Original Article

A Comparison Of Conventional Radiography With Ultrasound For The Detection Of Bony Fractures

[1] Dr. Sadia Rasheed Dar, [2]Dr Ahson Ahmad, [3] Dr Samina Mukhtar, [4]Dr Aftab Alam Tanoli, [5]Dr Zeeshan Ghias Khan, [6]Dr Itrat Siddiqa

[1] Radiologist at Citi Lab Hospital Blue Area, dr.sadiarasheed@gmail.com
[2] Evening Radiologist, Shifa International Hospital H - 8 / 4 Islamabad, Ahsonhhm@gmail.com
[3] CMH Rawalakot, sajawalmir111@gmail.com
[4]Associate Professor Forensic Medicine, Loralai Medical College, Loralai, drtanoli403@gmail.com
[5] Consultant Radiologist, DHQ Hospital Gahkuch Gilgit, shanoghias@gmail.com
[6] Radiology Department Government Mian Nawaz Sharif Hospital Yakki Gate, Lahore
DOI: 10.47750/pnr.2023.14.03.379

Abstract

OBJECTIVE: The objective of this study is to compare the accuracy of ultrasonography and conventional radiography in detecting fractures in individuals who have a clinical suspicion of having them. Settings and research design: Fifty patients with clinically suspected fractures from any age group and sex who visited our institution's emergency wing, orthopedic outdoor or indoor, and other departments were included in the study.
METHODS: Following a conventional radiograph (CR) examination of the patients, real-time ultrasonography was performed utilizing a high-frequency linear transducer in both the longitudinal and transverse planes. To examine the relative effectiveness of radiography and ultrasonography in identifying fractures, the findings from both techniques were compared.
RESULTS: The research shows that for the identification of long bone fractures, the accuracy, positive predictive value (PPV), negative predictive value (NPV), sensitivity, specificity, and accuracy of the CR versus USG are all 100%. The accuracy, NPV, PPV, specificity, and sensitivity of the CR versus USG were, however, 60%, 33.3%, 100%, 100%, and 50%, respectively, in the case of flat bones. Additionally, the accuracy, NPV, PPV, specificity, and sensitivity of the CR versus USG in the situation of a short bone fracture diagnosis are 66.67%, 33.3%, 100%, 100%, and 60%, respectively. Therefore, in this investigation, the overall accuracy, NPV, PPV, specificity, and sensitivity of CR against USG were 88%, 72.73%, 100%, 100%, and 82.35%, respectively.
CONCLUSIONS: USG is a radiation-free, readily accessible, portable, and cost-effective imaging approach for locating fractures that are only superficially placed. It is discovered to be more sensitive than CR in detecting fractures of short and flat bones and comparable in sensitivity to fractures of long bones.

KEYWORDS: Ultrasonography, Radiography, Fractures

INTRODUCTION: Injuries are a leading source of mortality and disability around the globe [1]. Among them, fractured bones are frequent injuries. When the continuity of the bone is broken, a surgical condition called a bone fracture results. When the bone breaks due to a significant force, they happen. Traumatic causes of bone fractures include falls, jolting impacts, and strong strikes. Pathological bone fractures may also be caused by diseases that weaken the bones and overuse [2].
According to form, there are four main categories of bones: sesamoid, sesamoid, flat, and long [3].
First, radiographs were used to identify every fracture [4]. On standard radiographs, the fractures could sometimes be invisible, however, if they are too small or occult, covered by other structures, or not perpendicular to the X-ray beam. Particularly in skeletally immature youngsters, a fracture may potentially involve cartilage and be invisible. Because

of this, complementary imaging would be preferred to rule out or confirm the occurrence of a fracture in order to prevent both short and long-term consequences [5,6].

