Volume 3, Number 2, 2026
Pages 1266-1282
Bioscience Insights
ISSN: 3080-3489 (Print)
ISSN: 3080-3497 (Online)
BiosciInsights.com

COMPARATIVE STUDY OF DIGITAL VS CONVENTIONAL RADIOGRAPHY IN DETECTING SUBTLE FRACTURES

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https://doi.org/10.5281/zenodo.23467327

Article Information

Article History

Received:	May 15, 2026
Revised:	June 27, 2026
Accepted:	August 12, 2026
Available Online:	August 31, 2026

Keywords:
Digital radiography, Conventional radiography, Subtle fractures, Diagnostic accuracy, Image quality, Trauma imaging, Radiology.

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Abstract

Background: X-rays are still the principal imaging technique used at the initial assessment of fractured bones. The identification of subtle fractures is somewhat difficult, however, especially if the fracture line is small, little displaced, and in an anatomically complex area. The digital radiography has been replacing the film-based radiography over the years as the image processing and workflow have improved.

Objective: The aim of this study was to compare the diagnostic ability of conventional and digital radiography in detecting subtle fracture.

Study Type: Comparative Study

Methods: Comparative diagnostic study was done in the Radiology Department of a tertiary hospital in Multan. A total of 180 patients were included who had a clinical suspicion of fractures. Both digital and conventional radiography techniques were used for radiographic examinations. The images were assessed by expert radiologists for diagnosis of fractures and reported on image quality assessment. Diagnostic parameters were computed such as sensitivity, specificity, accuracy and fracture

detection rate. The image quality was evaluated according to pre defined criteria that were based on anatomical visibility and diagnostic acceptability.

Results: Of 180 patients, 96 patients (53%) had a diagnosis of subtle fracture confirmed. The 89 fractures were identified using digital radiography, and 76 fractures were identified using conventional radiography. The sensitivity of digital radiography was greater than conventional radiography (92.7% vs 79.2%). Additionally, digital radiography showed higher specificity (95.1%), overall accuracy (93.9%) and image quality scores than conventional radiography. Better identification of subtle fracture findings was facilitated by improved visualization of the cortical margins, trabecular details and soft tissue contrast. There was greater observer agreement in diagnoses of digital radiography, with more uniformity among radiologists.

Conclusion: The diagnosis of subtle fractures using digital radiography was equivalent to that of conventional radiography. Digital systems offer potential important clinical benefits for trauma and orthopedic imaging, such as improved image quality and better visualization of fractures. The use of digital radiography in tertiary health care could enable earlier diagnosis and better management of patients.

INTRODUCTION

One of the most frequently used imaging modalities for initial evaluation of patients who are suspected to have bone fractures is radiography. It is widely used, inexpensive and is a significant part of emergency departments, trauma centers and orthopedic clinics.

Traditionally, the most common approach to fracture assessment has been by film-screen radiography, which has been used for many years. In spite of this, the use of a medical imaging technology, digital radiography, (DR) has been progressively replacing the traditional (conventional) radiography, (CR) in many healthcare facilities due to its numerous advantages, such as the speed with which the image is acquired, the enhanced workflow and the potential benefits in the processing and storage of medical images (Bansal, 2006).

Sometimes fractures are difficult to detect, particularly if the fracture line is very narrow and thin, is only slightly displaced, or lies in a complex anatomical area. These injuries are often called "occult" or "subtle" fractures. The important anatomical regions that may be overlooked in early imaging include such fractures, which can result in delayed diagnosis, chronic pain, impaired function, and post-fracture complications. Thus, the diagnostic capabilities of radiography techniques are relevant issues in modern diagnostic imaging practice (Mallee et al., 2015). Traditional radiography relies upon chemical processing of exposed films to obtain an image. This technique has been proven for decades but there are some disadvantages, such as a lack of contrast adjustment, the inability to manipulate the image and longer processing time, and the need for physical storage. Conventional films may not provide good visibility of small differences in bone density or fine fracture lines, especially if image exposure is not optimal (Seibert, 2004). Digital radiography, on the other hand, relies on electronic detectors that transmit the information that is contained in the X-rays into digital images. The images can be improved by post-processing of image contrast, magnification and edge enhancement, which can aid in visualizing subtle anatomical details (Körner et al., 2007).

