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A Comparative Study on the Diagnostic Utility of Ultrasonography and Conventional Radiography With Computed Tomography as the Gold Standard in the Detection of Facial Trauma Fractures

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Abstract

Introduction: Facial fractures require accurate and timely diagnosis, while conventional radiography may be limited by anatomical superimposition. Computed tomography (CT) provides detailed assessment but involves ionizing radiation and may have limited availability. Ultrasonography (USG) offers a radiation-free, portable alternative for selected facial fractures. This study compared the diagnostic performance of USG and conventional radiography using CT as the reference standard.

Materials and methods: This prospective comparative study was conducted in the Department of Radiodiagnosis, Vydehi Institute of Medical Sciences and Research Centre, Bengaluru, Karnataka, among 53 patients with suspected facial trauma fractures. All participants underwent USG, conventional radiography, and CT. Fractures involving the nasal bone, zygomatic arch, maxillary sinus, symphysis/parasymphysis, and frontal sinus were evaluated. Each participant contributed five predefined anatomical-site observations, resulting in 265 site-level observations. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy were calculated using CT as the reference standard.

Results: CT identified 72 fracture-positive anatomical-site observations across the evaluated anatomical sites. USG detected 63 (87.50%) fractures, while conventional radiography detected 51 (70.83%). USG demonstrated sensitivity of 87.50%, specificity of 98.45%, PPV of 95.45%, NPV of 95.48%, and overall accuracy of 95.47%. Conventional radiography demonstrated sensitivity of 70.83%, specificity of 97.93%, PPV of 92.73%, NPV of 90.00%, and accuracy of 90.57%. USG demonstrated numerically higher sensitivity and overall diagnostic accuracy than conventional radiography across the evaluated anatomical sites.

Conclusion: USG demonstrated good diagnostic performance for selected facial fractures and numerically higher sensitivity and overall diagnostic accuracy than conventional radiography. It may serve as a useful radiation-free adjunctive modality for selected facial fractures, particularly when rapid or bedside assessment is desirable, while CT remains important for comprehensive assessment and confirmation of complex facial trauma. Further studies involving larger, multicentric populations and a broader range of facial fracture patterns are warranted to validate these findings and better define the role of USG in facial trauma imaging.

Categories: Radiology
Keywords: computed tomography, conventional radiography, facial fractures, facial trauma, ultrasonography

Introduction

Facial trauma is a common presentation in emergency and trauma care and may result from road traffic accidents, falls, assaults, and sports-related injuries [1]. The complex three-dimensional anatomy of the facial skeleton makes these injuries variable in severity and extent, with potential involvement of the nasal bones, maxilla, zygoma, mandible, orbital walls, paranasal sinuses, and adjacent soft tissues [2]. Early and accurate identification of facial fractures is essential because missed or inadequately characterized injuries may result in facial deformity, impaired mastication, visual dysfunction, chronic pain, malunion, and other functional or cosmetic sequelae [3]. Conventional radiography has traditionally been used in the initial assessment of facial trauma because of its availability and relatively low cost; however, overlapping anatomical structures and limited visualization of complex fracture patterns can reduce its diagnostic yield [4].

Computed tomography (CT) has substantially improved the evaluation of facial trauma by providing high-resolution cross-sectional imaging and multiplanar reconstructions, allowing detailed assessment of fracture lines, displacement, comminution, and involvement of adjacent anatomical structures [5,6]. Consequently, CT is widely used as the reference imaging modality for the evaluation of complex facial

fractures [7,8]. However, its use may be associated with greater cost, the requirement for specialized equipment, and exposure to ionizing radiation. These considerations have generated interest in alternative or complementary imaging techniques, particularly ultrasonography (USG), which offers real-time imaging, portability, bedside availability, and absence of ionizing radiation [9]. Advances in high-frequency transducers have enabled visualization of superficial facial bones and cortical disruptions, making USG a potential adjunctive or screening modality for selected facial fracture sites [10].

