



## The comparison of radiography and point-of-care ultrasonography in the diagnosis and management of metatarsal fractures



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### ABSTRACT

**Objective:** It was aimed to compare the efficacy of point-of-care ultrasonography (POCUS) with radiography in the diagnosis and management of metatarsal fracture (MTF).

**Methods:** Patients aged 5–55 years admitted to emergency room due to low-energy, simple extremity trauma and had a suspected MTF, were included in this prospective study. Patients were evaluated by two different emergency physicians in the emergency room. The first physician performed POCUS examination. Second physician evaluated the radiography images. The obtained results were compared. **Results:** Seventy-two patients were enrolled in the study. Fracture was detected in 39% by radiography and in 43% of patients by POCUS. Multiple MTFs were identified in 5% of patients. Compared with radiography, POCUS had a sensitivity of 93%, specificity of 89%, positive predictive value of 84% and a negative predictive value of 95% (95% CI, 83–98%) in the detection of fractures. While soft tissue edema was seen in 61% of patients by POCUS, soft tissue edema with hematoma was detected in 14%. Compared with radiography, the sensitivity and specificity of POCUS in the decision for surgery were 100% and 98% (95% CI, 97–100%), respectively, whereas its sensitivity and specificity were both 100% in the decision for reduction.

**Conclusion:** In our study, we demonstrated that POCUS could be applied with success in the diagnosis and treatment of MTF in low-energy injuries. POCUS can be used as an alternative to radiography in the emergency rooms due to being easy to learn and practice and availability of soft tissue examination along with bone tissue examination.

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### Introduction

Acute metatarsal fractures (MTFs) constitute 35% of all foot fractures and one third of the fractures occur at the shaft or distal part of metatarsals (MTs) in adults. Most of the MTFs are caused by a simple fall-induced foot trauma or object falling on the foot from a height. MTFs usually occur between 2nd–5th decades. In addition, older women with osteoporosis and patients with diabetes mellitus for more than 25 years are at greater risk of MTF [1].

Emergency physicians often use radiographs to visualize bone fractures. Computed tomography (CT) scan or magnetic resonance imaging (MRI) is performed in case of inadequate radiography results [1,2]. However, the use of ultrasonography for imaging the fractures has become widespread in recent years. Visualizing

musculoskeletal tissue has become easier with the development of high-frequency linear transducers. Small fractures, up to 1 mm, can be distinguished by ultrasound imaging with the help of acoustic reflections of the bone [3,4].

Ultrasonography is superior to radiography as it is easy to learn and practice, and also cheaper. The absence of radiation exposure makes ultrasonography more popular. Its ease of use in case of disasters such as wars, earthquakes and in the pre-hospital setting arises from the portability of ultrasonography. Simultaneous evaluation of muscles, tendons, nerves and vascular structures along with bone tissue is the advantage of ultrasonography over radiography. In addition, evaluation of the joint space, visualization of the epiphyseal line in children and comparative evaluation with the contralateral intact extremity are possible by ultrasonography [3–5].

Several studies have been conducted demonstrating the efficacy of point-of-care ultrasonography (POCUS) in the diagnosis, the choice of treatment and the reduction of fractures in the

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emergency department [6–11]. However, there are few studies regarding the use of ultrasound in the MTFs.

In this study, it was aimed to compare the efficacy of POCUS with radiography in the diagnosis and determination of treatment method in patients who were admitted to the emergency room due to low-energy trauma and who had a suspected MTF.

## Materials and methods

Following local ethics committee approval, this prospective study was conducted at Emergency Department of Antalya Training and Research Hospital from May 2015 to July 2016. Patients aged 5–55 years, who were admitted to emergency room due to low-energy, simple extremity trauma, who had stable vital findings, no additional other injuries, and who had a suspected MTF, were included in the study. Written informed consents were obtained from the patients and/or their next of kin. Exclusion criteria were as follows: (a) diagnosed as MTF prior to hospital admission, (b) open fractures, (c) pregnancy, (d) neurovascular injury, (e) fractures with dislocation, (f) other systemic injuries, (g) unstable vital signs, (h) life-threatening injuries, (j) patients who did not consent to participate in the study.

Before the initiation of the study, emergency physicians participating in the study were given foot radiography evaluation training, followed by standard POCUS training to assess the metatarsal bones of the foot. Foot radiography training was consisted of one hour theoretical and one hour practical standard training. For POCUS examination, one hour theoretical and one hour practical standard training were given. All of the physicians included in the study performed a demo POCUS examination on three patients under the supervision of an instructor. Half of the ultrasound applicators consisted of emergency physicians who had studied bone fracture detection with POCUS before, and the others were emergency physicians who were using POCUS the first time.

