EURASIAN JOURNAL OF EMERGENCY MEDICINE
DOI: 10.4274/eajem.galenos.2021.06926
Original Article
Eurasian J Emerg Med. 2022;21(2): 120-5

Diagnostic Accuracy of the Sonographic Ottawa Foot and Ankle Rules for Ankle and Foot Fractures in Emergency Department

Farhad Heydari, Loabat Adib, Saeed Majidinejad, Reza Azizkhani

Department of Emergency Medicine, Faculty of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran

Abstract

Aim: This study was carried out to determine whether the addition of a bedside ultrasound (US) to the Ottawa Foot and Ankle Rules (OAR) could decrease the need for radiographic imaging in the patients presenting to emergency department (ED) with foot and/or ankle trauma.

Materials and Methods: In this prospective observational study, adult patients with acute foot and/or ankle injuries were included. Patients were first examined and OAR results were recorded. Then, US exam was performed by emergency physicians who were blinded to the OAR results. After that, the patients received radiography regardless of OAR exam and US findings. The US and OAR results were then compared to the formal radiography interpretation.

Results: A total of 240 patients with a mean age of 36±12 years were included in the study of which 86 (35.8%) were female. The sensitivity of OAR in detecting foot and/or ankle fractures was 97.5% [95% confidence interval (CI): 86.8 to 99.9%] and the specificity of OAR increased from 48.5 % (95% CI: 41.4 to 55.7%) to 99.5% (95% CI: 97.2 to 100) with the addition of US. The OAR can reduce radiography by 40%, and if ultrasonography was used before radiography, there would be an approximately 72% reduction in X-ray requests.

Conclusion: When used in conjunction with OAR, US can be used by trained physicians in ED to more accurately identify patients who would benefit from having an X-ray performed. US examination can further reduce the ordering of X-rays when compared to using OAR alone.

Keywords: Ultrasonography, foot, ankle, emergency department, injury

Introduction

Foot and ankle injuries in clinical practice are the most common traumatic injuries in patients admitted to the emergency department (ED) (1,2). Findings of ankle and foot injuries are often subtle, and diagnoses may be delayed, especially in cases of multiple trauma (1,3). Although a significant clinical fracture of the ankle or midfoot occurs in less than 15-22%, most patients undergo radiography at ED (4,5).

This small yield led to the introduction of the Ottawa Foot and Ankle Rules (OAR) in 1992 to reduce the radiographs ordered by physicians without adversely affecting the quality of health care (6). These rules were based solely on assessing bone tenderness and weight-bearing. In most cases of isolated ankle trauma, the OAR should be used within 48 hours of injury to determine whether ankle or foot radiographs are necessary (1,2,7).

Assessment of the ankle includes the ability to walk for at least four steps immediately after the injury and at the time of evaluation and notes localized tenderness of the posterior edge of the distal 6 cm or tip of either malleolus. Assessment of the foot includes the ability to walk for at least four steps immediately after the injury and at the time of evaluation and notes localized tenderness of the navicular bone or the base of the fifth metatarsal (1,2,7).

The OAR has a high sensitivity (92-100%) and a modest specificity (10-79%), and its use would lead to significant reduction in the number of radiographs by 30-40% (1,4). Bedside ultrasonography (US) is a reliable and helpful diagnostic tool for fractures in the ED. Ultrasound has many advantages, such as safety, ease of use at the bedside, low cost, availability, mobility, no radiation exposure, and increased patient satisfaction (3,8,9).

Corresponding Author: Loabat Adib, M.D., Department of Emergency Medicine Faculty of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran
E-mail: loabat.adib@gmail.com ORCID ID: orcid.org/0000-0002-5836-9690

Received: 01.07.2021
Accepted: 15.09.2021

Cite this article as: Heydari F, Adib L, Majidinejad S, Azizkhani R. Diagnostic Accuracy of the Sonographic Ottawa Foot and Ankle Rules for Ankle and Foot Fractures in Emergency Department. Eurasian J Emerg Med. 2022;21(2):120-5.