The most frequent kind of carpal fracture, which may have long-term effects, is the scaphoid fracture. However, up to 65% of scaphoid fractures are radiographically invisible straight soon after injury. Therefore, in patients who have suspected sesamoid bone fractures (also called as covert scaphoid fractures), the wrist must be immobilized in a scaphoid cast for at least 10 days, or until follow-up radiographs demonstrate that the scaphoid fracture is unrelated. However, this technique requires some patients to have their wrists immobilized for a number of days even when they don't have a fracture, which is inappropriate and raises both the expense of healthcare and the patient's quality of life [7]. Magnetic resonance imaging (MR imaging), which has been recommended as the preferred imaging modality for these patients due to its outstanding sensitivity (95-100%) and specificity (100%), is pricy and not generally used in poor nations.

However, patients with undetected scaphoid fractures may benefit from high-resolution ultrasonography (USG) as a different imaging technique. Because of technological advances in sonography that have increased the spatial resolution of this diagnostic tool, high-spatial-resolution US may reveal subtle post-traumatic changes of the cortex and/or periosteum that were present immediately following the injury but were not visible on conventional radiographs. High-resolution US is also simpler to get, takes less time, and costs significantly less than MR imaging [8].

In patients with blunt thoracic trauma admitted to outpatient clinics and emergency rooms, fractured ribs are the most common injury. When utilizing just direct radiography for diagnosis, non-displaced rib fractures may commonly go undetected. The literature has several studies that demonstrate improved sensitivity of ultrasonography (USG) in rib fractures [9].

Because bone naturally prevents the transmission of sound at high frequencies and because there is a significant difference in the acoustic impedance between the soft tissue and bone, USG has shown excellent results in the diagnosis of sternal, facial, nasal and diaphyseal fractures. [11–14] As a result, USG offers the best possible environment for imaging the bone contour. This means that any flaws (such as steps, breaks, or periosteal responses) should be clearly obvious [15].

METHODS: The research comprised 50 patients from any age group and sex who presented to our institution's emergency wing, orthopedic outdoor or indoor, and other departments with clinically suspected fractures.

Open, suspicious complex fractures, erratic individuals with abnormal vital signs, and pregnant women. Each patient had a thorough history review, a physical examination on the spot, and conventional radiography using the appropriate perspectives. The next stage was an ultrasound, which used a high-frequency linear transducer with a real-time scanner in both the longitudinal and transverse planes. To examine the relative effectiveness of ultrasonography and radiography in identifying fractures, the findings from both techniques were compared.

With a 5–12 MHz Broad Band linear array probe and a musculoskeletal setup, ultrasounds were performed using a real-time scanner (Philips Envisor C and Esaote). The patient examination was given to the suspected region in both the transverse and longitudinal axes. The site was carefully scanned with a very delicate touch. Rupture in the integrity of the bone's cortex was adopted as the USG criteria to imply a fracture since it is the most conclusive and reliable way to make the diagnosis of a fracture. One to two millimeters of cortical bone were clearly disrupted. The USG probe also detected movement of the fractured ends as step-off deformities or luxation of a bone segment. A threshold of about 2 mm was used as the criteria for determining whether displacement was there or not.

RESULTS: 50 patients from any age group and gender who visited our hospital's emergency wing, orthopedic indoor or outdoor, and included fractures from these and other departments that had a clinical suspicion for fractures. Pregnant ladies, unpredictable people with aberrant vital signs, and open, suspected complicated fractures. Each patient had a full assessment of their medical history, an immediate physical examination, and standard radiography performed from the right angles. The next step used ultrasonography employing a real-time scanner and a high-frequency linear transducer in both the transverse and longitudinal planes (Philips Envisor C and Esaote). The results from both

procedures were compared in order to assess the relative efficacy of ultrasonography and radiography in detecting fractures.
Real-time scanners (Philips Envisor C and Esaote) were used to conduct the ultrasounds, and a 5–12 MHz Broad Band interferometric probe with a neuromuscular preset was used. Both the transverse and longitudinal axes of the suspicious area were subjected to patient examination. With great care and delicacy, the site was scanned. The most reliable and definitive technique to diagnose a fracture is via a rupture in the integrity of the bone's cortex, which was approved as the USG criterion to infer a fracture. There was a one- to two-millimeter disruption of the cortical bone. The USG probe also identified luxation of a bone segment or step-off abnormalities in the movement of the fractured ends. The criterion for judging whether or not there was displacement involved a 2 mm threshold.
While USG was positive in 5 (83.55%) instances and verified no fracture in 1 (16.45%) case, CR detected small bone fractures in 3 (50%) individuals while being negative in the other 3 (50%) participants (Table 1).

