Assessing Maxillofacial Fractures: The Role of Multidetector Computed Tomography

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Abstract: Background: Maxillofacial fractures are prevalent and necessitate thorough radiological assessment for fracture detection, as well as to delineate their morphology and topography, while also evaluating any associated soft tissue damage.

Aim of Study: The aim of this study was to assess the diagnostic utility of MDCT in identifying maxillofacial fractures.

Patients and Methods: This prospective cross-sectional study was conducted at the Radiodiagnosis Department of Maharajahs Institute of medical sciences, involving twenty-eight patients presenting with facial trauma and suspected facial fractures are referred from the Emergency Department. Among them, there were 23 males and 5 females, with ages ranging from 18 to 50 years and a mean age of 29 years. Each patient underwent both conventional plain radiography and MDCT scans for evaluation.

Results: In the MDCT examination, orbital wall fractures were the most prevalent simple maxillofacial fractures, observed in 7 patients, while zygomaticomaxillary complex fractures were the most common complex fractures, identified in 4 patients. Additionally, among the orbital bony wall fractures, orbital floor fractures were the most frequently encountered, occurring in 8 patients.

Conclusion: MDCT stands out as the superior imaging technique for assessing maxillofacial fractures, offering a level of precision often beyond the reach of conventional radiography or clinical examination. MDCT enables clear visualization of complex injuries, facilitating easy determination of fracture fragment displacement and rotation. Moreover, 3D MDCT emerges as the optimal modality for illustrating the spatial relationships among fracture fragments in maxillofacial fractures.

Introduction

Fractures occurring in the facial region can pose life-threatening risks, such as airway obstruction and significant blood loss. Soft tissue swelling, lacerations, and pain often hinder physical examination of patients with maxillofacial fractures.

Understanding the injury patterns and their clinical implications enables radiologists to provide more clinically relevant reports, facilitating improved communication with referring clinicians. Multidetector Computed Tomography (MDCT) stands out as the preferred imaging modality for evaluating patients with maxillofacial fractures.

MDCT assists in accurately identifying the location, number, and extent of fractures, as well as detecting fragment displacement and soft tissue injuries.

MDCT offers the added advantage of 3D reconstruction and multiplanar reformation in coronal and sagittal planes. These capabilities are particularly valuable for assessing complex fractures involving multiple planes, providing surgeons with crucial information for precise planning and management.

In contrast, the role of MRI in maxillofacial trauma focuses on evaluating soft tissue injuries due to its excellent soft tissue contrast. Additionally, MRI is beneficial for assessing patients with neurological deficits. However, it plays a minimal role in evaluating cortical bone.

The significance of plain radiographs in assessing maxillofacial trauma has diminished over time due to their limited ability to provide comprehensive information.

Patients and Methods

For this prospective cross-sectional study, 28 patients (22 males and 6 females) with a mean age of 38 years were referred from the Emergency Department of Maharajahs institute of medical sciences, In the Department of Radiodiagnosis. The study spanned from February 2023 2018 to July and included individuals aged between 18 and 50 years who had experienced facial skeleton trauma.

All patients underwent conventional plain radiography and MDCT scans. Informed consent was obtained from all participants prior to their inclusion in the study.

Inclusion criteria

- Patients presenting with suspected maxillofacial fractures along with clinical symptoms.
- patients with normal X-ray results but ongoing clinical complaints were also included.

Exclusion criteria involved the exclusion of

- patients with normal findings.
- Pregnant females were also excluded from participation.

Methods involved the following procedures for all patients:

Clinical assessment:

1. Comprehensive history-taking, including personal details such as name, age, and gender, as well as a detailed account of the complaint and present symptoms, including the history of trauma and associated symptoms.

2. Clinical examination conducted initially by the emergency physician before referral to the Radiology Unit.

Radio diagnostic imaging:

1. **Conventional radiography:** Plain X-ray films were performed for all patients included in our study, focusing on the affected side.

2. **MDCT examination**: All patients underwent MDCT imaging as part of the examination protocol.

Examination Technique: MDCT examination of the facial region was conducted for all participants included in this study. Using a 16-Slice MDCT scanner (GE revolution). Patients were positioned supine with their heads directed towards the gantry without any gantry tilt, and no special preparation was required except for normal breathing.

