e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2025; 17(3); 2250-2255

Original Research Article

Advantages of MDCT in Evaluation of Frontal Bone Fractures using 3D and Coronal Reformatted Images Compared to Axial Images

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Received: 03-01-2025 / Revised: 10-02-2025 / Accepted: 06-03-2025
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Conflict of interest: Nil

Abstract:

Background: Computed tomography (CT) has revolutionized diagnostic imaging, particularly in the maxillofacial region, which is one of the most anatomically complex areas of the human body. It is currently the preferred modality for detecting facial bone fractures resulting from trauma.

Aim: This study aimed to evaluate the advantages of three-dimensional (3D) reconstructions and coronal reformatted images compared with conventional axial CT images in diagnosing frontal bone fractures.

Materials and Methods: The research was conducted at a tertiary care hospital in North India using a 128-slice GE Revolution CT scanner. Along with axial sections, coronal multiplanar reformatted (MPR) and 3D volume-rendered images were generated. Their diagnostic value in identifying and characterizing fractures was assessed in comparison with axial images.

Results: For most patients, 3D reconstructions provided equal or superior diagnostic accuracy compared with axial views. Coronal images also proved to be either equivalent or better in detecting fracture lines and extensions.

Conclusion: This study demonstrates the added value of 3D reconstructions and coronal reformatted images over axial sections in the assessment of frontal bone fractures. Multidetector CT is highly effective in evaluating such injuries and provides crucial information for clinical and surgical decision-making.

Introduction

Facial fractures represent a significant portion of emergency department admissions worldwide and are often associated with high morbidity and mortality. These outcomes are largely due to damage to facial structures, associated complications, and concurrent injuries to other body regions [1].

The diagnosis of maxillofacial trauma has become more precise with advances in trauma care. Although fractures can frequently be suspected based on clinical findings, swelling, bleeding, and soft tissue damage may obscure key indicators, making imaging indispensable [2].

The maxillofacial skeleton is among the most intricate anatomical regions, not only structurally but also because of its functional importance in daily life. Accurate diagnosis of fractures in this region requires both a thorough understanding of normal radiological anatomy and advanced imaging modalities.

While plain radiography was historically the first-line investigation for facial trauma, its diagnostic value has declined in recent years. Multidetector computed tomography (MDCT) is now regarded as the gold standard for assessing maxillofacial injuries, owing to its high accuracy, speed, and ability to detect both bone and soft tissue injuries [3,4]. Unlike traditional imaging, MDCT can clearly depict the number, location, and displacement of fracture fragments, as well as associated complications.

A major advantage of MDCT is its ability to produce three-dimensional (3D) reconstructions and multiplanar reformatted (MPR) images. These reconstructions provide detailed visualization of fracture patterns, fragment displacement, and comminution. Such information is invaluable for surgical planning and clinical management [5].

Given these benefits, this study explores the diagnostic utility of coronal reformatted and 3D reconstructed images in comparison to

conventional axial images for detecting and characterizing frontal bone fractures.

Materials and Methods

This prospective observational study was conducted at a tertiary care center in North India between January 2023 and August 2024.

Sampling and Study Population: All patients who met the inclusion and exclusion criteria were enrolled consecutively.

Inclusion criteria: Patients aged 10–65 years of either sex, presenting with clinical evidence of facial trauma, who underwent MDCT and were confirmed to have fractures.

Exclusion criteria: Patients who were uncooperative, severely debilitated, or had contraindications to CT examination were excluded.

Ethical Considerations: Approval for the study was obtained from the Institutional Ethics Committee. Written and verbal informed consent was taken from all participants prior to imaging.

Imaging Technique: Patients were scanned using a 128-slice GE Revolution CT scanner. Each patient was positioned supine, and a lateral tomogram was obtained to define the facial region of interest. Continuous volume scans were performed from the chin up to 4–5 cm above the supraorbital margins, using axial slices of 5 mm thickness.

The acquired tomographic data were reconstructed into coronal multiplanar reformatted (MPR) images at 0.5 mm intervals and three-dimensional (3D) volume-rendered images. All scans were reviewed on a GE workstation.

Evaluation Criteria: Fractures were assessed for detection, extent, and displacement. Findings from coronal and 3D images were compared with those from axial images. A scoring system was used to categorize the relative diagnostic value:

-A: Inferior to axial image (IA)

-B: Equivalent to axial image (SA)

-C: Comparable but easier to interpret (SS)

- D: Superior, providing additional information (SU)

Data Analysis: The comparative performance of coronal and 3D imaging against axial imaging was tabulated and analyzed for fracture detection, extent, and displacement.