Despite these advantages, the diagnostic performance of USG is influenced by operator expertise, the depth and location of the fracture, and the accessibility of the affected anatomical region [11]. Deep facial structures and anatomically complex areas may remain difficult to evaluate sonographically. Similarly, conventional radiography may fail to demonstrate subtle, non-displaced, or overlapping fractures, particularly in complex midfacial regions [12]. Therefore, although USG and conventional radiography may have potential roles in initial screening, their diagnostic performance needs to be assessed against an established reference standard [10,12]. Comparative evaluation of these modalities is particularly relevant in settings where CT availability may be limited and where rapid, accessible, and radiation-free imaging could contribute to initial patient assessment.

Accordingly, the present study aimed to evaluate the diagnostic accuracy of USG in detecting fractures at five predefined facial anatomical sites and to compare its diagnostic performance with conventional radiography using CT as the reference standard. The study specifically assessed fractures involving the nasal bone, zygomatic arch, maxillary sinus, symphysis/parasymphysis, and anterior wall of the frontal sinus, thereby defining the anatomical scope of the diagnostic evaluation.

Materials And Methods

Study design and setting

This prospective comparative study was conducted in the Department of Radiodiagnosis, Vydehi Institute of Medical Sciences and Research Centre, Bengaluru, Karnataka, India, over a period from June 2024 to December 2025. Patients presenting or referred with a history or clinical suspicion of facial trauma, head injury, or polytrauma were assessed for eligibility. Ethical approval was obtained from the Institutional Ethics Committee of Vydehi Institute of Medical Sciences and Research Centre, Bengaluru, Karnataka, India (IEC No. VIEC/2023/APP/PG/56), dated 14 February 2024.

Inclusion and exclusion criteria

Patients of all age groups and both sexes with documented facial trauma or suspected facial fractures were eligible for inclusion. Patients with residual facial deformities, malunited fractures, metabolic bone disease, malignancy involving the facial bones, or previously operated/reconstructed facial structures that could interfere with image interpretation were excluded. Patients who were unable to cooperate with imaging procedures or provide informed consent were also excluded. These criteria were applied to ensure adequate image acquisition and reliable interpretation across all imaging modalities.

Sample size

A consecutive sampling approach was followed, and eligible patients presenting during the study period were recruited until the required sample size was achieved. The sample size was calculated using the standard formula for estimation of a proportion:

$$n = \frac{Z^2 \times P \times (1 - P)}{d^2}$$

where Z = 1.96 for a 95% confidence level, P = 0.831 (83.1%), representing the sensitivity of USG for detection of facial fractures by Vijayan AM et al., and d = 0.10 as the allowable margin of error [8]. The calculated sample size was approximately 53 patients; therefore, 53 participants were enrolled.

Imaging protocol

All enrolled participants underwent imaging in a predefined sequence. USG was performed first using Samsung V6/V8 ultrasound systems (Samsung Medison Co., Ltd., Hongcheon-gun, South Korea) with a 2-14 MHz linear-array transducer. Scanning was performed over the facial surface, particularly over areas of tenderness, swelling, deformity, or suspected injury, with sagittal and transverse views obtained as appropriate. Fractures were identified based on findings such as cortical discontinuity, step deformity, or associated alteration in the normal bony contour [13]. Conventional radiography was subsequently performed using Allengers HF X-RAY MARS 4.2-SR
(Allengers Medical Systems Limited, Dera Bassi, Punjab, India) and GE Discovery XR 656 digital radiography systems (GE HealthCare Technologies Inc., Chicago, IL, USA). Appropriate projections, including Waters, submentovertex, lateral, and posteroanterior views, were obtained according to the suspected site of injury. CT was performed subsequently using a Siemens SOMATOM Definition AS 128-slice multidetector CT

scanner (Siemens Healthineers AG, Forchheim, Germany). Axial images with coronal and sagittal reconstructions were evaluated for the presence, location, and extent of facial fractures. CT findings were considered the reference standard for diagnostic comparison [11,12].

Image interpretation and study variables

The primary outcome was the diagnostic performance of USG and conventional radiography in detecting facial fractures in comparison with CT. The anatomical sites assessed included the nasal bone, zygomatic arch, anterior/lateral wall of the maxillary sinus, symphysis/parasymphysis region, and anterior wall of the frontal sinus. Each participant was assessed at all five predefined anatomical sites, resulting in five site-level observations per participant and a total of 265 anatomical-site observations among 53 participants. For each modality, findings were classified as true positive (TP), true negative (TN), false positive (FP), or false negative (FN) according to the corresponding CT findings. The principal diagnostic parameters included sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy. Demographic and clinical variables, including age, sex, occupation, mechanism of injury, and comorbidities, were also recorded. The final analysis comprised 72 CT-positive and 193 CT-negative site-level observations.

