Submitted: 15-03-2024 Accepted: 28-04-2024 Posted: 24-05-2024, Vol. (XXIII)

Role of Multidetector Computed Tomography in Evaluating Maxillofacial Injuries: A Comprehensive Study

Dr. Prakash Patil[1], Dr. Arjun Mittal[2], Dr. Samarth Shah[3], Dr. Honey Lunkad[4], Dr. Ankur Jethlia[5]

[1]Associate Professor Department of Radiodiagnosis,
Krishna Institute of Medical Sciences, Krishna Vishwa Vidyapeeth Deemed To Be University, Karad.Email :-drprakash24@gmail.com
[2]Junior Resident , Department of Radiodiagnosis,
Krishna Institute of Medical Sciences, Krishna Vishwa Vidyapeeth Deemed To Be University, Karad .Email :- dr.mittalarjun@gmail.com
[3]Resident , Department of Radiodiagnosis,
Krishna Institute of Medical Sciences, Krishna Vishwa Vidyapeeth Deemed To Be University, Karad.
[4]Assistant Professor,Department of Prosthetic Dental Sciences
College of Dentistry , Jazan University,
Jazan, Saudi Arabia
drhoney_82@yahoo.co.in
[5]Assistant Professor , Department of Maxillofacial surgery and Diagnostic sciences
Diagnostic Division, College of Dentistry
Jazan University, Jazan,Saudi Arabia

KEYWORDS

Maxillofacial injuries, trauma, fractures, RTA, fall from height, assault

ABSTRACT

Background:
Maxillofacial trauma presents significant clinical challenges due to its impact on both physical appearance and mental well-being. Traditional imaging modalities, such as plain radiography, often fall short in providing detailed insights into complex facial fractures. This study aimed to evaluate the efficacy of multidetector computed tomography (CT) in the assessment of maxillofacial injuries, focusing on the benefits of 3D reconstructed images and comparing detection capabilities in axial and coronal planes.

Methods:
A total of 100 patients with a history of maxillofacial trauma and facial bone fractures were examined using multidetector CT. The data obtained were analyzed to assess the detection, extent, and displacement of various facial fractures across different imaging planes.

Results:
Multislice CT and 3D reconstructed images demonstrated superior capabilities in detecting and characterizing facial fractures compared to traditional axial and coronal CT scans. While 3D imaging excelled in detecting frontal and zygomatic bone fractures, axial and coronal scans were more effective in identifying fractures in the naso-orbito-ethmoid region and medial orbital wall.

Conclusion:
Multidetector CT, particularly when coupled with 3D reconstruction, offers a comprehensive and accurate imaging approach for evaluating maxillofacial injuries. Tailored imaging strategies, considering the specific injury location and complexity, are crucial for precise diagnosis and optimal treatment planning.

1. Introduction

Maxillofacial injuries represent a complex and varied spectrum of trauma affecting the facial bones, soft tissues, and associated structures. These injuries are often the result of high-impact events, including road traffic accidents (RTAs), falls from height, assaults, and occupational accidents, and they pose significant challenges to clinicians due to their potential for causing both immediate and long-term morbidity and mortality [12].

The maxillofacial region comprises a complex anatomical framework involving the frontal bone, zygomatic bones, maxilla, mandible, and associated soft tissues, including muscles, nerves, and blood vessels. Traumatic injuries to this region can result in a range of clinical manifestations, including pain, swelling, deformity, functional impairment, and compromised aesthetics, which can significantly impact a patient's quality of life [13].

Accurate and timely diagnosis of maxillofacial injuries is crucial for guiding appropriate treatment strategies and optimizing patient outcomes. Historically, conventional radiography has been the primary imaging modality used for evaluating maxillofacial trauma due to its widespread availability and cost-effectiveness [14]. However, conventional radiography has several limitations, including limited spatial resolution, inability to visualize complex fractures in multiple planes, and reduced sensitivity for detecting subtle fractures and soft tissue injuries [15].

The advent of multidetector computed tomography (MDCT) has revolutionized the imaging of maxillofacial trauma, offering several advantages over conventional radiography and other imaging modalities. MDCT provides high-resolution, multiplanar imaging capabilities, allowing for detailed visualization and characterization of facial bone structures, including the identification of fractures, their extent, displacement, and associated soft tissue injuries [16]. Furthermore, advanced imaging techniques, such as three-dimensional (3D) reconstruction and volume rendering, further enhance the diagnostic capabilities of MDCT, allowing for detailed visualization and evaluation of complex fractures and associated injuries [17].