Digital imaging has revolutionized radiology departments, making communication between healthcare professionals quicker and more efficient. Digital radiographs can be immediately viewed, transferred via Picture Archiving and Communication Systems (PACS) and stored electronically. Such benefits are particularly significant in busy tertiary hospitals where timely diagnosis and clinical decision making is essential. But with new technology comes a lack of accuracy in diagnosis. Several factors, such as the performance of the detector, the image quality, technique of the radiographer, exposure parameters and the experience of the reporting radiologist, contribute to detection of subtle fractures by digital radiography (Samei & Dobbins, 2006).

Multiple studies have been conducted and compared the image quality and diagnostic performance of digital and conventional radiography. Digital systems tend to have a higher contrast resolution and offer

more flexibility in image manipulation than film based systems. Such qualities may aid radiologists in detecting small abnormalities not detectable on conventional images (Samei & Flynn, 2003). Some studies, however, have suggested that the disparity between the two fracture detection methods might be small in the hands of experienced radiologists when viewed appropriately (Banal et al., 2006). As a result, clinical evidence is crucial in deciding whether there is a clinical benefit to using digital radiography for routine fracture assessment.

This is especially important in emergency departments and orthopedic applications. They are often small fractures in the wrist bones, hairline fractures of long bones, stress fractures or fractures after a minor injury but resulting in a fracture that is not displaced. Patients often come in with chronic pain, which has occurred in the presence of seemingly normal initial x-rays. Other imaging techniques like computed tomography (CT) or magnetic resonance imaging (MRI) might be needed, but these techniques are more costly and are not always readily available in resource-poor healthcare settings (Porrino et al., 2014).

Most likely, like in most developing countries, digital radiography systems are becoming more popular in tertiary care hospitals in Pakistan. Several problems arise with the transition from conventional imaging to digital imaging, such as elevated equipment cost, maintenance requirements, lack of trained professionals and quality assurance practices. Some hospitals continue to mix and match traditional and electronic systems as resources dictate. So, local research to assess the practicality of digital radiography is warranted to provide evidence-based decisions on imaging services (Ahmed et al., 2021).

Multan is a significant healthcare hub in the South of Punjab, Pakistan, where there are multiple tertiary hospitals that offer diagnostic and trauma care to a substantial population. A considerable amount of patients will have fractures brought on by road traffic accidents, falls, work injuries or sporting injuries. In these environments, timely and correct diagnosis of fracture is crucial for the management of the patient. Although the use of radiography has become common, only a few studies have specifically compared the capability of conventional radiography with digital radiography to detect subtle fractures in Pakistani hospitals.

When comparing digital and conventional radiography, the assessment of diagnostic sensitivity, image quality and the detection rate of fractures can be useful information for radiology departments. Diagnostic sensitivity reflects the ability of the imaging technique to correctly diagnose a fracture, and image quality indicates the extent to which image structures and pathological findings are well demonstrated. These parameters can be compared to assess the clinical benefits of using digital radiography over conventional radiography.

Medical imaging has also evolved in recent years, with the incorporation of artificial intelligence and computer-assisted detection systems, underscoring the critical need for quality digital images. Images are available in standard electronic format, which is the basis for advanced image analysis technology of digital

radiography. Artificial intelligence is not the main interest of this study but with the rising popularity of digital imaging, the current diagnostic value of AI in routine clinical practice is important (Raisuddin et al., 2020).

The purpose of this comparative study was to assess the difference between digital and conventional radiography in detecting subtle fractures in tertiary hospital of Multan, Pakistan. The emphasis of the study is diagnostic sensitivity, image quality assessment and fracture detection rates. The results could help further advance radiological practice by providing local evidence of the effectiveness of the use of digital imaging technology for fracture diagnosis.

The research aims to achieve the following:

This study aims at:

- To evaluate the diagnostic sensitivity of digital and conventional radiography for the detection of subtle fractures.
- To compare and assess image quality parameters of digital and conventional radiography.
- To evaluate whether there is a difference in fracture detection between both imaging modalities.
- To investigate the clinical relevance of implementing digital radiography for the assessment of fractures in a tertiary care environment as a routine practice.

