Ultrasound-assisted triage of ankle trauma can decrease the need for radiographic imaging

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A B S T R A C T

Background: An ankle sprain is a common injury, and patients are usually examined with plain radiographs to rule out a fracture despite the fact that only a small minority actually have one.

Purpose: To investigate if ultrasound (US)-guided triage can decrease the need for radiographic imaging in patients with ankle trauma.

Hypothesis: Orthopedic surgeons can use point-of-care US with limited training to triage ankle trauma that requires standard radiographs.

Methods: Seven junior orthopedic surgeons underwent a 30-minute standardized training session using a basic US musculoskeletal examination designed to exclude ankle fractures.

One-hundred twenty-two patients with ankle trauma were included at the emergency department and underwent clinical investigation, including examination according to the Ottawa ankle rules as well as US and basic US musculoskeletal examination designed to exclude ankle fractures.

In this study group, radiographs identified 23 significant fractures. Ultrasound-guided triage could not exclude a fracture in 37 patients. All of the 23 fractures seen on radiographs were among the 37 patients where US could not rule out a fracture. Ottawa ankle rules managed to exclude the need for radiographs in 28 of the 122 patients, whereas 85 who underwent the US-guided triage could have avoided a radiograph. Avulsion fractures at the tip of the fibula were not considered significant.

Conclusion: This study demonstrates that with limited standardized training a junior, an orthopedic surgeon is able to use US-guided triage during the primary examination at the emergency department to exclude at least significant ankle fractures. This practice could decrease the need for radiographic imaging, avoiding a mandatory radiographic investigation in many patients with ankle trauma. It would also make it possible to treat many patients with ankle trauma more rapidly and to reduce costs and radiation exposure.

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1. Introduction

Patients sustaining ankle sprains make up a large group in emergency departments (ED) worldwide and constitute approximately 25% of all musculoskeletal injuries. It has been estimated that approximately 1 ankle sprain occurs per 10,000 people each day in Western countries [1–3]. Most of those patients experience an inversion injury of the ankle. In many studies, less than 15% of all patients who have sustained inversion sprains have a fracture; however, it may be difficult to establish the correct diagnosis by clinical examination alone [3–5]. Excluding a fracture is an important clinical decision because most ankle fractures need surgical treatment and/or immobilization, whereas almost all sprains can be treated with early mobilization including physiotherapy, sometimes using a functional brace during the rehabilitation [1].

The difference between a fracture and a sprain is therefore related to a major difference in terms of treatment. Most patients with ankle trauma undergo a radiographic examination to exclude an ankle fracture despite the fact that 85% do not have a fracture.

The Ottawa ankle rules (OARs) have been widely accepted as a reliable method to decrease the overuse of radiographic imaging. They do, however, only reduce the number of radiographs on patients without a fracture by approximately 30% to 40% [6]. The OARs have been shown to have a sensitivity of 95% to 100% but only a modest specificity [6]. This indicates that even when the OARs are strictly applied, most radiographic examinations are performed on nonfractured ankles. Many clinics do not use the Ottawa rules or use them arbitrarily [7]. Medicolegal aspects should be considered as an important factor for this in many locations.

All bimalleolar and trimalleolar fractures and some lateral malleolar fractures are considered unstable and need surgical treatment. Whether the ankle is unstable in the case of an isolated lateral malleolar fracture is a classical orthopedic dilemma because
instability is rarely recognized on standard radiographs [8]. Stress tests have only a moderate sensitivity and can only be reliably performed per-operatively. Stable ankle fractures with little displacement can be treated with immobilization. The displacement that can be tolerated for isolated lateral malleolar fractures is a matter of debate but usually considered between 0 and 5 mm, depending on type and localization of the displacement [9]. Proximal isolated fibular fractures caused by ankle sprain and ligament injury are almost always unstable. Avulsion fractures of the fibular tip are considered stable and are rather a sign of ligament injury than a true fracture. In most instances, they are treated as a sprain with early mobilization and physiotherapy [9].

There are also elusive soft tissue injuries in ankle sprains without a fracture that may need special treatment. Among these are acute peroneal ruptures/dislocations and isolated syndesmosis ruptures. The difficulty in diagnosing these injuries is a clinical challenge, and procedures and treatments are uncertain and controversial. Plain radiographs are of little use [8,10].

The use of ultrasound (US) by nonradiologists has increased dramatically over the last 10 years. During this decade, focus has shifted toward using US in the ED and in the prehospital setting to exclude a specific and easily diagnosed injury rather than to visualize an entire organ system [11,12]. The FAST-scan (Focused Assessment Sonography in Trauma) is well established for use in patients with major trauma [13]. Further emergency use ranges from diagnosing pneumonia in children to the evaluation of ocular trauma and to aid in gaining vascular access in the hypovolemic patient [11,14]. In the orthopedic field, earlier studies have shown that US can be safely used by paramedics in the prehospital setting to diagnose long bone fractures [15]. In one study, US was used to establish the diagnosis of ankle fractures. Eleven fractures were diagnosed by radiographs, 10 of which were seen using US. The only missed fracture was not correctly diagnosed initially because the proximal part of the fibula was not scanned. The study only included patients who were eligible for radiographic investigation according to the OAR criteria [16].