Table 1: The connection between radiographic and USG findings in various bone types.

Bone Type	**Short Bone**			**Flat Bone**			**Long Bone**		
Positive	2	3	5	4	4	8	0	21	21
Negative	1	0	1	2	0	2	13	0	13
Radiography Result	Negative	Positive	**Total**	Negative	Positive	**Total**	Negative	Positive	**Total**
Total	3	3	6	6	4	10	13	21	34

The results of the current investigation show that, for the purpose of detecting long bone fractures, the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy values of the CR versus USG were all 100%. The accuracy = 60%, NPV = 33.33, PPV = 100%, specificity = 100%, and sensitivity = 50% of the CR versus USG, in the case of flat bones. Additionally, the accuracy = 66.67%, NPV = 33.33%, PPV = 100%, specificity = 100%, and sensitivity = 60% of the CR versus USG in the situation of a short bone fracture diagnosis. Therefore, in this investigation, the overall accuracy = 88%, NPV = 72.73%, PPV = 100%, specificity = 100%, and sensitivity = 82.35% of CR against USG (Table 3).

Table 2: Comparing radiography's sensitivity, specificity, PPV, NPV, and accuracy to USG in various bone types.

	False -ve	**True -ve**	**False +ve**	**True +ve**	**Total**	**NPV**	**PPV**	**Specificity**	**Sensitivity**	**Accuracy**
Short Bone	2	1	0	3	6	33.33%	100%	100%	60%	66.67%
Flat Bone	4	2	0	4	10	33.33%	100%	100%	50%	60%
Long bone	0	13	0	21	34	100%	100%	100%	100%	100%

Table 3: Radiography's overall accuracy, NPV, PPV, specificity, and sensitivity when compared to USG.

Accuracy	88%
NPV	72.73%
PPV	100%
Specificity	100%
Sensitivity	82.35%

DISCUSSIONS: Traditionally, radiographic imaging and clinical examination have been used to examine injuries. However, there are several circumstances, such as with pregnant women, when radiography may be contraindicated

[16]. Due to the limited sensitivity of conventional radiography for certain kinds of fractures as well as improper indications for bone X-rays, there are a large number of negative conventional radiography findings. It results in missed diagnoses, inadequate treatment, financial burden, and unwarranted exposure of the patients to dangerous ionizing radiation [17]. This shows the necessity for other techniques that accurately diagnose fractures without radiation exposure danger. This job could be filled by ultrasound [18]. A promising diagnostic method for identifying fractures is ultrasound. Therefore, the development of handheld ultrasound equipment may make it possible to diagnose clinically significant fractures more rapidly via faster picture gathering and concurrent analysis at the bedside. These are practical in places where standard radiography and knowledgeable doctors are unavailable because of their compact size [19].

Figure 1: X- ray forearm showing comminuted and displaced fracture of the ulna.

Conventional radiography and ultrasonography both identified long bone fractures in 21 instances and excluded them in 13 cases, indicating that both modalities had comparable accuracy, NPV, PPV, specificity, and sensitivity in those cases (Figure 1). In comparison to conventional radiography and CT, research indicated that the USG had greater specificity and sensitivity for the diagnosis of long bone fractures [20]. In a previous study, emergency USG demonstrated 100% sensitivity for the identification of pediatric long-bone fractures [21]. According to research, USG may play a larger part in situations involving large numbers of infants, children, and pregnant people [22].