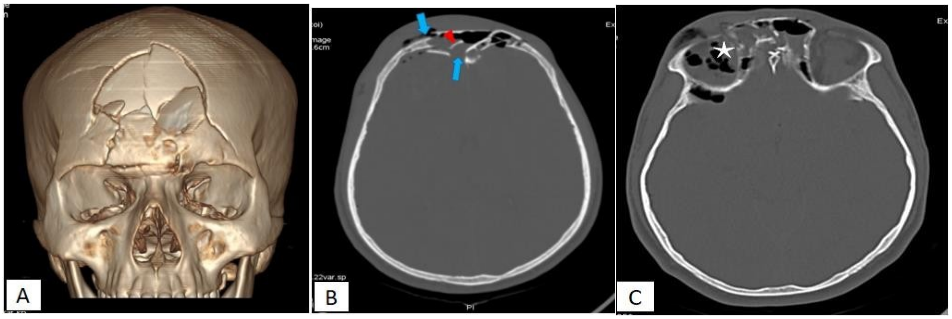


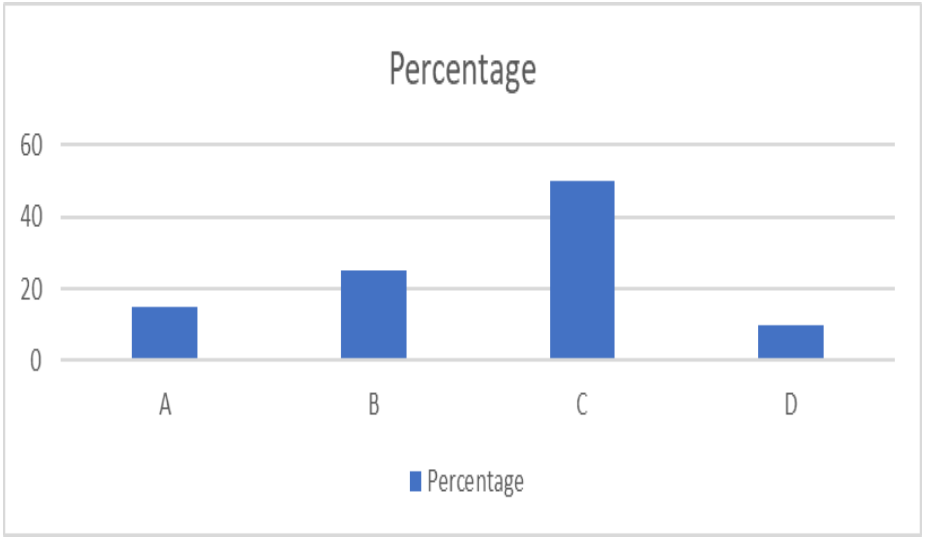
Figure 1: A- Three-dimensional rendered image, B and C- Axial computed tomography images illustrating comminuted depressed frontal bone fracture involving outer and inner table of frontal sinus (blue arrows) with resultant hemosinus with displaced bony fragments in the frontal sinuses (arrowhead) and the fracture is extending to bilateral orbital roof with resultant bilateral pneumo-orbit (asterisk) and comminuted un-displaced fracture of medial wall of right orbit.

Results and Observations:

Fractures Involving Frontal bone

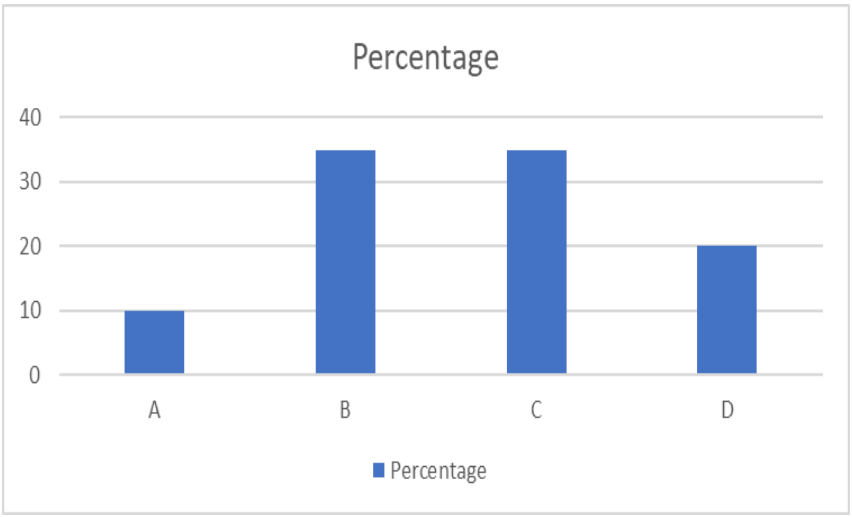
1. **Comparison of 3-dimensional image to axial image for fracture detection**

