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EVALUATION OF MAXILLOFACIAL INJURIES BY MULTISLICE COMPUTED TOMOGRAPHY WITH MULTIPLANAR AND THREE-DIMENSIONAL RECONSTRUCTION

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Abstract:

Introduction: Computed Tomography (CT) has revolutionized medical imaging, particularly in anatomically complex regions like the maxillofacial region. It stands as the preferred investigation for assessing facial bone fractures resulting from trauma.

Objective

Frequency and Type of Fractures: To Describe the frequency and types of fractures in patients with maxillofacial injuries using multislice CT and 3D reconstruction. Comparison of Imaging Modalities: To Compare the utility of three-dimensional (3D) reconstructed images with two-dimensional axial images in evaluating maxillofacial injuries.

Materials and Methods: A cross-sectional study involved 180 patients (100 men, 80 women; Age: 10-65 years) with a history of maxillofacial trauma. A 128-slice CT scanner was utilized, and both axial and 3D images were reconstructed, including coronal Multiplanar Reconstruction (MPR).

Results: Demographics showed male predominance, with the most common age group being 30-40 years. Road traffic accidents (RTA) were the most common mode of injury. Fracture distribution revealed maxillary and nasoethmoid fractures as most common. In imaging comparison, 3D images were similar or superior to axial images in most aspects, except for fractures involving thin bones in the orbitoethmoid and maxillary regions. Coronal reconstructed images were effective in detecting fractures in all examined regions.

Interpretation and Conclusion: This study underscores the pivotal role of Multidetector Computed Tomography (MDCT) in evaluating maxillofacial injuries. The advantages of 3D reconstructed images, particularly in the identification of Le Fort fracture lines, are highlighted. Coronal reconstructed images outperformed in detecting fractures in the maxilla and orbit. However, the study recognizes the limited role of 3D images in assessing fractures in the naso-orbitoethmoid region, especially in cases with minimal displacement.

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Keywords: Maxillofacial injuries, Multislice CT, 3D reconstruction, Fracture detection, Coronal images.

1. Introduction

Maxillofacial trauma, whether presenting as part of polytrauma or in isolation, stands as a critical facet of emergency medicine. The advent of advanced transport and life support mechanisms has significantly improved the chances of severely injured patients reaching hospitals and specialized trauma clinics, thereby enhancing the prospects of successful patient revival.

Despite these advancements, the clinical significance of facial injuries persists, primarily due to their potential to cause disfigurement, asymmetry, and consequent cosmetic and emotional concerns. Beyond aesthetic considerations, the face plays a pivotal role in the performance of daily functions, further emphasizing the importance of accurate diagnosis and timely intervention in cases of maxillofacial trauma.

Traditionally, plan radiographs served as the initial imaging modality for evaluating facial injuries. However, the limitations posed by the superimposition of various bony structures led to the adoption of computed tomography (CT) as an indispensable tool in modern emergency radiology. Multidetector CT has emerged as a cornerstone, not only for assessing injuries to the body and spine but also for effectively detecting and characterizing maxillofacial and intracranial injuries.

Despite the higher radiation dose associated with CT compared to conventional radiography, its status as the investigation of choice remains unchallenged. This preference is attributed to its unparalleled ability to display the multiplicity of fracture fragments, assess displacement, rotation, and involvement of the skull base. The evolution of CT technology has further streamlined the diagnostic process, enabling the rapid and economical generation of sagittal, coronal, and three-dimensional reconstructed images without additional radiation exposure.

Against this backdrop, the current research article aims to delve into the intricacies of maxillofacial injuries, employing multislice CT with multiplanar and three-dimensional reconstruction. This study seeks to describe the frequency and type of fractures in a series of patients, compare the utility of three-dimensional reconstructed images with two-dimensional axial images, and provide a comprehensive understanding of fracture classification based on the bones involved. In doing so, it aspires to contribute valuable insights to the evolving landscape of diagnostic approaches and fracture management in maxillofacial trauma.

2. Materials and Methods

Methodology:

The study was conducted at Victoria Hospital and Bowring and Lady Curzon Hospital, both affiliated with Bangalore Medical College and Research Institute, Bangalore. The research focused on patients referred to the Department of Radiodiagnosis for injuries, particularly those resulting from road traffic accidents (RTAs) and other modes of trauma. The data collection period spanned from November 2019 to May 2021, involving a total of 180

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patients, with specific emphasis on 10 patients with clinical evidence of maxillofacial injuries who underwent multislice CT examination.