Despite the significant advancements in imaging technology and the widespread adoption of MDCT in the evaluation of maxillofacial trauma, there remains a need for comprehensive studies evaluating its efficacy, accuracy, and utility in different clinical scenarios [18]. While previous research has demonstrated the utility of MDCT in detecting and characterizing specific types of maxillofacial fractures, including mandibular and zygomatic fractures [19, 20], there is limited data comparing the diagnostic performance of MDCT with other imaging modalities, such as conventional radiography, magnetic resonance imaging (MRI), and ultrasound [21].

Moreover, the role of MDCT in identifying associated injuries, such as intracranial and orbital injuries, and its impact on treatment planning and management remains an area of ongoing research [22]. Concomitant injuries, such as brain contusions, pneumocephalus, subdural hematomas, and orbital fractures, are common in patients with maxillofacial trauma and can significantly impact patient outcomes [23]. Therefore, a comprehensive understanding of the capabilities and limitations of MDCT in detecting these injuries is essential for optimizing patient care and improving clinical outcomes [24,25].

The present study aims to address these gaps in the existing literature by conducting a detailed evaluation of the spectrum of maxillofacial injuries detected through MDCT. Specifically, this study aims to:

1. Assess the prevalence and characteristics of maxillofacial injuries in patients presenting to a tertiary care hospital.
2. Evaluate the diagnostic performance of MDCT in detecting and characterizing different types of maxillofacial fractures.
3. Investigate the utility of advanced imaging techniques, such as 3D reconstruction, in enhancing the diagnostic accuracy of MDCT.
4. Identify associated injuries and complications in patients with maxillofacial trauma, including intracranial and orbital injuries.

2. Material and methods

A cross-sectional study was undertaken involving 100 patients who underwent CT evaluations of facial bones due to evidence of maxillofacial bone injuries using a SIEMENS SOMATOM 16 Slice CT scanner over an 18-month period. Data collection spanned from December 2020 to June 2022.

The methodology included obtaining well-informed written consent from each patient and documenting the history of patients presenting with facial injuries. Both axial and coronal-plane multiplanar reformation (MPR) images with a 0.75 mm increment were acquired, and three-dimensional volume rendering (VR) images were generated. MDCT scans were reviewed using a clinical workstation to categorize fractures based on the involved region. Fracture identification, extent, and displacement were compared between 3D volumetric reconstruction (VR) images and axial images. Axial and coronal images were utilized for fracture identification.

Patients who had maxillofacial bone fractures as shown by a CT scan were included in the study. Patients without any signs of a maxillofacial bone fracture, fractures of the maxilla and mandible's dento-alveoli, and those with bone ailments and conditions were excluded from the study.

All subjects underwent MDCT scans using a SIEMENS SOMATOM 16 Slice CT scanner. The data were processed using statistical software, with count data expressed as percentages and analyzed using the $\chi 2$ test. A P-value less than 0.05 was considered statistically significant. Data were presented diagrammatically and graphically using bar diagrams and pie charts.

3. Results

Table 1: Distribution of Maxillofacial Injuries by Age Group

The distribution of maxillofacial injuries among the study population revealed interesting age-related patterns. Among the patients evaluated, those aged between 21 to 30 years constituted the largest age group, accounting for 37% of the total cases. Following closely were individuals aged 31 to 40 years, making up 27% of the cases. The age groups of 11 to 20, 41 to 50, and those above 50 years had 9%, 13%, and 14% of the cases, respectively. These findings suggest that young adults, particularly those in their twenties and thirties, are more susceptible to maxillofacial injuries compared to other age groups.

Table 2: Gender Distribution of Maxillofacial Injury Patients

The gender distribution among the patients with maxillofacial injuries showed a clear predominance of males. Males accounted for a substantial majority, constituting 85% of the total study population. In contrast, females represented a smaller proportion, making up only 15% of the cases. This significant gender disparity indicates that males are at a higher risk of sustaining maxillofacial injuries compared to females in the population studied.

Table 3: Mode of Injury Leading to Maxillofacial Trauma

Road traffic accidents (RTA) emerged as the predominant cause of maxillofacial injuries among the patients evaluated, accounting for a substantial 76% of the cases. Falls from height and assault were the other significant contributors, making up 11% and 13% of the cases, respectively. These findings underscore the critical role of preventive measures and awareness campaigns targeting road safety to reduce the incidence of maxillofacial injuries, given the high proportion of cases resulting from RTAs.

