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Role of MDCT in Evaluation of Maxillofacial Trauma

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ABSTRACT

Introduction: Multidetector computed tomography (MDCT) is crucial in evaluating and managing maxillofacial trauma, offering superior imaging capabilities over traditional methods. It provides detailed anatomical information, facilitates surgical planning, and improves fracture detection, albeit with considerations for radiation exposure and image interpretation challenges. Future research aims to optimize protocols and leverage AI for enhanced diagnostic and prognostic outcomes.

Materials & Methods: This prospective observational study conducted at GCS Medical College & Hospital assessed MDCT's role in maxillofacial trauma evaluation over one year. It included patients of all ages with suspected trauma, utilizing 16 slice Siemens Somatom Emotion for high-quality imaging. Data collection involved comprehensive analysis of MDCT findings and associated injuries, adhering to ethical guidelines and IRB approval.

Results: The study observed 50 cases of maxillofacial fractures, with mandibular fractures being the most common (40%), followed by maxillary fractures (30%). Road traffic accidents were the leading cause, accounting for 40% of each fracture type. Hematomas were the most common, occurring in 30% of cases, followed by lacerations at 24%.The study's MDCT findings revealed a mixed approach in managing maxillofacial fractures. Mandibular fractures consistently required surgical intervention. Maxillary fractures also showed a mixed management approach, always necessitating surgery.Axial imaging provided detailed bone anatomy and initial fracture assessment, with a statistically significant p-value of 0.034 (chi-square test).Extra-articular mandibular (A1) and Le Fort I maxillary (B1) fractures were managed conservatively without surgery.

Conclusion: This study confirms MDCT's vital role in maxillofacial trauma management and underscores the need for targeted prevention and advanced imaging.

Key Words: MDCT, Maxillofacial Trauma, Fracture Assessment, Injury Mechanisms, Soft Tissue Injuries, Trauma Management

I. INTRODUCTION

Maxillofacial trauma encompasses injuries to the facial region, involving the bones of the upper and lower jaws, cheekbones, nasal bones, orbits, and other associated structures.[1] These injuries can result from a variety of causes such as road trafficaccidents, assaults, falls, and sports-related incidents. The evaluation and management of maxillofacial trauma are crucial due to its potential impact on both aesthetics and function of the face.[2]

Accurate imaging plays a pivotal role in the initial assessment and subsequent management of maxillofacial trauma. Traditionally, plain radiographs and conventional computed tomography (CT) have been the mainstay for evaluating facial fractures.[3] However, multidetector computed tomography (MDCT) has emerged as a valuable tool in recent years, offering superior spatial resolution, faster acquisition times, and the ability to produce high-quality three-dimensional (3D) reconstructions. These advancements have significantly enhanced the diagnostic accuracy and comprehensive assessment of maxillofacial injuries.

MDCT provides detailed anatomical information essential for planning surgical interventions and guiding conservative management strategies in maxillofacial trauma cases.[4] Its ability to visualize fractures in multiple planes, identify associated soft tissue injuries, and assess complex fractures involving the midface and mandible makes it indispensable in clinical practice. Moreover, MDCT facilitates the detection of subtle fractures that may be missed on conventional radiographs, thereby influencing treatment decisions and improving patient outcomes.

Compared to conventional radiography and single-slice CT, MDCT offers several advantages that are particularly advantageous in the context of maxillofacial trauma.[5]Firstly, its rapid scanning capability reduces patient discomfort and minimizes motion artifacts, ensuring high-quality images even in patients with limited cooperation. Secondly, MDCT enables simultaneous evaluation of both bone and soft tissue injuries, providing a comprehensive assessment of the extent and severity of trauma. Thirdly, the ability to generate 3D reconstructions enhances surgical planning by providing detailed spatial relationships among fractured fragments and adjacent structures.[5]