The present study examines the use of point-of-care US as a triage tool in the ED by Junior orthopedic surgeons. The training was limited in time and standardized as to avoid the standard objection to US, the inherent operator experience-dependent reliability. The goal was to determine if US could safely be used to exclude ankle fractures in a mixed group of adult patients with ankle trauma. To our knowledge, this has never been studied before in a structured manner.

2. Materials and methods

The study was conducted at Sahlgrenska University Hospital in Gothenburg at the orthopedic ED. The ED is Scandinavia’s largest adult orthopedic ED with approximately 30,000 orthopedic admissions a year.

All patients with ankle trauma admitted to the ED when one of the study physicians was on call were included. Consecutive inclusion was not possible because the physicians participating in the study constituted less than 10% of the physicians working at the ED. The random allocation of the work shifts when the study was undertaken made the inclusion fairly representative of the general flow of patients.

The first author, who had no previous experience in musculoskeletal US, was trained by a senior radiologist (L.-A.G.) in basic US examination skills. A series of examinations was performed on patients with known ankle fractures. Subsequently, a standardized method was designed, eliminating all aspects of the examination not specifically useful to diagnose ankle fractures. Soft tissue and ligamentous injuries were not included in the protocol, except for the indirect visualization of the syndesmosis by examining the relationship between the anterior aspects of tibia and fibula to evaluate whether the ankle joint was stable or not. The protocol included visualization of the entire length of the fibula and the distal 15 cm of the tibia using the probe both longitudinal to the axis of the bone and perpendicular to it looking for abnormalities of the cortex as well as subperiosteal bleeding (Figs. 1, 2, 3, and 4). The posterolateral distal part of the tibia was visualized from the lateral side behind the fibula.

Six junior orthopedic surgeons were recruited and trained according to the same standardized 30-minute training model. When any of these doctors were on call at the ED, they included all patients with ankle trauma in the study between October 2011 and October 2012. The only exclusion criteria were open or grossly displaced fractures and patients with dementia or other cognitive impairment. The distribution of patients among the 7 examining doctors was n = 46, 36, 21, 12, 11, 4, and 2. All the patients received oral and written information about the purpose and procedure of the study, and written informed consent was obtained. Ethical approval was obtained from the Human Ethics Committee at the Medical Faculty, Gothenburg University, Sweden (DNR 675–11).

Significant fracture was defined as any fracture of the ankle or proximal fibula, with the exception of avulsion fractures of the tip of the fibula. These avulsion fractures were noted in the protocol but not defined as a significant fracture (Fig. 5). All fractures of the medial malleolus were considered significant.

Patients were admitted and treated according to normal routine, with the addition of a mandatory OAR examination and the US examination of the ankle and lower leg. The US examination took between 4 and 8 minutes. All patients then underwent standard radiographs of the ankle regardless of clinical and US findings. Additional radiographs also visualized the proximal fibula if pain was present during examination. The clinical examination, OAR, and US findings were noted on a standardized form, and this information was stored in a blinded manner to the subsequent radiographic results. Sealed envelopes were used to store the information. The criterion standard for radiograph interpretation was the radiologist, whereas the US and OAR were conducted and evaluated by the orthopedic surgeon. The radiologist was blind to any US findings and whether a patient was included in the study or not. Radiographs were obtained after the US and OAR examination.

The Ottawa ankle examinations were defined as “positive” or “negative,” where positive meant that a radiograph was warranted according to the OAR algorithm. The US and radiographic examinations were both defined as “significant fracture,” “no significant fracture,” or “uncertain/other result.” Uncertain/other result meant that if the US operator could not obtain good enough images, he/she could err on the safe side and report he/she was not sure. The

![Fig. 1. Obvious fracture of distal fibula above lateral malleoli. Note: step off in the cortex (arrow A) and periosteal bleeding (arrow B).](image-url)
uncertain/other result for radiographs meant that more complicated results than the binary fracture/no fracture could be correctly logged.

Both the US and radiograph result reports also had a field for comments where avulsion fractures were noted and described along with additional information. All patients were asked whether they found the US examination painful or unpleasant.

The US examination was performed using an M-Turbo Sonosite system and a linear 15-MHz probe. The system was provided by a Secma/Sonosite representative complimentary for the study.