Standard data entry form was created. The patients were evaluated by two physicians at the emergency room. Physical examination findings of the patients (point tenderness, edema, ecchymosis, crepitus, deformity, abnormal range of motion, or neurovascular injury) were evaluated by two physicians and recorded. Then, MTF was assessed via POCUS by the first physician. The 7.5 MHz linear transducer of a standard ultrasound device located in the emergency room (Esaote, Firenze, Italy) was used for POCUS. First and 5th MTs were evaluated from dorsal, volar and lateral surfaces, and 2nd, 3rd and 4th MTs from dorsal and volar surfaces on both longitudinal and transverse axes. Eight-step POCUS protocol was applied for the evaluation of MTF (Table 1). Each step takes about 2 min to evaluate. The angulation and step-off were measured utilizing the standard software of the ultrasound device. The angulation was determined according to the angle formed by the two lines drawn along the cortical edges of the fracture ends. The step-off was recorded by measuring the distance between the fracture-cortex and healthy cortex. The findings were compared with the intact limb and its accuracy was determined. The final treatment method was decided by the physician who evaluated the radiography images.

**Table 1**  
Kozaci protocol for determination of fractures with POCUS<sup>6</sup>.

1	Detecting the presence of fractures (Cortical disruption)
2	Type of fracture (fissure, linear, fragmented spiral) and localization
3	The angulation of the fracture
4	The stepping-off distance of fracture
5	The extent of the fracture to the joint space
6	Control of the fracture if it contains the epiphyseal line or not
7	Control of accompanying adjacent bone fracture
8	Control of the presence of hematoma in the soft tissue and joint space

The second emergency physician evaluated the three-way foot radiography images. Following the detection of fractures via radiography, the localization, type, angulation and step-off of the fracture were recorded. The presence of fractures in the adjacent bone, and the involvement of the epiphyseal line and joint were evaluated. The average duration of the evaluation for the detection of fractures via radiography is 3 min on average. Fractures with  $>10^\circ$  angulation and  $>3\text{mm}$  step-off on POCUS and radiography images were identified as unstable fractures. In case of multiple MTFs, treatment was decided according to the most severe fracture.

For statistical analysis, Statistical Package for the Social Sciences (SPSS<sup>®</sup>) version 21 was used. Compared with radiography, sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of POCUS for the identification of fractures were calculated. Data were reported as percentages with a 95% confidence interval (CI). For descriptive statistics, data obtained by using Chi-square test and kappa statistics were compared.

## Results

During the study period, a total of 80 patients admitted to ED with suspected metatarsal fracture. Eight patients were excluded due to exclusion criteria (Fig. 1).

Total 72 patients with suspected MTFs were enrolled in this study. Of the patients, 33% were female and 67% were male. The mean age was  $33 \pm 18$  years. Seventeen (27%) patients were under the age of 18. The mechanism of injury was simple fall and/or crash.

In the study population, the most common physical examination findings were edema and tenderness (Table 2).

Fracture was detected in 28 (39%) patients by radiography and in 31 (43%) patients by POCUS (Table 2). MTFs were detected in 26 patients with both POCUS and Radiography. For 5 patients, only POCUS detected MTF. And for 2 patients, only radiography detected MF. Computerized tomography imaging was taken for diagnostic verification to these total 7 patients. All of these 7 patients had MTF according to computerized tomography imaging (Fig. 1).

Multiple MTFs were detected in 4 (5%) patients. Concomitant fractures were 3rd and 5th MTs in one patient, 3rd–4th and 5th MTs in one patient, 4th and 5th MTs in one patient, and 2nd–3rd and 4th MTs in one patient. Compared with radiography, sensitivity, specificity, PPV and NPV of POCUS in the detection of fracture were 93%, 89%, 84% and 95% (95% CI, 83–98%), respectively. The most common type of fracture was linear fracture (Table 3).

Regarding adjacent bone examination, fracture was detected in the adjacent bone in 9 (13%) patients by radiography and in 11 (15%) patients by POCUS. Adjacent bone fractures were as follows: phalanx fractures in nine patients and phalanx plus calcaneal fracture in one patient via radiography, and phalanx fractures in nine patients, cuneiform fractures in two patients and cuneiform/phalanx (either of them) plus calcaneal fracture in one patient via POCUS. POCUS had a sensitivity of 90% and a specificity of 95% (95% CI, 81–100%) in determining the fracture in the adjacent bone.

While soft tissue edema was observed in 44 (61%) patients, soft tissue edema plus hematoma was observed in 10 (14%) patients. These patients were considered at risk for the development of compartment syndrome and followed-up. Because of this risk, surgery was postponed in 2 patients and reduction was postponed in 1 patient. Splint was applied in these patients.

Fifth MTF was the most commonly detected fracture, and the basis of the fifth MT was the most commonly observed localization. Regarding the fractured MT, a fracture was interpreted as 2nd MTF on POCUS and 1st MTF on radiography, and another fracture was interpreted as 2nd MTF on POCUS and 3rd MTF on radiography. In 4 cases of fissure type fracture detected on POCUS examination, no fracture was detected with radiography. While 1 case was

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