ORIGINAL ARTICLE

Effectiveness of Ultrasonography in Detecting Metacarpal Fractures at Al-Nafees Medical Hospital, Islamabad: A Cross-Sectional Study

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ABSTRACT

Objective: To compare the effectiveness of ultrasound and direct radiography on the detection and management of metacarpal fractures.

Study Design: A cross-sectional Study.

Place and Duration of Study: This study was conducted at the Department of Emergency, Al-Nafees Medical Hospital, Islamabad, Pakistan from August 2022 to August 2023.

Methods: The study was conducted on 60 patients suspected of metacarpal fracture. All patients underwent point-of-care ultrasonography and direct radiography. Data, including swelling, point tenderness, crepitus, ecchymosis, deformity, neurovascular injury, or range of motion, was recorded.

Results: The results showed that direct radiograph detected fractures in 32 (53.3%) patients, while point-of-care ultrasonography detected fractures in 34 (56.6%) patients. Compared to direct radiograph, the sensitivity, specificity, positive predictive value, and negative predictive value of point of care ultrasonography for fracture detection were 92%, 87%, 89% and 90% respectively. point-of-care ultrasonography detected all adjacent bone fractures. The 5th metacarpal neck was the most common site of fracture. Compared to direct radiograph, the sensitivity, specificity, positive predictive value, and negative predictive value of point of care ultrasonography for fracture localization were 92%, 87%, 89% and 89% respectively. With point-of-care ultrasonography, angulation was detected in 41 (68.3%) patients and step-off in 14 (24%) patients. With direct radiograph, angulation was detected in 40 (66.6%) patients and step off in 13 (21.6%) patients. Point-of-care ultrasonography detected intramuscular hematoma in 9 (15%) patients. Based on the evaluation of physicians who performed direct radiograph and point-of-care ultrasonography, 17 (28.3%) patients required an elastic bandage, and 2 (3.3%) required surgery.

Conclusion: Point-of-care ultrasound is an effective tool for diagnosing metacarpal fractures and can be used as an alternative to radiography.

Keywords: *Metacarpals, Radiography, Ultrasonography.*

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Introduction

Metacarpal bones have different shapes, biochemical aspects, and anatomy. 40% of the fractures in the hand are often metacarpal fractures.[1] Functional outcomes vary based on the severity of the fracture and the success of treatment.[2] Direct radiography (DR) is done for assessing fracture type and treatment intervention. Oblique, lateral, and posteroanterior radiographic views are used for determining characteristics of a fracture. Computerized tomography (CT) further evaluates joint surfaces and fracture fragments in complex cases. But DR and CT pose radiation risks for the patients.[3,4]

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Ultrasound (US) does not involve radiation hazard, is simple, and portable. Musculoskeletal ultrasound is preferred in pre-hospital settings, radio-sensitive pediatric patients, and pregnant women.[5] Point-of-care ultrasound (POCUS) has been increasingly used for the detection of orthopedic injuries.[6] Additionally, it is also used for the evaluation of soft tissues, tendons, and ligaments.[7] A study found that the US has high sensitivity and specificity for the detection of metacarpal fractures.[8] However, there are limited studies on the use of POCUS for identifying fracture site, type, and angulation, as well as soft tissue injuries and elongation of joint space. The aim of this study is to compare the effectiveness of ultrasound and direct radiography in detecting and managing MF.

Methods

The cross-sectional study was conducted at the Emergency Department of Al-Nafees Medical Hospital from August 2022 to August 2023, following approval from the hospital's Ethical Review Board, vide letter no: 12/48, dated 23rd July 2022.

The patients aged from 5 to 55 years with suspected metacarpal fracture were included in the study by consecutive sampling. This age group was selected as very young patients (<5 years) may pose technical challenges to POCUS, and very old patients (>55 years) have different fracture patterns and comorbidities that may have influenced our findings. The sample size was calculated keeping 80% power of the test, 95% confidence interval, and 5% error margin. Patients with neurovascular injury, open fractures, fractures with dislocations, systemic and life-threatening injuries were excluded. Informed consent of the participants was taken. The ethical review committee of the hospital approved the study.

