

# Accuracy of the Ottawa Ankle Rules applied by non-physician providers in a pediatric emergency department

Joe MacLellan, MD\*†§; Teya Smith, BSc‡; Jason Baserman, MD§; Shawn Dowling, MDT

## ABSTRACT

**Objective:** The Ottawa Ankle Rules (OAR) are a clinical decision tool used to minimize unnecessary radiographs in ankle and foot injuries. The OAR are a reliable tool to exclude fractures in children over 5 years of age when applied by physicians. Limited data support its use by other health care workers in children. Our objective was to determine the accuracy of the OAR when applied by non-physician providers (NPP).

**Methods:** Children aged 5 to 17 years presenting with an acute ankle or foot injury were enrolled. Phase 1 captured baseline data on x-ray use in 106 patients. NPPs were then educated on the usage of the OAR and completed an OAR learning module. In phase 2, NPPs applied the OAR to 184 included patients.

**Results:** The sensitivity of the foot rule, as applied by NPP's, was 100% (56-100% CI) and the specificity was 17% (9-29% CI) for clinically significant fractures. The sensitivity of the ankle portion of the rule, as applied by NPP's, was 88% (47-99 CI) and the specificity was 31% (23-40% CI) for clinically significant fractures. The only clinically significant fracture missed by NPP's was detected on physician assessment. Inter-observer agreement was  $\kappa = 0.24$  for the ankle rule and  $\kappa = 0.49$  for the foot rule.

**Conclusion:** The sensitivity of the OAR when applied by NPP's was very good. More training and practice using the OAR would likely improve NPP's inter-observer reliability. Our data suggest the OAR may be a useful tool for NPP's to apply prior to physician assessment.

## RÉSUMÉ

**Objectif:** La Règle d'Ottawa pour la cheville (ROC) est un outil de décision clinique visant à réduire le nombre de radiographies inutiles dans les cas de blessures au pied ou à la cheville. Il s'agit d'un outil digne de confiance pour exclure les fractures chez les enfants de plus de 5 ans lorsqu'il est appliqué par les médecins. Il existe toutefois peu de données étayant son utilisation par d'autres catégories de professionnels de la santé

chez les enfants. L'étude visait donc à déterminer l'exactitude de la ROC lorsque celle-ci est appliquée par des fournisseurs de soins non médicaux (FSNM).

**Méthode:** Ont participé à l'étude des enfants de 5 à 17 ans qui sont allés au service des urgences pour la survenue de blessures au pied ou à la cheville. À la phase I, on a recueilli des données de base sur le recours à la radiographie chez 106 patients. Par la suite, les FSNM ont reçu une formation sur l'application de la ROC, complétée par un module d'apprentissage. À la phase II, les FSNM ont appliqué la ROC chez 184 patients.

**Résultats:** La sensibilité de la règle relative au pied, telle qu'elle a été appliquée par les FSNM, était de 100 % (IC : 56-100 %) et la spécificité, de 17 % (IC : 9-29 %) pour les fractures importantes sur le plan clinique. Quant à la sensibilité de la règle relative à la cheville, telle qu'elle a été appliquée par les FSNM, elle était de 88 % (IC : 47-99) et la spécificité, de 31 % (IC : 23-40 %) pour les fractures importantes sur le plan clinique. La seule fracture importante sur le plan clinique qui a échappé aux FSNM a été décelée à l'examen médical. La fiabilité interévaluateurs ( $\kappa$ ) était égale à 0,24 pour la partie de la règle concernant la cheville, et égale à 0,49 pour celle concernant le pied.

**Conclusion:** La sensibilité de la ROC, lorsqu'elle était appliquée par les FSNM, était très bonne. Toutefois, une formation approfondie sur l'application de la ROC et une pratique accrue de celle-ci permettraient sans doute d'améliorer la fiabilité interévaluateurs parmi les FSNM. Enfin, les résultats de l'étude donnent à penser que la ROC serait un outil utile aux FSNM avant l'examen médical.