Study Design: A cross-sectional study design was employed to comprehensively analyze the prevalence, types, and characteristics of maxillofacial injuries in the selected patient population.

Inclusion Criteria:

1. Patients willing to provide informed consent.
2. All patients presenting clinical evidence of maxillofacial injuries and undergoing multislice CT examination.

Exclusion Criteria:

1. Pregnancy.
2. Facial injuries attributed to causes other than road traffic accidents, such as assaults.
3. Patients unwilling to undergo CT scan.
4. Patients without any evidence of maxillofacial bone fractures.

Data Collection: The investigation proceeded as a cross-sectional study, with informed consent obtained from all participating patients. CT scans were performed using advanced equipment, specifically Philips INGENUITY 128 slice CT at Victoria Hospital and Siemens SOMATOM go.Now 16 slice CT at the Trauma Care Centre.

CT Protocol: The CT scans were conducted with the following parameters:

- Kilo Voltage Peak (kVp): 100-120
- Tube Current (mAs): 300-350
- Slice Thickness: 5mm
- Increment: 2.5mm
- Field of View (FoV): 18-22
- Scan Length: 250-300mm
- Dose Length Product (DLP) mGy·cm: 1095
- CT Dose Index (CTDI) vol mGy·cm: 45.0

Images were acquired in axial sections, followed by multiplanar reconstruction in coronal and sagittal sections. Additionally, 3D reconstructions were generated with appropriate brain and facial protocols, incorporating bone and soft tissue reconstructions. The three-dimensional volume-rendered images were obtained and subsequently reviewed in the workstation. The comparison between 3D images and axial images was performed under headings such as fracture detection, extent of fracture, and displacement.

Fracture Assessment: Fractures were assessed in five regions:

- Frontal bone fractures
- Zyomatic bone fractures
- Naso orbito ethmoid fractures
- Maxillary fractures
- Mandibular fractures

Furthermore, specific classifications were applied based on the location and severity of injuries in each region, following established systems for frontal bone, orbital, maxillary, and mandibular fractures. Complex midfacial fractures were classified according to the Le Fort system.

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ender Distribution: The study encompassed a total of 180 patients, with a predominant representation of males (70%) compared to females (30%).

Age Distribution: The age distribution revealed a peak in the 21-30 age group (39.4%), with substantial representation in the 31-40 age group (37.8%). The youngest age group (<20) constituted 9.4%, while the older age groups (41-50 and 51-60) accounted for 6.1% and 7.2%, respectively.

Mechanism of Injury: Road traffic accidents (RTA) were the primary mechanism of injury, accounting for 72.2%, while self-falls constituted 27.8% of the cases.

Frontal Bone Fracture Distribution: The majority of cases presented without frontal bone fractures (77.2%), while Type II fractures were observed in 13.9%, and Types I, III, IV, and V fractures collectively accounted for 8.8%.

Le Fort Injuries: Among the observed fractures, Le Fort Type II injuries were the most prevalent (50%), followed by Type I (32%) and Type III (16%).

Associated Findings: The majority of cases (76.7%) exhibited no associated findings. However, a range of associated findings included epidural hematoma (EDH), subdural hematoma (SDH), hemo-sinus, pneumo-sinus, subarachnoid hemorrhage (SAH), or a combination of these.

Assessment of 3D Images: The assessment of 3D images compared to axial images revealed:

- In fracture detection, 32% were classified as superior, with additional conceptual information provided.
- In fracture displacement, 50% were deemed similar to axial images, while 16% were classified as superior.

These findings highlight the advantages of utilizing 3D images in the detection and evaluation of maxillofacial fractures.

