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Computed Tomography evaluation of maxillofacial injuries

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ABSTRACT

Background & Objectives: The maxillofacial region, a complex anatomical structure, can be evaluated by conventional (plain) films, Tomography, Multidetector Computed Tomography, Three-Dimensional Computed Tomography, Orthopantomogram and Magnetic Resonance Imaging. The study was conducted with objective of describing various forms of maxillofacial injuries, imaging features of different types of maxillofacial fractures and the advantage of using Three- Dimensional Computed Tomography reconstructed image. **Materials & Methods:** A hospital based cross-sectional study was conducted among 50 patients during April 2014 to September 2016 using Toshiba Aquilion Prime 160 slice Multi Detector Computed Tomography scanner. **Results:** The maxillofacial fractures were significantly higher in male population (88%) than female population (12 %). Road traffic accidents were the most common cause of injury others being physical assault and fall from height. It was most common in 31-40 years (26%) and 21-30 (24%) years age group. Maxillary sinus was the commonest fracture (36%) followed by nasal bone and zygomatic bone (30%), mandible and orbital bones (28%). Soft tissue swelling was the commonest associated finding. Three dimensional images (3 D) compared to the axial scans missed some fractures. However, the extension of the complex fracture lines and degree of displacement were more accurately assessed. Complex fractures found were Le fort (6%) and naso-orbito-ethmoid (4%) fractures. **Conclusion:** The proper evaluation of complex anatomy of the facial bones requires Multidetector Computed Tomography which offers excellent spatial resolution enabling multiplanar reformations and three dimensional reconstructions for enhanced diagnostic accuracy and surgical planning.

Key words: 3D-CT, Computed tomography, Fractures, Maxillofacial, Road traffic accidents

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INTRODUCTION

Maxillofacial injuries are increasingly common among trauma patients occurring either in isolation or with other serious injuries. Despite the increasing safety precautions in driving, motor vehicle accidents account for majority of these injuries particularly involving the facial bones, orbits and adjacent soft tissue structures. Fall injuries, physical assault and sports injury account for minor proportion of these patients.[1] In Nepal alone, road traffic accidents (RTA) account for the highest mortality rate reaching approximately 15 to 20 times than that of developed nations. According to national statistics of Nepal, more than 11,000 people were injured due to RTA in 2009 to 2010 and are increasing year by year. There are various disparities in reported incidences of such trauma. Young males with orbito-zygomatic complex fractures are frequently involved.[2] Although many of the principles of detection and repair are basic, the evolution of imaging technology and therapeutic strategies has led to improved patient outcomes.

The maxillofacial region is one of the most complex anatomical structures of the human body and the radiographic imaging of this region becomes further difficult in traumatic patients. Imaging modalities used in the evaluation of the traumatic maxillofacial region include conventional (plain) films,

Multidetector Computed Tomography (MDCT), Three-Dimensional Computed Tomography (3 D-CT), Orthopantomogram (OPG) and Magnetic Resonance Imaging (MRI).[3]

Plain radiography is the initial imaging modality in trauma patients; but due to inadequate information its significance in maxillofacial trauma has declined in assessing the severity of the injury. 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 in much less time.[4] It is an important imaging modality in diagnosing the mandibular fractures.[5, 6]

The spatial resolution of MDCT is excellent, which enables Multiplanar Reformations (MPR) and 3-D reconstructions allowing better diagnostic accuracy and surgical planning and provides excellent information about fracture comminution and displacement.[7] Involvement multiple planes in complex fractures can be assessed which aids in the surgical management.[8] In MPR and 3-D reconstructions there is no additional burden of radiation exposure.

Facial fractures are classified into mid-face and mandibular fractures. There may be isolated bone fractures or complex facial fractures. Complex facial fractures commonly include Naso-Orbito-Ethmoid and Le fort fractures. The use of the Le Fort classification, although sometimes inadequate, is a succinct way of communicating and summarizing the major fracture planes that exist by evaluating the pterygoid processes and the distinctive components of each type of Le Fort fracture.[9]

This study describes the features of various maxillofacial injuries evaluated by MDCT and 3DCT imaging. The aim of this study was to describe various forms of maxillofacial injuries with the help of CT scan, imaging features of different types of fractures in patients with maxillofacial injuries and advantage of using 3D CT reconstructed image over axial CT images in patients with maxillofacial injuries.

MATERIALS AND METHODS

The study was carried out in the Department of Radiodiagnosis, College of Medical Science-Teaching Hospital, Bharatpur, after the approval of proposal by subject committee and Ethical Committee. It was a hospital based cross sectional study done for a period of two years from 2014 to 2016 in 50 patients who were referred to the department of Radiodiagnosis with maxillofacial injuries using TOSHIBA Aquilion Prime 160 slice CT scanner.

