion of the globe posterior to the lens is called posterior segment which is filled with vitreous humor and a wall made of three layers- sclera, choroid and retina. Trauma involving the posterior segment can result in vitreous hemorrhage or disruption of the above mentioned layers with resultant detachment of the same.

A) Vitreous hemorrhage

Disruption of the retinal vessels following trauma leads to hemorrhage into the vitreous which is avascular in itself. Acute vitreal hemorrhage appears heterogeneously hyperechoic on USG. On CT, it is seen as hyperattenuating contents within the posterior segment.

B) Retinal detachment

Retina is the neurosensory layer of the eye and is the innermost layer. Anteriorly it is firmly attached to the underlying choroid at ora serrata and posteriorly along the margins of the optic disc. In between these attachments, retina is loosely attached to the underlying choroid. Traumatic tear of the retina will result in seepage of fluid through this defect into the potential space between the retina and choroid causing retinal detachment. On USG, CT and MRI, it has a characteristic 'V configuration' with its apex towards the disc (Figure 7) and the detached membrane exhibits free movement on real-time imaging with ultrasound.[17]

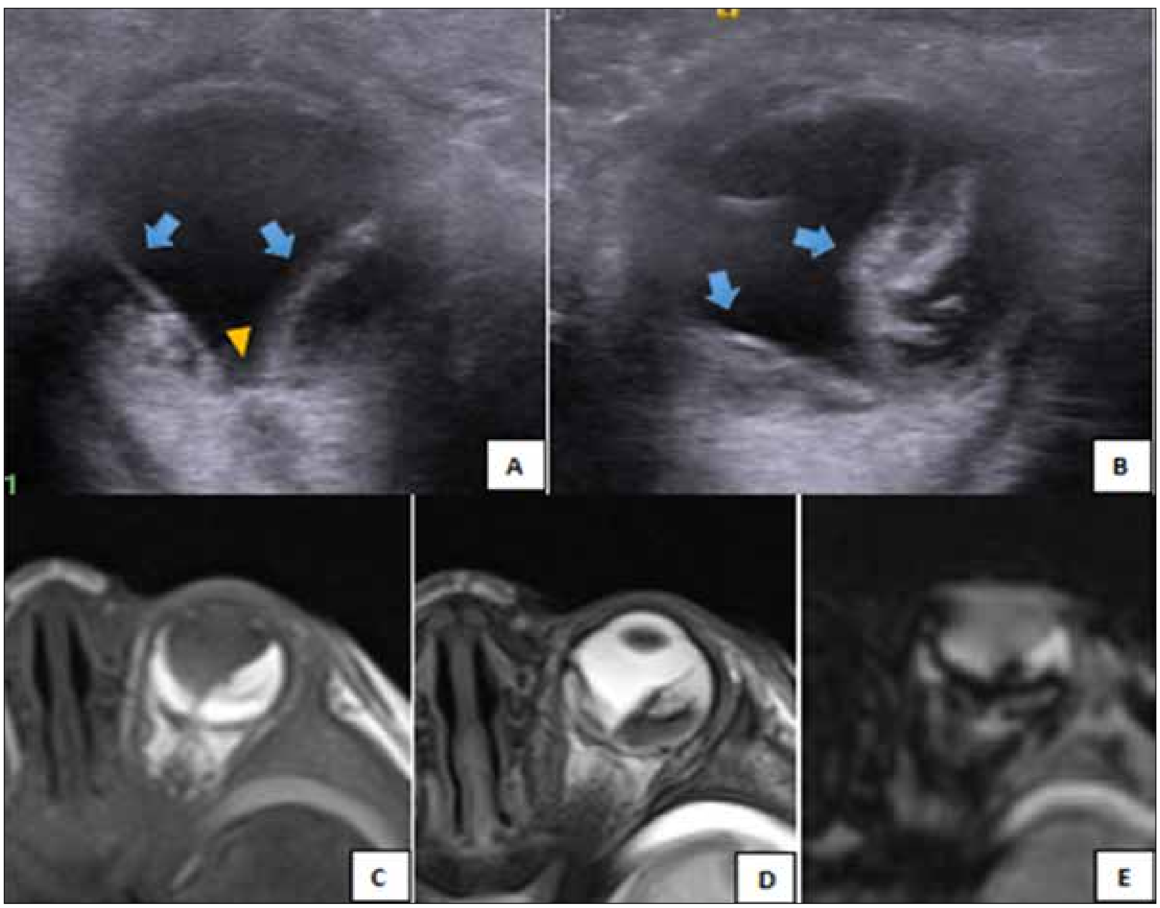

Figure 7: Traumatic retinal detachment with subretinal hemorrhage

Axial B mode ultrasonographic images (A and B) and axial T1W (C), T2W (D) and susceptibility weighted (E) MR images in male child of 12 months who was brought by his mother with complaints of repeated rubbing of the eyes following a blunt trauma to the left eye a week ago. Ultrasonographic images show the characteristic 'V configuration' of retinal detachment which appears thickened (B) (blue arrow) limited anterolaterally by ora serrata and posteriorly by the optic disc (yellow arrow head) with anechoic collection within the subretinal space with internal echoes, suggestive of subretinal hemorrhage. The same was confirmed on MRI which also shows typical 'V configuration' of retinal detachment with subretinal hemorrhage appearing hyperintense on T1W (C), hypointense on T2W (D) showing magnetic susceptibility (E), suggestive of early suacute hemorrhage

C) Choroidal detachment

Choroid is the vascular middle coat of the globe. Space between the choroid and sclera is called suprachoroidal space. Following any form of ocular trauma, if there is a fall in intraocular pressure such as in case of globe rupture, it results in ocular hypotony. Ocular hypotony is associated with fall in the suprachoroidal pressure that results in transudation of fluid into the suprachoroidal space eventually causing choroidal detachment. Tear of choroidal vessels can cause hemorrhagic choroid detachment. On imaging, it has a biconvex or lentiform configuration extending from the ciliary bodies anteriorly upto the level of the vortex veins posteriorly, sparing the posterior most part.[18] In contrast to detached retina, detached choroid remains fixed during eye movements on USG.