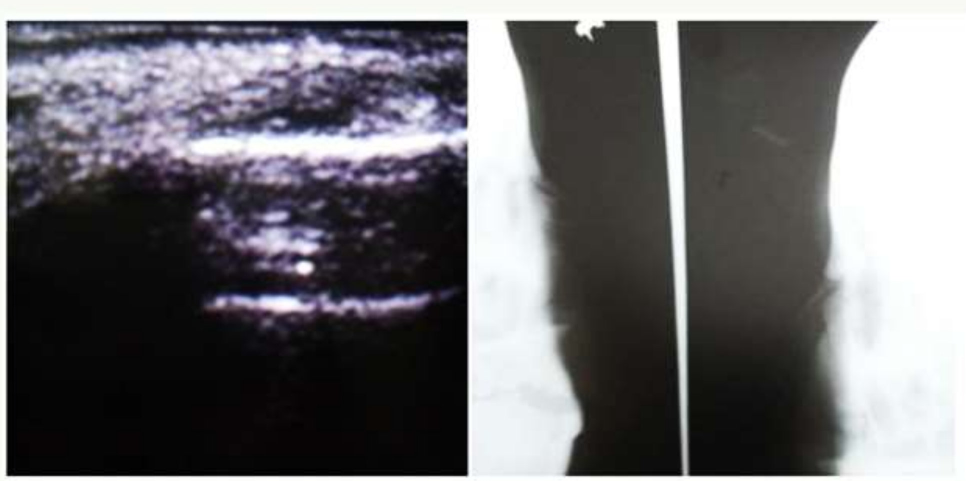

Figure 2: X-ray nasal bones-unremarkable USG image shows breech in the continuity of the left nasal bone.

Three individuals with possible nasal bone damage participated in the current investigation. Out of them, one instance tested positive on CR while the other two tested negative. Two instances tested positive for fracture while on USG, whereas one case tested negative. Conventional radiography is insufficient for diagnosing facial bone fractures due to the complexity of the facial bones and the density of the cranial base. Nasal bone radiographs often have a poor accuracy rate since there are so many false-positive and false-negative outcomes (Figure 2). According to another study, the diagnosis of nasal bone fractures by ultrasonography was 100% accurate, sensitive, specific, NPV, and PPV [23].

Figure 3: X-ray chest-no abnormality detected.
USG Image shows a clear break in the continuity of the fifth rib on the right side at the site of maximum pain with enhanced posterior acoustic shadowing at the fractured site.

Four individuals with chest injuries and possible rib fractures were included. RTA was the mode of injury. One instance was found to be negative in both investigations, whereas two cases were found to be positive in both modalities. Although a chest X-ray was inconclusive in one instance, USG detected the breach in the cortex at the location of the greatest discomfort, which was later confirmed by a CT scan. One instance of rib fracture with USG also revealed minimal pleural effusion in addition to the breach in the cortex. A third finding that encouraged the search for the concealed fracture was pleural effusion. Furthermore, unless the fracture affects heavily calcified cartilage, chondral rib fractures are virtually undetectable on chest x-rays. According to prior research, sonography detects 10 times as many fractures as radiography (Figure 3). In terms of identifying rib fracture, PPV, NPV, the specificity, and sensitivity of CR were 100%, 20%, 100%, and 15%, compared to 100%, 69%, 100%, and 90% with USG [24]. In two instances where radiography was negative in the current investigation, high-resolution ultrasonography was able to detect the discontinuity of the frontal bone's cortex [25]. In comparison to USG, this research showed that CR is less sensitive and has a lower negative predictive value when it comes to showing cortical discontinuity in minor bone fractures. Another research found that high-resolution sonography had a global sensitivity of 100% and a specificity of 79% for detecting occult scaphoid fractures [26]. (Figure 4). The sample size was modest, and there were relatively few fractures at joints (ankles, knees, and elbows) in this research [27].