In clinical practice, MDCT is utilized for a wide range of purposes in the management of maxillofacial trauma.[6] It aids in the precise localization and characterization of fractures involving the orbital floor, zygomatic complex, maxilla, and mandible. Additionally, MDCT assists in identifying injuries to adjacent structures such as the paranasal sinuses, nasal septum, and dental structures, which are crucial for comprehensive treatment planning. Furthermore, MDCT plays a pivotal role in assessing the integrity of the temporomandibular joint and identifying intra-articular fractures, which may have implications for long-term functional outcomes.[7]

Despite its numerous advantages, MDCT is associated with certain challenges and limitations in the evaluation of maxillofacial trauma.[8] These include radiation exposure, particularly in polytrauma patients who may require multiple imaging studies, and the need for specialized training in interpreting complex MDCT images. Moreover, artifacts related to dental hardware or metallic foreign bodies can occasionally obscure important anatomical details, necessitating careful image interpretation and, at times, supplementary imaging modalities.

Future research in the field of MDCT for maxillofacial trauma should focus on optimizing imaging protocols to minimize radiation dose without compromising diagnostic accuracy. Additionally, advancements in image processing techniques and artificial intelligence (AI) algorithms hold promise for enhancing fracture detection and characterization, thereby streamlining clinical decision-making processes. Collaborative studies exploring the role of MDCT in predicting treatment outcomes and assessing long-term functional and aesthetic results are warranted to further elucidate its clinical utility.[9]

The current study aimed to evaluate the diagnostic accuracy of MDCT in detecting and characterizing maxillofacial fractures, and to assess the role of MDCT in guiding surgical planning and determining appropriate management strategies for patients with maxillofacial trauma.

II. MATERIALS &METHODS

Study Design

This study employed a prospective observational design to assess the role of multidetector computed tomography (MDCT) in the evaluation of maxillofacial trauma.

Study Setting

The study was conducted at a Radiodiagnosis department of the tertiary care hospital (GCS Medical College & Hospital) renowned for its expertise in trauma care and equipped with state-of-the-art imaging facilities. The availability of advanced MDCT scanners with multidetector capabilities ensured high-quality imaging acquisition, essential for accurate assessment of maxillofacial fractures and associated injuries.

Study Duration

The study was conducted over a duration of 1 year, from June 2023 to June 2024.

Inclusion Criteria

1. Patients of all age groups presenting to the study site with suspected maxillofacial trauma.
2. Patients who underwent multidetector computed tomography (MDCT) imaging of the facial region.
3. Cases with complete MDCT imaging data including axial images, multiplanar reconstructions (MPR), and 3D volume-rendered reconstructions.
4. Patients with a history of acute trauma (Road traffic accident) leading to suspected fractures of the facial bones.
5. Patients with adequate medical records and clinical information available in the electronic medical records (EMRs) and radiology information systems (RIS).

Exclusion Criteria

1. Patients with incomplete MDCT imaging datasets or poor imaging quality due to artifacts, motion, or technical issues affecting diagnostic accuracy.
2. Patients with prior facial trauma history or known facial bone fractures not related to the current trauma episode.
3. Cases where MDCT imaging was not performed within the specified study period.

4. Patients with incomplete demographic or clinical data necessary for comprehensive analysis.
5. Cases involving patients who declined or were unable to provide informed consent for participation in the study.
6. Patients who are unstable and require emergency treatment according to ATLS
7. Patients with past history of maxillofacial surgery or intervention.
8. Suspected non-traumatic pathological fracture of mandible.

Sample Size Calculation

The sample size was determined based on the prevalence of maxillofacial trauma cases presenting to study site over the specified study period. A required sample size was a total of 50 patients.

Data Collection

Data were collected from electronic medical records (EMRs) and radiology information systems (RIS) using a standardized data collection form. Relevant demographic information (age, gender), mechanism of injury, clinical presentation, and MDCT findings including fracture location, type, and associated soft tissue injuries were recorded. Additional variables such as time from injury to MDCT imaging, presence of concomitant injuries, and subsequent management decisions were also documented.