MDCT with volumetric acquisition was done in axial planes from upper border of frontal sinus to chin using standard CT protocol. From axial images thin sections (1.25 mm) were made through inbuilt software followed by multiplanar reconstructions (MPR) in coronal and sagittal planes along with 3D reconstruction. Collected data was analyzed using SPSS (Statistical Package for the Social Sciences) 20. Descriptive analysis was done to generate frequency tables for various types of maxillofacial injuries.

RESULTS

Maxillary sinus wall fracture was the commonest fracture in this study accounting for 36% (18) of cases (Figure 1).The second most common fractures were nasal bone and zygomatic bone accounting for 30% (15) cases each. The next most common fractures were of mandible and orbital bones accounting for 28% (14) of cases. Frontal bone (16%), temporal bone (12%), parietal bone (6%), occipital bone (4%) and sphenoid bone (2%) were also present. Pterygoid plate fractures were present in 6% cases.

The frequency of maxillofacial fractures was higher in males accounting for 88% of cases whereas in females, it accounted for only 12 % of cases with male: female ratio of 7.3:1.

Zygomatic bone was the commonest fracture in females (6%). In males, maxilla was the most common fractured bone (32%).

RTA was the commonest cause of injury in males (72%) others being physical assault (10%) and fall from height (6%). In females RTA accounted for all the cases of maxillofacial injuries (12%). Overall RTA was the commonest mode of injury accounting for 84% of cases followed by fall from height 10% and physical assault 3%.

Maxilla and maxillary sinus fractures were the commonest fractures in this study accounting for 36% of cases. The mode of injury was road traffic accident. Combined anterior and medial wall fractures were the most common injury pattern observed (50%). (Table 2)

Nasal bone fracture was present in 26 % of cases. Majority of cases were from RTA (22%) followed by physical assault (2%) and fall from height (2%).Bony nasal septum fracture was present in 4% cases which was associated with nasal bone

Table 1: Frequency of fractures by age group

Age group (yrs)	Frequency	%
1-10	3	6
11-20	8	16
21-30	12	24
31-40	13	26
41-50	7	14
51-60	5	10
71-80	1	2
81-90	1	2
Total	50	100

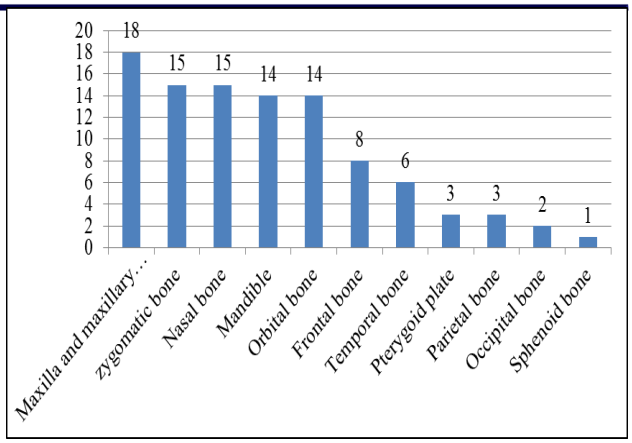

Figure 1: Frequency of different maxillofacial fractures

Table 2: Frequency of maxilla and maxillary sinus fractures

Maxillary sinus fracture	Frequency	Percentage of total	Percentage of total maxillary fractures
Anterior wall	2	4	11.1
Anterior, medial lateral wall	9	18	50
Anterior, medial wall, alveolar process	1	2	5.6
Anterior, lateral wall	1	2	5.6
Anterior wall, alveolar process	2	4	11.1
Medial wall, alveolar process	1	2	5.6
Lateral wall	2	4	11.1
Total	18	36	100

fractures.

Orbital bone fracture was present in 28% of cases. RTA was the mode of injury. Lateral wall was the most common fracture (50%) followed by medial wall (28.6%) and roof (14.3%). Combined inferior and medial wall fracture accounted for 1 case suggestive of complex blow out fracture.

Frontal bone fractures accounted for 16% of total cases. Out of which 62.5% (n=5) were Type 1 fracture, 25% were type 2 fractures and 12.5% was type 3 fracture. Type 4 and Type 5 fractures were not found in this study. Sphenoid wing fracture was present in only 2% of cases which was in greater wing of sphenoid bone. Road traffic accident was the cause of injury.

Temporal bone fracture was present in 12% of cases. Squamous portion was the most common fractured part (10%) followed by petrous portion (2%). RTA was the mode of temporal bone injury.

Soft tissue swelling was the commonest associated findings. It was followed by Sinus collection commonly maxillary sinus. Associated other serious injuries were pneumocephalus, contusion, SAH, SDH, EDH, Subdural hygroma and scalp hematoma.

Among the fractures missed by 3D image compared to the axial scans, maxillary sinus medial wall fracture was the commonest one (16%), followed by pterygoid plate fracture (4%), frontal sinus posterior wall (2%), nasal bone (2%) and sphenoid bone (2%).

Among total cases 4% had NOE fractures. Le fort fractures were present in 6% of total patients with Le Fort I, Le Fort II and Le Fort III patterns accounting for 2% each.