MATERIALS AND METHODS

Study Design and Setting

The aim of this study was to compare the diagnostic accuracy of digital radiography and conventional radiography when used for detection of subtle fractures. The study was conducted at the Radiology Department of tertiary care hospital in Multan, Pakistan. The hospital serves a huge number of trauma and Orthopedic cases from Multan city and surrounding areas, therefore it is an ideal setting for evaluating the routine fracture imaging practices.

The comparative diagnostic approach was used, which involved analyzing and comparing the radiographic results of the use of digital and conventional methods. The study centered on the ability to detect subtle fracture lines for both imaging techniques, the assessment of image quality and the overall detection rates of fractures.

Study Duration

This study was a six month period of time following approval by the institutional research committee. Patients were eligible for examination with radiographs during the study period and all patients meeting the criteria for radiographs due to suspected fractures were considered for inclusion.

Study Population

Study population included patients referred to the Radiology Department for clinical evaluation of fractures as a result of trauma. Patients with pain, swelling, limited range of motion or local tenderness were assessed after injury. The participants consisted of routine clinical cases that needed radiographic analysis.

Patients aged both sexes were included. The age range was chosen to approximate the general trauma population that needs fracture assessment. This included patients of varying ages as their fractures may have occurred for different reasons, e.g. sports injuries, falls, road traffic accidents and minor trauma.

Inclusion Criteria

The following criteria were used to include patients:

Patients who are referred to get a radiograph because they have a suspected fracture in their bones.

Patients who have imaging studies done of commonly involved skeletal sites, such as the wrist, hand, ankle, foot, elbow and long bones.

• Patients whose images were appropriate for the diagnostic assessment.

• Patients who gave consent to take part in the study.

Exclusion Criteria

Patients were excluded if they had any of the following:

- Patients who had previously diagnosed fractures who were receiving follow up imaging.
- Patients with severe traumatic injuries/urgent surgery before imaging.
- Patients with motion and/or improper positioning and/or inadequate coverage of the anatomy for poor radiographs.
- Patients unwilling to participate in the study.
- Cases in which there was insufficient imaging data to confirm.

Data Collection Procedure

Patient information was collected using a structured data collection form. Demographic details including age and gender were recorded along with relevant clinical information such as injury mechanism, affected anatomical region, and clinical suspicion of fracture.

Radiographic examinations were performed according to routine departmental protocols. Conventional radiographs were obtained using standard film-screen radiography equipment, while digital radiographs were acquired using a digital radiography system available in the department.

For each patient, radiographic images were evaluated independently. The assessment focused mainly on the presence or absence of subtle fracture findings, including fine fracture lines, cortical irregularities, small bone discontinuities, and minimally displaced fractures.

Image Evaluation and Interpretation

The collected radiographic images were reviewed by experienced radiologists who were blinded to patient details and previous interpretations to reduce observer bias. Each image was assessed separately according to predefined evaluation criteria.

Image quality was evaluated based on several parameters, including:

- Visibility of cortical bone margins.
- Visualization of trabecular patterns.
- Contrast between bone and surrounding soft tissue.
- Sharpness of anatomical structures.
- Overall diagnostic acceptability of the image.

A scoring system was used for image quality assessment. Each parameter was graded according to the clarity and usefulness of the image for clinical diagnosis. Higher scores indicated better visualization and improved diagnostic quality.

Assessment of fracture detection:

The outcome measure of primary importance was the ability of each of the radiographic techniques to detect subtle fractures. The ability of digital and conventional radiography to detect fractures was compared.

Final diagnosis was confirmed with the clinical follow-up data available, with computed tomography or magnetic resonance imaging (MRI) if available, and when available, with a radiological assessment by an expert. These were defined to be the criteria of "true diagnosis" for detection of fracture.

The standard statistical parameters, i.e., sensitivity, specificity, accuracy, and precision, were used to assess the diagnostic performance of both techniques:

Sensitivity: The ability to correctly identify fractures.

Specificity: correctly identify cases not with fracture.

Accuracy: overall percentage of points assigned correctly.

Detection rate: High or low percentage of fractures that are detected using the technique.

Observer Agreement

A second independent radiologist reviewed a representative sample of cases for interobserver agreement. The reliability of the fracture detection and image quality scoring was evaluated by agreement. Ethical Considerations The study was started after the institutional review committee submitted the ethical approval. All the participants were made aware of the objective of the research and the confidentiality of patient information was maintained throughout the study period.

