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The comparison of point-of-care ultrasonography and radiography in the diagnosis of tibia and fibula fractures

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ABSTRACT

Objective: We aimed to compare the efficacy of Point-of-care ultrasonography (POCUS) with radiography in the diagnosis of tibia fracture (TF) and fibula fracture (FF), and determation of fracture characteristics.
Methods: Patients aged 5–55 years who were admitted to ED due to low-energy, simple extremity trauma, who had a suspected TF and FF on physical examination were included in this prospective study. One physician performed POCUS examination. Other physician evaluated the radiography images. The obtained results were compared.
Results: A total of 62 patients were included in the study. TF was detected in 21 patients by radiography and in 24 patients by POCUS. FF was detected in 24 patients by radiography and in 25 patients by POCUS. Ten of the patients had both TF and FF. Compared with radiography, sensitivity, specificity, PPV and NPV of POCUS in the detection of TF were 100%, 93%, 88% and 100% (95% CI, 91–100%), respectively. Compared with direct X-ray imaging, sensitivity, specificity, PPV and NPV of POCUS in the detection of FF were 100%, 97%, 96% and 100% (95% CI, 96–100%), respectively. We determined that POCUS is also successful in detection of fracture features such as angulation, step-off, extension into the joint space that can determine the treatment decision.
Conclusion: This study demonstrated that POCUS was found to be as successful as direct X-ray imaging in the diagnosis of TF and FF.

Introduction

High and low-energy traumas can cause tibia fractures (TF). While high-energy trauma usually causes complex fractures, low-energy trauma can also result in complex fractures in patients with osteoporosis [1,2].

Tibia fractures are seen in less than 7%, but can be accompanied by fibula fractures (FF), because forces are transmitted to the fibrous body via the interosseous membrane [3]. Knee injuries, particularly in the proximal tibia, ankle fractures and soft tissue injuries in the distal tibia may occur in TF. Therefore, the location, type, shape of the fracture, extension into the joint space and soft tissue damage must be carefully evaluated to ensure correct treatment of the fracture and to prevent future complications [3,4].

Direct X-ray is usually used for the diagnosis of TF and FF. Computed tomography (CT) is used for better evaluation of fracture fragments and joint surfaces in case of inadequate X-ray imaging results. It will allow better visualization of especially knee, tibial plateau and tibial plafond fractures [2,3]. However, both CT and direct X-ray imaging have the risk of radiation exposure.

Ultrasound (US) is preferred over conventional X-ray imaging to visualize many areas of the body, with advantages of easier access to equipment, lack of ionizing radiation and portability. In the last decade, many clinicians have used point-of-care ultrasound (POCUS) in many different medical specialties. Ultrasonography imaging has been used in areas where diagnostic imaging is limited, such as emergency department (ED), critical care, battlefields, and disaster areas [5–7].

The use of POCUS recently become widespread in EDs and intensive care units. Many studies have shown that musculoskeletal ultrasonography is used to reduce serial X-rays, particularly in the radiation-sensitive pediatric population, prehospital setting, pregnant patients, and fracture reduction, with distinct

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advantages. It is also used to visualize ligaments, tendons, and soft tissues along with bone injuries [8–18].

POCUS is shown to be successful in imaging TF and FF, but there are few studies on this topic [5,17,18]. In addition, there are no studies in the literature describing the fracture properties such as angulation, step-off, extension into the joint space required for the treatment plan. In this study, we aimed to compare the efficacy of POCUS with radiography in the diagnosis of TF and FF, and determation of fracture characteristics in patients who were admitted to ED due to low-energy trauma.

Materials and methods

This prospective study was conducted between March 2016 and January 2017 at the Antalya Training and Research Hospital Emergency Service after approval of the hospital ethics committee. Patients aged 5–55 years, who were admitted to ED due to low-energy, simple extremity trauma, who had a suspected TF and FF on physical examination, whose vital findings were stable, who had isolated leg and ankle trauma without additional injuries 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) performed X-ray prior to hospital admission, (b) open fractures, (c) neurovascular injury, (d) fractures with dislocation, (e) other systemic injuries, (f) unstable vital signs, (g) life- threatening injuries, (h) pregnancy, and (i) patients who did not consent to participate in the study.