The MDCT protocol involved volumetric data acquisition starting below the mandible and continuing until the frontal sinuses were clear. While direct coronal images were more delicate than reformatted images, obtaining direct coronal images in cases of traumatic maxillofacial fractures proved challenging. Following scanning, the acquired images underwent post-processing and reconstruction. Multiplanar Reconstructions (MRP) were generated using machine software in both coronal and sagittal planes. Thin axial slices from the MDCT scanner and the reconstruction of 3D images served as crucial adjuncts to axial and MRP images for evaluating spatial relationships.

It's important to note that while 3D images are valuable, they shouldn't be solely relied upon for fracture detection and characterization. Multidetector CT has revolutionized CT imaging by transitioning from a trans axial cross-sectional technique to a true 3D imaging modality capable of arbitrary cut planes, offering excellent 3D displays of the data volume. Multi-slice CT scanners offer optimal performance, enabling reductions in scan time, section collimation, and substantially increasing scan length.

Image interpretation: The axial source images and post-processing images were meticulously examined to identify the presence and extent of facial fractures, as well as to assess soft tissue involvement. Fractures were categorized into specific sub-groups, including nasal fractures, nasoethmoidal fractures, complex fractures of the zygomatic malar region, orbital floor fractures, maxillary sinus wall fractures, frontal sinus fractures, jaw fractures, Le Fort fractures, and other miscellaneous fractures.

Final diagnosis of patients was determined based on operative findings obtained during fracture reduction and fixation.

Statistical analysis: data were collected, tabulated, and analysed using SPSS 20 software for Windows, with a significance level set at $p<0.05$.

An example case involves a 52-year-old female who presented to the Emergency Department following a road traffic accident, after which MDCT was conducted.

Results

Table (1), illustrates that the study cohort consisted of 23 males (82.1%) and 5 females (17.8%). Among them, 18 patients (64.28%) were aged ≤30 years, while 10 patients (35.7%) were older than 30. The mean age of the participants was 29±10.5 years.

Our study revealed that road traffic accidents accounted for 50% of the cases, while falls from height represented 21.4%, physical assault accounted for 17.9%, and sports injuries comprised 10.7% of the cases.

According to Table (2), MDCT examinations revealed the presence of several types of simple fractures: orbital wall fractures in 7 cases, nasal bone fractures in 6 cases, mandibular fractures in 3 cases, maxillary sinus wall fractures in 2 cases, fractures of the maxilla (involving the hard palate and alveolar process) in 2 cases, isolated zygomatic arch fractures in one case, and frontal sinus fractures in one case. Consequently, the most prevalent simple maxillofacial fracture observed was the orbital wall fracture, detected in 7 patients.

Table (3) illustrates that MDCT identified various complex fractures, including zygomatico-maxillary complex fractures in 4 cases, Le Fort II fractures in 3 cases, Le Fort I fractures in 2 cases, Le Fort III fractures in 2 cases, and NOE fractures in one case. Consequently, the zygomatico-maxillary complex fracture emerged as the most prevalent complex fracture, observed in cases, accounting for 14.29% of the total.

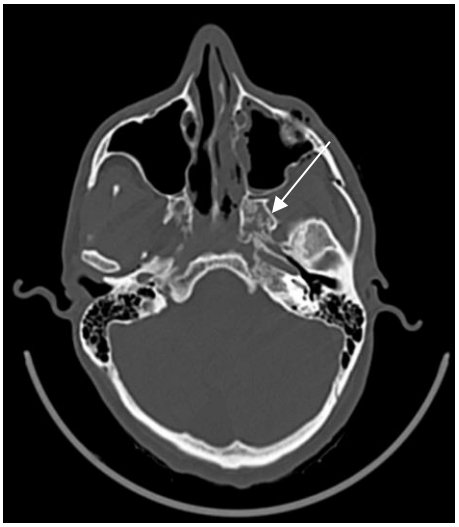
In Table (4), it was revealed that among 28 patients diagnosed with facial fractures, plain X-ray identified simple facial fractures in 20 cases, whereas MDCT detected such fractures in 23 patients. Similarly, Table

Table(5), indicated that while plain X-ray identified 6 complex facial fractures, MDCT detected 12 cases of complex facial fractures.