All patients underwent POCUS and DR. Data, including swelling, point tenderness, crepitus, ecchymosis, deformity, neurovascular injury, or range of motion, were recorded. POCUS was performed by a 7.5 MHz linear probe on an Esaote ultrasound machine. Transverse and longitudinal images from volar, lateral, and dorsal surfaces of 1st and 5th metacarpal bones, and transverse and longitudinal images from volar and dorsal surfaces of 2nd, 3rd, and 4th metacarpal bones were obtained. Steps of POCUS are summarized in Table 1. For DR, lateral and postero-anterior radiographs were obtained. Physicians with at least 5 years of experience interpreted the results and were unaware of the finding of alternate imaging results.

Mild soft tissue injuries were managed with an elastic bandage. Severe soft tissue injuries and mild angulation were managed with splints. Step off and severe angulation was treated with splints and reduction. Fractures with more than 2mm extension in the joint space were treated surgically.

Data was analyzed by SPSS version 23. Sensitivity, specificity, positive, and negative predictive values of POCUS were calculated. Chi-square test was used for comparison of descriptive data.

Table-1: Steps of Point-of-care ultrasound (POCUS)

S.No	
1	Locate the fracture
2	Determine the type of fracture (linear, torus, fragmented, fissure) and its location.
3	Measurement of the degree of angulation
4	Measure stepping-off distance
5	Evaluate the extension of the fracture in the joint
6	Evaluation of epiphyseal line?
7	Evaluate the adjacent bone fracture

Results

The study was conducted on 60 patients suspected of metacarpal fracture. 6 (10%) were women and 54 (90%) were men. The average age was 25 ± 10 years. Flash and crash resulted in injury in all patients. Findings of DR and POCUS are shown in Figures 1 and 2. DR detected fractures in 32 (53.3%) patients, while POCUS detected fractures in 34 (56.6%) patients. Linear fracture was the most common.

Among patients who underwent POCUS, 3 (9%)

patients had sensitivity, 17 (50%) had sensitivity along with swelling, all patients had deformity and ecchymosis, 21 (62%) had limited joint mobility, and none of them had neurovascular injury. In patients who underwent direct radiography, 32 (195) patients experienced sensitivity, 16 (50%) had sensitivity with swelling, all patients had deformity and ecchymosis, 20 (62.5%) had limited joint mobility, and none of them had neurovascular injury.

Compared to DR, sensitivity, specificity, PPV, and NPV of POCUS for fracture detection were 92%, 87%, 89% and 90% respectively. Examination of adjacent bone in patients with 5th metacarpal fracture showed 4th metacarpal fracture in 5 patients and both 3rd and 4th metacarpal fracture in 2 patients. 1 patient had 1st proximal phalangeal fracture, and 2 patients had scaphoid fractures. POCUS detected all adjacent bone fractures. The majority of patients had a 5th metacarpal neck fracture. Compared to DR, the sensitivity, specificity, PPV, and NPV of POCUS for fracture localization were 92%, 87%, 89% and 89% respectively.

With ultrasound, angulation was detected in 41 (68.3%) patients and step off in 14 (24%) patients. With direct radiography, angulation was detected in 40 (66.6%) patients and step off in 13 (21.6%) patients. Compared to DR, the sensitivity, specificity, PPV, and NPV of POCUS for detecting fracture angulation were 95%, 98%, 95% and 98% respectively. Sensitivity and specificity of POCUS for step-off detection and the need for reduction were 100%. POCUS detected intramuscular hematoma in 9 (15%) patients. Fracture did not extend into the joint space or epiphyseal line in any patients. Based on the evaluation of physicians who performed DR and POCUS, 17 (28.3%) patients required an elastic bandage, and 2 (3.3%) required surgery.