Statistical analysis

Data were entered in Microsoft Excel (Microsoft Corporation, Redmond, Washington, United States) and analyzed using IBM SPSS Statistics for Windows, Version 26 (Released 2018; IBM Corp., Armonk, New York, United States). Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were summarized as frequency and percentage, n (%). The sensitivity, specificity, PPV, NPV, and overall diagnostic accuracy of USG and conventional radiography were calculated using CT as the reference standard. A p-value <0.05 was considered statistically significant.

Results

The study included 53 participants with a mean age of 33.0 ± 12.0 years. The majority were aged 18-30 years (30, 56.60%), followed by 41-50 years (9, 16.98%) and 31-40 years (6, 11.32%). There was a marked male predominance, with 47 (88.68%) males and six (11.32%) females. Manual laborers (15, 28.30%) constituted the largest occupational group, followed by students (14, 26.42%) and office workers (11, 20.75%). Road traffic accidents were the predominant mechanism of injury (42, 79.25%), followed by falls from height (6, 11.32%), while 44 (83.02%) participants had no documented comorbidities (Figure *1*, Table *1*).

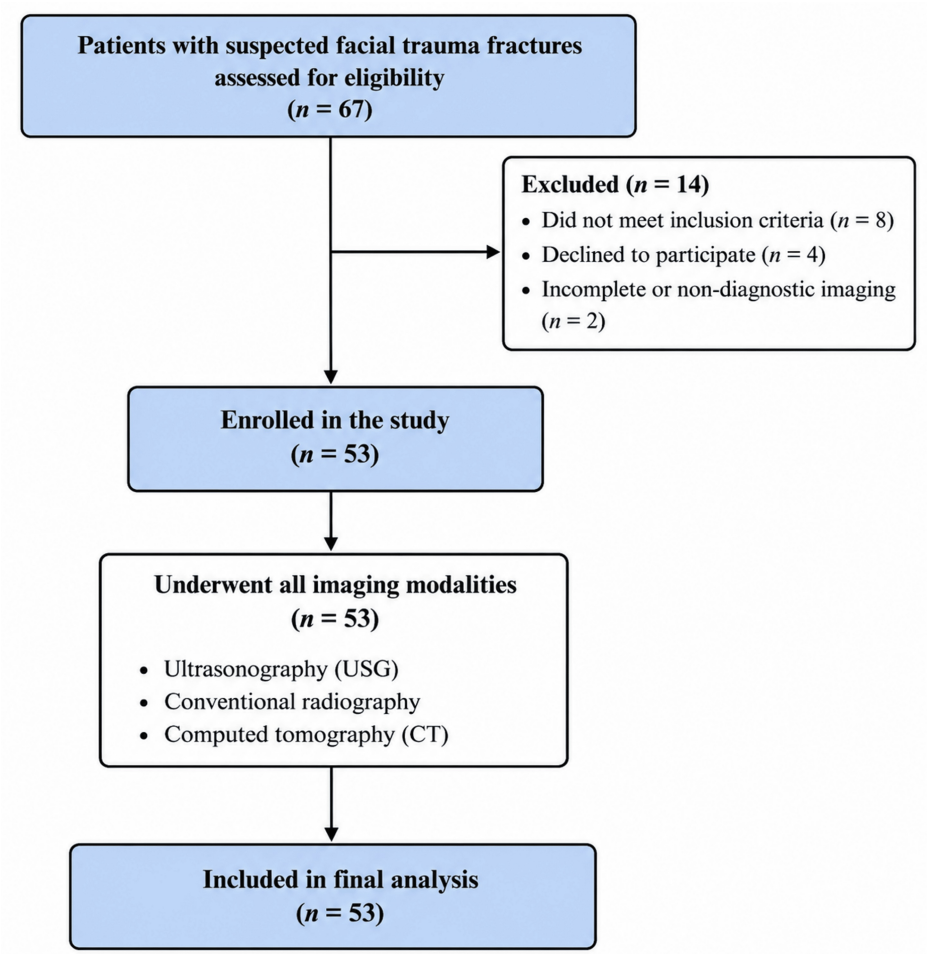


FIGURE 1: Participant flow diagram

Variable	Category	N (%) / Mean ± SD
Age (years)	<18 years	3 (5.66%)
	18–30 years	30 (56.60%)
	31–40 years	6 (11.32%)
	41–50 years	9 (16.98%)
	51–60 years	4 (7.55%)
	>60 years	1 (1.89%)
	Mean ± SD	33.0 ± 12.0
Gender	Male	47 (88.68%)
	Female	6 (11.32%)
Occupation	Manual laborer	15 (28.30%)
	Student	14 (26.42%)
	Office worker	11 (20.75%)
	Driver	7 (13.21%)
	Homemaker	6 (11.32%)
Mechanism of injury	Road traffic accident	42 (79.25%)
	Fall from height	6 (11.32%)
	Assault/violence	3 (5.66%)
	Sports injury	2 (3.77%)
Co-morbidities	Hypertension	5 (9.43%)
	Diabetes mellitus	2 (3.77%)
	Diabetes mellitus + hypertension	2 (3.77%)
	None	44 (83.02%)

TABLE 1: Baseline demographic and clinical characteristics of study participants (n = 53)

Data are presented as mean ± standard deviation (SD) for continuous variables and frequency with percentage, n (%), for categorical variables.

SD: standard deviation; RTA: road traffic accident; HTN: hypertension; DM: diabetes mellitus; GRBS: general random blood sugar

CT identified a total of 72 fracture-positive anatomical-site observations among the 265 site-level observations contributed by the 53 participants. The anterior/lateral wall of the maxillary sinus was the most frequently involved anatomical site (38, 52.78%), followed by the zygomatic arch (17, 23.61%) and nasal bone (11, 15.28%). Symphysis/parasymphysis fractures accounted for four (5.56%) fractures, while anterior wall fractures of the frontal sinus were the least frequent (2, 2.78%) (Table *2*).