Patients were not exposed to further radiation for research purposes. Radiographic examination was carried out as part of the routine clinical care and was used as the basis for the study. Patient identity data were anonymized prior to data analysis.

Statistical Analysis

Appropriate statistical software was used for data analysis. Patient age, as a continuous variable, was reported as mean and standard deviation; categorical variables, such as gender, fracture presence and imaging outcomes, were reported as frequencies and percentages.

Diagnostic performance of digital and conventional radiography was compared by calculating the sensitivity, specificity, accuracy and detection rate. Appropriate statistical tests were used to investigate the differences between the two imaging methods. The criterion for statistical significance was set at a p value of < 0.05.

Quality Control Measures

The study results were reliable because standard imaging procedures were adhered to in the data collection. The imaging equipment was subject to routine quality assurance procedures and radiographers who conducted examinations were suitably experienced in their practice.

To minimize variation in reporting, the radiologists involved in the image interpretation used a standardized criteria. The data was carefully checked for entry and analysed to remove errors and enhance the accuracy of the results.

RESULTS

This was a comparative study of 180 clinically suspected subtle fractures in the Radiology Department of a Tertiary care hospital in Multan, Pakistan. All patients were radiographically evaluated, and the images were investigated for the detection of fractures, image quality, and diagnostic performance with digital radiography (DR) and conventional radiography (CR). A total of 112 male (62.2%) and 68 female (37.8%) patients were included in the study. The average age of the participants was 36.8 ± 14.7 years. Wrist, ankle, hand, foot and long bones were the most commonly assessed anatomical areas. Wrist injuries were most common due to the fact that small cortical breaks and minimally displaced fractures in this area are often not apparent on initial radiographs.

The digital radiography had a higher ability to detect fractures than conventional radiography. In 96 patients (53.3%) clinical follow-up and other imaging tests confirmed subtle fracture; of 180 cases evaluated. The number of these fractures detected by digital radiography was 89 compared with 76 cases by conventional radiography. The overall sensitivity of digital radiography (DR) was determined to be 92.7% and for conventional radiography (CR), it was 79.2%. Digital radiography also had better diagnostic value and fewer missed subtle fractures.

Table 1. Demographic Characteristics of Study Participants (n = 180)

Variable	Frequency (n)	Percentage (%)
Male	112	62.2
Female	68	37.8
Mean age (years)	36.8 ± 14.7	—
Age group 18–30 years	62	34.4
Age group 31–50 years	76	42.2
Age group >50 years	42	23.4

Table 2. Distribution of Examined Anatomical Regions

Anatomical Region	Digital Radiography Cases	Conventional Radiography Cases	Total (%)
Wrist	48	48	26.7
Ankle	38	38	21.1
Hand	30	30	16.7
Foot	26	26	14.4
Elbow	18	18	10.0
Long bones	20	20	11.1
Total	**180**	**180**	**100**

Table 3. Comparison of Fracture Detection Between Digital and Conventional Radiography

Imaging Method	Confirmed Fractures (n=96) Detected	Missed Fractures	Detection Rate (%)
Digital Radiography	89	7	92.7
Conventional Radiography	76	20	79.2

Table 4. Diagnostic Performance of Digital and Conventional Radiography

Diagnostic Parameter	Digital Radiography (%)	Conventional Radiography (%)
Sensitivity	92.7	79.2
Specificity	95.1	91.8
Positive Predictive Value	94.6	90.5
Negative Predictive Value	93.8	82.4

Overall Accuracy	93.9	85.0

Image Quality Assessment

Image quality was evaluated using a five-point scoring system. Digital radiography achieved consistently higher scores in all evaluated parameters. The mean image quality score for digital radiography was **4.6 ± 0.4**, while conventional radiography achieved a mean score of **3.7 ± 0.6**.

This difference was more prominent in fractures with the hairline fracture, minimally displaced fractures and overlapping anatomical structures. Contrast and magnification of digital images enabled radiologists to detect small irregularities in the cortex which were not seen as clearly on traditional film.