Score	Percentage
A	15
B	25
C	50
D	10



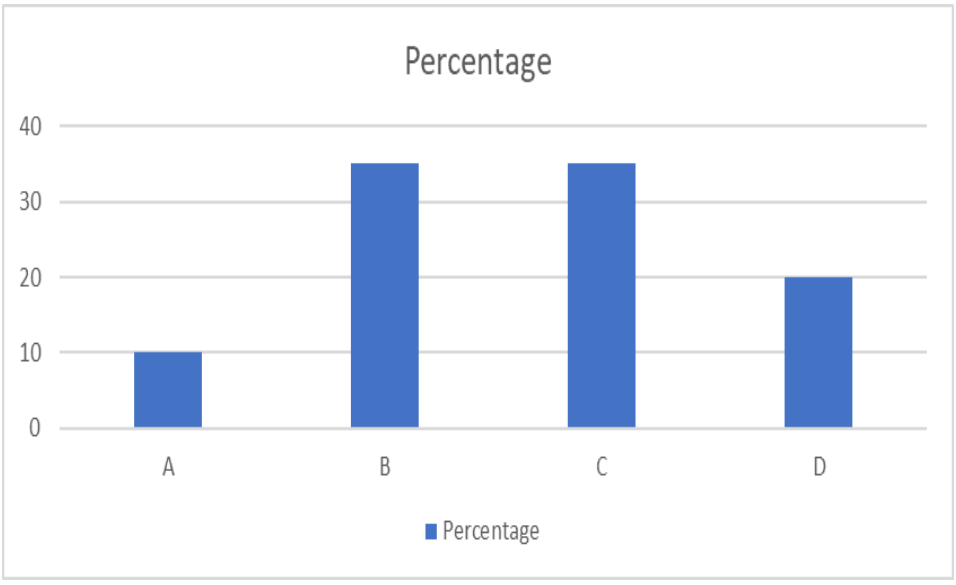
2. **Comparison of 3-dimensional image to axial image for fracture extent**

Score	Percentage
A	10
B	35
C	35
D	20



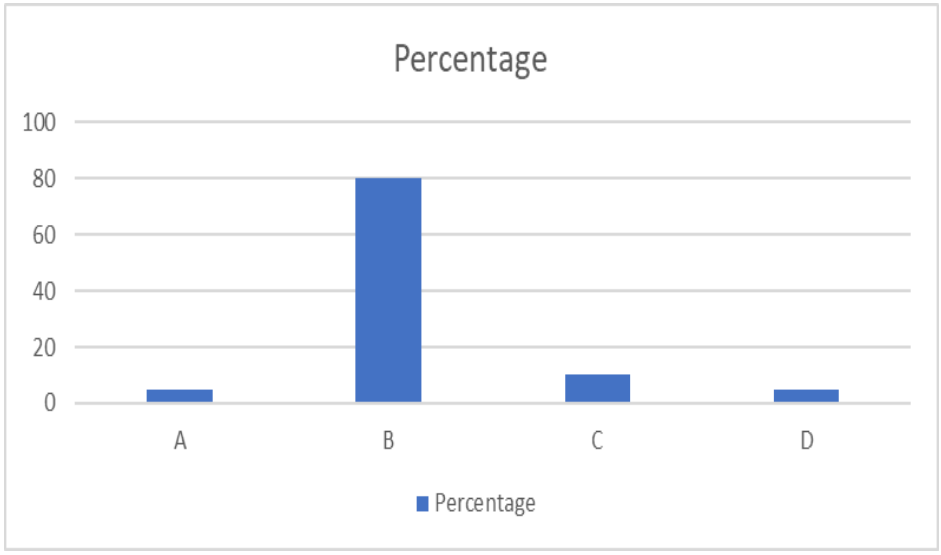
3. **Comparison of 3-dimensional image to axial image for fracture displacement**

Score	Percentage
A	10
B	35
C	35
D	20



4. **Comparison of coronal images to axial images for fracture detection**

Score	Percentage
A	5
B	80
C	10
D	5



A total of 72 patients with frontal bone fractures were included in this study. Imaging comparisons were made between axial, coronal, and 3D reconstructed views for fracture detection, extent, and displacement.