Anatomical site	CT-confirmed fractures
Anterior/lateral wall of the maxillary sinus	38 (52.78%)
Zygomatic arch	17 (23.61%)
Nasal bone	11 (15.28%)
Symphysis/parasymphysis	4 (5.56%)
Anterior wall of frontal sinus	2 (2.78%)
Total	72 (100.00%)

TABLE 2: Anatomical distribution of CT-confirmed facial fractures (n = 72)

Data are presented as frequency with percentage, n (%). The distribution represents facial fracture sites identified on computed tomography (CT), which was considered the reference standard.

Using CT as the reference standard, 72 CT-positive site-level observations were identified. USG detected 63 (87.50%) of these fractures, whereas conventional radiography detected 51 (70.83%). USG showed numerically higher detection rates than conventional radiography across all evaluated anatomical sites, with the highest detection for nasal bone fractures (10, 90.91%) and maxillary sinus fractures (34, 89.47%). Conventional radiography detected 29 (76.32%) maxillary sinus fractures, 12 (70.59%) zygomatic arch fractures, and eight (72.73%) nasal bone fractures. Frontal sinus fractures showed the lowest detection by both modalities, with USG detecting one (50.00%) and conventional radiography detecting none (Table *3*).

Anatomical site	CT-confirmed fractures	USG	X-ray
Anterior/lateral wall of the maxillary sinus	38	34 (89.47%)	29 (76.32%)
Zygomatic arch	17	15 (88.24%)	12 (70.59%)
Nasal bone	11	10 (90.91%)	8 (72.73%)
Symphysis/parasymphysis	4	3 (75.00%)	2 (50.00%)
Anterior wall of frontal sinus	2	1 (50.00%)	0 (0.00%)
Total	72	63 (87.50%)	51 (70.83%)

TABLE 3: Detection of facial fractures by CT, ultrasonography, and conventional radiography

Data are presented as frequency with percentage, n (%). CT was considered the reference standard, and the number and percentage of fractures detected by ultrasonography (USG) and conventional radiography (X-ray) were compared across anatomical sites.

Using CT as the reference standard, USG demonstrated a sensitivity of 87.50%, a specificity of 98.45%, a PPV of 95.45%, an NPV of 95.48%, and an overall diagnostic accuracy of 95.47%. Conventional radiography showed a sensitivity of 70.83%, a specificity of 97.93%, a PPV of 92.73%, NPV of 90.00%, and an overall accuracy of 90.57%. USG therefore demonstrated higher sensitivity and overall diagnostic accuracy, while both modalities showed high specificity (Table *4*).