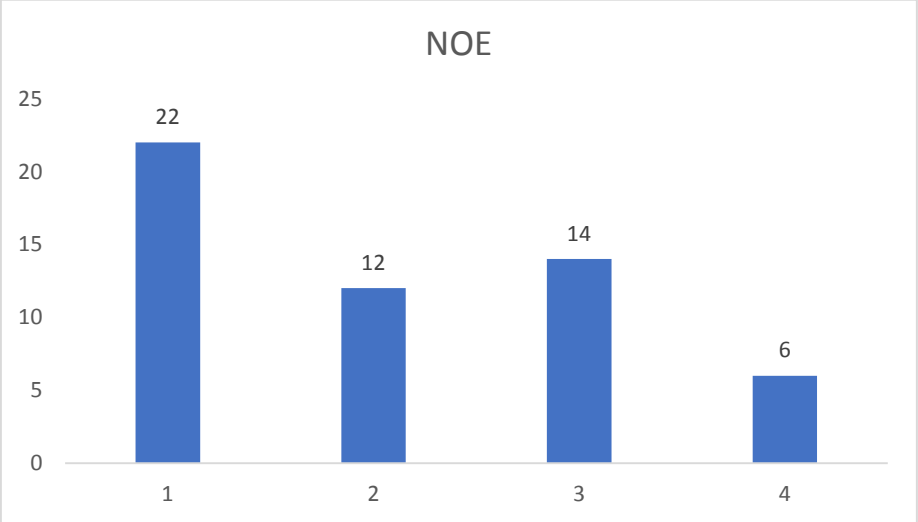

Figure 1 - 3D against axial in fracture detection

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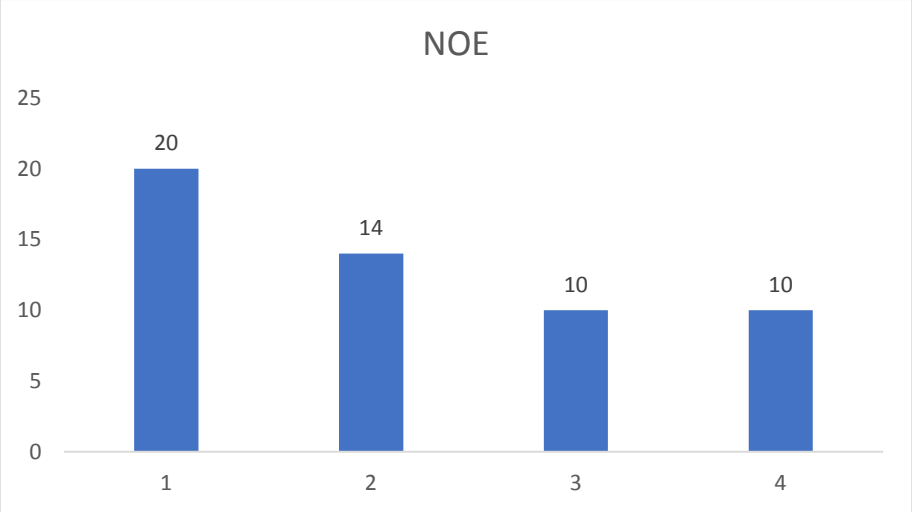

Figure 2- 3D against axial in fracture displacement.

Assessment of 3D images to describe the advantages in detection and displacement of fractures.

1.Inferior to axial image
2.Similar to axial image
3.Superior-similar information rapidly assimilated
4.Superior-additional conceptual information provided