Before the initiation of the study, emergency physicians participating in the study were given a total of 2 h, 1 h theoretical and 1 h practical, of tibia and adjacent bone, fibula, examination and radiography evaluation training. Then, these physicians were given a standard POCUS training for 2 h, 1 h theoretical and 1 h practical, to assess tibia and adjacent bone, fibula with POCUS. Practical training was done on intact bone and fractured bone. In addition, the physicians who would do the POCUS examination had a trial examination in 3 patients before the study patients. Physicians who had previously participated in bone ultrasonography study and who had at least 1 year of bone ultrasonography experience were classified as experienced physicians. Pysicians who had not previously participated in bone ultrasonography study and who were given only a standard POCUS training were classified as less experienced physicians. Half of the consecutive patients who were taken into the study were evaluated by experienced physicians and the other half of the patients were evaluated by the less experienced physicians with POCUS.

Standard data entry form was created. The patients were evaluated by two physicians in the emergency department. Physical examination findings (point tenderness, edema, ecchymosis, crepitus, deformity, abnormal range of motion, or neurovascular injury) of the patients were evaluated by two physicians and recorded. Then, the first physician evaluated tibia and adjacent bone fibula with POCUS. The 7.5 MHz linear transducer of a standard ultrasound device (Esaote, Firenze, Italy) in the emergency room was used for POCUS. First, tibia was evaluated from anterior and posterior surfaces, and from knee joint to the ankle joint on both longitudinal and transverse axes. Eight-step POCUS protocol was applied for the evaluation of TF (Table 1). In the first step, the anterior, posterior, medial and lateral surfaces of bone cortex in the longitudinal and transverse planes were scanned for the detection of fracture. When cortical impairment was detected, especially tibiofibular syndesmosis areas were compared to other extremity for the confirmation of the presence of fracture. 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 intact cortex. Then the fibula was evaluated. The evaluation of the fibula was performed transversally and longitudinally by examining the fibula from knee to the ankle from anteroposterior and lateral surfaces. During the POCUS examination, repeated evaluations were performed on areas where ultrasonic sensitivity was present. The findings were confirmed by comparison with the intact extremity. The final treatment method was decided by the physician who evaluated the direct X-ray images. Each step takes about 2 min to evaluate.

The second emergency physician evaluated 2-way X-ray images of the tibia and adjacent bone fibula. After detection of fracture on direct X-ray image, localization of fracture in tibia and fibula, fracture type, angulation, and step-off were measured, and the involvement of the epiphyseal line and joint were evaluated.

CT examination was used as the ‘gold standard' in any cases of uncertainty in either group (fracture was detected only by direct X-ray or only by POCUS examination).

SPSS 21 package program was used for statistical analysis. Demographic data are reported as frequencies, medians with interquartile range for ordered non-normal data, and means with standard deviations for continuous normal data. We calculated point-of-care ultrasound test performance characteristics, including sensitivity, specificity, positive and negative predictive values with 95% confidence intervals.

Results

During the study period, 64 patients who were thought to have TF were admitted to ED. Two patients (one patient was pregnant and was unable to undergo direct X-ray imaging, and one patient had a dislocation with fracture) were excluded from the study. A total of 62 patients were included in the study. Tibia fracture was detected in 21 patients by both direct X-ray imaging and POCUS. Tibia fracture was detected in 3 patients by only POCUS. Fibula fracture was detected in 24 patients by both direct X-ray imaging and POCUS. Fibula fracture was detected in 1 patient by only POCUS. CT examination was used as the ‘gold standard' for the confirmation of 3 patients with TF detected by only POCUS and 1 patient with FF detected by only POCUS (Fig. 1). Ten of the patients had both TF and FF.

Twenty-one (34%) of the patients included in the study were female and 41 (66%) were male. All of the patients were injured by simple fall and/or impact.

Table 1
Kozaci protocol for determination of fractures with POCUS [12].

1	Detecting the presence of fractures (Cortical disruption)
2	Detecting the 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