Diagnostic parameter	Ultrasonography	Conventional radiography
True positive (TP)	63 (87.50%)	51 (70.83%)
False positive (FP)	3 (1.55%)	4 (2.07%)
False negative (FN)	9 (12.50%)	21 (29.17%)
True negative (TN)	190 (98.45%)	189 (97.93%)
Sensitivity	87.50%	70.83%
Specificity	98.45%	97.93%
Positive predictive value	95.45%	92.73%
Negative predictive value	95.48%	90.00%
Overall accuracy	95.47%	90.57%

TABLE 4: Overall diagnostic accuracy of ultrasonography and conventional radiography using CT as the reference standard

Data are presented as frequencies with percentages, n (%), and diagnostic performance measures as percentages. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy were calculated using computed tomography (CT) as the reference standard. Diagnostic performance was assessed using a 2 × 2 contingency table approach. Values for TP and FN percentages are calculated using the total number of CT-positive observations (n=72) as the denominator, whereas FP and TN percentages are calculated using the total number of CT-negative observations (n=193). The comparative differences in diagnostic performance are presented descriptively; statistical significance was not inferred from these estimates. A p-value <0.05 was considered statistically significant.

CT: computed tomography; USG: ultrasonography; X-ray: conventional radiography; TP: true positive; TN: true negative; FP: false positive; FN: false negative; PPV: positive predictive value; NPV: negative predictive value

On site-specific analysis, USG demonstrated the highest sensitivity for nasal bone fractures (90.91%), followed by maxillary sinus (89.47%) and zygomatic arch fractures (88.24%). Its specificity ranged from 93.33% to 100.00%. Conventional radiography showed maximum sensitivity for maxillary sinus fractures (76.32%), followed by nasal bone (72.73%) and zygomatic arch fractures (70.59%), while sensitivity was 0.00% for frontal sinus fractures. The PPV and NPV of USG were generally high across the evaluated sites. PPV was 100.00% for symphysis/parasymphysis and frontal sinus fractures; however, the PPV for frontal sinus fractures on conventional radiography was not estimable because there were no positive radiographic classifications (Table *5*).

Anatomical site	Modality	True Positive	False Positive	False Negative	True Negative	Sensitivity	Specificity	PPV	NPV
Nasal bone	USG	10 (90.91%)	1 (2.38%)	1 (9.09%)	41 (97.62%)	90.91%	97.62%	90.91%	97.62%
	X-ray	8 (72.73%)	1 (2.38%)	3 (27.27%)	41 (97.62%)	72.73%	97.62%	88.89%	93.18%
Maxillary sinus	USG	34 (89.47%)	1 (6.67%)	4 (10.53%)	14 (93.33%)	89.47%	93.33%	97.14%	77.78%
	X-ray	29 (76.32%)	1 (6.67%)	9 (23.68%)	14 (93.33%)	76.32%	93.33%	96.67%	60.87%
Zygomatic arch	USG	15 (88.24%)	1 (2.78%)	2 (11.76%)	35 (97.22%)	88.24%	97.22%	93.75%	94.59%
	X-ray	12 (70.59%)	2 (5.56%)	5 (29.41%)	34 (94.44%)	70.59%	94.44%	85.71%	87.18%
Symphysis/parasymphysis	USG	3 (75.00%)	0 (0.00%)	1 (25.00%)	49 (100.00%)	75.00%	100.00%	100.00%	98.00%
	X-ray	2 (50.00%)	0 (0.00%)	2 (50.00%)	49 (100.00%)	50.00%	100.00%	100.00%	96.08%
Frontal sinus	USG	1 (50.00%)	0 (0.00%)	1 (50.00%)	51 (100.00%)	50.00%	100.00%	100.00%	98.08%
	X-ray	0 (0.00%)	0 (0.00%)	2 (100.00%)	51 (100.00%)	0.00%	100.00%	Not estimable	96.23%

TABLE 5: Site-specific diagnostic accuracy of ultrasonography and conventional radiography

Data are presented as percentages for sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). Diagnostic performance was calculated separately for each anatomical fracture site using CT as the reference standard. A 2 × 2 contingency table approach was used for calculation of diagnostic indices. PPV was not estimable for frontal sinus fractures on conventional radiography because both TP and FP were zero. A p-value <0.05 was considered statistically significant.

