Review article:

Radiological evaluation of maxillofacial trauma: Role of MDCT with MPR and 3-D reconstruction

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ABSTRACT:

Maxillofacial injuries are one of the most frequently encountered emergencies accounting for a large proportion of patients in emergency department. The complex anatomy of the facial bones requires multiplanar imaging techniques for a proper evaluation. Now-a-days, road traffic accidents and violence are the common reasons which have led to increase in the frequency of maxillofacial injuries. The most common fracture, either isolated or associated with other fractures, was the orbital floor fracture. Due to rapid progression in diagnostic imaging, accuracy of detection of injuries and patients outcome of maxillofacial traumas has dramatically improved. The main purpose of diagnostic imaging is to detect and localize the exact number, site of facial fractures and soft tissue injuries. MDCT offers excellent spatial resolution, which in turn enables exquisite multiplanar reformations, and 3-D reconstructions, allowing enhanced diagnostic accuracy and surgical planning. We have reviewed related literature through internet. The terms searched on Google scholar and Pubmed are maxillofacial injuries, trauma, fractures, multidetector computed tomography, multiplanar and 3-dimensional reconstruction.

KEYWORDS: Maxillofacial fractures; multidetector computed tomography; multiplanar; 3-dimensional reconstruction

INTRODUCTION:

Maxillofacial injuries are one of the most frequently encountered emergencies accounting for a large proportion of patients in emergency department (1,2). Now-a-days, road traffic accidents and violence are the common reasons which have led to increase in the frequency of maxillofacial injuries (1,2,3). Clinically, maxillofacial fracture can be suspected in a patient with trauma for the presence of certain clinical signs, although such signs may be initially concealed by overlying edema, hemorrhage and soft tissue swelling (4). Due to rapid progression in diagnostic imaging, accuracy of detection of injuries and patients outcome of maxillofacial traumas has dramatically improved. The main purpose of diagnostic imaging is to detect and localize the exact number, site of facial fractures and soft tissue injuries.

This review article aims in providing multiplanar imaging techniques and 3-dimensional reconstructive methods which are beneficial for understanding the pattern of fractures and for better clinical and surgical management. We have reviewed related literature through internet. The terms searched on Google scholar and Pubmed are maxillofacial injuries, trauma, fractures, multidetector computed tomography, multiplanar and 3-dimensional reconstruction.

MAXILLOFACIAL ANATOMY:

Maxillofacial regions include maxillary, mandibular, nasal, orbital, zygomatic and ethmoid bones. The alveolar process and the bony components of the hard palate are the components of maxillary region while mandible and the temporomandibular joint constitute the mandibular region (5). Nasal region is made up of nasal bones, lacrimal bones, frontal process of the maxilla, nasal septum and ethmoid cells. Orbital anatomy is little bit complex and is formed by seven bones i.e. maxillary, zygomatic, frontal, lacrimal, palatine, ethmoid and sphenoid bones. The zygomatic region comprises of zygomatic process of the frontal bone, zygomatic bone and zygomatic process of maxilla. Road traffic accidents, injuries from violence, sport accidents or falls are the most common causes of maxillofacial injuries. The combination of traffic accidents and injuries from violence account for 80% of maxillofacial fractures (3).

CLASSIFICATION OF FRACTURES:

Facial fractures are classified into central mid-face fractures, lateral mid-face fractures and mandibular fractures. Central midface fractures include: nasal, nasoethmoidal, orbital wall, maxillary sinus and Le Fort I and II fractures. Lateral mid-face fractures include fractures of the zygomatic-malar complex, zygomatic arch fractures and orbital floor fractures (4), while Le

Fort III fractures are combined central and lateral midface fractures (6,7).

Le Fort type I: There is transverse fracture with involvement of alveolar zygomatic arch, internal walls of maxillary sinuses, vomer and internal pterygoid plates resulting in separation of hard palate from facial bones with displacement of hard palate (3). Blow on the upper lip results in this type of fracture (4).