Detection of Fractures: When 3D images were compared with axial scans, 50% of cases demonstrated superior clarity, 25% were equivalent, 15% were inferior, and 10% provided additional useful details. Coronal images showed nearly identical performance to axial scans, with 80% being equivalent, 10% easier to interpret, 5% inferior, and 5% superior.

Assessment of Fracture Extent: In evaluating the full extent of fractures, 3D images were found to be superior in 20% of cases, easier to interpret in 35%, equivalent in another 35%, and inferior in 10%.

Evaluation of Displacement: For displacement assessment, 3D imaging again outperformed axial scans in 20% of patients, provided faster interpretation in 35%, was equivalent in 35%, and inferior in 10%.

Overall Findings: Three-dimensional imaging was highly effective in identifying the presence and displacement of frontal bone fractures. However, it

was less reliable in visualizing fractures extending into the posterior sinus wall and orbital roof due to overlapping bony structures. Coronal images, on the other hand, were comparable to axial views for most fracture assessments.

Discussion

Earlier studies have consistently highlighted the superiority of computed tomography (CT) over conventional radiography in evaluating maxillofacial trauma. For instance, Tanrikulu and Erol (2001) demonstrated that CT was far more effective than plain X-rays in both identifying and classifying fractures [6].

In the present study, multidetector CT (MDCT) once again proved to be the most accurate and reliable imaging tool for patients with craniofacial trauma. Its high spatial resolution allows multiplanar reformations (MPR) and three-dimensional (3D) reconstructions, which enhance both diagnostic accuracy and surgical planning [2,7].

The ability to reconstruct images in sagittal, coronal, and 3D planes provides clinicians with valuable insights into complex fracture patterns, especially when fractures are comminuted, displaced, or extend across multiple anatomical planes. Importantly, these reconstructions can be generated from the original axial data, avoiding additional radiation exposure for patients. This makes MDCT particularly suitable for maxillofacial imaging.

Our analysis of 72 patients with frontal bone fractures confirmed that the frontal bone, due to its prominent anatomical position, is highly vulnerable in facial trauma. Such fractures may occur directly or as an extension of skull fractures. They can involve the anterior wall, posterior wall, or both. Complex fractures of both tables are often associated with additional midfacial or skull base injuries [2].

Anterior wall fractures are generally less severe and may not require intervention, whereas posterior wall involvement is clinically significant due to its association with skull fractures, pneumocephalus, and possible central nervous system complications. Accurate detection of posterior table damage is crucial, as it indicates the risk of anterior cranial fossa involvement [11].

In this study, 3D reconstructions were especially helpful for identifying fractures and assessing fragment displacement—being superior in 50% of cases for detection and 35% for displacement. However, 3D imaging had limitations in evaluating fracture extension into the orbital roof or posterior sinus wall, likely due to overlapping bone structures obscuring finer details. Coronal reconstructions, on the other hand, were comparable to axial scans in detecting these subtle extensions.

Overall, MDCT provided a comprehensive view of fracture morphology, enabling accurate diagnosis, timely surgical planning, and improved clinical outcomes. These findings reaffirm MDCT as the gold standard for evaluating maxillofacial trauma, particularly when enhanced by coronal and 3D reconstructions.

Conclusion

Multidetector computed tomography (MDCT) has established itself as the imaging modality of choice for evaluating patients with craniofacial injuries. Its rapid image acquisition, high spatial resolution, and ability to generate multiplanar and three-dimensional reconstructions make it particularly valuable in acute trauma cases.

This study demonstrates that coronal reformatted and 3D volume-rendered images provide significant advantages over standard axial sections when assessing frontal bone fractures. Three-dimensional imaging was particularly effective in detecting fractures and evaluating fragment displacement, while coronal reconstructions proved comparable to axial views in delineating fracture extensions.

By offering detailed insights into the number, location, extent, and displacement of fractures, MDCT plays a crucial role in accurate diagnosis and surgical planning. These capabilities help minimize complications, guide timely interventions, and ultimately improve patient outcomes in cases of frontal bone trauma.

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