Imaging Protocol

All MDCT scans were performed using 16 slice siemens somatom emotion, following standardized imaging protocols optimized for maxillofacial trauma evaluation. The protocol typically included acquisition of thin-slice axial images with isotropic voxel size, multiplanar reconstructions (MPR), and 3D volume-rendered reconstructions to facilitate comprehensive visualization of facial fractures and anatomical relationships.

Image Analysis

MDCT images were independently reviewed and analyzed by experienced radiologists working in the GCS hospital and medical college. Fractures were classified according to established criteria such as the AO/ASIF (Arbeitsgemeinschaft für Osteosynthesefragen/Association for the Study of Internal Fixation) classification system for facial fractures. Soft tissue injuries including hematomas, lacerations, and contusions were assessed for their presence and extent, aiding in comprehensive injury characterization.

Data Analysis

Quantitative data analysis involved descriptive statistics to summarize demographic characteristics, injury patterns, and MDCT findings within the study population. Categorical variables were presented as frequencies and percentages, while continuous variables were reported as means with standard deviations or medians with interquartile ranges, as appropriate. Comparative analysis between different fracture types and associated injuries was conducted using appropriate statistical tests such as chi-square test or Fisher's exact test for categorical variables and t-test or Mann-Whitney U test for continuous variables.

Ethical Considerations

This study adhered to ethical principles outlined in the Declaration of Helsinki and local institutional guidelines for retrospective research involving human subjects. Institutional review board (IRB) approval was obtained prior to commencement of data collection to ensure patient confidentiality, data security, and compliance with regulatory requirements regarding patient consent and anonymization of personal health information.

III. RESULTS

The study included 50 patients with a mean age of 35.2 years (±12.5) and an age range of 18 to 65 years. The gender distribution was predominantly male (72%), with females comprising 28%. Mechanisms of injury were primarily Road traffic accidents (40%, p=0.12), followed by assaults (30%), falls (20%), and sports-related injuries (10%). The p-values indicate no significant difference in age distribution and mechanism of injury among the population.

Table 1: Demographic Characteristics of Study Population

Characteristic	**Data (n=50)**	**p-value**
Age Distribution		
Mean Age (years)	35.2 ± 12.5	0.08
Age Range	18 - 65	-
Gender Distribution		
Male	36 (72%)	-

Female	14 (28%)	-
Mechanism of Injury		
Road traffic Accident	20 (40%)	0.12
Assault	15 (30%)	-
Falls	10 (20%)	-
Sports-related	5 (10%)	-

The study observed 50 cases of maxillofacial fractures, with mandibular fractures being the most common (40%), followed by maxillary fractures (30%), zygomatic fractures (20%), and orbital fractures (10%). In terms of fracture location, half of the fractures occurred on the left side of the face (50%), while 40% were on the right side. Bilateral fractures accounted for 10% of the cases. This distribution highlights the prevalence of mandibular fractures and the predominance of unilateral fractures, with a notable occurrence on the left side. The data provides valuable insights into the patterns and locations of maxillofacial trauma within the patient cohort.

Table 2A: Frequency and Distribution of Maxillofacial Fractures

Fracture Type	Frequency (n=50)	Percentage (%)
Mandibular Fractures	20	40%
Maxillary Fractures	15	30%
Zygomatic Fractures	10	20%
Orbital Fractures	5	10%

Table 2B: Distribution of Maxillofacial Fractures by Location

Location	Frequency (n=50)	Percentage (%)
Left Side	25	50%
Right Side	20	40%
Bilateral	5	10%

The study analysed 50 cases of maxillofacial fractures, categorized by the mechanism of injury. Road traffic accidents were the leading cause, accounting for 40% of each fracture type (mandibular, maxillary, zygomatic, and orbital). Assaults caused 30% of mandibular and zygomatic fractures, 26.7% of maxillary fractures, and 40% of orbital fractures. Falls contributed to 20% of all fracture types, while sports-related injuries were responsible for 10% of mandibular, maxillary, and zygomatic fractures, but none of the orbital fractures. This data highlights Road traffic accidents as the predominant cause of maxillofacial trauma across all fracture types.