Emergency medical specialists are among the first-line physicians who are responsible for the management of traumatic patients. When the US is performed by the same person who has previously examined the patient, it provides a quick diagnosis because it can quickly combine images with the patient's history and clinical condition (8-10).

In this regard, studies reported high sensitivity and specificity of US in diagnostics of long bone fractures (11). To date, bedside US has been found to have a sensitivity of 87.3-100% and specificity of 90.1-99.1% in the detection of foot and ankle fractures (12). While OAR has been found to modestly decrease the numbers of unnecessary radiographs taken (1,2,4), few studies have been published regarding the ability of bedside US to further lower the need for X-rays in patients with ankle and midfoot injuries (5).

This study was carried out to determine whether the addition of a bedside US to the assessment process could be performed to decrease the need for radiographic imaging in the patients presenting to the ED with foot and/or ankle trauma.

Materials and Methods

Study Design

This prospective observational study was conducted at the emergency departments of Alzahra and Kashani University Hospital in Isfahan, Iran between November 2017 to May 2019. The study was approved by the Ethics Committee of Isfahan University of Medical Sciences (IR.MUI.REC.1396.3.988). Oral and written informed consent from all patients were obtained.

Study Setting and Population

All patients older than 16 years and hemodynamically stable who presented to the ED with acute foot and/or ankle injuries were included. Emergency medicine residents evaluated them and recorded the patients' sex, age, the cause of the injury (walking, running, sports, or traffic accident) and clinical data including the OAR results of each patient who met the inclusion criteria.

Patients who were admitted to the ED more than 48 hours after injury, those with an open fracture, or visible major dislocations, or decreased level of consciousness or intoxicated patients, no informed consent, multiple traumas, or diminished sensation related to neurologic deficits, and with a history of prior fracture at the injury site were excluded from the study.

Study Protocol

First, a history was obtained from the patients then they underwent physical examination and OAR findings were recorded. Then, ultrasound examinations by one of the four independent emergency physicians (sonographers) were performed in a standard format based on previously published work (5,9-11) and conducted before radiography. Sonographers were blinded to the OAR results.

Standard radiographies were obtained after the US and OAR examination. The patients in the study received X-ray of the foot and/or ankle regardless of OAR exam and US findings. Radiography results were interpreted by the reporting radiology team who had not visited or examined the patients and were blinded to US results. The OAR, US and X-ray results were then collected using a study checklist. The final assessment of the radiography of the ankle and foot by the reporting radiology team was considered the criterion standard for the diagnosis of a fracture. The ongoing clinical management of the patient was conducted by the primary emergency physicians under hospital protocols. Finally, the US and OAR results were compared to the formal X-ray interpretation. At least 15 days after the initial ED visit, clinical follow-up was performed to determine if an undetected fracture was present.

Each sonographer received a two-hour theoretical and a two-hour of practical training that included basic ankle and foot assessment by another emergency medicine specialist who is experienced in musculoskeletal US. All bedside ultrasonography examinations were conducted by a Philips Affiniti 50 US Machine and a 5-12-MHz linear probe. The US was used for scanning of four regions: proximal of the distal tibia (up to 10 cm), proximal of the distal fibula (up to 10 cm), fifth metatarsal bone (proximal to the distal tip), and navicular bone in the anteromedial aspect of the ankle. The US was performed on the affected areas of the feet and ankles (9-11). The presence of cortical disruption, stepping, or axial deviation on the bone surface were described as a fracture in an ultrasonographic view.

Statistical Analysis

All data were saved and statistical analysis of data was performed using SPSS version 22 software (IBM Corp, Armonk, NY, USA). Qualitative data were expressed as frequencies and percentages, while quantitative data were expressed as the mean and standard deviation (SD). Test characteristics of sensitivity and specificity, positive and negative predictive values, and positive and negative likelihood ratios were calculated with 95% confidence interval (CI). A p value less than 0.05 was considered statistically significant.