Open Globe Injury

Open globe injury can occur following blunt trauma that results in globe rupture due to inside-out mechanism of impact where sclera gives away at its weakest point, i.e just posterior to the attachment of extraocular muscles.[19] It can also occur in penetrating or perforating injuries. USG is contraindicated in patients with suspected open globe injury. CT is the preferred first line imaging modality. It has a sensitivity of 71 to 75% in diagnosing open globe injuries in patients with strong clinical suspicion. [20,21] However, the sensitivity for diagnosis of occult open globe injury varies from 56 to 68% depending on the observer proficiency.[21] MRI is indicated in patients with clinical suspicion of open globe injury that are not picked up on CT.[17]

Ocular globe should be evaluated in all planes to rule out open globe injury. There can be direct and indirect evidences of open globe injury. It becomes obvious in the presence of extensive trauma such as gunshot or penetrating or perforating injuries. Direct signs include altered globe contour, obvious eye wall discontinuity (depicted better on MRI) and 'flat tire' sign. 'Flat tire' sign occurs due to loss of intraocular volume which results in deformed contour of the globe. Presence of an open globe injury in the posterior segment will cause extravasation of the vitreous through the defect that causes sinking of the lens into the posterior segment and therefore, the anterior chamber appears deeper than the normal eye. In the presence of anterior chamber open globe injury as in corneal laceration, the anterior chamber appears shallow. Presence of an intraocular foreign body and ocular emphysema should raise a suspicion of open globe injury (Figure 8).

Non traumatic causes of altered globe contour like coloboma, staphyloma, pathological myopia should be excluded.[11,15] Scleral bands used in treatment of retinal detachment, silicone oil, scleral buckle, silicon sponge etc can be potential mimics of intraocular air or foreign body. History of recent interventions like pneumatic retinopexy, endothelial keratoplasty, intraocular tamponade should be elicited to rule out other causes of ocular emphysema.[11,15,17]

Intraocular Foreign Body

Foreign bodies can be seen in almost 10 to 17% of ocular injuries.[22] Prompt diagnosis of intraocular foreign body is necessary due to associated complications such as infection, retinal toxicity, abscess formation and vision loss. CT is the imaging modality of choice.[19, 22-24] Radiographs can detect the presence of radioopaque foreign bodies. USG can also be useful in detection of intraocular foreign body but has low sensitivity than CT and intraocular air foci can be mistaken for foreign body.[14] MR imaging has a higher sensitivity in detection of organic foreign body but the possibility of metallic foreign body has to be absolutely excluded prior to performing an MR examination.[25]