CT: computed tomography; USG: ultrasonography; X-ray: conventional radiography; PPV: positive predictive value; NPV: negative predictive value.

Descriptively, USG showed numerically higher values than conventional radiography for all evaluated diagnostic performance measures. The absolute difference was greatest for sensitivity, with USG demonstrating 87.50% compared with 70.83% for X-ray, representing a 16.67-percentage-point difference. Differences in specificity, PPV, NPV, and overall accuracy were 0.52, 2.72, 5.48, and 4.90 percentage points, respectively, in favor of USG (Table *6*).

Diagnostic parameter	USG	Conventional radiography	Absolute difference
Sensitivity	87.50%	70.83%	+16.67%
Specificity	98.45%	97.93%	+0.52%
PPV	95.45%	92.73%	+2.72%
NPV	95.48%	90.00%	+5.48%
Overall accuracy	95.47%	90.57%	+4.90%

TABLE 6: Comparative diagnostic performance of ultrasonography and conventional radiography

Data are presented as percentages, with the absolute difference between ultrasonography and conventional radiography expressed in percentage points. Diagnostic performance measures were compared descriptively with CT as the reference standard. The comparative diagnostic performance measures are presented descriptively and do not imply statistically significant superiority of ultrasonography.

USG: ultrasonography; X-ray: conventional radiography; CT: computed tomography; PPV: positive predictive value; NPV: negative predictive value

Discussion

The present study demonstrated a predominantly young adult and male population, with a mean age of 33.0 ± 12.0 years and the highest proportion of participants belonging to the 18-30-year age group (30, 56.60%). Males constituted 47 (88.68%) of the study population, with a male-to-female ratio of 7.83:1. Road traffic accidents were the predominant mechanism of injury (42, 79.25%), consistent with the recognized contribution of vehicular trauma to maxillofacial injuries. Previous studies have similarly reported a predominance of young adult males among patients with facial trauma. Rajeev et al. reported a mean age of 34.4 years with approximately 18 (90%) male participants in a study evaluating USG for facial fractures,

while Vijayan et al. also reported a predominantly male cohort (26, 86.7%) in their prospective evaluation of USG for maxillofacial fractures [8,14]. The predominance of road traffic accidents in the present study is also consistent with the established role of high-energy trauma in producing complex facial injuries involving multiple anatomical regions.

CT identified 72 fractures across five anatomical sites, with the anterior/lateral wall of the maxillary sinus being the most frequently involved site (38, 52.78%), followed by the zygomatic arch (17, 23.61%) and nasal bone (11, 15.28%). This distribution reflects the complex three-dimensional anatomy of the midface and the susceptibility of the maxillary and zygomatic regions to direct facial impact. CT is particularly valuable in this setting because conventional radiographs are affected by superimposition of facial structures, whereas CT provides detailed cross-sectional and multiplanar assessment of fracture location and extent. Avery et al. emphasized that CT is the most useful imaging modality for evaluating facial injury, particularly because of the complexity of facial anatomy and the limitations of plain radiographic interpretation [15]. Similarly, contemporary reviews describe CT as central to the assessment of maxillofacial injuries and to the characterization of fracture patterns relevant to treatment planning [16,17].

USG demonstrated 87.50% sensitivity, 98.45% specificity, 95.45% PPV, 95.48% NPV, and 95.47% overall accuracy in the present study. It detected 63 (87.50%) of the 72 CT-confirmed fractures, with particularly high sensitivity for nasal bone (10, 90.91%), maxillary sinus (34, 89.47%), and zygomatic arch fractures (15, 88.24%). These findings are comparable with previous evidence supporting the role of USG in superficial maxillofacial fractures. Vijayan et al. reported a sensitivity and specificity of 83.1% and 99%, respectively, for USG in maxillofacial fractures, while Rajeev et al. reported a sensitivity of 83.33% and a specificity of 98.88% [8,14]. In nasal bone fractures, Javadrashid et al. reported 94.9% sensitivity and 100% specificity for USG compared with CT, demonstrating particularly strong performance for superficial bony structures [18]. A meta-analysis has also supported the diagnostic value of USG for maxillofacial fractures, although performance varies according to anatomical site and study methodology [11]. The high diagnostic performance observed in the present study therefore appears consistent with the broader literature, particularly for fractures involving relatively superficial facial structures.

