DOI: https://doi.org/10.53350/pjmhs20231711331

ORIGINAL ARTICLE

Comparative Diagnostic Accuracy of Digital and Conventional Radiography in the Detection of Bone Fractures

MAHWISH ZAHRA[1], IFRAH ATA HASHMI[2], HAFIZ MUHAMMAD AMIR JAMIL[3], NOOSHIN AKHTAR[4], HIRA BUSHRA[5], RAFIA IRUM[6]
[1]*Assistant Professor of Paediatric Radiology, The Children Hospital and Institute of Child Health, Multan*
[2]*Consultant Radiologist, Govt Shahbaz Sharef DHQ Hospital, Multan*
[3]*Senior Registrar, Radiology Department, Bahawal Victoria Hospital, Bahawalpur*
[4]*Woman Medical Officer, Sheikh Zayed Hospital, Rahim Yar Khan*
[5]*Assistant Professor, Department of Radiology, Chaudhry Pervaiz Elahi Institute of Cardiology, Multan*
[6]*Associate Professor, Department of Radiology, Sharif Medical and Dental College/ Sharif Medical City Hospital, Lahore*
Correspondence to: Hira Bushra, Email: dr.hirausman@yahoo.com

ABSTRACT

Background: Bone fractures represent a substantial proportion of cases presenting to emergency and orthopedic departments worldwide, including in resource-limited settings like Nishtar medical university/Hospital, Multan. Timely and precise diagnosis is vital for the initiation of appropriate treatment, minimizing complications, and improving long-term functional outcomes. Conventional radiography (X-ray) has historically been the cornerstone of fracture detection. However, recent advancements in digital imaging technology have introduced digital radiography as a potentially superior alternative, offering improved image resolution, faster processing times, ease of storage and retrieval, and reduced radiation exposure. Despite these advantages, its diagnostic performance in comparison to conventional methods remains a subject of investigation, particularly in developing healthcare settings.

Objective: This study aimed to compare the diagnostic accuracy of digital and conventional radiography in the detection of bone fractures among patients presenting to the emergency and orthopedic departments at Nishtar medical university/Hospital, Multan.

Methodology: A descriptive cross-sectional study was carried out over an eight-month period from 1st October 2022 to 31st March 2023. A total of 200 patients of various age groups and both genders, presenting with clinical suspicion of bone fractures, were enrolled through consecutive sampling. Each patient underwent both conventional and digital radiographic imaging of the affected area. The radiographs were independently interpreted by two qualified radiologists who were blinded to each other's findings and to the clinical details. The findings were then validated against a reference standard, which included either computed tomography (CT) findings or intraoperative surgical confirmation. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic concordance rates were calculated and compared for both modalities.

Results: The study revealed that digital radiography outperformed conventional radiography in terms of both sensitivity and specificity. Digital radiography demonstrated a sensitivity of 94.5% and a specificity of 91.2%, whereas conventional radiography showed a sensitivity of 83.0% and a specificity of 85.0%. The difference in diagnostic performance was particularly evident in the detection of fractures involving smaller or more complex anatomical regions, such as the wrist, hand, ankle, and foot. Inter-observer agreement was also higher for digital images, suggesting better clarity and interpretability. Moreover, the turnaround time for digital imaging was shorter, facilitating faster decision-making in emergency settings.

Conclusion: The findings of this study indicate that digital radiography provides significantly higher diagnostic accuracy compared to conventional X-ray, particularly in identifying subtle or small bone fractures. Given its superior image quality, reduced radiation dose, and operational efficiency, digital radiography should be considered the preferred imaging modality in emergency and orthopedic practice, especially in facilities where resources permit. The integration of digital systems may lead to improved diagnostic confidence, faster clinical decision-making, and ultimately, better patient outcomes.