Le Fort type II: The fracture line passes across the nasal bridge, lacrimal bones, internal wall and floor of both orbits, obliquely across the anterior maxillary sinus, extending posteriorly to the lower pterygoid plates (3). It is one of the most severe central mid facial fractures and commonly occurs due to blow over the central facial region (4).

Le Fort type III: This fracture separates the entire facial skeleton from the skull base. The fracture line traverses bilaterally from nasal bridge to the lacrimal bones, internal wall of orbit and floor of the inferior orbital fissure; one portion of the fracture line extends across the lateral orbital wall upto the zygomatico-frontal sutures whereas second fracture line extends from the orbital floor to the lower portion of the pterygoid plates. There is also fracture of zygomatic arches, resulting in separation of facial skeleton from skull base (3,4). Le Fort type II and III fractures are distinguished on the basis of involvement of lateral orbital wall and zygoma in Le Fort type III (6).

Frontal bone fractures are also commonly encountered during maxillofacial injuries, however this is not the part of maxillofacial region which results from direct trauma or extension of skull fracture (4). Anterior table is involved in 61% of these fractures, anterior and posterior sinus walls in 28% and only 5% are limited to the posterior sinus table (usually as an extension of a skull fracture) (4). Pneumocephalus is often associated with posterior table fractures.

Orbital fractures (Figure 3 and 7): These are complex fractures because of their complex anatomy and are often associated with maxillary, zygomatic and/or nasal fractures, either in their internal or external region. Fracture of orbital floor is the most common orbital fracture and is caused by blow out (3). The mechanism of blow-out fracture is force of direct impact on the eye ball which is absorbed by the orbital rim and is transmitted to the orbital floor and the eyeball usually remains intact. Air-fluid level or complete opacification of the maxillary sinus is common seen; while presence of orbital emphysema is uncommon (4). Orbital fat protrudes through the fracture line (sign of the pending drop or tear) (6). Diplopia could be due to herniation of inferior rectus and inferior oblique muscles. Involvement of orbital rim is an indication for surgery (4). Coronal reconstructions from MDCT clearly demonstrate the fractures of the orbital floor. Other orbital fractures include fracture of internal wall, which occurs either in isolation or in association with other fractures (4,6). Fracture of lateral orbital wall has been reported to occur at a frequency of nearly 30% (4) while fractures of orbital roof are rare (approx. 1 to 5%) according to various studies (8). When these fractures are secondary to direct impacts, the supraorbital rim is fractured. These fractures may extend to the orbital apex and affect neurological structures entering the orbit (8).

Nasal fractures (Figure 1, 6, 7) are the most common facial fractures which accounts for 50% of isolated fractures (3,4). Its severity depends on the direction and force of the impact. 66% of nasal fractures result from lateral force and 13% are from frontal impact (4). Lateral blow causes depression of the nasal cartilage or fracture of the ipsilateral nasal bone, while fractures of both nasal bones and of the nasal septum are caused by frontal blow. The indications for open repair of the nasal trauma are septal fracture, septal dislocation, alteration of nasal bridge or severe soft tissue injury, whereas close reduction is required for other fractures (1,4,9).

The frequency of nasoethmoidal fractures is approximately 7%. It often results from frontal blow over the bridge of the nose, displacing the nasal pyramid posteriorly, fracturing the nasal bones, frontal processes of the maxillae, lacrimal bones, ethmoid sinuses, cribriform plate, and nasal septum (4). They could be often associated with hypertelorism and telecanthus as well as with damage to the lacrimal duct with epiphora. It may also result in rhinorrhea and intracranial pneumocephalus or infection.

Maxillary sinus wall fracture (Figure 2, 3, 4, 5, 6, 7): constitutes the second most common type of fractures (16%). There are three classic fracture patterns of the maxilla, Le Fort I, II, and III. Isolated fractures of the maxillary sinus are uncommon and generally consist in depressed fractures of the anterior wall of the maxillary sinus (1,3).