Conventional radiography demonstrated a lower observed diagnostic performance than USG, with a sensitivity of 70.83%, a specificity of 97.93%, a PPV of 92.73%, an NPV of 90.00%, and an overall accuracy of 90.57%. It missed 21 (29.17%) of the 72 CT-confirmed fractures, with particularly poor detection of frontal sinus fractures. The lower sensitivity of conventional radiography is consistent with the recognized limitations of two-dimensional imaging in the anatomically complex facial skeleton, where overlapping bony structures may obscure fracture lines or displacement. Descriptively, USG showed a 16.67-percentage-point higher sensitivity than conventional radiography (87.50% vs 70.83%), together with slightly higher specificity and overall accuracy. However, these differences should be interpreted as observed differences in diagnostic performance rather than evidence of statistically significant superiority, as the anatomical-site observations were clustered within individual participants. Rajeev et al. similarly reported greater fracture detection by USG than conventional radiography, while studies of nasal trauma have demonstrated substantially better diagnostic performance of USG than conventional radiography for selected superficial fractures [14]. Nevertheless, the lower sensitivity of both USG and conventional radiography compared with CT supports their interpretation as complementary or screening techniques rather than replacements for CT when complex, deep, or clinically significant facial fractures are suspected.

Strengths and limitations

The strengths of the present study include its prospective comparative design, assessment of USG and conventional radiography within the same patient cohort, and use of CT as the reference standard, allowing direct comparison of diagnostic performance. The study also evaluated multiple anatomical sites and reported comprehensive diagnostic parameters, including sensitivity, specificity, PPV, NPV, and overall accuracy.

However, the study has certain limitations, including the relatively small sample size of 53 patients from a single tertiary-care center, which may limit generalizability. The number of fractures at some anatomical sites, particularly frontal sinus fractures, was small, resulting in less precise site-specific estimates. Because each participant contributed five anatomical-site observations, the 265 site-level observations were clustered within 53 patients; therefore, these observations cannot be regarded as equivalent to 265 independent participants. The comparative diagnostic performance measures were consequently interpreted descriptively. USG is operator-dependent, and its performance may vary according to examiner expertise and anatomical accessibility. The exclusion of patients who were unable to cooperate with imaging procedures may also have introduced selection bias, particularly by under-representing patients with severe trauma, altered sensorium, or injuries requiring urgent intervention. Therefore, the findings may not be generalizable to all patients with severe or complex facial trauma. In addition, the study evaluated only five predefined facial fracture sites, and therefore the findings should not be extrapolated to all patterns or anatomical regions of facial trauma. Finally, the study was conducted at a single tertiary-care center, and the diagnostic performance of USG may vary according to operator experience, equipment, and local imaging protocols. Larger multicentre studies incorporating appropriate patient-level clustered statistical methods and a broader range of facial fracture patterns are warranted to validate these findings.

Conclusions

USG demonstrated good diagnostic performance for the detection of facial fractures when CT was used as the reference standard. It showed numerically higher sensitivity and overall diagnostic accuracy than conventional radiography, while both modalities demonstrated high specificity. USG may therefore serve as a useful radiation-free adjunctive imaging modality for selected facial fractures, particularly when rapid or bedside assessment is desirable. However, CT remains important for comprehensive evaluation and confirmation of complex facial trauma. Further studies involving larger, multicentric populations and a broader range of facial fracture patterns are warranted to validate these findings and better define the role of USG in facial trauma imaging.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Pallavi N, Suresh A, Raghavendra KL

Acquisition, analysis, or interpretation of data: Pallavi N, Suresh A, Raghavendra KL

Drafting of the manuscript: Pallavi N, Suresh A, Raghavendra KL

Critical review of the manuscript for important intellectual content: Pallavi N, Suresh A, Raghavendra KL

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Institutional Ethics Committee, Vydehi Institute of Medical Sciences and Research Centre, Bengaluru issued approval VIEC/2023/APP/PG/56. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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