Results

A total of 240 patients with a mean age of 36±12 years (range: 18-75 years) were included in the study (Figure 1). Of all patients, 86 (35.8%) were female and 154 (64.2%) were male. In 40 patients (16.7%), a total of 42 fractures were detected using radiography

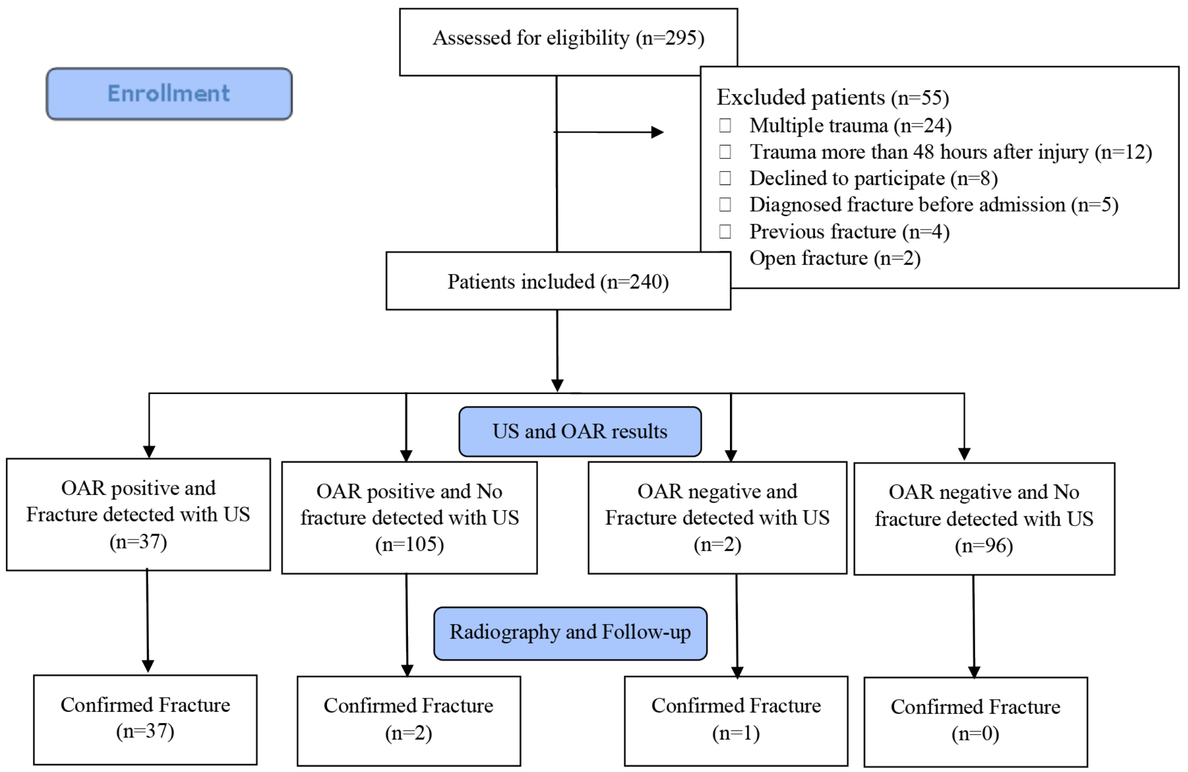

Figure 1. Study flowchart

US: Ultrasound, OAR: Ottawa Foot and Ankle Rules, n: Number

(31% medial malleolus fracture, 28.5% lateral malleolus fracture, 28.5% fifth metatarsal fracture, 4.8% first metatarsal fracture and 4.8% talus and 2.4% posterior malleolus fractures). Two of the patients had bimalleolar fractures (Table 1).

In 40 patients with fractures, 38 (95%) were identified using US, and one talus fracture and one posterior malleolus fracture were missed. Overall, 37 OAR-positive patients (37.7%) were diagnosed with ankle and/or foot fractures by both US and X-ray (Figure 1). In one OAR-negative patient, US revealed an avulsion fracture of the lateral malleolus (Table 2). A significant fracture was defined as having a displacement greater than 3 mm in accordance with the definition used when validating the OAR (5). All missed fractures were insignificant fractures and treated non-surgically.