Imaging findings depend on the type of foreign body which are most commonly metal and glass (Figure 9).[26] Metallic and glass foreign bodies do not elicit immune response.[25] Metallic foreign bodies, even those less than 1 mm in size are readily detected on CT (Figure 10).[15] Detection of intraorbital glass on CT depends on the type of glass, its attenuation in Hounsfield units (HU) and its size as demonstrated by Gor MD et al[23] in their experiment on porcine eye. They found CT to be the most sensitive modality. Sensitivity of CT was 96.2% for glass fragments of size 1.5mm and 48.3% for those of size 0.5mm. Green beer bottle glass (550 HU) had the highest detection rate of 90.3% while spectacle glass (80 HU) had the least detection rate of 48.3% .[23]

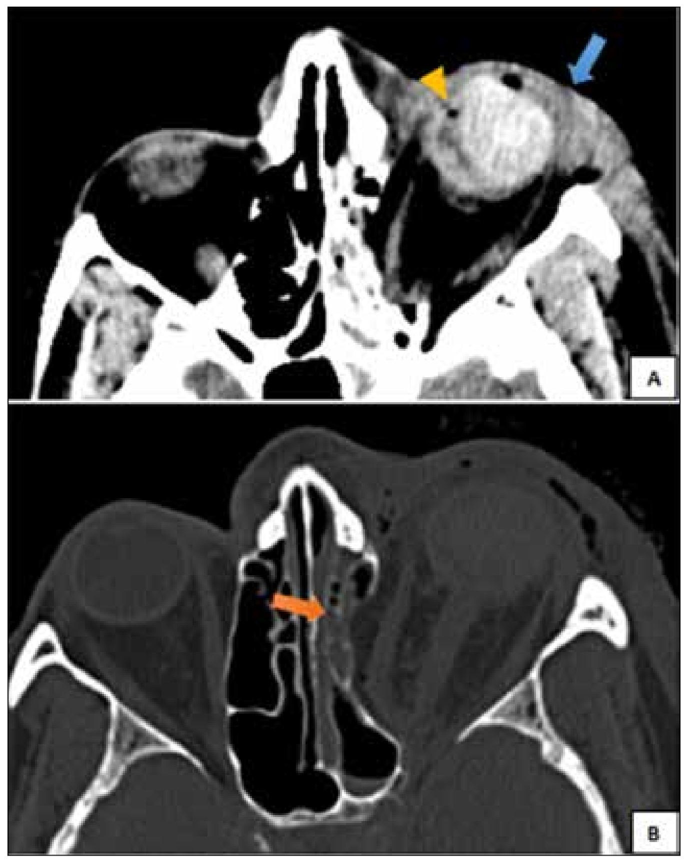

Figure 8: Open globe injury with ocular hemorrhage

CT orbit axial soft tissue (A) and bone (B) window images in a 52 year old male following high impact motor vehicle accident shows altered contour of the left ocular globe with a focus of air within the globe (yellow arrow head), representing open globe injury. Left globe appears hyperdense with indistinct anterior and posterior segments due to extensive ocular hemorrhage with preseptal soft tissue thickening (blue arrow) and resultant proptosis. Note is made of dehiscent medial wall of left orbit (orange arrow)

Detection of organic foreign bodies is radiologically challenging but carries high clinical implication as they can elicit marked inflammatory response and are associated with high infection rates[27] Wood is the most commonly seen organic foreign body (Figure 11).[25] On CT, wood is hypoattenuating and mimics intraocular air when imaged immediately following injury.[17] This can be differentiated from air foci due to the presence of geometric margins.[19] It appears isoattenuating in subacute stage and hyperattenuating in chronic stage with surrounding soft tissue reaction due to granulomatous inflammation.[28] MRI is the problem solving imaging modality. Appearance of wood on MRI depends on the type of wood whether it is dry wood or fresh wood. It appears hypo-to isointense on T1W images and iso-to hyperintense on T2W images, depending on the amount of hydration. Dry wood on the other hand has high air content within and appears hypointense to fat on both T1W and T2W images.[11] T2W and post contrast T1W fat saturated images are helpful in demonstrating the foreign body with surrounding enhancing inflammatory response [17]