3. Results

A total of 122 patients, 64 women and 58 men, were included, with a mean age of 42 years ranging from 18 to 92 years. Radiographs identified 23 significant fractures, and all of them were interpreted as fracture or uncertain/other finding by the US triage doctor. Because we are evaluating US as a triage method, any suspected positive or uncertain result on US would have been complemented with standard radiographs. This means that only US results that were classified as "no fracture" would have been considered safe not to undergo radiographs. There were 13 uncertain/other findings and 24 fractures on the US examination, giving a total of 14 potentially unnecessary radiographs. If US triage had decided if radiographs were necessary, 85 radiographs could have been avoided.
A total of 13 avulsion fractures were revealed on plain radiographs. Eight of these were noted as avulsion fractures with US and 2 as uncertain finding. In 9 cases, US showed a suspected avulsion fracture that could not be verified with plain radiographs.

The one patient with an uncertain/other result on plain radiographs was originally described by the radiologist as “maybe having a completely undislocated thin line in the distal fibula at the level of the syndesmosis.” This patient was treated as if she had a fracture with plastic immobilization and had additional radiographs at weeks 6 and 12 where no sign of an earlier fracture could be seen according to a consensus of 3 senior radiologists. This case was defined in the results above as not having a significant fracture.

The syndesmosis was indirectly visualized by US with a ventral horizontal view of the ankle. In the cases of unstable bimalleolar or trimalleolar fractures (n = 3), it was obvious that the distance between the tibia and fibula was increased and that it was easily manipulated by manual small movement of the ankle. The distance was not formally measured. No case of isolated syndesmosis injury without fracture was noted with US or indirectly on radiographs.

None of the patients reported that the US examination was more painful than the OAR clinical examination.

The OARs classified 28 patients as not needing a radiograph. None of these had significant fracture on radiographs, but 1 patient had an avulsion fracture of the fibular tip that could be seen on both US and radiographs. Two more of these patients had suspected avulsion fractures of the fibular tip seen on US but that could not be verified on plain radiographs.

4. Discussion

The hypothesis that orthopedic surgeons can use point-of-care US to safely triage ankle trauma was verified. This method appears to be superior to only using the OAR. The results of the present study also indicate that limited training appears to be sufficient to teach the basic skills needed for Junior physicians to establish the diagnosis of significant ankle fractures. This is in line with the recent expansion of US into new fields of use. It is now being used by many ED physicians and is no longer reserved for radiologists. The most common critique of this new trend is that US is an instrument requiring much training and experience and should only be used by specialists. In the last decade, however, numerous studies have shown that limited but specific training can make nonradiologists, including paramedics, sufficiently proficient to conduct safe US examinations for a specific medical question [12,17].

In the setting of this study, US was shown to be a useful tool for triage and not a replacement for radiographic imaging. Neither is it a replacement for the OAR but rather an addendum, depending on the facilities available and the training of the health care personnel. This tool can, with increasing experience, also give added value to study soft tissue injuries and guide further examinations and follow-up regime. It enhances our clinical findings but is not a definite diagnostic tool.

Ultrasound is probably as sensitive to establish the diagnosis of avulsion fractures of the fibula tip as radiographs, and for these injuries, plain radiographs are not a reliable criterion standard to compare with. The 9 avulsions seen on US, however, not verified on radiographs are a hint of the difficulty to find these fractures on radiographs. Ultrasound as opposed to plain radiographs produces equal or better information in terms of isolated syndesmotic injury. Ultrasound enables even less-well trained operators to visualize the distal ventral distance between the fibula and the tibia. The acute diagnosis of isolated syndesmotic injuries is controversial, and US-assisted triage is not the final solution. Ultrasound-assisted triage does, however, provide more information to this elusive diagnosis than the OAR alone and probably better information than just a plain non–weight-bearing ankle radiograph.

On an international scale diagnostic imaging is very limited in the developing world [18]. Equipment for radiographs is expensive, immobile, and difficult to repair. The World Health Organization has recommended the use of US imaging in developing countries and established minimum specifications for a “general purpose scanner” [19]. In some locations, US is available, whereas x-ray services are not. In situations like these, the ability to exclude a fracture and avoid long travels or inadequate treatment can be valuable. Simplified musculoskeletal US examination can be done with a linear probe and almost any US system.

Ultrasound is a simple and straightforward method. Because the examiner can use the pressure of the probe during the examination, fractures can be examined dynamically to see if the bone is moving. Even this manipulation is surprisingly painless to the patient, and not a single patient described the procedure as more than mildly painful.

The inclusion criteria were, as stated above, liberal, and few patients (n < 5) who were admitted during the study period with a study doctor on call were excluded because of dementia or gross open fracture.

The present study has some limitations. It is not a consecutive number of cases, and the inclusion is distributed over 1 year. The inclusion has, however, been evenly spread out over the year and time of the day giving a representative group of patients, as can be seen on the range of age and the proportion of men and women.

5. Conclusion

The results of the present study give an indication that point-of-care US in the hands of in-training physicians can be used to safely triage patients with ankle trauma. Ultrasound-guided triage seems to be able to decrease the number of radiographs more than the OARs.

References