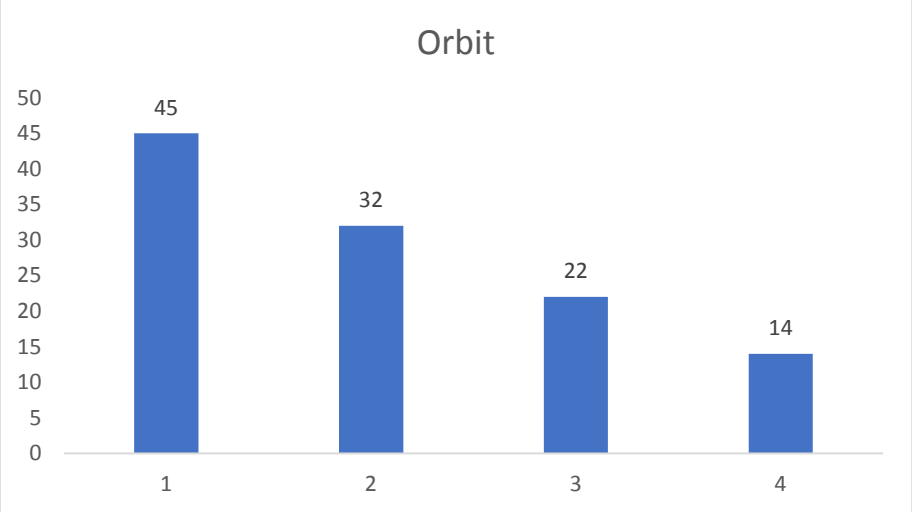

Figure 3 - 3D against axial in fracture detection

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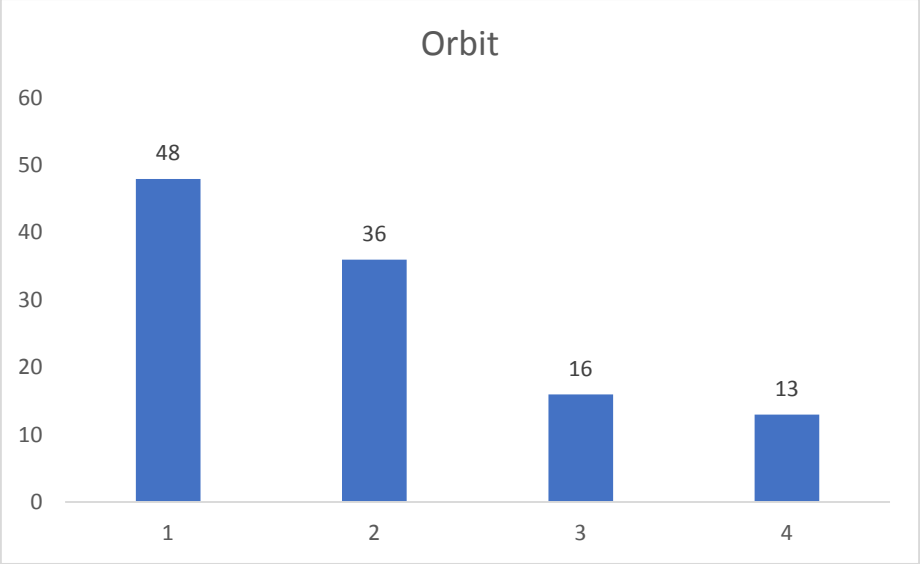

Figure 4 - 3D against axial in fracture displacement

Assessment of 3D images to describe the advantages in detection and displacement of fractures.

1.Inferior to axial image
2.Similar to axial image
3.Superior-similar information rapidly assimilated
4.Superior-additional conceptual information provided