Indications for surgical exploration include copper and lead foreign bodies, large iron foreign body lodged adjacent to the sclera, neurological deficit, restriction of ocular mobility and acute or chronic infection.[11] Foreign bodies lodged in proximity to the apex are preferrably left undisturbed considering the risk of associated collateral damage.[29]

Caroticocavernous Fistula

Posttraumatic diplopia, pulsatile proptosis and chemosis a few weeks following trauma suggest a diagnosis of carotico-cavernous fistula which is characterised by fistulous communication between the cavernous segment of internal carotid artery (ICA) and the cavernous sinus. It occurs due

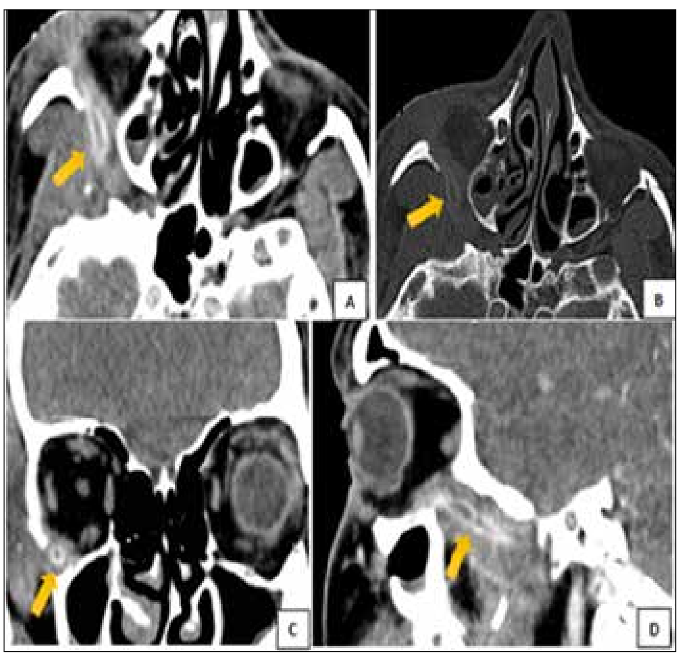

Figure 9:Intraorbital foreign body

CECT face and orbit axial soft tissue (A) and bone window (B), coronal and sagittal reformatted soft tissue window (C and D) in a 34 year old male who presented with a history of retained foreign body following assault show the presence of a long cylindrical foreign body (yellow arrow) seen along the inferolateral aspect of the right orbit in the extraconal compartment extending upto the right infratemporal fossa. The presence of the foreign body is more conspicuous in the soft tissue window than in the bone window

Figure 10: IIntraorbital metallic foreign body

Axial bone window image in a 42 year old male welder who presented with history of retained metal fragment within the right eye shows the presence of a radiodense metallic foreign body in the extraconal compartment of right orbit (blue arrow) with associated star artifact.