Zygomatic-malar complex fracture results from a direct blow to the lateral mid face. Fracture of the three processes of the malar bone i.e. orbital, zygomatic and maxillary extending from the lateral orbital wall, to the postero-lateral wall of the maxillary sinus through the zygomatic arch, separating zygoma and maxilla (3,4). The presence of significant displacement of fragments, trismus, entrapment and / or orbital apex involvement is indications for surgery (10).

They are classified according to the direction and magnitude of displacement and bony integrity of the zygoma. Knight and North (11) in 1961 classified on plain radiograph as below:

Type 1 nondisplaced fractures

Type 2 isolated zygomatic arch fracture

Type 3 depressed, nondisplaced fractures

Type 4 medially displaced fractures

Type 5 laterally displaced fractures

Type 6 complex or comminuted fractures

There is a general mandate that all displaced fractures require open reduction and fixation (11). The recent classification for these fractures (12) as follows: Type A- Fracture involving only one of the three processes of the malar bone; zygomatic arch, external orbital rim or infraorbital rim; Type B- Displaced trimalar fracture; Type C-Comminuted trimalar fracture.

Mandibular fractures (Figure 4 and 7) includes symphyseal fractures, alveolar process fractures, fractures of the body or horizontal ramus, fractures of the angle, fractures of the ascending ramus, coronoid process fractures and fractures of the mandibular condyle. Condylar fractures are further divided into intracapsular and extracapsular. Intracapsular fractures requires medical treatment while extracapsular fractures requires surgical management (6). The signs and symptoms of mandibular fractures are pain, trismus, difficulty chewing, malocclusion, swelling and hematoma in the mandibular region (13). Any alteration in the occlusion is highly suggestive of mandibular fracture (14). Fracture of horizontal ramus or symphysis manifests as ecchymosis in the floor of the mouth (14). Pseudoarthrosis, mandibular oteomyelitis, ischemic necrosis of the condylar head and posttraumatic injury of the articular disc are the late complications of mandibular fractures (6). Magnetic resonance imaging (MRI) is the modality of choice for diagnosing these complications (6). MRI is also the best imaging modality for the evaluation of the temporomandibular joint, before and after surgical treatment (13).

IMAGING MODALITIES:

The significance of various imaging modalities is to identify the presence of fracture, number and exact location of fractures, dislocation of bone fragments and soft tissue injuries. These valuable informations are mandatory for proper management. Various imaging modalities for evaluation of maxillofacial traumas are plain radiography, MDCT and MRI.

PLAIN RADIOGRAPHY:

Plain radiography is the initial imaging modality in trauma patients; but due to inadequate information its significance in maxillofacial trauma is declined in assessing the severity of the injury. In patients of multiple traumas especially in cases of cervical spine injuries, it could be life threatening while positioning the patients; hence its role is limited.

MULTIDETECTOR COMPUTED TOMOGRAPHY:

The incidence of cervical spine injuries with facial trauma accounts for 1 to 10% according to various studies (17,18) that could be asymptomatic at the time of initial presentation. Basilar skull fractures are usually associated with unilateral mid face injuries and upper cervical spine injuries are associated with unilateral mandible injuries. 50% of patients with maxillofacial trauma have intracranial injuries (17,18). So, while imaging the patient of maxillofacial trauma, CT of the skull and cervical spine should also be considered (1). MDCT is an important imaging modality in the diagnosing the mandibular fractures (6,15). Mandibular condylar fractures are better evaluated on sagittal plane (19) while 3-D reconstructions are very helpful in planning surgical management (17,18,19). Multidetector computed tomography (MDCT) detects mandibular fracture with 100% sensitivity whereas orthopanoramic radiograph and conventional x-rays had 86% sensitivity (13).