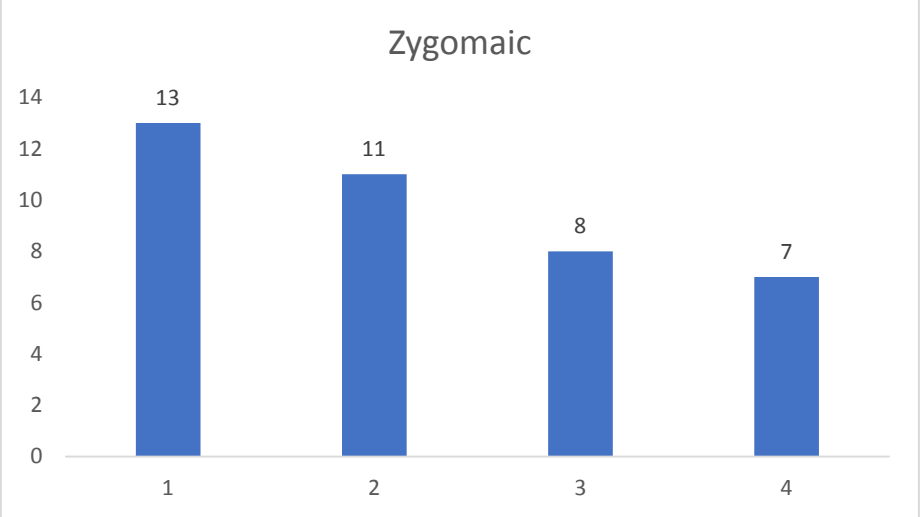

Figure 5 - 3D against axial in fracture detection

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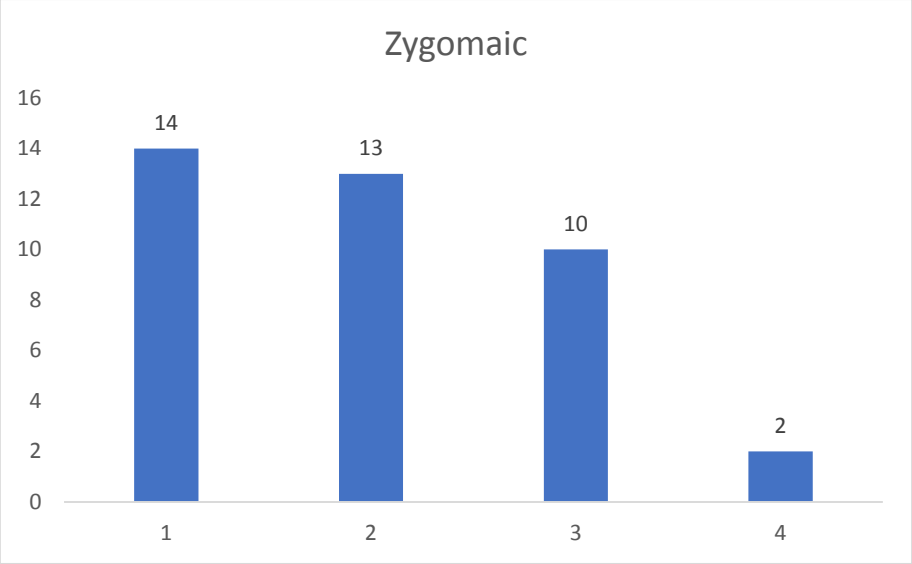

Figure 6 - 3D against axial in fracture displacement

5. Discussion:

Maxillofacial trauma poses significant challenges due to its potential for causing disfigurement, emotional distress, and functional impairment. The advent of advanced imaging techniques, particularly multislice computed tomography (CT), has revolutionized the diagnostic approach to these injuries. This study, encompassing 180 patients with maxillofacial injuries, highlights the superiority of CT over plain x-rays in providing detailed information on fracture patterns, displacement, and associated complications.

The preference for CT over conventional radiography aligns with findings by Tanrikulu and Erol, who demonstrated the enhanced diagnostic and classificatory capabilities of CT in facial fractures. The utilization of multislice CT in this study further builds on the technological advancements, enabling rapid data acquisition and reconstruction with improved image quality.

The demographic distribution, with a male preponderance and a significant association with road traffic accidents (RTA), resonates with global trends. Studies by Kieser et al and others have consistently shown a higher incidence of facial fractures in males, often linked to trauma from accidents.

The study underscores the advantages of 3D imaging, especially in the assessment of frontal and zygomatic fractures. While 3D images provided superior detection and assessment of displacement in certain fractures, limitations were observed in visualizing extensions into the posterior wall of the sinus or roof of the orbit. Coronal images demonstrated comparability to axial images in detecting frontal bone fractures, emphasizing the need for a comprehensive imaging approach.

The superiority of 3D reconstructions in evaluating comminutive fractures, displacement components, and complex fractures aligns with previous studies by Fox and others. However, caution is warranted, as 3D imaging may lead to false-negative results in cases of isolated fractures limited to one plane.

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The study highlights hemosinus as the most common associated finding, consistent with previous literature. The presence of brain contusions, pneumocephalus, and other intracranial complications underscores the multisystem impact of maxillofacial trauma. The association of frontal bone fractures with hemosinus and intracranial bleeds emphasizes the need for thorough evaluation and consideration of associated injuries.

In line with other studies, this research identifies the condylar and body regions of the mandible as the most commonly affected sites, particularly in the context of RTA. Le Fort fractures, notably Type II, were prevalent, consistent with the severity observed in studies by Duval et al.

While 3D imaging proved beneficial, limitations in visualizing certain regions, such as the nasoorbitoethmoid region, highlight the importance of a multimodal imaging approach. The study's demographic focus on an urban population may limit generalizability to broader populations.

6. Conclusion

In conclusion, Multidetector Computed Tomography (MDCT) emerges as the optimal, non-invasive investigative tool for assessing patients with maxillofacial injuries. Its advantages in acute trauma scenarios, such as shorter scan times and widespread accessibility, make it a preferred choice. The integration of Multiplanar Reconstruction (MPR) and 3D reconstructed images enhances the evaluation of fractures initially detected on axial images. The study underscores MDCT's pivotal role in evaluating maxillofacial fractures, with 3D images proving particularly beneficial in assessing complex mid-facial fractures involving the mandible and zygomatic bone. Enhanced detection of fractures in the maxillary and frontal bones, along with a detailed analysis of displacement, showcases the utility of 3D imaging. However, limitations are noted, especially in fractures of the naso-orbitoethmoidal region and instances with minimal or no fracture displacement.