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REVIEW ARTICLE

CONTEMPORARY IMAGING IN MAXILLOFACIAL TRAUMA

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ABSTRACT

Maxillofacial traumas (MFTs) are gradually becoming common reason for presenting at Emergency Departments. Nowadays, these traumas formed a social disease because of an increasing frequency and magnitude of traffic accidents, as well as the growing incidents of violence in urban. In initial phase of trauma an efficient imaging assessment of patients with MFT is crucial. Once patient compensation has been achieved, to detect fractures and/or soft tissue damage require immediate therapy and preoperative planning with required imaging techniques for a proper assessment.

INTRODUCTION

Maxillofacial traumas (MFTs) are one of the most frequently encountered emergencies in emergency department (Nisha Mehta *et al.,* 2012; Pathria and Blaser, 1989). Nowadays, 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. Clinically, maxillofacial fractures can be conjectured in a trauma patient for the presence of certain clinical signs, though such signs may be primarily obscured by overlying edema, bleeding and soft tissue swelling. Accuracy in detection of injuries in MFTs has significantly improveddue to rapid progression in diagnostic imaging. The main objective of diagnostic imaging is to detect site and number of facial fractures (Som *et al.,* 2002).This review article aims in providing conventional imaging, multiplanar imaging techniques and 3-dimensional reconstructive methods which are beneficial for understanding the pattern of fractures and for better clinical and surgical management.

Maxillofacial Anatomy

By otolaryngologists, the maxillofacial anatomy is divided into upper, middle, and lower thirds. The upper third of the face consists of the frontal bone (including the frontal sinuses) and is outlined from the middle third by the superior orbital rims and walls.

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The middle third of the face extends superiorly from the superior orbital rims to the maxilla inferiorly and thus includes the orbits, the nasal cavity, and all paranasal sinus except frontal. The middle third of the face is delineated posterolaterally by the zygomaticotemporal sutures and posteromedially by the pterygoid plateswhere former connects the midface to the calvaria and later connects it to the skull base. The lower third of the face includes the mandible and TMJ (Rosenbloom *et al.,* 2011).

Classification of Fractures

Lefort Fractures

Le Fort fractures are complex facial fractures that result from a high-force impact on the midface structures and were first described in the early 20th century by French surgeon Rene Le Fort.

Lefort I

A type I Le Fort fracture, also termed as a Guerin fracture or “floating palate,” as it separates the hard palate from the skull base. Horizontally oriented fracture extends the anterior, lateral, and medial maxillary walls, bisecting the inferior margin of the piriform aperture and nasal septum and spans posteriorly through the pterygoid plates. Because the fracture extends anteroposteriorly in the axial plane, it is typically best depicted on coronal and three-dimensional images (Fig. 1 and 2).

Lefort II

A type II Le Fort fracture, also known as a “pyramidal” fracture, as pyramid-shaped maxillary fragment may move independently from rest of the midface and skull base. The apex of the pyramid is situated just below the nasofrontal suture. The fracture of obliquely oriented spans through the floor and medial wall of orbit and zygomaticomaxillary suture, excluding the zygomatic bone. Axial and coronal reformatted images are useful for visualizing the extension of a type II Le Fort fracture in an oblique plane through the medial and inferior orbital walls (Kellman,2010)(Fig. 1 and 2).

Figure 1: Axial section of CT

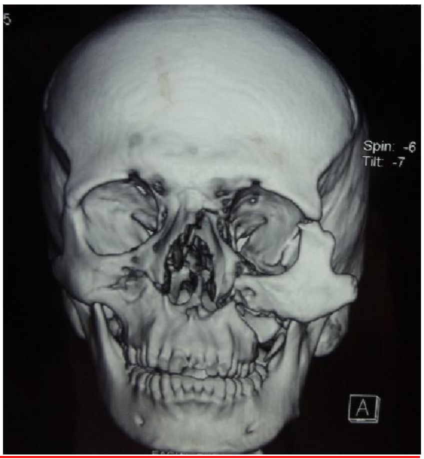

Figure 2 (a): Frontal view of 3D reconstruction

Figure 2 (b): Lateral view of 3D reconstruction

Lefort III

A type III Le Fort fracture, also known as craniofacial dissociation, causes complete detachment of the face from the skull base. This fracture begins at the nasofrontal suture and travels laterally through the medial and lateral orbital walls and zygomatic arch. Involvement of zygomatic arch and lateral orbital wall on axial and coronal images of Computed Tomography(CT) distinguishes Lefort III from Lefort II (Kellman, 2010).