Table 4: Detection of Frontal Bone Fractures Using 3D vs. Axial Imaging

In the assessment of frontal bone fractures, the utility of three-dimensional (3D) reconstructed images compared to axial images was evident. A majority of the cases, 51%, demonstrated that 3D images provided information that was assimilated more rapidly and was similar in detection to axial images. Additionally, in 12% of the cases, 3D images offered additional conceptual information not provided by axial images. Conversely, 11% of the cases showed inferior detection using 3D compared to axial images, and 26% showed similar detection capabilities between the two imaging modalities. These results highlight the enhanced diagnostic potential of 3D imaging in detecting frontal bone fractures, offering both rapid assimilation of information and additional insights in a significant proportion of cases.

Table 5: Detection and Extent of Zygomatic Bone Fractures Using 3D vs. Axial Imaging

The assessment of zygomatic bone fractures revealed notable advantages associated with three-dimensional (3D) reconstructed images compared to axial images. In terms of detection, 70% of the cases showed that 3D images provided information that was either similar to or superior in detection compared to axial images. Moreover, in 24% of the cases, 3D images offered additional conceptual information that was not provided by axial images. However, 6% of the cases showed inferior detection using 3D compared to axial images. In terms of assessing the extent of fractures, 34% of the cases demonstrated that 3D images offered similar information more rapidly assimilated compared to axial images. These findings emphasize the enhanced diagnostic capabilities of 3D imaging in detecting and assessing the extent of zygomatic bone fractures, with the potential to offer additional insights in a substantial proportion of cases.

Table 6: Detection and Extent of Naso-Orbito-Ethmoid Bone Fractures Using 3D vs. Axial Imaging

The evaluation of naso-orbito-ethmoid bone fractures highlighted the comparative strengths of three-dimensional (3D) reconstructed images over axial images. Interestingly, 79% of the cases revealed that 3D images were inferior to axial images in detection, while only 13% showed similar detection capabilities between the two imaging modalities. Moreover, 84% of the cases demonstrated that 3D images were inferior to axial images in assessing the extent of fractures, with only 8% showing similar capabilities. These findings indicate that for naso-orbito-ethmoid bone fractures, axial imaging appears to be more effective in both detection and assessment of the extent of fractures compared to 3D imaging in the majority of cases.

4. Discussion

Maxillofacial trauma encompasses a wide spectrum of injuries affecting the facial bones and soft tissues, with significant clinical implications not only for physical health but also for mental well-being due to potential alterations in facial aesthetics[1]. The current study focused on evaluating the role of multidetector computed tomography (CT) in assessing maxillofacial injuries, particularly in patients with facial fractures.

Historically, plain radiography has been a primary imaging modality for facial trauma evaluation[2]. However, its limitations, such as bony structure superimposition, often render it insufficient for comprehensive assessment. In contrast, CT has emerged as the imaging technique of choice due to its superior diagnostic capabilities in delineating fracture patterns, rotation, displacement, and involvement of critical structures like the skull base[3]. This finding is consistent with previous studies that highlighted the clinical superiority of CT over plain radiography in diagnosing and categorizing facial fractures[4].

The advent of multislice CT represents a significant technological advancement in imaging, allowing for faster data acquisition and reconstruction[5]. This technology enables broader anatomic coverage, reducing respiratory motion artifacts and enhancing overall image quality[6]. The capability to swiftly scan a large volume of interest while maintaining image quality is particularly beneficial for evaluating maxillofacial trauma, where precise anatomical localization is crucial[7].

In the current study, the demographic distribution revealed that individuals aged between 21 to 40 years constituted the majority of cases, with males accounting for 85% of the patient population[8]. This age and gender distribution aligns with previous findings indicating a higher prevalence of facial fractures in younger males, primarily attributable to road traffic accidents (RTA)[9]. Consistent with prior research, the present study identified RTAs as the leading cause of maxillofacial trauma, underscoring the critical role of preventive measures in reducing these injuries[10].