Figure 4: X-ray four views for scaphoid bone-unremarkable USG image shows the fracture of the scaphoid bone with minimal periosteal reaction.

CONCLUSIONS: In order to prevent the patient from being exposed to radiation, the ultrasonographic examination may serve as a replacement for radiography in the identification of bone fractures. The regular use of ultrasonography in the identification of fractures should be the subject of further investigation.

REFERENCES:

1. Pourmoosa, R., Pourmoosa, J., Taheri, A., Khademloo, M., & Majidi, H. (2022). Comparative evaluation of ultrasonography and lateral radiography in nasal fractures diagnosis. American Journal of Otolaryngology, 43(3), 103439.
2. Iacob, R., Stoicescu, E. R., Cerbu, S., Iacob, D., Amaricai, E., Catan, L., ... & Iacob, E. R. (2022, May). Could Ultrasound Be Used as a Triage Tool in Diagnosing Fractures in Children? A Literature Review. In Healthcare (Vol. 10, No. 5, p. 823). Multidisciplinary Digital Publishing Institute.
3. Lentge, F., Jehn, P., Zeller, A. N., Moysich, H. C., Gellrich, N. C., & Tavassol, F. (2022). Quantitative ultrasonographic diagnostics for midface and mandible fractures. Journal of Stomatology, Oral and Maxillofacial Surgery.
4. Tripathi, N., Sharma, A., Khatri, G., Chawla, S., Kaul, A., & Sharma, Y. (2022). An analytical cross-sectional study to evaluate the diagnostic accuracy of ultrasonography in detecting nasal bone fractures compared with CT as the reference standard. European Journal of Molecular and Clinical Medicine, 9(1), 1130-1135.
5. Gilbertson, J., Pageau, P., Ritcey, B., Cheng, W., Burwash-Brennan, T., Perry, J. J., & Woo, M. Y. (2022). Test characteristics of chest ultrasonography for rib fractures following blunt chest trauma: a systematic review and meta-analysis. Annals of Emergency Medicine.
6. Shrimal, P., Bhoi, S., Sinha, T. P., Murmu, L. R., Nayer, J., Ekka, M., ... & Aggarwal, P. (2022). Sensitivity and specificity of waterbath ultrasound technique in comparison to the conventional methods in diagnosing extremity fractures. The American Journal of Emergency Medicine, 53, 118-121.
7. Kozaci, N., Avci, M., Yuksel, S., Donertas, E., Karaca, A., Gonullu, G., & Etli, I. (2022). Comparison of diagnostic accuracy of point-of-care ultrasonography and X-ray of bony injuries of the knee. European Journal of Trauma and Emergency Surgery, 1-7.
8. Astaraki, P., Baghchi, B., & Ahadi, M. (2022). Diagnosis of acute nasal fractures using ultrasound and CT scan. Annals of Medicine and Surgery, 103860.
9. Quek, S. E., James, V., Castillo, L., Tan, R. M. R., & Ong, G. Y. K. (2022). Point of Care Ultrasound Identification of Multiple Rib Fractures in a Pediatric Patient with Osteogenesis Imperfecta Type 3. Children, 9(6), 864.
10. Dumitriu, D., Menten, R., & Clapuyt, P. (2022). Ultrasonography of the bone surface in children: normal and pathological findings in the bone cortex and periosteum. Pediatric Radiology, 1-12.
11. Alvarez, P. M., Fideler, K. L., Iobst, C. A., & Klamar, J. E. (2022). Fracture of an unossified medial epicondyle: a case report of an unusual presentation diagnosed utilizing ultrasonography. Current Orthopaedic Practice, 33(3), 311-314.
12. Mobasseri, A., & Noorifard, P. (2022). Ultrasound in the diagnosis of pediatric distal radius fractures: does it really change the treatment policy? An orthopedic view. Journal of Ultrasonography, 22(90), e179-e182.
13. Thejeel, B., & Endo, Y. (2022). Imaging of total hip arthroplasty: Part I–Implant design, imaging techniques, and imaging of component wear and fracture. Clinical Imaging.