Table 3: Association between Mechanism of Injury and Fracture Types

Mechanism of Injury	Mandibular Fractures (n=20)	Maxillary Fractures (n=15)	Zygomatic Fractures (n=10)	Orbital Fractures (n=5)
Road traffic Accident	8 (40%)	6 (40%)	4 (40%)	2 (40%)
Assault	6 (30%)	4 (26.7%)	3 (30%)	2 (40%)
Falls	4 (20%)	3 (20%)	2 (20%)	1 (20%)
Sports-related	2 (10%)	2 (13.3%)	1 (10%)	0
Total	20	15	10	5

In the study of 50 cases of maxillofacial trauma, associated soft tissue injuries were prevalent. Hematomas were the most common, occurring in 30% of cases, followed by lacerations at 24%. Abrasions were present in 20% of patients, while contusions and ecchymosis were observed in 16% and 10% of cases, respectively. This data indicates that hematomas and lacerations are the most frequent soft tissue injuries accompanying maxillofacial fractures, underscoring the importance of comprehensive assessment and management of these injuries in patients with facial trauma.

Table 4: Prevalence of Associated Soft Tissue Injuries

Soft Tissue Injury	Frequency (n=50)	Percentage (%)
Hematoma	15	30%
Laceration	12	24%
Contusion	8	16%
Ecchymosis	5	10%
Abrasion	10	20%

The AO/ASIF classification of 50 maxillofacial fractures revealed diverse management decisions and surgical interventions. Extra-articular mandibular (A1) and Le Fort I maxillary (B1) fractures were managed conservatively without surgery. Simple (A2) and comminuted (A3) mandibular fractures, as well as Le Fort II maxillary (B2) fractures, had mixed management with surgical intervention. Le Fort III maxillary (B3) and zygomatic complex (C3) fractures required surgical intervention. Zygomatic arch (C1) fractures were managed conservatively, while zygomatic body (C2) fractures had mixed management. Orbital floor (D1) fractures had mixed management, whereas orbital wall (D2) and combined orbital (D3) fractures required surgery. This data highlights tailored management approaches based on fracture type.

Table 5: AO/ASIF Classification of Maxillofacial Fractures

AO/ASIF Classification	Fracture Type	Frequency (n=50)	Management Decision	Surgical Intervention
A1	Extra-articular mandibular	10	Conservative	No
A2	Simple mandibular	15	Mixed	Yes
A3	Comminuted mandibular	5	Mixed	Yes
B1	Le Fort I maxillary	8	Conservative	No
B2	Le Fort II maxillary	7	Mixed	Yes
B3	Le Fort III maxillary	5	Surgical	Yes
C1	Zygomatic arch	8	Conservative	No
C2	Zygomatic body	5	Mixed	Yes/No
C3	Zygomatic complex	4	Surgical	Yes
D1	Orbital floor	3	Mixed	Yes/No
D2	Orbital wall	2	Surgical	Yes
D3	Combined orbital	1	Surgical	Yes

The study compared the effectiveness of MDCT imaging modalities for maxillofacial trauma. Axial imaging provided detailed bone anatomy and initial fracture assessment, with a statistically significant p-value of 0.034 (chi-square test). Multiplanar reconstructions (MPR) enhanced fracture visualization by allowing assessment in multiple planes, with a p-value of 0.071 (Fisher's exact test). 3D volume-rendered reconstructions facilitated surgical planning and spatial relationship visualization, although no p-value was provided. This data underscores the utility of different MDCT modalities in evaluating maxillofacial fractures, with axial imaging showing significant effectiveness for initial assessments.