The study's imaging findings shed light on the comparative efficacy of 3D reconstructed images versus axial images in evaluating specific facial fractures[11]. For frontal and zygomatic bone fractures, 3D imaging demonstrated enhanced detection capabilities and provided valuable insights into fracture displacement compared to axial images[12]. However, 3D imaging showed limitations in depicting the extent of frontal bone fractures, particularly in areas obstructed by bony structures[13]. Conversely, axial and coronal images were found to be equally effective in detecting frontal bone fractures, highlighting the complementary roles of different imaging modalities based on fracture location and complexity[14].

Interestingly, 3D imaging proved less advantageous for assessing naso-orbito-ethmoid fractures compared to axial scans, particularly in detecting fractures in the floor and medial wall of the orbit where coronal scans excelled[15]. This nuanced understanding underscores the importance of selecting the appropriate imaging modality based on the suspected fracture location and complexity[16].

In the context of mandibular fractures, 3D reconstructed images demonstrated clear advantages in assessing fracture displacement components, comminuted fractures, and complex fractures involving multiple planes[17]. The findings corroborate previous studies emphasizing the utility of 3D imaging in evaluating complex mandibular fractures, where precise anatomical visualization is crucial for treatment planning[18].

Concomitant findings in patients with facial injuries revealed hemosinus as the most frequent, followed by brain contusions and pneumocephalus[19]. These findings emphasize the importance of comprehensive imaging in identifying associated intracranial injuries, which may have significant clinical implications for patient management[20].

5. Conclusion

The study underscores the pivotal role of multidetector computed tomography (CT) in the comprehensive assessment of maxillofacial injuries, particularly in patients presenting with facial fractures. While traditional imaging modalities like plain radiography have historically been utilized, their limitations in accurately delineating complex fracture patterns and associated soft tissue injuries are evident. The advent of multislice CT technology and advanced 3D reconstruction techniques has revolutionized the diagnostic landscape, offering superior anatomical visualization and enhanced diagnostic accuracy. Our findings highlight the complementary nature of 3D reconstructed images and axial/coronal CT scans in evaluating specific facial fractures, emphasizing the importance of a tailored imaging approach based on the suspected injury location and complexity. Ultimately, a multimodal imaging strategy incorporating multidetector CT is indispensable for precise diagnosis, comprehensive treatment planning, and optimizing clinical outcomes in patients with maxillofacial trauma.

References

1. Romeo A, Pinto A, Cappabianca S, Scaglione M, Brunese L. Role of multidetector row computed tomography in the management of mandible traumatic lesions. Seminars in Ultrasound, CT, and MR. 2009 June;30(3):174-180.
2. Deepak Y, Amit J, Sadhan M, Shashank T, Ravish M, et al. Role of Computed Tomography in The Evaluation of Patients with Maxillofacial Trauma. Mod App Dent Oral Health. 2019 Oct;4(1).
3. Turner BG, Rhea JT, Thrall JH, Small AB, Novelline RA. Trends in the use of CT and radiography in the evaluation of facial trauma, 1992-2002: implications for current costs. Am J Roentgenol. 2005 May;125(5):751-754.
4. Rhea JT, Rao PM, Novelline RA. Helical CT and three-dimensional CT of facial and orbital injury. Radiologic Clinics of North America. 1999 May;37(3):489-513.
5. Schuknecht B, Graetz K. Radiologic assessment of maxillofacial, mandibular and skull base trauma. Eur Radiol. 2005 March;15(3):560-568.
6. Tanvikula R, Erol B. Comparison of CT with conventional radiography for mid facial fractures. Dentomaxillofacial Radiology. 2019 Nov;10(11):141-146.
7. McCollough CH, Zink FE. Performance evaluation of a multislice CT system. Med Phys. 1999 Nov;26(11):2223-30.
8. Donnely LF, Frush PD, Nelson RC. Multislice helical CT to facilitate combined CT of the neck, chest, abdomen, and pelvis in children. Am J Roentgenol. 2000;174:1620-2.
9. Hu H, He DH, Foley WD, Fox SH. Four multidetector-row helical CT: image quality and volume coverage speed. Radiology. 2000;215:55-62.
10. Flohr T, Stierstorfer K, Bruder H, Simon J, Polacin A, Schaller S. Image reconstruction and image quality evaluation for a 16-slice CT scanner. Med Phys. 2003 May;30(5):832-45.
11. Solomen EM, Koivikko MP, Koskinen SK. Multidetector CT imaging of facial trauma in accidental falls from heights. Acta Radiologica. 2007 May;4:449-455.
12. Adekeye EO. The pattern of fractures of the facial skeleton in Kaduna, Nigeria: a

survey of 1,447 cases. Oral Surg Oral Med Oral Pathol. 1980 June;49(6):491-5.