14. Azizkhani, R., Hosseini Yazdi, Z., & Heydari, F. (2022). Diagnostic accuracy of ultrasonography for diagnosis of elbow fractures in children. European Journal of Trauma and Emergency Surgery, 48(5), 3777-3784.
15. de Borja, C., Watkins, R., & Woolridge, T. (2022). Common Ultrasound Applications for Pediatric Musculoskeletal Conditions. Current Reviews in Musculoskeletal Medicine, 1-9.
16. Snelling, P. J., Keijzers, G., & Ware, R. S. (2022). Point-of-care ultrasound pronator quadratus hematoma sign for detection of clinically non-angulated pediatric distal forearm fractures: a prospective cohort study. Journal of Ultrasound in Medicine, 41(1), 193-205.
17. Kanyana, R., Olaniyan, A. O., & Uzorka, A. (2022). Investigation on Ultrasound Long Bone Fracture Imaging Using the Migration Method. Biophysical Reviews and Letters, 17(01), 19-32.
18. Lawson, M., Tully, J., Ditchfield, M., Metcalfe, P., Qi, Y., Kuganesan, A., & Badawy, M. K. (2022). A review of current imaging techniques used for the detection of occult bony fractures in young children suspected of sustaining non-accidental injury. Journal of Medical Imaging and Radiation Oncology, 66(1), 68-78.
19. Menger, M. M., Körbel, C., Bauer, D., Bleimehl, M., Tobias, A. L., Braun, B. J., ... & Histing, T. (2022). Photoacoustic imaging for the study of oxygen saturation and total hemoglobin in bone healing and non-union formation. Photoacoustics, 28, 100409.
20. Syrop, I., Fukushima, Y., Mullins, K., Raiser, S., Lawley, R., Bosshardt, L., ... & Fredericson, M. (2022). Comparison of Ultrasonography to MRI in the Diagnosis of Lower Extremity Bone Stress Injuries: A Prospective Cohort Study. Journal of Ultrasound in Medicine.
21. Cognet, J. M., Bauzou, F., Louis, P., & Mares, O. (2022). Using Ultrasonography During the Fixation of Distal Radius and Finger Fractures. Hand Clinics, 38(1), 109-118.
22. Spriet, M., Arndt, S., Pige, C., Pye, J., O'Brion, J., Carpenter, R., ... & Dowd, J. P. (2022). Comparison of skeletal scintigraphy and standing 18F-NaF positron emission tomography for imaging of the fetlock in 33 Thoroughbred racehorses. Veterinary Radiology & Ultrasound.
23. Sepuya, R. G., Dozeman, E. T., Prittie, J. E., Fischetti, A. J., & Weltman, J. G. (2022). Comparing diagnostic findings and cost of whole body computed tomography to traditional diagnostic imaging in polytrauma patients. Journal of Veterinary Emergency and Critical Care, 32(3), 334-340.
24. Shelmerdine, S. C., White, R. D., Liu, H., Arthurs, O. J., & Sebire, N. J. (2022). Artificial intelligence for radiological paediatric fracture assessment: a systematic review. Insights into Imaging, 13(1), 1-17.
25. Scheier, E., Fuchs, L., Taragin, B. H., Balla, U., & Shavit, I. (2022). Use of Point-of-Care Ultrasound to Identify Occult Fractures of the Tibia in the Pediatric Emergency Department: A Case Series. The Journal of Emergency Medicine, 62(4), 559-565.
26. Cauvin, E. R., & Smith, R. K. (2022). Ultrasonography of the fetlock. Atlas of equine ultrasonography, 49-84.
27. Weingrow, D. (2022). Under What Situations is Ultrasound Beneficial for the Detection of Rib Fractures?. Annals of Emergency Medicine, 79(6), 540-542.