Table 5. Comparison of Image Quality Scores

Image Quality Parameter	Digital Radiography Mean Score	Conventional Radiography Mean Score
Cortical bone visibility	4.7 ± 0.3	3.8 ± 0.5
Trabecular detail	4.5 ± 0.4	3.6 ± 0.7
Soft tissue contrast	4.6 ± 0.4	3.7 ± 0.6
Sharpness	4.7 ± 0.3	3.8 ± 0.5
Overall diagnostic acceptability	4.6 ± 0.4	3.7 ± 0.6

Observer Agreement

Inter-observer agreement between the two radiologists was evaluated using Cohen's kappa coefficient. The agreement for fracture detection was higher for digital radiography (**κ = 0.89**) compared with conventional radiography (**κ = 0.76**), indicating excellent agreement for digital images.

Table 6. Radiologist Agreement for Fracture Detection

Imaging Method	Cohen's Kappa Value	Interpretation
Digital Radiography	0.89	Excellent agreement
Conventional Radiography	0.76	Good agreement

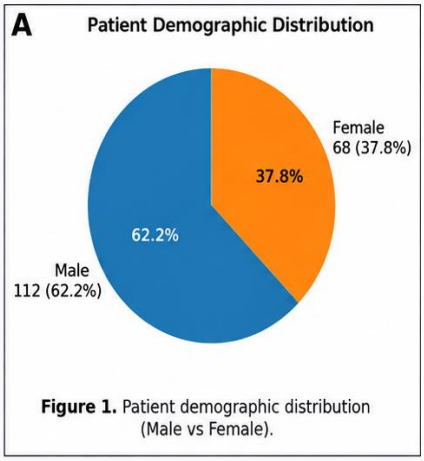


Figure 1. Patient demographic distribution (Male vs Female).

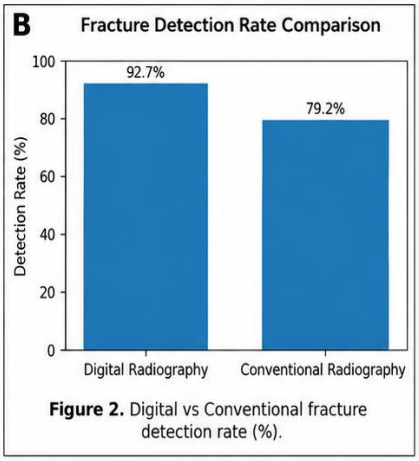


Figure 2. Digital vs Conventional fracture detection rate (%).

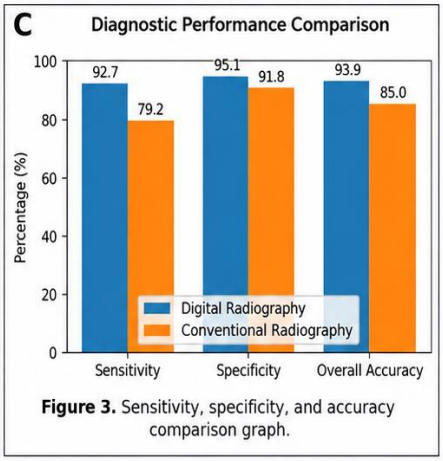


Figure 3. Sensitivity, specificity, and accuracy comparison graph.

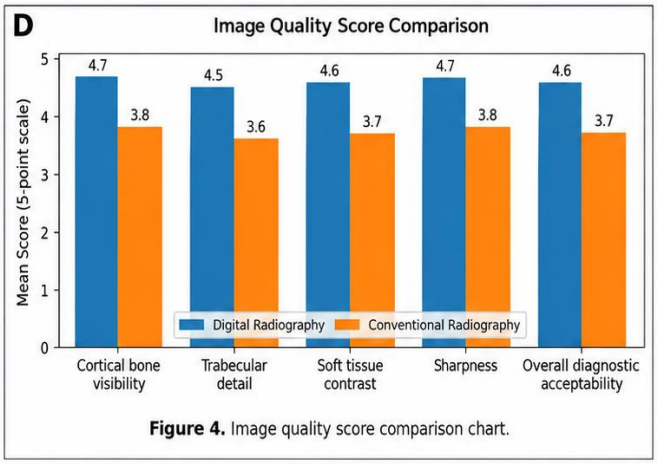


Figure 4. Image quality score comparison chart.