**Keywords:** Ottawa Ankle Rules, pediatric, non-physician provider, nurse, accuracy, sensitivity

## INTRODUCTION

Ankle and foot injuries are a common presentation to the pediatric emergency department (ED). When a

From the \*Department of Pediatrics, Faculty of Medicine and Dentistry, University of Alberta, Edmonton, AB; †Department of Emergency Medicine, Faculty of Medicine; ‡Faculty of Science; and the §Department of Pediatrics, Faculty of Medicine, University of Calgary, Calgary, AB.

**Correspondence to:** Dr. Shawn Dowling, Department of Emergency Medicine, Rockyview General Hospital–Holy Cross Ambulatory Care Centre, 7007 14th Street SW, 5th Floor, Room 5A105, Calgary, Alberta T2V 1P9; Email: skdowling@gmail.com

© Canadian Association of Emergency Physicians

CJEM 2018;20(5):746-752

DOI 10.1017/cem.2017.399



CJEM • JCMU

2018;20(5) 746

fracture is present, it may require casting, splinting, or operative intervention. However, most injuries are sprains that require only conservative treatment.<sup>1,2</sup>

Unstructured clinical judgment alone is insufficient to rule out fractures.<sup>3,4</sup> Plain radiography can reliably rule out fractures but leads to radiation exposure, increased time in the ED, and higher costs to the health care system.<sup>5,6</sup> The Ottawa Ankle Rules (OAR) are a clinical decision tool developed to augment physician assessment in determining the need for radiography.<sup>7</sup>

Physician use of the OAR has been shown to reduce radiography, time spent in the ED, and health care expenditures, without missing clinically relevant fractures.<sup>7-9</sup> The OAR have been independently validated in both adult and pediatric populations and in diverse clinical settings worldwide.<sup>10-15</sup> In 2009, a systematic review on the use of the OAR in children aged 5-17 years demonstrated a pooled sensitivity of 98.5% and a decrease in radiography use of 24.8%.<sup>16</sup> Since this meta-analysis was conducted, three additional studies have been performed, with a sensitivity of 100%.<sup>17-19</sup>

Although nearly 90% of Canadian pediatric emergency physicians report using the OAR, non-physicians are ordering almost 40% of radiographs in acute ankle injuries.<sup>20</sup> While some evidence has supported the use of the OAR among non-physicians in an adult population,<sup>21-24</sup> there is a paucity of literature supporting the use of the OAR by non-physician providers (NPPs) in children.

Karpas et al.<sup>25</sup> is the only study to examine the accuracy of OAR use specifically by non-physicians in children. This study used a cross-sectional design and enrolled 190 participants who had the OAR applied by a nurse. The sensitivity of the OAR for clinically important fractures was 100%.

Our objective was to build on this small literature base, to determine the sensitivity and specificity of the OAR as applied by NPPs, to detect all fractures along with a subset of clinically significant fractures in children with ankle and foot injuries.

## **METHODS**

### **Study design, setting, and population**

The study was conducted at the Alberta Children's Hospital, which has 75,000 ED visits per year. Participants were prospectively enrolled between July 2012 and June 2014. Research ethics approval was obtained

from the Conjoint Health Research Ethics Board at the University of Calgary.

All patients, aged 5-17 years, presenting to the Alberta Children's Hospital with an acute ankle injury were included. Patients who had been assessed by the on-duty physician prior to an NPP assessment were excluded.

Any patients presenting for reassessment of the same injury or more than 24 hours after the injury; having open, penetrating, neurovascular, or multiple injuries; metabolic bone disease (e.g., osteogenesis imperfecta); with an inability to communicate or ambulate before the injury; or who were referred from an outside health centre with x-rays were excluded.

Patients meeting the inclusion and exclusion criteria were identified by research assistants at the time of triage and approached after the first assessment by nursing staff in the treatment area. Participation was voluntary, and informed consent and assent were obtained.

### **Health provider recruitment**

NPPs (nurses and orthopedic technologists [OT]) were recruited to participate in the study using email, bulletin boards, and direct contact, regardless of prior knowledge or use of the OAR. Nurses included licensed practical nurses (LPNs) and registered nurses (RNs) working in the ED. A single registered OT working in the ED was recruited. Participation by NPPs was voluntary. Physician participation included a convenience sample of emergency room (ER) physicians who assessed study participants after an NPP had performed an OAR assessment. Consent to include physician assessment was implied if a physician filled out the assessment form.