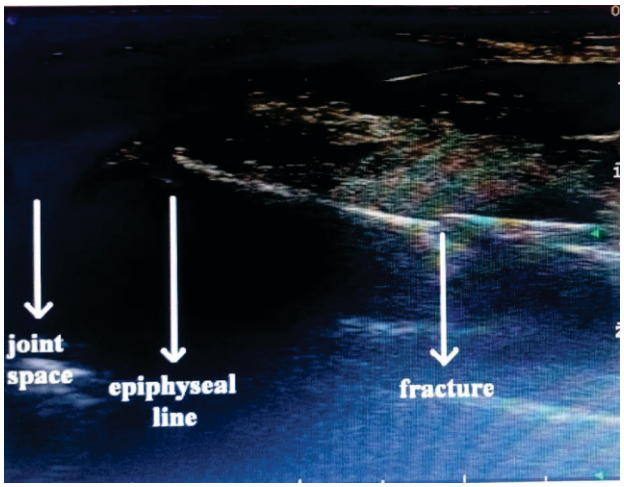

Fig.1: Ultrasonographic image showing joint space, epiphyseal line, and fracture in an 11-year-old patient

Fig.2: Lateral and posteroanterior radiographic images of the same patient

Discussion

Metacarpal fractures are isolated injuries and are mostly closed and stable. Suspected metacarpal fractures are evaluated using plain radiographs and US. In this study, we compared the effectiveness of POCUS and DR for the detection and management of fractures. The results showed that POCUS effectively diagnoses fractures as well as their type and location. A previous study showed that fractures of ribs, distal radius, and proximal tibia can be better detected by US compared to plain radiographs. US more accurately detected the degree of cortical deformation than radiography.[9] Another study conducted on patients with metacarpal fractures showed that POCUS detected fractures that were undiagnosed by plain radiographs.[10] In the current study, the sensitivity, specificity, PPV, and NPV of POCUS for fracture detection were 92%, 87%, 89% and 90% respectively. A previous study reported that the sensitivity and specificity of US for hand fractures were 90% and 98% respectively.[11] A study specifically conducted on metacarpal fracture showed that US had 97.5% sensitivity, 93.8% specificity, 98.5% PPV, and 91.5% NPV.[12] The values in our study are lower due to the inclusion of only 5th metacarpal fractures. In the current study, DR detected fractures in 32 (53.3%) patients, while POCUS detected fractures in

34 (56.6%) patients. A previous study showed that POCUS detected fractures in 95% patients with edema, tenderness, and deformity and 80% patients with limited joint movement.[13] This suggests that a complete physical examination is important for correct diagnosis and optimum management of fractures. Unlike radiography, POCUS imaging is accompanied by dynamic examination. During POCUS imaging, physicians obtain images from highly sensitive areas and repeatedly review them, making diagnosis easier.[14,15]

Treatment of metacarpal fracture depends upon various factors, including the site of fracture, step-off distance, degree of angulation, extension into the joint space, and fracture of adjacent bones. In the current study, the most common site of the fracture was the 5th metacarpal neck, similar to the finding of a previous study.[16] In the current study, the sensitivity and specificity of POCUS for step-off detection and the need for reduction were 100%. The results of our research show that POCUS has high sensitivity for fracture detection and the need for reduction. A previous study reported that ultrasound guidance was practical for the reduction and pinning of metacarpal fractures.[17] A study conducted on distal radius fractures showed that POCUS had 100% sensitivity and specificity for reduction decision.[18] With POCUS, angulation was detected in 41 (68.3%) patients and step off in 14 (24%) patients. With DR, angulation was detected in 40 (66.6%) patients and step off in 13 (21.6%) patients. A study found that POCUS detected angulation in 65% and step-off in 25% patients.[19]

In this study, POCUS detected hematoma in 16% patients in whom plain radiographs failed to detect hematoma. A previous study reported that POCUS detected hematoma in 14% patients. Intramuscular hematoma leads to compartment syndrome; however, in the current study, patients with low-energy injuries and open fractures were included, thus neurovascular and tendon injuries were not reported in any of the patients.[20]

The limitations of our study are a small sample size; larger studies are recommended for further analysis. Additionally, we did not study the cost-effectiveness, time-consumption, and impact of the imaging method on clinical management.

Conclusion

POCUS is an effective tool for diagnosing metacarpal fractures and can be used as an alternative to radiography.

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Conflict of Interest: The authors declare no conflict of interest

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Author Contributions

AA: Manuscript writing for methodology design and investigation
SHB: Conception and design of the work
MS: Data acquisition, curation, and statistical analysis
MAB: Validation of data, interpretation, and write-up of results
SK: Revising, editing, and supervising for intellectual content
HI: Writing the original draft, proofreading, and approval for final submission