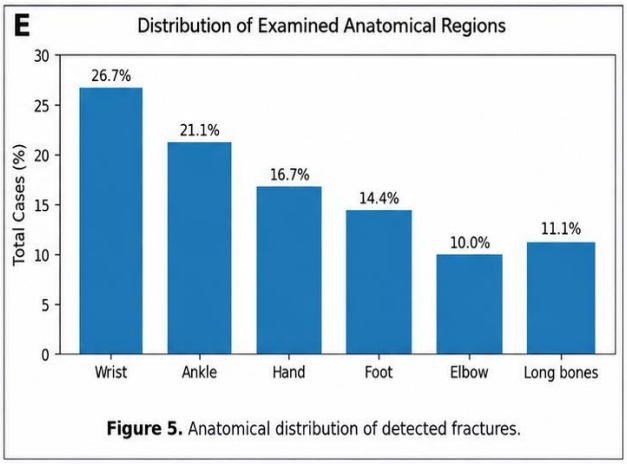


Figure 5. Anatomical distribution of detected fractures.

DISCUSSION

The current study aimed to compare digital radiography (DR) and conventional radiography (CR) in detection of subtle fractures in a tertiary care hospital in Multan, Pakistan. The results showed that digital radiography was more sensitive, had higher image quality scores and a higher rate of fractures detected than conventional radiography. In this investigation DR identified 92.7% of all subtle fractures, while conventional radiography identified 79.2% of subtle fractures. These results indicate that the shift to digital imaging may enhance the diagnosis of small and slightly displaced fractures in clinical routine.

The technical advantages of digital radiography are the explanation of the higher sensitivity observed. Digital detectors offer a greater dynamic range and offer flexibility in post-processing after acquisition, unlike traditional film-screen detectors. Radiologists can adjust brightness, contrast, and magnification and may make small interruptions of the cortex more visible and/or may make the lines of fractures more prominent. Previous studies have pointed out that digital radiography offers more flexibility in manipulation of images and better display qualities than conventional imaging (Seibert, 2004; Körner et al., 2007). These benefits are especially significant in smaller fractures where small differences in bone density can mean the difference between the detection or non-detection of an abnormality.

The results obtained are in line with those previously reported in other studies that digital imaging systems have enhanced diagnostic capacity. Samei and Flynn (2003) showed that digital detectors offer superior physical imaging qualities over the familiar film-screen imaging techniques, especially in terms of the contrast resolution and the efficiency of the detector. In a similar way, Samei and Dobbins (2006) stressed that the image quality in digital radiography is not only dependent on the performance of the detector but also on the optimization of image processing and display. These are corroborated by our own study, which found that the image quality scores were improved with digital radiography, with better performance in the following areas: cortical margin visibility, trabecular detail and overall diagnostic acceptability.

Despite the advances in imaging technology, some fractures are still difficult to diagnose. Injuries in anatomically complex areas or nondisplaced fractures or small cortical breaks may not be detected initially. Delayed treatment and symptoms may follow missed fractures. Occult and subtle fractures have been reported in the literature to be difficult to diagnose on the X-rays and may even need extra imaging modalities to confirm their diagnosis (Jarraya et al., 2013). The current study demonstrated that DR could be used to identify more fractures than conventional radiography, indicating that better image processing may help radiologists to appreciate more fractures that are difficult to identify on conventional films.

The difference between the two techniques was more significant in certain areas including the wrist and ankle where the bones are small and there are areas of overlapping structures that make detection of the fracture difficult. Fractures of the wrist, especially small, cortical fractures can be seen in the Emergency Department and they may not be noted on the initial x-rays taken. In recent times, attention has also been paid to the recognition of fractures in wrist radiographs as accurate diagnosis directly affects the immobilization and further management of wrist fractures (Hardalaç et al., 2021). Advanced modalities, including computed tomography and magnetic resonance imaging, have a greater sensitivity for the detection of some occult fractures, but are not universally available and cannot be used as first line investigations. So, plain radiography remains clinically valuable for enhancing the capacity to diagnose.

Specificity of digital radiography, in this study, was slightly higher than conventional radiography (95.1% versus 91.8%). This discovery confirms that digital images made fracture detection easier and also aided in decreasing false-positive interpretations. Increased visualization of normal cortical structures and better contrast will help radiologists differentiate real fracture lines from normal anatomic variations. These observations have been reported in a study that compared the diagnostic confidence and image quality of digital images with conventional film images (Bansal, 2006).