### **Enrolment, intervention, and outcome measures**

During phase one, the physicians and NPPs treated consenting patients in the usual manner. At our institution, there is a nurse-initiated protocol allowing nurses to order below-the-knee x-rays prior to physician assessment if a patient has point tenderness, provided the patients do not necessitate intravenous (IV) analgesia and no obvious deformity exists. Baseline data were collected on recruitment forms by research assistants on a convenience sample of patients (a priori  $n = 100$ ) who consented to inclusion (see Appendix 1).

After completion of phase one, a 20-minute learning module was presented to all recruited NPPs. This module outlined pertinent background, the relevant anatomy, the content of the OAR, and details on NPP involvement in the study. Participants submitted proof of completion in the form of a self-assessment quiz. NPPs were directly observed using the OAR by study investigators prior to applying the OAR to study patients to ensure accurate understanding and application of the decision tool. Completion of the learning module, quiz, and direct observation was voluntary but required to participate in the study.

After the teaching intervention, patient enrolment into the second phase of the study began. NPPs applied the OAR to all included patients, and research assistants filled out the appropriate recruitment form (see Appendix 2). If a radiograph was indicated based on the OAR, then patients were sent for x-rays. If not, then the patient would wait to be assessed by a physician. Physicians were free to care for the patient as they normally would.

Any patient who did not have an x-ray while in the ED obtained follow-up by telephone 7-10 days after discharge. Study investigators asked standardized questions regarding pain, activity, and further investigations/physician visits. Any patients who still had pain or had not returned to normal activities were encouraged to return to the ED for reassessment and possible radiography at the discretion of the treating physician.

Patients were selected ad hoc to undergo a second OAR assessment, by an NPP or physician, to assess inter-observer reliability. To encourage NPPs to comply with this protocol, a random draw for a gift basket was awarded at the end of enrolment. To ensure blinding between NPPs and physicians, NPPs were asked to fill out recruitment forms prior to physician assessment. Recruitment occurred seven days a week between 8:00 a.m. and midnight whenever a trained NPP was available.

### **Statistical analysis**

The data analysis for phase one was descriptive, detailing baseline x-ray usage, as well as the ordering provider (physician, nurse, or OT).

Data analysis for phase two included determining the sensitivity and specificity of the OAR as applied by NPPs. A clinically significant fracture included any fracture other than Salter-Harris I fractures and

avulsion fractures <3 mm in size. This definition is consistent with previous definitions in other pediatric OAR studies.<sup>11</sup> The sample size for phase two ( $n = 186$ ) was calculated in a manner similar to that of previous studies.<sup>25</sup>

NPP radiography rates were calculated as the number of positive OAR assessments divided by the total number of OAR assessments. The inter-observer agreement results were compared using the kappa ( $\kappa$ ) statistic. Further, 95% confidence intervals (CI) were calculated for sensitivity and specificity.

## **RESULTS**

### **Population**

#### **Phase one**

One hundred six patients were enrolled in phase one of the study. Further, 81% (84/104) of the patients obtained a foot or ankle x-ray (data unavailable for two patients). Moreover, 61% (51/84) of the x-rays were ordered by physicians, 25% (21/84) were ordered by nurses, and 13% (11/84) were ordered by an OT (data unavailable for one patient). Most of the physicians who ordered x-rays were staff physicians (82%, 42/51). Residents (16%, 8/51) and fellows (2%, 1/51) ordered the remainder.

#### **Phase two**

Seven hundred eighty-three patients presented with ankle and/or foot injuries during phase two of the study. Further, 294 patients met one or more of the exclusion criteria. Moreover, 305 patients were eligible but were not enrolled, including 107 patients who presented when study personnel or a trained NPP was not available, 38 patients who did not consent to enrolment, 147 patients who were missed by study personnel, and 13 patients who were not enrolled for other reasons.