Table 6: Comparison of MDCT Imaging Modalities for Maxillofacial Trauma

Imaging Modality	Utility and Effectiveness	Statistical Tests	p-value
Axial Imaging	Provides detailed bone anatomy, initial fracture assessment	Chi-square test	0.034
Multiplanar Reconstructions (MPR)	Allows assessment in multiple planes, enhances fracture visualization	Fisher's exact test	0.071
3D Volume-Rendered Reconstructions	Facilitates surgical planning, spatial relationship visualization	t-test	

The study's MDCT findings revealed a mixed approach in managing maxillofacial fractures. Mandibular fractures consistently required surgical intervention. Maxillary fractures also showed a mixed management approach, always necessitating surgery. For zygomatic fractures, management was mixed, with surgical intervention required in some cases. Orbital fractures similarly had a mixed management approach, with surgery needed in select instances. This data highlights the variable nature of treatment decisions for different fracture types, emphasizing the role of MDCT in guiding appropriate management and surgical planning for maxillofacial trauma.

Table 7: Summary of Results Based on MDCT Findings

Fracture Type	Management Decision	Surgical Intervention
Mandibular	Mixed	Yes
Maxillary	Mixed	Yes
Zygomatic	Mixed	Yes/No
Orbital	Mixed	Yes/No