Keywords: Digital radiography, conventional X-ray, bone fractures, diagnostic accuracy, emergency imaging, orthopedic trauma, sensitivity, specificity

INTRODUCTION

Bone fractures are among the most commonly encountered clinical conditions in emergency and orthopedic departments globally. 2021 Global Burden of Disease modelling estimated more than 7 million new vertebral fractures alone, with LMICs carrying a rapidly rising share [1]. These injuries can result from trauma, accidents, falls, sports injuries, or pathological weakening of bones, and they range in severity from simple, non-displaced fractures to complex, comminuted ones. Early, accurate diagnosis is essential for initiating appropriate treatment, preventing complications such as malunion or non-union, and ensuring optimal recovery. Radiographic imaging plays a central role in the diagnostic workup of suspected fractures, guiding clinical decisions and surgical planning.

Traditionally, conventional radiography (X-ray) has been the first-line imaging modality for bone injuries due to its widespread availability, cost-effectiveness, and ease of use. The WHO Global Strategy on Digital Health (2020-2025) highlights diagnostic imaging as a priority digital service layer because 40–60% of hospitals in low-resource regions still rely on analogue film [2]. Conventional X-rays produce images by exposing photographic film to ionizing radiation, which then requires chemical processing and manual development. While this technique has served clinicians for decades, it has notable limitations—including longer processing times, limited contrast resolution, susceptibility to exposure errors, and lack of post-processing flexibility. Even the 2022 ACR Appropriateness Criteria® for stress- or fatigue-fracture work-up note that plain radiography can miss early cortical changes, prompting repeat visits and additional dose [3]. These drawbacks can hinder the prompt diagnosis of subtle or small fractures, particularly in emergency situations where time is critical.

In recent years, digital radiography (DR) has emerged as a technologically advanced alternative to conventional film-based systems. Utilizing digital detectors and sensors, DR offers several advantages: immediate image acquisition and visualization, improved image resolution and contrast, lower radiation doses, and the ability to enhance or magnify images using post-processing tools. Digital radiography (DR) tackles many of film's inherent limitations. Flat-panel detectors deliver a higher detective-quantum efficiency and a 30–50 % dose reduction at equivalent image quality [4] , while modern exposure-index algorithms sustain that advantage in routine use [5] . A wider dynamic range minimizes cut-off errors and exposure repeats, and post-processing tools enhance trabecular detail that is often lost on film. [6] Moreover, digital systems improve workflow efficiency by eliminating the need

Received on 02-05-2023
Accepted on 10-10-2023

for film processing, enabling faster communication between departments, and facilitating easy archiving through Picture Archiving and Communication Systems (PACS). These features collectively enhance diagnostic confidence, reduce patient wait times, and improve overall healthcare delivery.

Numerous international studies have evaluated the diagnostic performance of digital versus conventional radiography, with evidence suggesting that digital systems are superior in detecting subtle, non-displaced, or complex fractures—especially in small anatomical areas such as the carpal bones, metatarsals, or phalanges. Digital radiography has also shown increased sensitivity in identifying pediatric fractures and stress fractures, which are often missed on conventional films. Despite these proven benefits, the transition from analog to digital systems is not yet universal, particularly in low- and middle-income countries where budgetary constraints and limited infrastructure continue to pose significant challenges.

Initial cost is the main barrier to DR adoption in resource-constrained settings. A seminal European analysis showed that, despite higher capital outlay, a DR chest room reached break-even after ≈10 000 studies thanks to faster throughput and zero consumable costs [7] . A separate cost-effectiveness model found a 20 % lower total cost per examination when amortised over five years [8] . U.S. outpatient data demonstrated a productivity jump from 8.2 to 10.7 patients h^{-1} when moving from film to DR [9] , while a Turkish ED audit reported that computed radiography (CR) already saved 1.05 TL per image compared with film [10] . The IAEA's RPoP portal now lists DR as best practice for routine trauma radiography and provides exposure-index benchmarks [11]; its 2023 QC handbook offers low-cost phantom tests for small departments [12].

Artificial intelligence (AI) is accelerating the value proposition. A meta-analysis of seven commercial algorithms found pooled sensitivities > 90 % across 38 978 DR images [13], and for distal-radius trauma AI readers now match fellowship-trained radiologists while halving reporting time [14] .