Frontal Sinus Fractures

Fractures of the upper third of the face typically affect the wall of the frontal sinus. Fractures may involve only the anterior sinus wall or extend into the posterior wall. A fracture along posterior wall creates a communication between the frontal sinus and the anterior cranial fossa which lead to complications likeCSF rhinorrhea andintracranial infection. A fracture involving the medial aspect of the frontal sinus may extend into the nasofrontal duct, can cause a mucocele that obstructs sinus drainage and requires surgical correction (Lieger *et al.,*2009).

Orbital Fracture

Fracture of orbital floor is the most common orbital fracture and is caused by blowout (Salvolini, 2002). The mechanism of blow-out fracture is force of direct impact is applied on the eye ball which is absorbed by the orbital rim and is transmitted to the orbital floor. Usually eyeball remains intact. Air-fluid level or complete opacification of the maxillary sinus is commonly seen (Som and Brandwein, 2002). Orbital fat protrudes through the fracture line (tear drop sign) (Rohrich*et al.,* 1992).Due to herniation of inferior rectus and inferior oblique muscles diplopia can occur (Som*et al.,* 2002). Coronal sections of CT clearly demonstrate the fractures of the orbital floor (Som and Brandwein, 2002; Rohrich*et al.,*1992). Fracture of lateral orbital wall has been reported to occur at a frequency of nearly 30% (Som*et al.,* 2002). while fractures of orbital roof are rare according to various studies.[10] When these fractures are secondary to direct impacts, there might be involvement of the supraorbital rim fracture which may extend to the orbital apex and affect neurological structures entering the orbit (Schuknecht and Graetz, 2005). (Fig 1 and 2)

Nasal Fracture

Nasal bone fractures are the most common of maxillofacial skeletal injuries because of its superficial location and the relative thinness of the bone. This fracture typically result from blunt force directed from either an anterior or a lateral direction. According to the anatomic plane it is classified as follows:
Type 1: fractures do not involve the nasal septum and extends from the caudal tip of the nose to the anterior nasal spine;

Type 2: fractures involve the septum as well as the anterior nasal spine; and type 3 fractures involve orbital bone as well as the nasal bone and septum. A fracture that extends into the nasal cartilage may disrupt the perichondrium resulting in septal hematoma and with resultant septal perforation it can lead to impaired nasal breathing, abscess formation, and necrosis.

Naso-Orbitoethmoid Complex

Fractures of the naso-orbitoethmoid (NOE) complex are caused by a high-impact force applied anteriorly to the nose and transmitted posteriorly through the ethmoid bone. It involves the nasal bones, medial orbital walls and ethmoid sinuses. Exophthalmos is the most frequent complication due to a decrease in intraorbital volume, increased distance between the medial canthi of the eyes (telecanthus) due to medial canthal tendon injury, and CSF rhinorrhea due to fracture through the cribriform plate (Fig. 1 and 2).

Zygomatic-Malar Complex Fracture

It results from a direct blow to the lateral mid face. Fracture of theorbital wall, to the postero-lateral wall of the maxillary sinus through the zygomatic arch, separating zygoma and maxilla. The presence of significant displacement of fragments, trismus, entrapment and / or orbital apex involvement is indications for surgery (Rohrich*et al.,* 1992).
They are classified according to the direction and magnitude of displacement and bony integrity of the zygoma. Knight and North(Martello and Vasconez, 1997) 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 (Martello and Vasconez, 1997). The recent classification for these fractures (Knight andNorth, 1961) as follows: Type A- Fracture involving only one of the three processes of the malar bone; zygomatic arch, supra-orbital rim or infraorbital rim; Type B- Displaced trimalar fracture; Type C-Comminuted trimalar fracture (Fig 1 and 2).