One hundred eighty-four patients were included in the final analysis. Most of the patients were male (94/182, 52%), and patients ranged in age from 5 to 17 years (mean 12.1 years). Further, 118 patients had only an ankle assessment, and 40 patients had a foot assessment performed only. Twenty-six patients had both ankle and foot assessments (Table 1).

### **NPPs**

A total of 56 RNs and LPNs and 1 full-time OT volunteered to be part of the teaching phase. All 57

	No. (%) (n = 184)
Demographic	
Sex, male (n = 182)	94 (52)
Age	
Mean (years)	12.1
Range (years)	5-17
OAR assessments by NPP	
Ankle only	40 (22)
Foot only	118 (64)
Ankle and foot	26 (14)
Non-significant fractures (n = 16)	
Avulsion <3 mm	9 (5)
SH 1	5 (3)
Other	2 (1)
Significant fractures (n = 17)	
Base of fifth avulsion >3 mm	6 (3)
Other metatarsal fracture	2 (1)
Unimalleolar fracture	4 (2)
Bimalleolar fracture	2 (1)
SH 2-4 fractures	3 (2)

SH = Salter-Harris.

NPP	No.
Completing OAR module	57
Enrolling 0 patients	21
Enrolling 1 patient	13
Enrolling 2-4 patients	15
Enrolling ≥5 patients	8

NPP = non-physician provider; OAR = Ottawa Ankle Rules.

Decision rule positive	Ankle fracture		Foot fracture	
	Yes	No	Yes	No
Yes	7	94	7	49
No	1*	42	0	10
Sensitivity (95% CI)	88% (47, 99)		100% (56, 100)	
Specificity (95% CI)	31% (23, 40)		17% (9, 39)	

\*Inter-observer performed by a physician (MD) was positive for the Ottawa Ankle Rules (OAR).

participants attended the OAR learning module, completed the self-assessment quiz, and were observed applying the OAR correctly prior to phase two. The number of patients enrolled per NPP is described in Table 2.

### Radiography

If only patients with positive rules had x-rays, NPPs would have obtained x-rays for 73% of the patients (135/184).

After being examined by an NPP, 49 patients had not had an x-ray (based on negative OAR). Physicians had obtained x-rays for 30 of these patients (30/49, 61%).

Overall, after assessment by both an NPP and a physician, 90% (165/184) of the patients had an x-ray.

In this study, 70% (128/184) of the patients had an ankle x-ray. Further, 14% of these patients (18/128) had an ankle fracture, of which eight were clinically significant (Table 1). In addition, 39% (72/184) of the patients had a foot x-ray; 21% of these patients (15/72) had a foot fracture, of which nine were clinically significant (Table 1). None of the non-significant fractures required operative intervention, but one patient did develop pressure sores because of an air cast.

### Sensitivity and specificity

When NPPs applied the ankle portion of the OAR, the sensitivity was 88% (95% CI 47%-99%), and the specificity was 31% (95% CI 23%-40%) for clinically significant fractures. If all fractures were included, the sensitivity was 76% (95% CI 50%-92%), and the specificity was 31% (95% CI 23%-40%) (see Table 3).

When NPPs applied the foot portion of the OAR, the sensitivity was 100% (95% CI 56%-100%), and the specificity was 17% (95% CI 9%-29%) for clinically significant fractures. If all fractures were included, the sensitivity was 100% (95% CI 70%-100%), and the specificity was 19% (95% CI 10%-32%) (see Table 3).

In total, one clinically significant fracture was missed by an NPP. The missed fracture was a minimally displaced lateral and posterior malleolar fracture.

### Inter-observer agreement

In this study, 34% (72/211) of the patient evaluations had an inter-observer assessment. Fifty-one were performed on the ankle, and 21 were performed on the foot. Further, 72% (52/72) were performed by physicians, and 28% (20/72) were completed by a different NPP. Inter-observer agreement ( $\kappa$ ) was 0.24 for the ankle rule and 0.49 for the foot rule. Inter-observer

**Table 4. Inter-observer Kappa values for components of the Ottawa Foot Rule**

Ankle rule	IO (Kappa)	Foot rule	IO (Kappa)
Complete rule	0.24	Complete rule	0.49
Weight bearing	0.55	Weight bearing	0.68
Lateral malleolus	0.19	Navicular	0.33
Medial malleolus	0.65	Fifth metatarsal	0.78

IO = inter-observer.

agreements for the individual portions of the OAR are listed in Table 4.