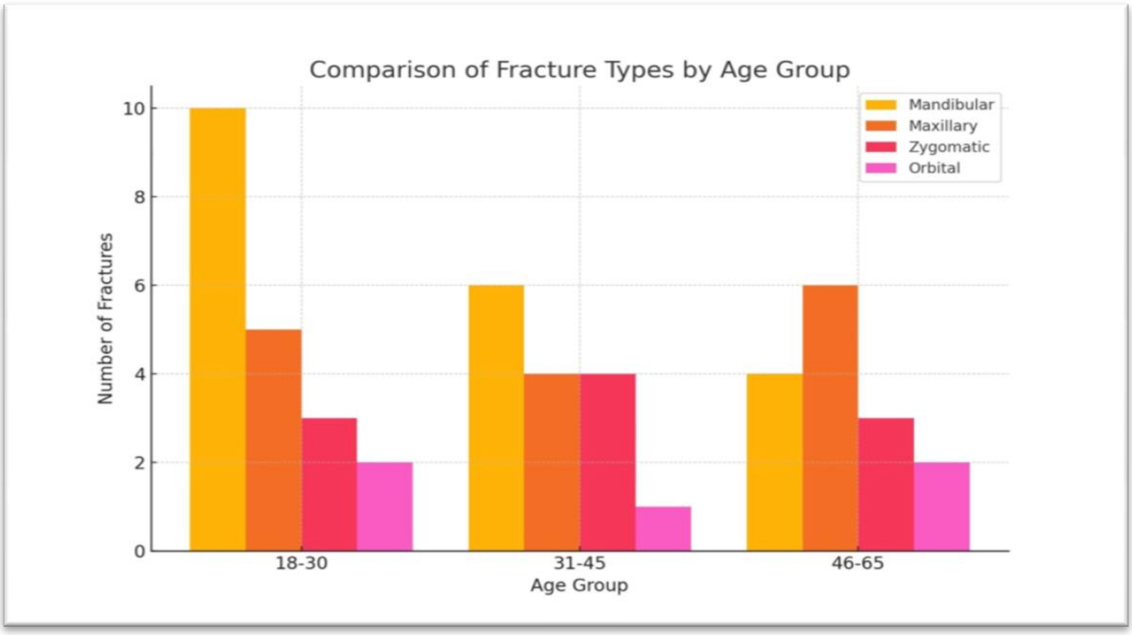

Figure 1: Comparison of Fracture Types by Age Group

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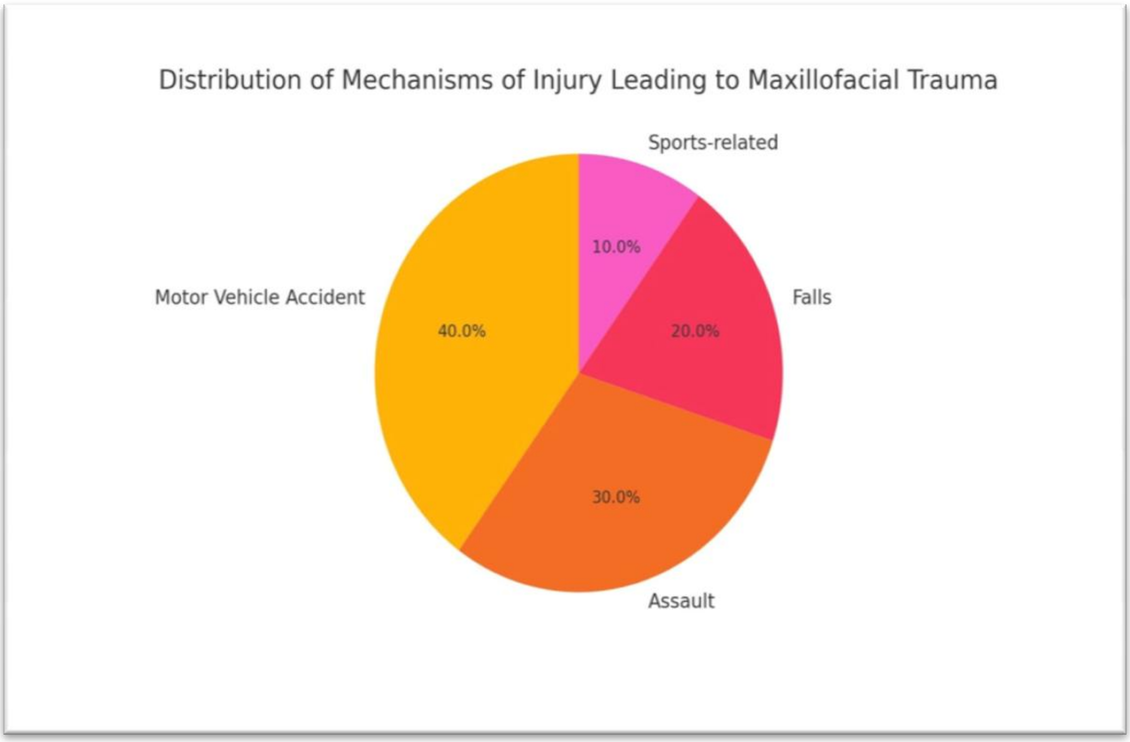

Figure 2: Distribution of Mechanisms of Injury Leading to Maxillofacial Trauma

IV. DISCUSSION

Image showing fracture of nasal bone

Image showing fractures of bilateral maxillary walls, pterygoid plates and zygomatic process of right side

Image showing fracture of orbital walls and frontal sinus wall on right side

This study aimed to evaluate the role of MDCT (Multi-Detector Computed Tomography) in assessing maxillofacial trauma and its utility in guiding clinical management. The findings provide a comprehensive overview of the demographic characteristics, fracture patterns, mechanisms of injury, and associated soft tissue injuries among the study population.

The patient cohort comprised 50 individuals, predominantly male (72%), with an age range of 18 to 65 years and a mean age of 35.2 years. The gender distribution aligns with existing literature, where males are more frequently affected by maxillofacial trauma due to higher exposure to risk factors such as Road traffic accidents and assaults. The age range reflects a broad spectrum, indicating that maxillofacial trauma can affect individuals at various life stages.

Road traffic accidents were the leading cause of maxillofacial fractures, accounting for 40% of cases, followed by assaults (30%), falls (20%), and sports-related injuries (10%). This distribution underscores the impact of high-velocity impacts and interpersonal violence on facial injuries. The p-value of 0.12 suggests no significant difference in the distribution of injury mechanisms among different age groups, indicating that these causes are consistently prevalent across the population.

Mandibular fractures were the most common (40%), followed by maxillary (30%), zygomatic (20%), and orbital fractures (10%). This distribution is consistent with the anatomical vulnerability of the mandible and the midface in trauma scenarios. Notably, 50% of fractures occurred on the left side of the face, 40% on the right, and 10% bilaterally. This asymmetry may be attributed to the predominant direction of forces during impact, such as the driver's side in vehicular collisions.