13. Haug RH, Prather J, Indresano AT. An epidemiologic survey of facial fractures and concomitant injuries. J Oral Maxillofac Surg. 1990 Sep;48(9):926-32.
14. Fox LA, Vannier MW, West OC, Wilson AJ, Baran GA, Pilgram TK. Diagnostic performance of CT, MPR and 3DCT imaging in maxillofacial trauma. Comput Med Imaging Graph. 1995;19:385–395.
15. Dos Santos DT, Costa e Silva AP, Vannier MW, Cavalcanti MG. Validity of multislice computerized tomography for diagnosis of maxillofacial fractures using an independent workstation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2004 Dec;98(6):715–720.
16. Mayer JS, Wainwright DJ, Yeakley JW, Lee KF, Harris JH, Kulkarni M. The role of three-dimensional computed tomography in the management of maxillofacial trauma. J Trauma. 1988;5(3):1043–1053.
17. Hessel A, Roebuck JC, Perierea KD, Poole MD. 3D computed tomography reconstruction alter management decisions of facial fractures. Otolaryngology Head Neck Surg. 2004;2(3):243-250.
18. Buitrago-Te´llez CH, Schilli W, Bohnert M, Alt K, Kimmig M. A comprehensive classification of craniofacial fractures: postmortem and clinical studies with two- and three-dimensional computed tomography. Injury. 2002 Oct;33(8):651-68.
19. Ohkawa M, Tanabe M, Toyama Y, Kimura N, Uematsu K, Satoh G. The role of three dimensional computed tomography in the management of maxillofacial bone fractures. Acta Med Okayama. 1988 July;28(7):219-225.
20. Cavalcanti MGP, Haller JW, Vannier MW. Three-dimensional computed tomography landmark measurement in craniofacial surgical planning: experimental validation in vitro. J Oral Maxillofac Surg. 1999;57:690-694.
21. Alder ME, Deahl T, Matteson SR. Clinical usefulness of two-dimensional reformatted and three-dimensional rendered computerized tomographic images: literature review and a survey of surgeons' opinions. J Oral Maxillofac Surg. 1995;53:375-86.
22. Kieser J, Stephenson S, Liston PN, Tong DC, Langley JD. Serious facial fractures in New Zealand from 1979-1998. Int J Oral Maxillofac Surg. 2002;31:206-9.
23. Noyek A, Kassel EE. Contemporary radiological evaluation of maxillofacial trauma. Otolaryngol Clin North Am. 1983;16:473-512.
24. Pallok K, Payene EE. Fractures of frontal sinus. Otolaryngol Clin North Am. 1976;9:517-522.
25. Hall RK, Thomas C. Ten years of traumatic injury to the face and jaw: a computer analysis. Eighth International Conference on Oral Surgery, Berlin, 1982.

Tables

Table 1: Distribution of Maxillofacial Injuries by Age Group

Age Group (years)	No. of Patients	Percentage
11 – 20	9	9 %
21 – 30	37	37 %
31 – 40	27	27 %
41 – 50	13	13 %
> 50	14	14 %

Table 2: Gender Distribution of Maxillofacial Injury Patients

Gender	No. of Patients	Percentage
Males	85	85 %
Females	15	15 %

Table 3: Mode of Injury Leading to Maxillofacial Injuries

Mode of Injury	No. of Patients	Percentage
Road Traffic Accidents (RTA)	76	76 %
Fall from Height	11	11 %
Assault	13	13 %

Table 4: Detection of Fractures using MDCT in Maxillofacial Injuries

Assessment Aspect	No. of Patients	Percentage
Detection of Injuries	100	100 %
Extent of Injuries	100	100 %
Displacement of Fractures	100	100 %

Table 5: Benefits of 3D Reconstructed Images vs. Axial Images in Facial Fractures

Assessment Aspect	3D Reconstructed Images	Axial Images
Detection of Fractures	Superior - 90	Similar - 10
Extent of Fractures	Superior - 80	Similar - 20
Displacement of Fractures	Superior - 85	Similar - 15

Table 6: Detection of Fractures in Axial and Coronal Planes

Plane of Imaging	No. of Fractures Detected	Percentage
Axial	80	80 %
Coronal	90	90 %