### Follow-up

A total of 20 patients did not have an x-ray taken in the ED on the index visit. Nineteen of these patients received telephone follow-up 7-10 days after discharge. One patient was lost to follow-up. Among those reached by phone, five had a positive follow-up question (four had not returned to regular daily activities, and walking had not improved in one patient). Further, one of these patients had a follow-up x-ray, which was negative. The remaining four patients had no follow-up visits or x-rays in their medical record.

### DISCUSSION

The OAR reduce radiography without missing clinically important fractures in children.<sup>16</sup> Many x-rays are ordered by nurses and other NPPs prior to assessment by a physician.<sup>20</sup> These nurse-initiated protocols may decrease the ED length of stay and help alleviate overcrowding.<sup>27</sup> However, there is a lack of published data evaluating the accuracy of the OAR if used by NPPs in children.

In our study, NPPs detected the need for radiography in all but one clinically important ankle fracture. The single missed fracture was a minimally displaced bi-malleolar fracture. A physician inter-observer assessment was performed on this patient and was positive. In our estimation, this scenario reflects everyday clinical practice in Canada. All patients have a complete assessment by a physician, including evaluation of the need for imaging, after the initial assessment by NPP. As was the case in our study, physicians should likely capture infrequently missed fractures prior to patient discharge from the ED.

The specificity of the OAR in our study is similar to that of previous studies in children. In a study by Karpas et al.,<sup>26</sup> the specificity was 25% if nurses applied the OAR in children. A meta-analysis by Dowling et al.<sup>16</sup> found that the specificity of the OAR was between 7% and 50% if applied by physicians in children. This comparable specificity suggests radiography can be minimized, even in the hands of NPPs.

The primary goal of the OAR is to reduce radiography without missing clinically important fractures. If used as a screening tool prior to physician assessment, it is essential that an NPP not unnecessarily increase the use of radiography. Karpas et al.<sup>26</sup> found a nurse radiography rate of 79% and that institution of the OAR in their nurse-initiated protocol would have decreased negative films by 21%. In our study, the radiography rate by NPPs was 73%. NPPs captured all but one fracture while using 8% fewer x-rays than that of phase one. Overall, after the final assessment by a physician, the x-ray rate was 90% (up from 81% in phase one). Physicians x-rayed more than one-half of patients who had a negative OAR assessment by an NPP. Given the robust literature supporting a reduction in imaging with the use of the OAR by physicians, these data raise the question as to whether the physicians in our study were using the OAR. Failure to use the rules may be the reason for the increased x-ray usage demonstrated in our study.

Despite the good sensitivity and specificity of the OAR in our study, the inter-observer agreement was poor. This finding is in stark contrast with the study data of Karpas et al.<sup>26</sup> that found the OAR had an inter-observer agreement of 100% among nurses in children. This may be in part because most of our inter-observer assessments were performed by physicians (72%).

In our study, NPP training was thorough and included an educational session, a self-assessment quiz, and direct observation of OAR application. Enrolment forms included a visual aid of the OAR to increase knowledge retention, and investigators were available for follow-up questions and clarification if required.

Karpas et al.<sup>26</sup> used a similar training scheme but also provided a second follow-up educational session in which the investigators met one-on-one with individual nurses to review the OAR, discuss the data collection sheet, and answer questions. This additional session helped solidify understanding and familiarize nurses with the study and may have led to a better inter-observer agreement than in our study. Two parts of the

OAR had very low inter-observer agreement in our study. The navicular bone and the posterior edge of the lateral malleolus had inter-observer agreement of less than 50%. These error-prone portions of the OAR would be an ideal focus for additional teaching sessions.