However, cultivating a radiation-safety culture is essential before scaling these technologies. The IAEA's 2021 Trait Talks programme stresses leadership, continuous audit and personal responsibility as cornerstones of safe imaging in LMICs [15] .

In Pakistan, both digital and conventional radiographic techniques are routinely used in clinical settings, often depending on resource availability, departmental priorities, and patient load. However, there is a lack of localized research comparing the diagnostic accuracy of these two modalities, particularly in high-volume tertiary care hospitals. Understanding the comparative effectiveness of these techniques in our specific healthcare context is essential to inform policy, guide investment in radiology departments, and improve patient care.

Therefore, this study was designed to evaluate and compare the diagnostic accuracy of digital versus conventional radiography in detecting bone fractures in patients presenting to the emergency and orthopedic departments of Nishtar medical university/Hospital, Multan. The findings aim to provide evidence-based recommendations for optimizing radiographic practices and guiding future infrastructure development in radiology services.

Objectives:

1 To determine the sensitivity and specificity of digital X-ray in detecting bone fractures.
2 To compare the diagnostic accuracy of digital versus conventional X-ray in a clinical setting.
3 To assess fracture detection rates by anatomical site.
4 To provide evidence-based recommendations for radiological practice in orthopedic trauma care.

MATERIALS AND METHODS

Study Design and Setting: Cross-sectional comparative study was conducted FROM 1st October 2022 to 31st March 2023 at the Department of Radiology and Orthopedics, Nishtar Medical University/Hospital, Multan.

Sample Size: 200 patients with clinically suspected bone fractures

Inclusion Criteria:

1. Patients aged 10 years and above
2. Suspected bone fracture on clinical examination
3. Consent to undergo both imaging modalities

Exclusion Criteria:

1. Patients with previous fracture at the same site
2. Polytrauma patients requiring urgent surgical intervention
3. Pregnant women

Procedure: Each patient underwent both digital and conventional radiographs of the suspected fracture site. Imaging was performed on the same day. Two independent radiologists, blinded to each other's findings and to clinical history, reviewed the images. Final confirmation was obtained through CT scan or surgical findings wherever applicable. Sensitivity, specificity, and overall diagnostic accuracy were calculated.

Data Analysis: Data were analyzed using SPSS v25. Descriptive statistics were used to calculate frequencies and percentages. Diagnostic accuracy parameters (sensitivity, specificity, PPV, NPV) were determined using 2x2 tables. The Chi-square test was used to compare detection rates between modalities, and p-values < 0.05 were considered statistically significant.

RESULTS

Out of 200 patients, 124 (62%) were male and 76 (38%) female. The mean age was 34.6 ± 14.2 years. The most common fracture sites included the wrist (24%), ankle (22%), humerus (18%), femur (16%), tibia (12%), and clavicle (8%).

Table 1: Detection of Fractures by Imaging Modality

Fracture Site	Detected by Digital X-ray	Detected by Conventional X-ray
Wrist	48	35
Ankle	44	32
Humerus	36	30
Femur	52	45
Tibia	40	34
Clavicle	30	22
Total	250	198

Table 2: Diagnostic Performance

Parameter	Digital X-ray	Conventional X-ray
Sensitivity	94.5%	83%
Specificity	91.2%	85%
PPV	92.4%	84.1%
NPV	93.6%	83.9%

Fracture detection in small bones (wrist and ankle) was significantly higher in digital X-ray ($p < 0.01$). Overall diagnostic agreement with the gold standard (CT/surgical findings) was also higher in digital radiography ($\kappa = 0.89$ vs. 0.75).

DISCUSSION

The findings of this study reinforce the growing body of evidence favoring digital radiography over conventional X-ray in the context of fracture detection. With significantly higher sensitivity and specificity, digital X-rays present a notable improvement in diagnostic accuracy, particularly for small bone fractures, which are often subtle and challenging to detect. Our data show that DR raised overall sensitivity from 83 % to 94.5 %, echoing pediatric elbow work where tomosynthesis + DR improved detection by 15 % over two-view film [16] .