Multidetector computed tomography (MDCT) is the imaging modality of choice and is the most accurate investigation in evaluating the patients of maxillofacial trauma. MDCT helps in detecting the exact site, number and extent of fractures, displacement of fragments and soft tissue injuries (1,3,4). As the scanning time of MDCT is less, it allows rapid scanning of critically ill, elderly and uncooperative patients. Early and proper diagnosis allows the clinicians for prompt management of maxillofacial traumas and hence preventing the early and late complications. The spatial resolution of MDCT is excellent, which enables multiplanar reformations (MPR) and 3-D reconstructions, allowing better diagnostic accuracy and surgical planning (4). 3-D reconstruction and multiplanar reformation in coronal and sagittal planes are very useful in assessing the bony architecture in large comminuted, displaced and complex fractures involving multiple planes (16) which helps the surgeons for appropriate planning. In MPR and 3-D reconstructions, there is no additional burden of radiation exposure to patients, as these images are obtained from the original 2D images which enables MDCT as the imaging modality of choice in patients of maxillofacial trauma.

MAGNETIC RESONANCE IMAGING (MRI):

Role of MRI in maxillofacial trauma is to evaluate soft tissue injuries, providing excellent soft tissue contrast; and also in assessing the patients with neurological deficits. Besides it has no radiation hazards, however it is often not a feasible modality secondary to accessibility and availability. Though MRI has multiplanar capabilities but it has longer scanning time than MDCT, so its use is trauma patients is limited. Besides this, it has no significant role in assessing the cortical bone.

CONCLUSION:

Maxillofacial injuries are commonly encountered emergencies which needs early diagnosis and management. Road traffic accidents and social violence are the common reasons which have led to increase in the frequency of maxillofacial injuries. The complex anatomy of the facial bones requires multiplanar imaging techniques for a proper evaluation. The main purpose of diagnostic imaging is to detect and localize the exact number, site of facial fractures and soft tissue injuries. MDCT offers excellent spatial resolution, which in turn enables exquisite multiplanar reformations, and 3-D reconstructions, allowing enhanced diagnostic accuracy and surgical planning.

Figure 1: Axial CT image (bone window) showing fracture of bilateral nasal bones, lateral wall of bilateral maxillary sinuses and nasal septum.

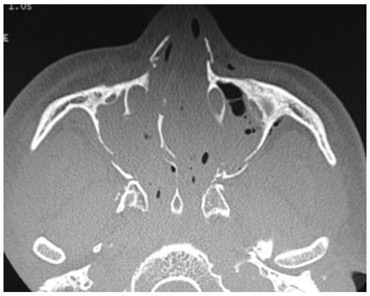

Figure 2: Axial CT image (bone window) showing comminuted and displaced fracture of maxilla involving the alveolar process.

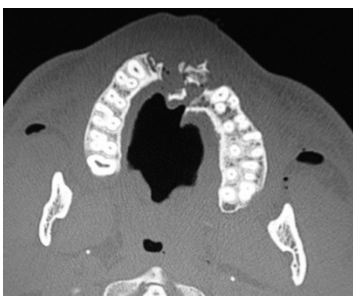

Figure 3: Coronal CT image (bone window) showing comminuted and displaced fracture of maxilla involving the hard palate. Fracture of lateral wall of bilateral maxillary sinuses, floor of left orbit and bilateral lamina papyracea.

Figure 4: Coronal CT image (bone window) showing comminuted and displaced fracture of body of mandible, lateral and medial walls of bilateral maxillary sinuses and hard palate.

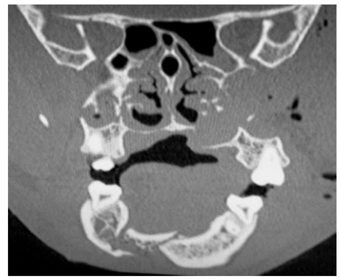

Figure 5: Axial CT image (bone window) showing fracture of bilateral medial and lateral pterygoid plates, lateral wall of bilateral maxillary sinuses and anterior wall of left maxillary sinus.

Figure 6: 3-D volume rendered image showing fracture of maxilla and nasal bones.

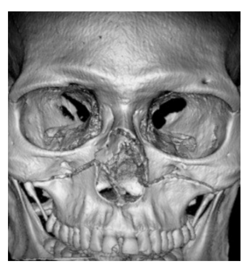

Figure 7: 3-D volume rendered image showing fracture of mandible, maxilla, hard palate, bilateral maxillary sinuses, bilateral lamina papyracea, floor of right orbit, nasal bones and nasal septum.

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