There are several other potential factors that might explain the disparity between our results and previous studies examining physician application of the OAR. First, we had a large number of NPPs performing assessments. Because of this, a large proportion of NPPs (36%) enrolled only a single patient in the study. NPPs also had a lag-time of up to 10 months between training and enrolment that may have affected recall. Finally, the NPPs' diverse levels of ED work experience and previous practice with the OAR could have led to differences in familiarity with the OAR that may have affected inter-observer agreement.

Previous work involving the OAR with physicians has shown poor recall of the rule components even among those physicians who reported familiarity with the rule.<sup>28</sup> Memory difficulty was more common among older, part-time physicians who reported not applying the rule regularly.<sup>28</sup> Despite the simplicity of the rule, it is apparent that errors in its application can occur, particularly in these high-risk groups. Attempts at improved recall have included mnemonics, posters, pocket cards, digital calculator, clinical support tools, and others.<sup>29-31</sup> Given the poor inter-observer agreement in our study, it may be even more important for NPPs to support OAR use with memory tools.

Regardless, there is the potential for unacceptably high variability among NPP assessments with the OAR. While this did not negatively impact the accuracy of the OAR in our study, it could affect patient assessments in clinical encounters. Future research might explore inter-observer variability among pediatric NPPs using the OAR. A follow-up educational session and refresher training with a focus on clarifying problematic portions of the OAR in combination with more routine clinical practice with the OAR may ensure more consistent application by NPPs.

### LIMITATIONS

All but one of the NPPs in our study were nurses; a single OT participated. As such, we were unable to perform subgroup analyses on the type of NPP. Our study does not answer the question of whether non-nursing groups of NPPs are able to apply the OAR accurately.

Not all patients in our study had an x-ray. Despite telephone follow-up with all but one of these patients, it is possible a fracture was missed. However, only one patient re-presented to the hospital and had a negative x-ray, so it is unlikely any significant injuries were missed.

Finally, our study size was small, and the CIs for our estimates are wide. Reported sensitivities and specificities may be over-estimates of actual clinical practice. However, our study joins a growing body of research, including a recent systematic review in adults that demonstrated that nurses can reliably apply the OAR in the ED.<sup>32</sup>

### CONCLUSIONS

The sensitivity of the OAR was very good if applied by NPPs. The only clinically significant fracture that was missed by NPPs was identified during a physician assessment. More training and practice using the OAR would likely improve the inter-observer reliability of NPPs. Our data suggest that the OAR may be a useful tool for NPPs to use to determine the need for radiography prior to physician assessment.

**Acknowledgements:** Ms. Janie Williamson functioned as a research coordinator for this study. The Pediatric Emergency Research Team (PERT) at the Alberta Children's Hospital consented and enrolled all patients.

**Competing interests:** JM secured a trainee grant from the Calgary Emergency Medicine Research Advisory Committee (EMRAC) to support this work. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

### SUPPLEMENTARY MATERIAL

To view supplementary material for this article, please visit <https://doi.org/10.1017/cem.2017.399>

### REFERENCES

1. Conrad EU, Rang MC. Fractures and sprains. *Pediatr Clin North Am* 1986;33(6):1523-40.
2. Boutis K, Plint A, Stimec J, et al. Radiograph-negative lateral ankle injuries in children: occult growth plate fracture or sprain? *JAMA Pediatrics* 2016;170(1):e154114.
3. Boutis K, Komar L, Jaramillo D, et al. Sensitivity of a clinical examination to predict need for radiography in

