Original article

Role of MDCT and 3D computed tomography in the assessment of maxillofacial fractures and their types: a tertiary care hospital experience

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ABSTRACT

Background: Maxillofacial region is a complex anatomical region that is commonly injured due to trauma and Multidetector Computed Tomography and Three-Dimensional Computed Tomography are used for accurate assessment of fractures and associated soft tissue injuries for correct clinical management. The objective of this study was to determine the frequency, various types of maxillofacial fractures and associated injuries using MDCT and 3D computed tomography (3D CT) at Sharif Medical City Hospital, Lahore.

Patients and methods: This was a cross-sectional study, carried out in the Department of Diagnostic Radiology, Sharif Medical City hospital, Lahore from December 2018 to November 2019. 3D reconstructed CT images were obtained in 70 patients with maxillofacial injuries referred to the Radiology Department of Sharif Medical City Hospital, using 16 slices Toshiba® Aquillion Multidetector Computed Tomography scanner. CT images were evaluated by consultant radiologists and data was collected.

Results: The maxillofacial fractures were significantly higher in the male population 61 (87%) than the female population 9 (13%). Road traffic accidents were the most common cause of injury and the mean age was 30±12 years with the most common age group were 21-30 years (32.8%). Maxilla and maxillary sinus wall fracture were commonest fracture 23 (33%) followed by orbital 20 (28%) bone fractures. Hemosinus 22 (31.4%) was the commonest associated injury.

Conclusion: The complex anatomy of the facial bones requires MDCT and 3D CT which offers excellent spatial resolution, and helpful in the accurate diagnosis of the maxillofacial fractures their exact site, number, and associated injuries, and surgical planning.

Keywords:

Maxillofacial fractures, 3D-CT

INTRODUCTION

Maxillofacial injuries are common among trauma patients occurring either in isolation or associated with other serious injuries. Motor vehicle accidents account for the majority of these injuries particularly involving the facial bones, orbits, and adjacent soft tissue structures. Trauma due to falling from a height, physical assault, and sports injury account for a minor proportion of these patients.[1] Over 3400 people die on the world's roads every day and tens of millions of people are injured or disabled every year. WHO predicted that road accidents were claiming 30,310 lives in Pakistan annually. In Pakistan, 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, approximately 20 people out of 100,000 die in road accidents in a year, making Pakistan rank 67 globally for a higher percentage of road traffic accidents. Researchers have mentioned that Punjab has proven to have the highest road accident deaths. 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 trauma patients. Imaging modalities used in the evaluation of the injured maxillofacial region include conventional (plain) films, Multidetector Computed Tomography (MDCT), Three-Dimensional Computed Tomography (3D CT), Orthopantomogram (OPG), and Magnetic Resonance Imaging (MRI).[3,4] Plain radiography is the initial

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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.[5] MDCT with 3D CT 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 mandibular fractures.[5,6] The spatial resolution of MDCT is excellent, which enables Multiplanar Reformations (MPR) and 3D reconstructions allowing better diagnostic accuracy and surgical planning and provides excellent information about fracture comminution and displacement.[7] Involvement of multiple planes in complex fractures can be assessed which aids in surgical management.[8] In MPR and 3D reconstructions there is no additional burden of radiation exposure. A face can be organized in five distinct anatomic regions, nasal, orbital, zygomatic, maxillary, and mandible. Injuries to the face can be classified as a single region or multiple contiguous regions. 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] Aim of this study was to describe various types of maxillofacial fractures, their frequency, and associated injuries with the help of MDCT and 3D CT in patients with maxillofacial injuries.

PATIENTS AND METHODS

This was a cross-sectional study and carried out in the Department of Radiology, Sharif Medical City Hospital, Jati Umra done for a period of one year from Dec 2018 till November 2019. All trauma patients with maxillofacial injuries referred to the Radiology Department of Sharif Medical City Hospital, for the 3D-CT face from the emergency department, fulfilling the inclusion (patients with trauma history along with clinical suspicion of maxillofacial fractures) and exclusion criteria (pregnant patients, previous history of surgery in maxillofacial region and not willing to be part of the study) were enrolled in the study. Informed consent from all the patients was taken for non-contrast MDCT, included in the study. The demographic features, including age and gender, were recorded and history was taken to know the cause of trauma. CT protocol was beam collimation: 2-3 mm, pitch: 1.2, tube current: 220mAs, voltage 120 kV. 3D reconstructed CT images were obtained of each patient using 16 slices Toshiba® Aquillion Multidetector Computed Tomography MDCT with the volumetric acquisition in axial planes from the 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 and examined for fractures (cortical breach/discontinuity of bone, hypodense lines) and associated injuries (skull fractures, scalp hematoma, hemosinus, subdural/ extradural hematoma, subarachnoid hematoma (hyperdense 50-60 HU) contusion, pneumocephalus, subcutaneous and orbital emphysema (air density -1000 HU). Fractures were identified and sub-grouped to nasal bone fractures, zygomatic (arch and body), orbital walls (roof, floor, medial and lateral walls), maxilla and maxillary sinus walls (anterior, medial, lateral walls and alveolar process) frontal sinus, the mandible (angle, body, condyle or neck, parasymphyseal, ramus, coronoid process, alveolar ridge). Le Forte I, II, III, and combined Le Forte (pterygoid plates fracture is mandatory) fractures and Zygomaticomaxillary fracture pattern (fracture of the zygomatic arch, inferior orbital rim, and lateral orbital wall.) were also identified. No patient preparation was required. Collected data were 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