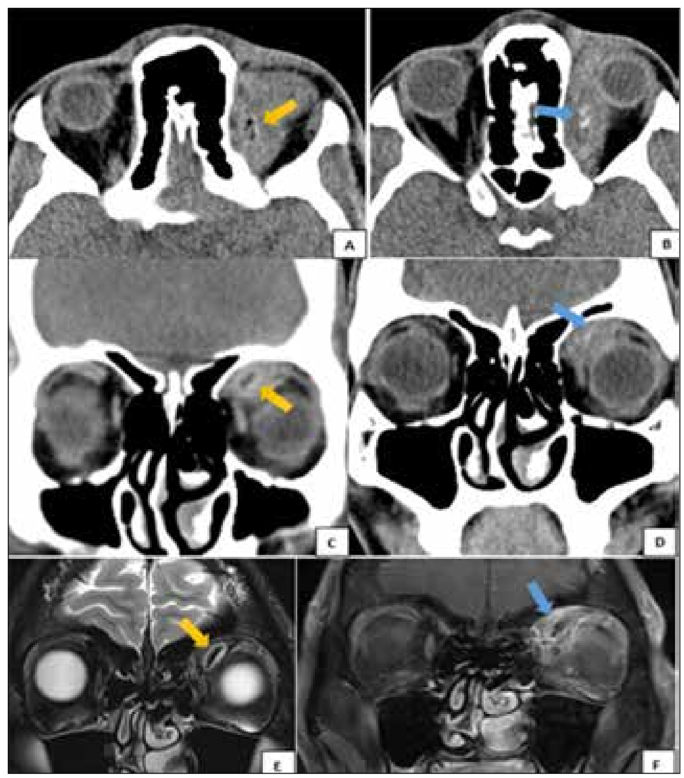

Figure 11:Intraorbital organic foreign body

Axial (A and B) and coronal reformatted (C and D) contrast enhanced CT image of a 18 year old male patient who presented with gradually progressive swelling in the left eye following penetrating tree branch injury 1 year back show the presence of a well defined hypodense foreign body (yellow arrow) in the superomedial compartment of left orbit with associated extensive soft tissue reaction (orange arrow) suggestive of granulomatous reaction, which is causing mild outward and downward displacement of the left ocular globe. Coronal T2W TSE FS image (E) of the same patient shows a hypointense foreign body (yellow arrow) surrounded by heterogenously enhancing soft tissue reaction (orange arrow) well depicted on coronal post contrast T1 FS image (F).

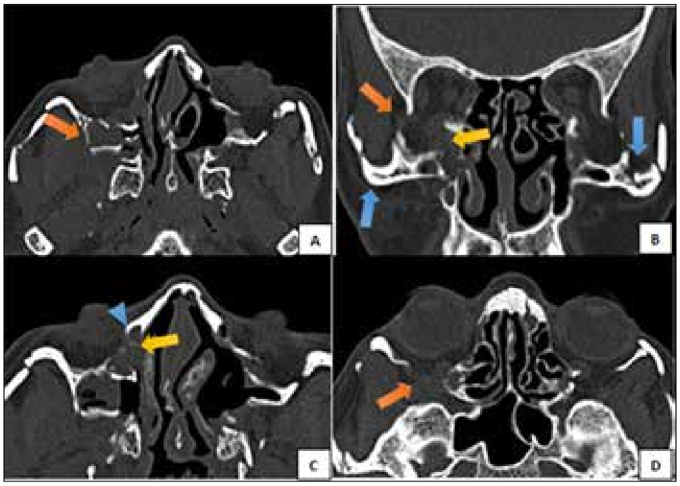

Figure 12 : Complex facio-orbital fractures

Axial CT (A, C and D) and coronal (B) reformatted bone window images in a 25 year old female following high intensity road traffic accident show fractures of the inferior and lateral orbital walls bilaterally with marked inferolateral displacement (blue arrow), herniation of orbital contents into the infratemporal and pterygomaxillary fossae (orange arrow) and bone defect along the inferomedial aspect of the right orbit with herniation of orbital contents medially into the nasal cavity. There is associated disruption of the right nasolacrimal duct (blue arrow head)

to a tear in the arterial wall of cavernous ICA with fistula formation that results in reversal of flow in the venous tributaries. Therefore, superior ophthalmic vein appears dilated on CT.[15] However, isolated dilatation of superior ophthalmic vein without demonstration of the fistula can be seen as a normal variant, in cavernous sinus thrombosis, venous varix and Grave's disease. CT Angiography is the initial investigation for evaluation. However, invasive catheter angiography remains the modality for definitive diagnosis and management.[30]

Traumatic Optic Neuropathy

Traumatic optic neuropathy is a cause of post traumatic vision loss. Role of imaging in traumatic optic neuropathy is to evaluate the cause for the same. It can occur due to fracture of the optic canal, complete or partial transection of the optic nerve or compromised vascularity of the optic nerve. High resolution CT imaging of the orbital apex is indicated to look for bony injuries at the apex impinging the optic nerve and to guide surgical intervention as these require surgical decompression.[15] Complete or partial optic nerve transection might not necessitate any emergency intervention.[11] Patients with posttraumatic vision loss with radiologically intact optic nerve are treated with high doses of corticosteriods. CT might also reveal optic nerve swelling in some of these cases. MRI can depict high T2W signal in the injured optic nerve. Diffusion weighted (DWI) and diffusion tensor (DTI) imaging have been found to be useful for early diagnosis of postraumatic optic neuropathy. Apparent diffusion coefficient (ADC) and fractional anisotropy (FA) have been demonstrated to predict the posttraumatic visual acuity in these patients.[31]