DISCUSSION

Maxillofacial injuries occur by either blunt or penetrating forces or combination of both. There is discrepancy in the global incidence of facial fractures mainly due to patient's age, socioeconomic status, geographical location, level of industrialization and according to different seasons.[10]

In our study RTA accounted for majority of cases of maxillofacial injuries (84%) with other causes being physical assault (10%) and fall from height (6%). The location of the hospital midway along the busiest highway of the country could explain for increased number of RTA cases presenting to the hospital. The injuries were found to be overwhelmingly common in male population (88 % of cases) compared to females (12%) with male: female ratio of 7.3:1. The maxillofacial injuries were most common in 31-40 years and 21-30 years age group accounting for 26% and 24% of total cases respectively.

The facial fractures of all injuries are found to be common in young males.[11] Although the frequent mode of facial injuries in developing countries in studies by Adekeye et al.,[12] Bochlogyros et al.[13] and Haug et al.[14] was road traffic accidents, various results in developed countries show high incidence of assault as the commonest cause of maxillofacial injury.[15] Because of social, cultural, and environmental factors the causes of maxillofacial fractures vary.[16]

In a five year prospective study by Motamedi et al.[17] and six month prospective study by Kamulegeya et al.,[18] the most common fracture found was mandibular fracture, however, maxilla and maxillary sinus was the most common middle third facial region fracture. Isolated posterior maxillary wall fractures are rare. They are commonly associated with ipsilateral mandibular fractures and may involve TMJ.[19] In our study maxilla and maxillary sinus fractures were the commonest fractures accounting for 36% of cases. The mode of injury was RTA. Combined anterior and medial wall fractures were the most common injury pattern observed (50%)

Ogura et al.[20] characterized the locations of different mandibular fractures using MDCT. Mandibular fractures were classified into median, paramedian, angle, condylar and coronoid process types. The percentage of multiple mandibular fractures was 80.9% median type, 74.3% paramedian type, 52.9% angle type and 60.9% condylar type. The data showed a significant relationship between multiple fractures and the median type, paramedian type and condylar type in decreasing order. In our study, mandibular fractures accounted for 28 % (14) of total cases. Combined body and ramus fractures was the most common pattern (28.6%).

In present study, orbital bone fracture was present in 28% of cases. RTA was the mode of injury. Lateral wall was the most common fracture (50%) followed by medial wall (28.6%) and roof (14.3%). Combined inferior and medial wall fracture accounted for one case suggestive of complex blow out fracture. This occurs due to force of impact transmitted by the orbital rim to the orbital floor causing it to shatter usually in the middle third portion. The inferior orbital and eyeball usually remains undamaged. The presence of an air-fluid level or the fracture of the maxillary sinus is common.

Obuekewe et al.[21] found that road traffic accidents was responsible for most zygomatic complex fractures. 76.1% were males and 23.9% females. The most common site of fracture in decreasing order were that of the zygomatic bone (88%) zygomatic arch (8.2%), and both the zygomatic bone and arch (3%). In a metaanalysis of maxillofacial trauma by Ravindran et al.,[22] the most prevalent midface injury was in the zygomatic region (209, 36.4%), followed by orbital (102, 17.8%), Le Fort I (18, 3.1%), Le Fort II (43, 7.5%) and Le Fort III (10, 1.7%).

Nasal bone fracture is the commonest isolated bone fractures.23 In our study, nasal bone fracture was present in 26 % of cases. Bony nasal septum fracture was present in 4% cases.

Among the fractures missed by 3D image compared to the axial scans in our study, maxillary sinus medial wall fracture was the commonest one (16%), followed by pterygoid plate fracture (4%), frontal sinus posterior wall (2%), nasal bone (2%) and sphenoid bone (2%) fractures.

In the assessment of frontal bone fracture, detection and displacements were seen better on 3D images in more percentage of patients. However, its extension, especially into posterior wall of sinus or roof of orbit was not adequately visualized due to the overlap of the bony anterior wall of the sinus restricting visualization. 3D images were found to be similar for the detection and description of extent in most patients with zygomatic bone fractures. In the assessment of displacement, it was found to be superior to axial images in most patients.

Kaur et al.[24] evaluated mid facial fractures in 100 patients using 3D CT. It was shown that 3D reconstruction helped in preoperative analysis and surgical planning. It was valuable in case of severe facial injury enabling a clear perception of

extent of major fracture lines and resulting displacement of fragments.

Many studies have noted that 3D reconstructed images are helpful in the evaluation of fracture comminution, displaced components, and complex fractures involving multiple planes. The extent of comminuted fractures is better demonstrated on the 3D-CT, where the size, shape, and displacement of individual fragments are clearly revealed.[25-28] The combination of multislice CT and 3D volume rendering technique allowed several improvements in imaging interpretation.

Absence of free paranasal sinus fluid (clear sinus sign) in facial CT is a highly reliable criterion for excluding fractures involving the paranasal sinus walls.[29]

CONCLUSION

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.

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