The sensitivity, specificity, positive predictive value (PPV), and the negative predictive value (NPV) of OAR and US in detecting foot and/or ankle fractures was shown in Table 3. We found that the specificity of OAR increased from 48.5% to 99.5% (95% CI: 97.2 to 100%) with the addition of US.

These results indicate that implementation of OAR can reduce radiography by 40% (97 patients), and if ultrasonography was used before radiography in OAR-positive patients, there would be an approximately 72% reduction in X-ray requests (Table 2).

Discussion

Most patients entering the emergency department with foot and/or ankle trauma are exposed to radiographic examinations. The OAR has a modest specificity (10-79%), and its use would lead to significant reduction in the number of unnecessary radiographs by 30-40% (1). Despite the widespread use of OAR, fractures are seen in less than 15% of patients with ankle and foot trauma (1-4). Therefore, at least 80-85% of X-rays will be negative (3). Foot and ankle injuries are almost universally assessed by the OAR, which has reported a sensitivity of 92% to 100% and a specificity of 10% and 79% for foot and ankle fractures respectively (1,4,13). In this study, the sensitivity and specificity of OAR in detecting significant foot and/or ankle fractures were 97.5 and 48.5 %. Also, a fracture rate of 16.7% was detected. It was similar to the original papers establishing the OAR, which had a positive fracture rate of 17% (1,4,13). One talus fracture and one posterior malleolus fracture were missed. In other studies, fifth metatarsal and distal fibula fracture were missed (4,11,12).

Similar to current study, a systematic review and meta-analysis (n=27) by Bachmann et al. (1) showed that the OAR has a high sensitivity (ranged from 96.4-99.6%) and a modest specificity (ranged from 26.3-47.9%). Its use should reduce radiography

Table 1. Baseline characteristics of the patients

Variables		No fracture (n=200)	Fracture (n=40)	p value
Age (year)		37.11±12.33	33.87±11.41	0.127
Sex	Male	131 (65.5%)	23 (57.5%)	0.335
	Female	69 (34.5%)	17 (42.5%)	
Location of fracture	Medial malleolus fracture	-	13 (31%)	
	Lateral malleolus fracture	-	12 (28.5%)	
	Fifth metatarsal fracture	-	12 (28.5%)	
	First metatarsal fracture	-	4 (4.8%)	
	Posterior malleolus fractures	-	1 (4.8%)	
	Talus fracture	-	1 (2.4%)	

n: Number

Table 2. Comparison of US exam and OAR results in fracture detection with X-ray

Examination results		X-ray result		Total
		Positive (fracture)	Negative (no fracture)	
US exam	Positive	38	1	39
	Negative	2	199	201
OAR	Positive	39	103	142
	Negative	1	97	98
Total		40	200	240

OAR: Ottawa Ankle Rules, US: Ultrasonography

Table 3. Diagnostic value of ultrasonography and OAR in diagnosis of ankle and/or foot fractures

Examiner		Sensitivity (%) (95% CI)	Specificity (%) (95% CI)	PPV (%) (95% CI)	NPV (%) (95% CI)	LR+ (95% CI)	LR- (95% CI)	Accuracy (%) (95% CI)
OAR		97.5 (86.8-99.9)	48.5 (41.4-55.7)	27.5 (24.7-30.5)	99.0 (93.2-99.9)	1.9 (1.6-2.2)	0.05 (0.01-0.36)	56.7 (50.2-63.0)
US	Overall	95.0 (83.1-99.4)	99.5 (97.2-100)	97.4 (84.3-99.6)	99.0 (96.4-99.7)	190.0 (26.9-1344)	0.05 (0.01-0.19)	98.7 (96.4-99.7)
	Positive OAR	94.9 (82.7-99.4)	100 (96.5-100)	100 (100-100)	99.0 (96.2-99.7)	-	0.05 (0.01-0.20)	99.1 (95.9-100)

PPV: Positive predictive value, NPV: Negative predictive value, LR+: Positive likelihood ratio, LR-: Negative likelihood ratio, US: Ultrasonography, OAR: Ottawa Ankle Rules

by 30-40% in a population with a fracture burden of 15% (1). Finally, Bachmann et al. (1) reported that although there are high sensitivity and good negative LRs with the OAR, differences in physical examination skills, clinical experience, and interpretation of test criteria can affect sensitivity and negative LR.