Mandibular Fractures

It includes symphysealorparasymphysealfractures, fractures of the body or horizontal ramus, mandibular angle fractures, fractures of mandibular coronoid and condylar process. Condylar fractures are further divided into intracapsular fracture which requires medical treatment and extracapsular fracture requires surgical management (Manson*et al.,* 1990). The signs and symptoms of mandibular fractures are hematoma, pain, trismus, difficulty chewing, malocclusion and swelling in the mandibular region (Schuknecht and Graetz, 2005).Any deranged in the occlusion is highly suggestive of mandibular fracture (Romeo*et al.,* 2009). Fracture of horizontal ramus, symphysis or parasymphysis manifests as ecchymosis in the floor of the mouth (Romeo*et al.,* 2009).
Late complications of mandibular fractures include pseudoankylosis, osteomyelitis of mandible, ischemic necrosis of the condylar head and posttraumatic injury of the articular disc. Magnetic resonance imaging (MRI) is the modality of choice for diagnosing these complications and it is also the best imaging modality for the evaluation of the temporomandibular joint, before and after surgical treatment (Romeo*et al.,* 2009)(Fig 3 and 4).

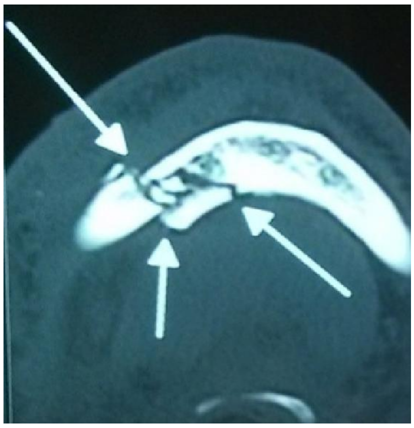

Figure 3.Fracture of body of mandible

Figure 4. Parasymphyseal fracture

Dentoalveolar Fractures

Alveolar process fracture, the most common maxillary fracture pattern which may result from direct force applied to the alveolar process or from indirect force transmitted from the underlying teeth which acts as a fulcrum. It is treated as an open fracture because of the abundance of bacteria in the mouth and breach of the overlying mucosa requires surgical debridement and prophylactic antibiotics. Other complications of alveolar process fractures include crown or root fracture, dental intrusion or extrusion, malocclusion or dental root avulsion (Stacey*et al.,* 2006).

Imaging Modalities

Imaging is an important diagnostic adjunct to the clinical assessment of the MFT. Since the discovery of x-rays, radiology has played a vital role in detection of MFT's. With the expanding array of imaging modalities, dental radiology has played revolutionary role in determining diagnosis, treatment plan and prognostic value(Lieger*et al.,* 2009). The aim of any radiographic evaluation for MFTs is to determine the site, location and position of both hard and soft tissues, in all the three spatial planes. In the late 1940s and 1950s various radiographic techniques were used to evaluate maxillofacial injuries. Mandibular and condylar fractures were detected using a combination of occlusal, mandibular lateral-oblique, TMJ (Stuart C. White, 2009) and posterior-anterior projections,(Barton, 1955)whereas midface fractures evaluation included posterior-anterior, Caldwell, Waters, Towne, and submentovertex (Akamine, 1955). Intraoral periapical and occlusal radiographs are used for dentoalveolar trauma evaluation but all these images have certain limitations like anatomic superimposition of structures, effect of soft tissue edema on image contrast, lack of soft tissue imaging, variability in exposure and technique problems related to film coverage, and geometricdistortion (McIvor and Wake, 1955; Morris, 1948).