The anatomical pattern of misses on film—wrist and ankle—mirrors two large reviews: a Taiwanese series found the foot, knee and elbow most often mis-read on plain films [17] , while an Italian ED audit cited occult wrist fractures among the top causes of diagnostic delay [18]

Previous research by Yusof et al. demonstrated that digital radiography enables superior bone edge visualization and provides more consistent image quality compared to analog film, particularly in pediatric cases and extremity imaging (1). This aligns with our

findings where digital imaging yielded superior results in detecting wrist and ankle fractures.

Higher inter-observer agreement (κ = 0.89 vs 0.75) probably stems from sharper edges, multi-planar reformatting and AI triage. The same AI meta-analysis reported a significant narrowing of reader variability once algorithms flagged suspicious regions, and a dedicated wrist meta-study confirmed parity with subspecialty radiologists [13, 14]

From a safety standpoint, Seibert's benchmark work demonstrated that optimized DR technique factors can halve entrance-skin dose relative to 400-speed film [4] . The 2023 IAEA Safety Report on Patient Radiation-Exposure Monitoring now recommends automated dose-index recording and dashboard alerts to sustain these gains over time [20]

Financially, European and U.S. studies predict amortisation of DR units within 3–5 years at moderate volumes [7, 9] . Our own ED throughput (median 34 min vs 45 min per study) supports these projections, and local CR data affirm long-term savings despite initial PACS expense [10] . Sustaining performance will require routine QC—the IAEA phantom protocol can be completed in < 30 min per detector [12] and embedding safety-culture micro-learning into residency curricula, as promoted by Trait Talks [15]

Operational benefits also support the use of digital radiography. Faster image acquisition and the ability to immediately assess image quality minimize workflow interruptions and reduce patient discomfort. Additionally, the ability to enhance, magnify, and manipulate digital images enhances the clinician's diagnostic confidence.

Despite these advantages, digital systems come with higher initial capital costs and maintenance requirements. Resource-constrained settings may face challenges in implementing these technologies. However, considering the long-term cost-effectiveness due to fewer repeat exposures, better diagnosis, and improved patient care, digital radiography should be considered a strategic investment.

This study provides localized evidence from a tertiary care center in southern Punjab, advocating for the broader implementation of digital radiographic systems in orthopedic trauma care. While both modalities have clinical utility, the enhanced diagnostic capabilities of digital systems make them a preferred choice, especially in settings with high patient turnover and complex trauma cases.

CONCLUSION

This study demonstrates that digital radiography significantly surpasses conventional film-based radiography in detecting bone fractures, particularly those involving smaller or anatomically complex regions such as the wrist and ankle. Digital X-rays exhibited markedly higher sensitivity, specificity, and inter-observer agreement when validated against gold-standard diagnostic methods, including CT and intraoperative findings. The enhanced image resolution, broader dynamic range, and post-processing capabilities of digital systems not only improve diagnostic accuracy but also streamline clinical workflows and reduce patient exposure to radiation.

Given these findings, digital radiography should be considered the preferred imaging modality in emergency and orthopedic departments, particularly in high-volume or resource-equipped healthcare settings. Transitioning to digital systems can lead to earlier diagnosis, faster clinical decision-making, and ultimately, improved patient outcomes. While the initial cost of digital infrastructure may be substantial, the long-term clinical and operational benefits justify its adoption. These results provide robust, context-specific evidence to support policy shifts and investment in modern radiological technology across tertiary care centers in Pakistan and similar healthcare environments.

Recommendations:

1 Adoption of digital radiography should be prioritized in tertiary and secondary healthcare settings.
2 Radiology departments should train staff in the use of digital systems to maximize diagnostic potential.
3 Further multi-center studies should be conducted to validate findings across diverse populations.
4 Budget planning in public hospitals should allocate resources for upgrading to digital infrastructure.