Another systematic review (n=22) by Jonckheer et al. (2) demonstrated that the sensitivity and specificity of the OAR after an ankle sprain in adults range from 92-100% and from 16-51%, respectively. Several rules and diagnostic processes have been developed to improve the specificity of the OAR and to assist physicians in deciding whether or not to perform radiography (2).

Similar to our study, Yazdani et al. (7) showed that in diagnosing ankle and/or foot fractures, the OAR had a sensitivity of 100% and a specificity of 40.50%, and implementation of the OAR had the potential for reducing radiographs by 33%.

Our study demonstrated that the US can be used as a good diagnostic tool for detecting fractures in patients with foot and/or ankle trauma. The US has a sensitivity and specificity of 95.0%, and 99.5%, and the specificity of OAR increased from 48.5% to 99.5% (95% CI: 97.2 to 100) with the addition of US. Also, if US were used before X-ray in OAR-positive patients, there would have been a 72% reduction in X-ray requests.

In a study performed by Canagasabey et al. (5) on 110 patients, they reported that the sensitivity and specificity of US assessment for diagnosing fractures in Ottawa positive patients were 90.9% (95% CI: 65.7 to 98.3), and 90.9% (95% CI: 88.1% to 91.7%), respectively. They showed that if ultrasound is used in patients before radiography, there would be an approximately 80% reduction in radiograph requests (5). In another study by Hedelin et al. (4), 122 patients were examined with US as a triage tool to exclude ankle fractures in the ED by junior orthopedic surgeons. They demonstrated that OAR could exclude the request for radiographs in 23% of patients, whereas US-guided triage could have resulted in a 70% reduction in X-ray requests (4). Similar to our study, one OAR-negative patient had an avulsion fracture of the lateral malleolus on both US and X-ray. The rate of reduction in X-ray requests in these two studies (80% and 70%) is similar to the results of our study (72%).

Ekinci et al. (9) and Atilla et al. (14) stated that the US had good sensitivity and specificity for diagnosing fractures in OAR-positive patients. Tollefson et al. (15) reported that among patients with positive OAR, the specificity of OAR increased from 50% to 100% with the addition of US. In a study by Shojaee et al. (12) the accuracy of US was compared to radiography in patients with a suspected diagnosis of the distal leg or ankle fracture. The sensitivity and specificity of ultrasound were 98.9%, and 86.4% respectively.

Finally, our findings and related studies suggest that if the US assessment for foot and/or ankle fractures in patients were performed prior to radiography, the number of X-rays ordered would be significantly reduced.

Study Limitations

The diagnosis time of the US evaluation was not measured in our study, because the US examination is performed by the same physician who examines the patient. Because this study included US followed by X-ray for all patients, we were not able to compare the rapidity of diagnosis of one modality versus another, nor could we quantify the effect of the imaging modality on the length of stay in the ED. The results of our study cannot be generalized to penetrating injuries, multiple traumas, children, and injuries over one week.

Conclusions

In this study, US had a high sensitivity and specificity for diagnosing ankle and foot fractures. When used in conjunction with OAR, US can be used by trained physicians in the ED to more accurately identify patients who would benefit from having an X-ray performed. US examination can further reduce the ordering of X-rays when compared to using OAR alone.

Acknowledgements

The present article was extracted from the thesis by Dr. Loabat Adib to achieve her specialist degree in emergency medicine from Isfahan University of Medical Sciences. The authors would like to express their gratitude to the staff of the ED of Al-Zahra and Kashani Hospital, Isfahan, Iran.

Ethics

Ethics Committee Approval: The study protocol was approved by the Ethics Committee of Isfahan University of Medical Sciences (no: IR.MUI.REC.1396.3.988).