In 1960s, tomography and rotational panoramic radiography revealed regional views of maxillofacial skeleton and were commercialized. Tomography served as complementary imaging modality in detecting fractures of the orbital floor and the mandibular condyle (Akamine, 1955; Jacob and Dolan, 1980). whereas panoramic radiography played a vital role specifically in imaging trauma to the jaws (Grasser, 1965). Main limitation in conventional radiography is,it presents only a two-dimensional (2D) view of complicated three-dimensional (3D) structures. Along with recent technological advancement, radiological imaging has moved towards digital, 3D and interactive imaging applications. This was initially achieved by the use of conventional single and later multislice CT (MSCT).In late 1970-80s Godfrey Hounsfield and Allan M. McCormack applied computer processing to the principles of tomography resulted in the introduction of computerized tomography (CT) (Weber, 2001).CT was the first technology provided superior diagnostic accuracy in the diagnosis of maxillofacial injury (Brant-Zawadzki *et al.,* 1982)particularly with respect to soft tissue diagnosis (Kreipke *et al.,* 1984).This ''incremental'' scanning approach was subject to errors relating to patient movement and limited Z-axis (vertical) image resolution which resulted in loss of fracture conspicuity. Increasing innovations in mechanics with the development of the power slip ring aided the development of spiral CT, also termed as helical CT in the late 1980s. Spiral CT provides rapid acquisition (<20 seconds) of thin section axial CT data and facilitates multi-planar reformatted (MPR) 2-dimensional (2D) and 3D image reconstruction assisting fracture detection.

However for maxillofacial patients with severe trauma standard (3 mm collimation with a 1:1 pitch) spiral CT images provide coronal MPR images that are inadequate for the assessment of facial fractures oriented primarily in the axial plane (Fox *et al.,* 1995).Since the 1990's CT developments have been directed toward more rapid acquisition of a volumetric 3D data set. MSCT is a system replaces a single detector row with a multiple detector array (now up to 64 rows) that attain tomographic data at different slice locations. This provides numerous advantages like significant reduction in scanning time, reduced artifacts, and sub-millimeter resolution though these scanners are extremely expensive. The most recent being, cone beam computed tomography (CBCT) is gaining rapid acceptance in dentistry. CBCT scanners are based on volumetric tomography, a principle using a 2D extended detector and a 3D x-ray beam. It provides cross-sectional imaging without super imposition of local complex anatomy onto the image that is often a valuable supplement to intraoral and panoramic radiographs. The information content in such examinations is high, the dose and costs are low (Ziegler *et al.,* 2002; Heiland *et al.,* 2004)

Conclusion

Developments in the past six decades can be attributed to innovations like (1) the change from analog to digital imaging with associated advances in electronics and computing and (2) success of imaging theory in providing cross-sectional and multidimensional imaging. These innovations have markedly improved the ability to accurately visualize the condition of the facial trauma patient and now provide exciting opportunities to expand the role of oral and maxillofacial imaging from a passive, planar diagnostic service to a multidimensional surgical assistive modality. Contemporary radiologists and oral surgeons must also now concern themselves with a myriad of nonsurgical care issues related to reimbursement and preventive practice strategies reducing the risk of litigation. Technological innovation and external influences will continue to shape progress, however the evolving role of imaging in maxillofacial trauma remains what it has always been: to provide a noninvasive insight into the effects of trauma on the facialskeleton and provide guidance on surgical reconstruction.

REFERENCES

Akamine, R. N. Diagnosis of traumatic injuries of the face and jaws. *Oral Surg Oral Med Oral Pathol* 1955;8:349-58.

Barton, E. J. Roentgenographic evidence of condylar meck fractures. Oral Surg Oral Med Oral Pathol 1955;8:58-63.

Brant-Zawadzki, M. N., Minagi, H., Federle, M. P. and Rowe, L. D. High resolution CT with image reformation in maxillofacial pathology. *AJR Am J Roentgenol* 1982;138:477-83.

Fox, L. A., Vannier, M. W., West, O. C., Wilson, A. J., Baran, G. A. and Pilgram, T. K. Diagnostic performance of CT, MPR and 3D CT imaging in maxillofacial trauma. Comput Med Imaging Graph 1995;19:385-95.

Grasser, H. [The panoramic and orthopantographic x-ray technics and their value in the diagnosis of jaw fractures]. ZahnarztlPrax 1965;16:109-10; [In German.]

Heiland, M., Schmelzle, R., Hebecker, A. and Schulze, D. Intraoperative 3D imaging of the facial skeleton using the SIREMOBIL Iso-C3D. DentomaxillofacRadiol 2004;33: 130-2.

Jacoby, C. and Dolan, K. Fragment analysis in maxillofacial injuries: the tripod fracture. *J Trauma* 1980;20:292-6.