Total of 70 patients were included in the study who sustained trauma to the maxillofacial region. The mean age was 30 (SD: ± 12) years. Table 1 describes the age range of patients with faciomaxillary injuries. Maximum fractures were observed in the age group of 21 to 30 years (32.8%) followed by 11 to 20 years of age (25.7%). The frequency of maxillofacial fractures was higher in males accounting for 61 (87%) of cases whereas, in females, it accounted for only 9 (13 %) of cases with a male: female ratio of 6.7:1. RTA was found to be the most common mode of injury accounting for 62 (88%) cases followed by fall from height in 5 (7.1%) and physical assault in 3 (4.5%) patients. Figure 1 summarizes the types and frequency of various fractures identified in this study.

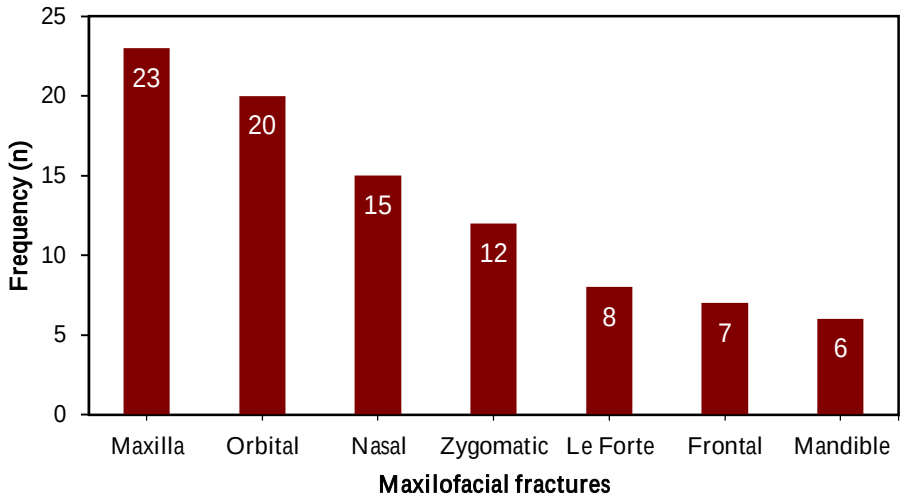

Figure 1. Frequency of various types of maxillofacial fractures

Table 1. Frequency of fractures by age group

Age group (years)	Frequency	Percentage
1-10	05	7.14
11-20	18	25.7
21-30	23	32.8
31-40	10	14.3
41-50	5	7.14
51-60	5	7.14
61-70	2	2.8
71-80	1	1.4
81-90	1	1.4

Table 2. Frequency of maxilla and maxillary sinus fractures

Maxillary sinus fractures	Frequency (*n*=23)	Percentage of maxillary fractures
Anterior wall	05	22
Anterior, medial wall	03	13
Anterior, lateral wall	04	17
Anterior, medial, lateral walls	06	26
Anterior, medial, lateral, alveolar process	03	13
Medial wall, alveolar process	01	4
Lateral wall, alveolar process	01	4

Maxilla and maxillary sinus fractures were the commonest fractures in this study accounting for 23 (33%) cases. Among maxilla and maxillary sinus fractures, combined anterior, medial, and lateral fractures were the commonest 6 (26%) followed by anterior wall fractures alone 5 (22%), combined anterior and lateral wall 4 (17%), and combined anterior and medial wall fractures 03 (13%). The frequency percentage of the maxilla and maxillary sinus fractures is shown in Table 2.

Orbital bone fractures were the second most common fracture, present in 20 (28%) cases. The lateral wall was the most commonly fractured part in orbital fractures, 5 (25%) followed by floor 3 (15%), roof 3(15%), and medial wall 1 (5%). Combined lateral wall and roof fractures were 3(15%), combined lateral wall and floor fractures were 2(10%), combined floor and roof fractures were 2 (10%). Combined lateral, medial walls, and roof fracture accounted for 1 (5%).

Zygomatic bone fractures were found 12 (17.1 %). Nasal bone fractures were present in 15 (21.4 %) patients. Fractures of the mandible were 06 (8.5%) among these most common were found at angle 3 (50%), followed by body 2 (33%) and ramus 1 (17%). Frontal bone fractures accounted for 7 (10%) of total cases with the involvement of frontal sinus in 4 (57%) half of the cases. The temporal bone fracture was present in 6 (8.5%) of cases. The squamous portion was the most common fractured part 4 (66.6%) followed by petrous portion 2 (33.3%). Zygomaticomaxillary fracture pattern was seen in 1 (1.4%) case. Le fort fracture pattern was present in only 8 (11.4%) of total patients with more common compound type, Le Forte I, II 1 (1%), Le Fort II and III 3 (4.2%), Le Fort I, II and III 3 (4.2%). Isolated Le Forte III accounting for 1 (1%). Fractures of pterygoid plates 8 (11.4%) were difficult to assess on 3 D CT and also the extent of fracture was difficult to evaluate in the posterior wall of the frontal sinus. To overcome this difficulty axial sections were used to adjunct 3D imaging. Associated injuries were found and most common were scalp hematoma 22 (31.4%) followed by hemosinus 21(30%) (associated with frontal and maxillary sinus fracture), subcutaneous and orbital emphysema 17(24%), subarachnoid hemorrhage 13 (18.5%), subdural hematoma 13 (18.5%), extradural hematoma 10 (14.2

%), contusions 16 (22.8%) and pneumocephalus 11 (15.7%).