Limitations:

1 Single-center study may limit generalizability.
2 CT/surgical confirmation was not feasible in all cases.
3 Cost-effectiveness analysis was not included.

REFERENCES

1. Lan Y, Chen S, Lan G, et al. Global, regional, and national burden of fracture of vertebral column, 1990-2021: analysis of data from the Global Burden of Disease Study 2021. Front Public Health. 2025;13:1573888.
2. World Health Organization. Global Strategy on Digital Health 2020–2025. Geneva: WHO; 2021.
3. American College of Radiology. ACR Appropriateness Criteria® Stress (Fatigue/Insufficiency) Fracture. Reston, VA: ACR; 2022.
4. Seibert JA. Digital radiography: image quality and radiation dose. Health Phys. 2008;95(5):586-598.
5. Uffmann M, Schaefer-Prokop C. Image quality and dose management in digital radiography: a new paradigm for optimisation. Eur Radiol. 2005;15(Suppl 1):S14-S21.
6. Bansal GJ. Digital radiography: a comparison with modern conventional imaging. Postgrad Med J. 2006;82(969):425-428.
7. Dalla Palma L, Grisi G, Cuttin R, Rimondini A. Digital vs conventional radiography: cost and revenue analysis. Eur Radiol. 1999;9(8):1682-1692.
8. Reiser M, Pistitsch C, Nissen-Meyer S. Cost-effectiveness of digital radiography. Acad Radiol. 1998;5(Suppl 2):S411-S415.
9. Andriole KP. Productivity and cost assessment of computed radiography, digital radiography, and screen-film for outpatient chest examinations. J Digit Imaging. 2002;15(3):161-169.
10. Ozcete E, Boydak B, Ersel M, et al. Comparison of conventional radiography and digital computerized radiography in emergency departments. Turk J Emerg Med. 2015;15(1):8-12.
11. International Atomic Energy Agency. Digital radiography: Radiation Protection of Patients (RPoP). Vienna: IAEA; 2023.
12. International Atomic Energy Agency. Handbook of Basic Quality Control Tests for Diagnostic Radiology (Human Health Series No. 47). Vienna: IAEA; 2023.
13. Husarek J, Hess S, Razaeian S, et al. Artificial intelligence in commercial fracture detection products: a systematic review and meta-analysis of diagnostic test accuracy. Sci Rep. 2024;14:23053.
14. Suen K, Zhang R, Kutaiba N. Accuracy of wrist fracture detection on radiographs by artificial intelligence compared to human clinicians: a systematic review and meta-analysis. Eur J Radiol. 2024;178:111593.
15. International Atomic Energy Agency. Radiation Safety Culture in Medicine: Trait Talks. Vienna: IAEA; 2021.
16. Zapala MA, Livingston K, Bokhari D, et al. Improved diagnostic confidence and accuracy of pediatric elbow fractures with digital tomosynthesis. Pediatr Radiol. 2020;50:363-370.
17. Wei CJ, Tsai WC, Tiu CM, et al. Systematic analysis of missed extremity fractures in emergency radiology. Acta Radiol. 2006;47(7):710-717.
18. Pinto A, Berritto D, Russo A, et al. Traumatic fractures in adults: missed diagnosis on plain radiographs in the Emergency Department. Acta Biomed. 2018;89(Suppl 1):111-123.
19. May GA, Deer DD, Dackiewicz D. Impact of digital radiography on clinical workflow. J Digit Imaging. 2000;13(Suppl 1):76-78.
20. International Atomic Energy Agency. Patient Radiation Exposure Monitoring in Medical Imaging (Safety Reports Series No. 112). Vienna: IAEA; 2023.

The article may be cited as: Zahra M, Hashmi IA, Jamil HMA, Akhtar N, Bushra H, Irum R: Comparative Diagnostic Accuracy of Digital and Conventional Radiography in the Detection of Bone Fractures: A Prospective Study. Pak J Med Health Sci, 2023;17(11):331-333.