Table (6) illustrates that for simple fractures, both conventional plain radiography and MDCT demonstrated a sensitivity of 85.2%, specificity of 87.2%, positive predictive value of 93.8%, and negative predictive value of 70%. Regarding complex fractures, they exhibited a sensitivity of 50%, specificity of 93.8%, positive predictive value of 85.7%, and negative predictive value of 71.5%.

Fig (1).Posterior wall of frontal sinus fracture.

Fig(2).Facture of bilateral maxillary walls with hemosinus.



Fig(3).Undisplaced fracture of zygomatic process of left temporal bone

Fig(4).Nasal bone fracture

Fig(5).Fracture extending into alveolar processes and body of maxilla.

Fig(6).Communited mildly displaced fracture involving body of mandible in right paramedian location.

Fig(7).Undisplaced fracture of zygomatic process of left temporal bone with other bony fractures.

Fig(8).Displaced fracture of left styloid process.

Table(1). Age and gender distribution in 28 patients with maxillofacial fractures.

Variables	n=28
Age (years)	
Mean ± SD	29 ± 10.5
Range	18-50
Age groups	
≤30	18 (64.28%)
>30	10 (35.7%)
Gender	
Male	23 (82.1%)
Female	5(17.8%)

Table (2): Distribution of different maxillofacial fractures in 28 patients according to the MDCT findings

	No	%
Orbital fracture	14	50
Nasal fracture	12	42.86
Maxillary sinus wall fracture	9	32.14
Zygomatico-maxillary complex fracture	5	17.86
Mandibular fracture	5	17.86
Fracture maxilla	4	14.3
Frontal sinus fracture	3	10.7
Le Fort II fracture	2	7.14
Le Fort I fracture	2	7.14
Le Fort III fracture	2	7.14

Table (3): Incidence of simple facial fractures in 28 examined patients with maxillofacial fractures.

	No	%
Orbital wall fracture	7	25
Nasal fracture	6	21.43
Mandibular fracture	3	10.7
Maxillary sinus wall fracture	2	7.14
Fracture maxilla	2	7.14
Isolated zygomatic arch fracture	1	3.57
Frontal sinus fracture	1	3.57

Table (4): Incidence of complex facial fractures in 28 patients with maxillofacial fractures.

Complex Facial Fracture	No	%
Zygomatico-maxillary complex (ZMC)	4	14.29
Le Fort II	3	7.14
Le Fort I	2	7.14
Le Fort III	2	7.14
Naso-orbito-ethmoidal (NOE)	1	3.57

Table (5): Incidence of different simple facial fractures detected by X-ray and MDCT.

Facial Fracture	X-ray	MDCT
Orbital wall fracture	5	7
Nasal fracture	5	5
Mandibular fracture	4	4
Maxillary sinus wall fracture	2	2
Fracture maxilla	1	2
Frontal sinus fracture	2	2
Isolated zygomatico-arch fracture	1	1

Table (4): Incidence of complex facial fractures

Complex Facial Fracture	X-ray	MDCT
Zygomatico-maxillary complex (ZMC) fracture	5	5
Le Fort II	0	2
Le Fort I	0	2
Le Fort III	0	2
Naso-orbito-ethmoidal (NOE) fracture	1	1
Total	6	12

Table (7): Diagnostic performance of X-ray and MDCT in diagnosis of simple and complex fractures.

	Sensitivity	Specificity	PPV	NPV
Simple fracture	85.2%	87.2%	94.1%	70%
Complex fracture	50.3%	93.5%	85.6%	71.2%

Discussion

Utilizing multislice CT alongside 3D imaging enhances the interpretation of fracture patterns and bony fragment displacement, thereby facilitating swifter and more precise communication of diagnostic information to the referring physician [4].

In our investigation, the predominant gender among patients was male, comprising 23 individuals, accounting for 82.1% of the total, while the number of female patients was 5, representing 17.8% of the total population. This finding aligns with Ahmad et al. [5], who examined the utility of Multidetector Computed Tomography (MDCT) in facial trauma cases. They observed that males constituted 70% of their study cohort, while females comprised 30%.