DISCUSSION

The present study was conducted to identify maxillofacial fractures their types, frequency along associated injuries using 3D CT in patients with trauma to the maxillofacial region. There is a difference in the global incidence of maxillofacial fractures mainly due to patients' age, geographical location, level of industrialization, and different seasons.[10] In this study total of 70 patients were referred with maxillofacial trauma and injuries were found to be overwhelmingly common in the male population about 61 (87%) of cases compared to females 9 (13%) with a male: female ratio of 6.7:1. This result was in agreement with Deepak et al. Maximum fractures were observed in the age group of 21 to 30 years 23 (32.8%) followed by 11 to 20 years of age 18 (25.7%). The least amount of fractures were seen in 71 to 90 years of age group 1 (1.4%) with mean age 30 years (SD: ± 12) comparable to other researches done previously.[11] Facial fractures of all injuries are found to be common in young males.[12] Increasing number of maxillofacial injuries among the teenage group is due to social and cultural differences.

In this study, road traffic accidents accounted for the majority of cases of maxillofacial injuries 62 (88.5%) followed by physical assault 5 (07%) and fall from height 3 (4.5%) which are similar to other studies.[11,13] RTA was found more commonly in the winter season especially during fog and on the busy roads.[13] Although the frequent mode of maxillofacial injuries in developing countries in previous studies was road traffic accidents, other study results in developed countries show a high incidence of assault as the commonest cause of maxillofacial injury.[14-17] Causes of faciomaxillary trauma vary in different reports according to social, cultural, and environmental factors.[18] In this study maxilla and maxillary sinus fractures were the commonest fractures accounting for 23 (33%) cases. Among maxilla and maxillary sinus fractures, combined anterior, medial, and lateral wall fractures were the commonest (26%) followed by anterior wall fractures alone (22%), which is similar to a previous report.[19] Le fort fracture pattern was present in only 8 (11.4%) of total patients with more common compound types, Le Forte I, II 1 (1%), Le Fort II and III 3 (4.2%), Le Fort I, II and III 3 (4.2%). Isolated Le Forte III accounting for 1 (1%). These results are in agreement with a study done by Parsad et al.[19] In the present study, orbital bone fractures were second most common, present in 20 (28%) cases as shown by Deepak et al.[13] Lateral wall was the most common fracture 5 (25%) followed by floor 3 (15%) and roof 3 (15%). In this study, the nasal bone fracture was present in 15(21%) cases.[13] In the present study zygomatic fractures were found in 12 (17.1%) of cases.[20] Ogura and coauthors characterized the locations of different mandibular fractures using MDCT. In this study, mandibular fracture accounted for 6 (8.5%) of cases and angle of mandible most common fractured site 3 (50%).[21] 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 the posterior wall of the sinus was not adequately visualized due to the overlap of the bony anterior wall of the sinus restricting visualization. Also, pterygoid plate fractures were difficult to assess on 3D CT due to its anatomical location and axial images were used as an adjunct for pterygoid plate fractures identification, similar to previous studies.[13,19,20] 3D images were very helpful in the detection of maxillary sinus wall fractures and for the detection and description of extent in patients with zygomatic bone fractures. In the assessment of displacement, it was found to be superior to axial images in most patients. Kaur and the group evaluated midfacial fractures in 100 patients using 3D CT.[22] 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 the extent of major fracture lines and the 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 assessed.[23-27] The combination of multislice CT and 3D volume rendering technique allowed several improvements in imaging interpretation. In the present study associated injuries were hemosinus 22 (31.4%) (associated with frontal and maxillary sinus fracture) [28] followed by scalp hematoma 21(30%) and subcutaneous and orbital emphysema 17(24%). The presence of an air-fluid level and the fracture of the maxillary sinus is common. The 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] Other associated injuries were subarachnoid hemorrhage 13 (18.5%), subdural hematoma 13 (18.5%), extradural

hematoma 10 (14.2 %), contusions 16 (22.8%) and pneumocephalus 11 (15.7%), a study done by Elbaih AH et al has shown that brain injuries are commonly associated injuries with maxillofacial trauma.[30,31]

CONCLUSION

The complex anatomy of the facial bones requires multiplanar imaging techniques and 3D MDCT offers excellent spatial resolution, which in turn enables us to correctly diagnose the maxillofacial fractures, localization of the exact site, number, and associated soft tissue injuries, and surgical planning.

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