Informed Consent: Oral and written informed consent was obtained from all parents, before enrolment into the study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: F.H., L.A., S.M., R.A., Concept: F.H., L.A., S.M., R.A., Design: L.A., F.H., Data Collection or Processing: F.H., L.A., S.M., R.A., Analysis or Interpretation: F.H., L.A., Literature Search: F.H., L.A., S.M., R.A., Writing: L.A., F.H.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: This study was funded by Isfahan University of Medical Sciences.

References

1. Bachmann LM, Kolb E, Koller MT, Steurer J, ter Riet G. Accuracy of Ottawa ankle rules to exclude fractures of the ankle and mid-foot: systematic review. BMJ. 2003;326:417.
2. Jonckheer P, Willems T, De Ridder R, Paulus D, Holdt Henningsen K, San Miguel L, et al. Evaluating fracture risk in acute ankle sprains: Any news since the Ottawa Ankle Rules? A systematic review. Eur J Gen Pract. 2016;22:31-41.
3. Crosswell S, Leaman A, Phung W. Minimising negative ankle and foot X-rays in the Emergency Department—Are the Ottawa ankle rules good enough? Injury. 2014;45:2002-4.
4. Hedelin H, Goksör L-Å, Karlsson J, Stjernström S. Ultrasound-assisted triage of ankle trauma can decrease the need for radiographic imaging. Am J Emerg Med. 2013;31:1686-9.
5. Canagasabey MD, Callaghan MJ, Carley S. The sonographic Ottawa foot and ankle rules study (the SOFAR study). Emerg Med J. 2011;28:838-40.
6. Stiell IG, Greenberg GH, McKnight RD, Nair RC, McDowell I, Worthington JR. A study to develop clinical decision rules for the use of radiography in acute ankle injuries. Ann Emerg Med. 1992;21:384-90.
7. Yazdani S, Jahandideh H, Ghofrani H. Validation of the Ottawa Ankle Rules in Iran: a prospective survey. BMC Emerg Med. 2006;6:1-7.
8. Zamani M, Mazaheri M, Heydari F, Masoumi B. Comparison of diagnostic accuracy of bedside ultrasonography and radiography for calcaneal fractures in the emergency department. Journal of Emergency Practice and Trauma. 2021;7:17-21.
9. Ekinci S, Polat O, Günalp M, Demirkan A, Koca A. The accuracy of ultrasound evaluation in foot and ankle trauma. Am J Emerg Med. 2013;31:1551-5.
10. Champagne N, Eadie L, Regan L, Wilson P. The effectiveness of ultrasound in the detection of fractures in adults with suspected upper or lower limb

injury: a systematic review and subgroup meta-analysis. BMC Emerg Med. 2019;19:1-15.

11. Crombach A, Azizi N, Lameijer H, El Moumni M, Ter Maaten JC. Point-of-care bedside ultrasound examination for the exclusion of clinically significant ankle and fifth metatarsal bone fractures; a single blinded prospective diagnostic cohort study. J Foot Ankle Res. 2020;13:1-7.
12. Shojaee M, Hakimzadeh F, Mohammadi P, Sabzghabaei A, Manouchehrifar M, Dolatabadi AA. Screening characteristics of ultrasonography in detection of ankle fractures. Emergency. 2016;4:188.
13. Wu J, Wang Y, Wang Z. The diagnostic accuracy of ultrasound in the detection of foot and ankle fractures: a systematic review and meta-analysis. Medical Ultrasonography. 2021;23:203-12.
14. Atilla OD, Yesilaras M, Kilic TY, Tur FC, Reisoglu A, Sever M, et al. The accuracy of bedside ultrasonography as a diagnostic tool for fractures in the ankle and foot. Acad Emerg Med. 2014;21:1058-61.
15. Tollefson B, Nichols J, Fromang S, Summers RL. Validation of the Sonographic Ottawa Foot and Ankle Rules (SOFAR) Study in a Large Urban Trauma Center. J Miss State Med Assoc. 2016;57:35-8.