In our research, the ages of participants spanned from 18 to 50 years, with a mean age of 29 years. The most common age group was under 30 years, constituting 64.9% of the total, while the least common age group comprised patients over 30 years, totaling 35.7% of the overall population. Ahmad et al. [5] observed a broader age range among patients, from 12 to 70 years. They noted that 55% of patients were between 11 and 30 years old, with 20% falling within the 31 to 40-year-old category.

In our investigation, road traffic accidents emerged as the leading cause of injuries, accounting for 50% of the total cases, followed by falls from height, which constituted 21.4% of the total. Physical assault and sports injuries were also notable, representing 17.9% and 10.7% of the total, respectively. These findings parallel those of Downing et al. [6].

Similarly, Ahmad et al. [5] found that road traffic accidents were the primary cause of injury, accounting for 58.33% of cases, followed by falls from height (20%), physical assault (16.66%), and sports injuries (5%).

In our study, we examined 28 patients presenting with a total of 60 maxillofacial fractures using MDCT. Among these fractures, orbital fractures were the most prevalent, observed in 14 cases (50%). This finding is somewhat consistent with the study by Abdel Wahab et al. [7], who reported orbital fractures as the most common, accounting for approximately 73% of cases, followed by nasal fractures at 63%. However, our results differ from those of Hwang and You [8], who found orbital fractures to be less frequent, representing only 7.6% of cases, ranking third after nasal and mandibular fractures.

In our study, we determined that for simple fractures, conventional plain radiography and MDCT exhibited a sensitivity of 85.2%, specificity of 87.2%, positive predictive value of 94.5%, and negative predictive value of 70%. Conversely, in complex fractures, the sensitivity was 50.3%, with a specificity of 93.8%, positive predictive value of 85.7%, and negative predictive value of 71.5%. These findings align with those of Schuknecht and Graetz [13], who similarly reported the sensitivity of MDCT for detecting simple maxillofacial fractures as 100%, surpassing conventional X-rays with a sensitivity of only 86%.

Ahmad et al. [5] concluded that injuries in the maxillofacial region represent a prevalent emergency necessitating prompt and precise diagnosis for effective management. They found that MDCT exhibits high sensitivity, specificity, and accuracy in detecting fractures, underscoring its importance in clinical practice.

Raju et al. [14] utilized multi-slice Computed Tomography (CT) to identify and classify maxillofacial fractures, highlighting the advantages of three-dimensional (3D) images over traditional two-dimensional axial images in assessing these injuries. Their study demonstrated that MDCT offers superior spatial resolution for evaluating fractures in the maxillofacial region. Specifically, 3D rendered images offer enhanced visualization of fracture patterns and bony fragment displacement, particularly in complex areas like the mandible and zygomatic bone, aiding in more efficient communication of diagnostic information to specialized surgeons. Additionally, 3D imaging proved superior in identifying Le Fort fracture lines. MDCT emerges as an accurate, noninvasive technique for evaluating maxillofacial injuries, boasting shorter scan times and widespread availability.

In our study, we discovered that multidetector CT emerges as the preferred imaging modality for assessing patients with maxillofacial injuries. It provides superior visualization of both hard and soft tissue structures, facilitates multiplanar and three-dimensional image reconstruction, and offers quicker scanning times compared to traditional radiography, with simpler patient positioning. Accurate characterization of facial fractures and associated complications is crucial for surgical planning and appropriate management.

Facial injuries often present as urgent cases, necessitating prompt diagnosis and intervention. Factors such as road traffic accidents and incidents of social violence contribute significantly to the rise in maxillofacial injuries. Due to the intricate nature of facial bone anatomy, comprehensive evaluation requires multiplanar imaging techniques. The primary objective of diagnostic imaging is to identify and precisely localize facial fractures, as well as assess any soft tissue injuries.

Conclusion

MDCT emerges as the optimal imaging tool for identifying facial skeletal fractures, surpassing conventional radiography and clinical examination due to its ability to accurately visualize complex injuries. Its exceptional spatial resolution facilitates detailed multiplanar reformations and precise 3D reconstructions, thereby enhancing diagnostic precision and aiding in surgical planning. MDCT excels in determining fracture fragment displacement and rotation, particularly in complex facial injuries, making it the preferred modality for elucidating spatial relationships among fragments. Consequently, following stabilization of traumatized patients, MDCT typically serves as the primary and most crucial imaging procedure for polytrauma cases.

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