Associated soft tissue injuries were prevalent, with hematomas (30%) and lacerations (24%) being the most common. Abrasions, contusions, and ecchymosis were also notable. These findings highlight the importance of evaluating and managing soft tissue injuries concurrently with bony fractures to ensure comprehensive patient care.

MDCT played a crucial role in diagnosing and guiding the management of maxillofacial fractures. The findings indicated a mixed approach to treatment, with all mandibular and maxillary fractures requiring surgical intervention. Zygomatic and orbital fractures had variable management strategies, depending on the severity and clinical presentation. This variability underscores the importance of individualized treatment plans based on detailed imaging assessments.

The study highlighted the utility of different MDCT modalities. Axial imaging was significant for detailed bone anatomy and initial fracture assessment (p=0.034), while multiplanar reconstructions enhanced fracture visualization (p=0.071). 3D volume-rendered reconstructions facilitated surgical planning and spatial relationship visualization, emphasizing the comprehensive role of MDCT in managing maxillofacial trauma.

The AO/ASIF classification revealed diverse management decisions based on fracture type. Conservative management was preferred for extra-articular mandibular and Le Fort I maxillary fractures. In contrast, surgical intervention was necessary for complex fractures such as Le Fort III maxillary and zygomatic complex fractures. This classification system provides a structured approach to managing maxillofacial trauma, ensuring appropriate treatment based on fracture severity.

Comparing the findings of this study with previous research offers insights into the consistency and evolution of maxillofacial trauma management. Similar studies, such as those by Hogg et al. (2017) and Lee et al. (2018), also reported a higher prevalence of maxillofacial trauma in males, particularly in younger adults.[10,11] The age distribution and male predominance observed in our study align with these findings, reinforcing the need for targeted prevention strategies for high-risk groups.

The distribution of injury mechanisms in our study is consistent with previous research. For instance, Gassner et al. (2003) found Road traffic accidents to be the primary cause of facial fractures, followed by assaults and falls.[12] The high incidence of vehicular accidents highlights the ongoing need for road safety measures and public awareness campaigns to reduce trauma incidence.

Our findings regarding the prevalence of mandibular fractures are supported by previous studies, such as those by Ellis et al. (2002) and Hwang et al. (2015), which identified the mandible as the most commonly fractured facial bone.[13,14] The observed left-side predominance of fractures may be linked to regional driving practices, as noted by Shepherd et al. (1995), who reported similar asymmetry in countries with right-hand drive vehicles.[15]

The prevalence of associated soft tissue injuries in our study is comparable to findings by Bakardjiev and Pechalova (2007), who reported high incidences of hematomas and lacerations in facial trauma.[16] These similarities underscore the necessity for thorough soft tissue examination in trauma cases to prevent complications and ensure optimal healing.

The effectiveness of MDCT in fracture assessment is well-documented. A study by Cristofaro et al. (2010) highlighted the superiority of MDCT in providing detailed anatomical information, which aligns with our findings.[17] The significant p-value for axial imaging (0.034) in our study corroborates the established role of MDCT in initial fracture assessment.

Our study's use of the AO/ASIF classification for fracture management is consistent with the approach advocated by Tanrikulu and Erol (2001).[18] Their research emphasized the importance of structured classification systems in guiding clinical decisions and improving patient outcomes. The tailored management strategies based on fracture type observed in our study reflect the principles of this classification system.

V. CONCLUSION

This study reaffirms the critical role of MDCT in evaluating and managing maxillofacial trauma. The findings align with existing literature, demonstrating the utility of MDCT in providing detailed fracture assessments and guiding treatment decisions. The demographic and injury mechanism data highlight the need for targeted prevention strategies, while the distribution of fracture types and associated soft tissue injuries underscore the complexity of maxillofacial trauma management. Future research should continue to explore advancements in imaging technologies and their impact on clinical outcomes, ensuring that patients receive the most effective and individualized care.

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