Orbital Compartment Syndrome

Normal intraorbital pressure is 3 to 6 mm Hg.[32] In trauma, the intraorbital pressure can exceed even the arterial

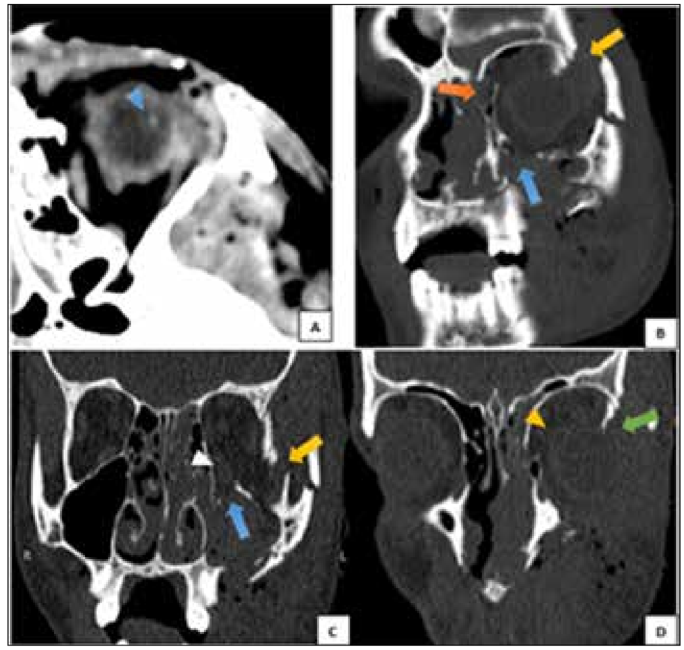

Figure 13 : Complex zygomatico-maxillary fracture with orbital fractures

Axial CT soft tissue window (A) and coronal reformatted bone window (B, C and D) in an 18 year old male who presented with history of road traffic accident show fractures involving the medial (orange arrow), lateral (yellow arrow) and inferior (blue arrow) walls of left orbit. There is comminuted fracture of the left lateral orital wall (yellow arrow) with a medially displaced fragment indenting the globe along its superolateral aspect (green arrow) causing a focal contusion on the surface of the globe (blue arrow head). Images also show comminuted blowout fracture of the left inferior orbital wall (blue arrow). The left inferior rectus (white arrow head) appears bulky with loss of normal elliptical contour suggestive of entrapment. Disruption of the lateral and inferior walls with resultant inferolateral dislocation is associated with the depression and outward displacement of the left globe (yellow arrow head)

pressure. Few studies have reported irreversible loss of vision within 60-100 minutes of high intraorbital pressure.[33] Intraorbital hypertension exceeding the arterial pressure can cause compromise of the vasa vasorum of the optic nerve and central retinal artery resulting in optic nerve and retinal ischemia respectively. Lack of lymphatic drainage of the orbit worsens it further because venous drainage via major veins like the superior ophthalmic vein are also compromised.[11]

Diagnosis of orbital compartment syndrome is based on clinical examination characterised by positive apparent pupillary defect, fall in visual acuity, tense orbit and rise in intraocular pressure which necessiates immediate decompressive canthotomy.[11] Role of imaging is to identify the cause of intraorbital hypertension like intraorbital retrobulbar hemorrhage, extensive emphysema, subperiosteal hematoma or foreign body. On CT imaging, intraocular hypertension is evident by proptosis, stretching of optic nerve and conical tenting of the posterior globe known as the 'Guitar pick sign' defined as a posterior globe angle of less than 130°[11, 34] Posterior globe angle of 120-130° have been shown to have good recovery while angle less than 120° indicates poor prognosis with need for emergency surgical intervention.[34]

Conclusion

Imaging plays a vital role in the evaluation, classification and planning management in patients with orbital trauma.

CT is the most preferred imaging modality. Orbital trauma is usually associated with facial and/ or head trauma. Therefore, clinical examination cannot always be relied upon. Often, the radiologist is the first to diagnose orbital and ocular injury. Appropriate and timely imaging helps in early diagnosis and prompt management of orbital and ocular injuries thereby improving outcomes and prevent permanent visual disability.

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