Kellman, R. M. Maxillofacial trauma. In: Flint PW, Haughey BH, Lund, VJ, et al, eds. Cummings otolaryngology: head and neck surgery. 5th ed. Philadelphia, Pa: Mosby, 2010; 318–341.

Knight, J. S. and North, J. F. The classification of malar fractures: an analysis of displacement as a guide to treatment. *Br J PlastSurg* 1961;13:325-32.

Kreipke, D. L., Moss, J. J., Franco, J. M., Maves, M. D. and Smith, D. J. Computed tomography and thin-section tomography in facial trauma. *AJR Am J Roentgenol* 1984;142:1041-5.

Lieger, O., Zix, J., Kruse, A. and Iizuka, T. Dental injuries in association with facial fractures. *J Oral MaxillofacSurg* 2009;67(8):1680–1684.

Lieger, O., Zix, J., Kruse, A. and Iizuka, T. Dental injuries in association with facial fractures. *J Oral MaxillofacSurg* 2009;67(8):1680–1684.

Manson, P. N., Markowitz, B., Mirvis, S., Dunham, M. and Yaremchuk, M. Toward CT-based facial fracture treatment. PlastReconstrSurg 1990;85:202-12.

Martello, J. Y. and Vasconez, H. C. Supraorbital roof fractures: a formidable entity with which to contend. *Ann PlastSurg* 1997;38:223-7.

McIvor, J. and Wake, M. Radiography and radiology. In: Williams J, editor. Rowe and Williams' maxillofacial Bingham CB. The fractured malar. *Oral Surg Oral Med Oral Pathol* 1955;8:13-20.

Morris, J. H. Dental roentgenographictechique—interpretation relationships. *Oral Surg Oral Med Oral Pathol* 1948;1:58-63.

Nisha Mehta, Parag Butala, Mark, P. Bernstein. The Imaging of Maxillofacial Trauma and its Pertinence to Surgical Intervention. *RadiolClin N Am* 50;2012:43-57.

Pathria, M. N. and Blaser, S. I. Diagnostic imaging of craniofacial fractures. *RadiolClin North Am* 1989;27:839-53.

Rohrich, R. J., Hollie,r L. H. and Watumuli, D. Optimizing the management of orbitozygomatic fractures. ClinPlastSurg 1992;19:149-65.

Romeo, A., Pinto, A., Cappabianca, S., Scaglione, M. and Brunese, L. Role of multidetector row computed tomograghy in the management of mandible traumatic lesions. SeminUltrasound CT MRI 2009;30:174-80.

Rosenbloom, L., Delman, B. N. and Som, P. M. Facial fractures. In: Som PM, Curtin HD, eds. Head and neck imaging. 5th ed. St Louis, Mo: Elsevier, 2011; 491–524.

Salvolini, U. Traumatic injuries: imaging of facial injuries. EurRadiol 2002;12:1253-61.

Schuknecht, B. and Graetz, K. Radiologic assessment of maxillofacial, mandibular, and skull base trauma. EurRadiol 2005;15:560-8.

Som, P. M. and Brandwein, M. S. Facial fractures and postoperative findings. En: Som PM, Curtin HD (eds). Head and neck imaging. Mosby, St. Louis: 2002:374-438.

Som, P. M. and Brandwein, M. S. Facial fractures and postoperative findings. En: Som PM, Curtin HD (eds). Head and neck imaging. Mosby, St. Louis: 2002:374-438.10.

Stacey, D. H., Doyle, J. F, Mount, D. L., Snyder, M. C. and Gutowski, K. A. Management of mandible fractures. PlastReconstrSurg 2006;117:48-60e.

Stuart, C. White. Michael J. Pharoah. Oral Radiology Principles and Interpretation 6th edition chapter 14.2009 p.no 225-243.

Weber, A. History of head and neck radiology: past, present, and future. Radiology 2001;218:15-24.

Ziegler, C. M., Woertche, R., Brief, J. and Hassfeld, S. Clinical indications for digital volume tomography in oral and maxillofacial surgery. *DentomaxillofacRadiol.,* 2002; 31:126-30.

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