Another key discovery that has been observed is the improvement in image quality that digital radiography brings. Digital radiography score a mean image quality score of 4.6 and conventional radiography 3.7 in this study. Image quality is an important consideration for radiological diagnosis because even with the expertise of the observer, some subtle abnormalities may be overlooked if there is inadequate contrast

and/or sharpness. Digital systems give instant access to images and enable changes without repeating the exposure, thus making the workflow more efficient and minimizing unnecessary delays in emergency situations (Bansal, 2006).

On the clinical level, these results can be of interest for hospitals in developing healthcare systems. While some tertiary hospitals in Pakistan are currently replacing their conventional systems with digital radiography, others are still using the latter because of financial and infrastructure constraints. The outcomes of this research are evidence of why it is important to continue funding digital imaging systems as enhanced diagnostic capabilities could lead to earlier fracture management and higherquality patient outcomes. But the technology can't take the place of trained radiologists and skilled radiographers. Correct positioning, exposure selection and interpretation experience still play a vital role in making accurate diagnosis of fractures.

The results should be compared with future developments of radiology as well. The basis of computer-assisted diagnosis and artificial intelligence-based image analysis is digital radiography. In recent years, the research on using AI systems for fracture detection has grown, especially in musculoskeletal radiographs (MR) (Raisuddin et al., 2020; Hardalaç et al., 2021). While this study did not evaluate artificial intelligence, enhanced digital image acquisition could help to integrate AI into future clinical use.

There are some limitations of this study. First, it took place in a single tertiary care hospital, which may restrict the applicability of the results to other health care facilities. Second, the assessment was reliant on the radiologist's interpretation, and experience of the observer may affect diagnostic results. Third, advanced imaging modalities (CT or MRI) were not routinely used in all cases, as these are not routinely done for every minor fracture. Further evidence may be found in future multicenter studies with larger numbers of patients, and comparison with more sophisticated imaging methods.

To conclude, this study has shown that digital radiography is more diagnostic sensitive, has higher fracture detection rates and improved image quality in the assessment of subtle fractures, than conventional radiography. Digital radiography may have a beneficial role in the early diagnosis and aid better clinical decision-making in a tertiary hospital setting, especially when fracture findings are small and difficult to appreciate.

CONCLUSION

The study aimed to compare and assess the diagnostic accuracy of DR and CR in diagnosing the subtle fractures in the Multan tertiary care hospital. Results showed improved diagnostic results from use of digital radiography over conventional radiography. It showed greater sensitivity, a better fracture detection, and better image quality characteristics, especially for limited displacement fracture and small cortical disruption detection.

Digital radiography was found to be a clear benefit in cases where the fractures were not as well seen on conventional radiography. The contrast levels of the image were adjustable, the image could be magnified and areas of interest were enhanced both in terms of anatomical detail and interpretation, which helped to reduce the number of subtle fractures missed. These results underscore the significance of image quality for correct radiographic diagnosis, which in traumatic cases can affect the clinical decision-making process, regardless of the size of the improvement in the visualization.

While traditional X-rays are an effective and readily available imaging tool, certain drawbacks in contrast adjustment and image processing that can compromise the ability of this technique to detect small fractures. Given these advantages, it is to be expected that digital radiography would bring tangible benefits to the modern radiology department in terms of quicker and better clinical management, reduced repeat imaging, and increased diagnostic confidence.

In Pakistan, tertiary centers are dealing with a large volume of trauma-related cases and implementing DR can lead to improved patient care and effective radiological services. Successful implementation of these, however, does not only depend on the availability of highly developed equipment, but also on the availability of trained radiographers, experienced radiologists and regular quality assurance procedures to ensure reliable diagnostic performance.

Overall, the results of this study showed that digital radiography performed better than conventional radiography for subtle fracture detection in this study population. The results underscore the role of digital imaging systems in clinical practice, but indicate that the contribution of radiologist experience and proper imaging procedure still plays an important role in the diagnosis of fractures. Additional multicenter studies of larger populations and with comparison to more sophisticated imaging techniques are recommended to support evidence for the use of digital radiography in fracture assessment.

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