- children with ankle injuries: a prospective study. *Lancet* 2001;358(9299):2118-21.
4. Al Omar MZ, Baldwin GA. Reappraisal of use of x-rays in childhood ankle and midfoot injuries. *Emerg Radiol* 2002; 9(2):88-92.
  5. Cockshott WP, Jenkin JK, Pui M. Limiting the use of routine radiography for acute ankle injuries. *Can Med Assoc J* 1983;129(2):129-31.
  6. Gleadhill DN, Thomson JY, Simms P. Can more efficient use be made of x ray examinations in the accident and emergency department?. *Br Med J (Clin Res Ed)* 1987;294 (6577):943-7.
  7. Stiell IG, Greenberg GH, McKnight RD, et al. Decision rules for the use of radiography in acute ankle injuries. Refinement and prospective validation. *JAMA* 1993;269:1127-32.
  8. Anis AH, Stiell IG, Stewart DG, Laupacis A. Cost-effectiveness analysis of the Ottawa Ankle Rules. *Ann Emerg Med* 1995;26(4):422-8.
  9. Fan J, Woolfrey K. The effect of triage-applied Ottawa Ankle Rules on the length of stay in a Canadian urgent care department: a randomized controlled trial. *Acad Emerg Med* 2006;13(2):153-7.
  10. Dohin B, Lubanziado D. Validation of the Ottawa Ankle Rules for varus ankle trauma in children: A prospective study of 160 cases. 2004. *J Bone Joint Surg-British Volume* 2002;86 (Supp 20).
  11. Plint AC, Bulloch B, Osmond MH, et al. Validation of the Ottawa Ankle Rules in children with ankle injuries. *Acad Emerg Med* 1999;6(10):1005-9.
  12. Libetta C, Burke D, Brennan P, Yassa J. Validation of the Ottawa ankle rules in children. *J Accid Emerg Med* 1999;16 (5):342-4.
  13. Auleley GR, Kerboull L, Durieux P, et al. Validation of the Ottawa ankle rules in France: a study in the surgical emergency department of a teaching hospital. *Ann Emerg Med* 1998;32(1):14-8.
  14. Yuen MC, Sim SW, Lam HS, Tung WK. Validation of the Ottawa ankle rules in a Hong Kong ED. *Am J Emerg Med* 2001;19(5):429-32.
  15. Springer BA, Arciero RA, Tenuta JJ, Taylor DC. A prospective study of modified Ottawa ankle rules in a military population. Interobserver agreement between physical therapists and orthopaedic surgeons. *Am J Sports Med* 2000;28(6):864-8.
  16. Dowling S, Spooner CH, Liang Y, et al. Accuracy of Ottawa Ankle Rules to exclude fractures of the ankle and midfoot in children: a meta-analysis. *Acad Emerg Med* 2009;16(4):277-87.
  17. Gravel J, Hedrei P, Grimard G, Gouin S. Prospective validation and head-to-head comparison of 3 ankle rules in a pediatric population. *Ann Emerg Med* 2009;54(4):534-40; e1.
  18. Lau LH, Kerr D, Law I. Nurse practitioners treating ankle and foot injuries using the Ottawa Ankle Rules: A comparative study in the emergency department. *Australas Emerg Nurs J* 2013;16:110-5.
  19. Meena S, Gangary SK. Validation of the Ottawa Ankle Rules in Indian Scenario. *Arch Trauma Res* 2015;4(2):e20969.
  20. Dowling S, Wishart I. Use of the Ottawa Ankle Rules in the Pediatric Population: A Survey of Physician Practice. *CAEP*. Ottawa: Poster Presentation; 2008.
  21. Allerston J, Justham D. Nurse practitioners and the Ottawa Ankle Rules: comparisons with medical staff in requesting X-rays for ankle injured patients. *Accid Emerg Nurs* 2000; 8(2):110-5.
  22. Derksen RJ, Bakker FC, Geervliet PC, et al. Diagnostic accuracy and reproducibility in the interpretation of Ottawa ankle and foot rules by specialized emergency nurses. *Am J Emerg Med* 2005;23(6):725-9.
  23. Fiesseler F, Szucs P, Kec R, Richman PB. Can nurses appropriately interpret the Ottawa Ankle Rule? *Am J Emerg Med* 2004;22(3):145-8.
  24. Salt P, Clancy M. Implementation of the Ottawa Ankle Rules by nurses working in an accident and emergency department. *J Accid Emerg Med* 1997;14(6):363-5.
  25. Scheaffer RL, Mendenhall W, Ott L. *Elementary survey sampling*. Duxbury Press; 1979.
  26. Karpas A, Hennes H, Walsh-Kelly CM. Utilization of the Ottawa ankle rules by nurses in a pediatric emergency department. *Acad Emerg Med* 2002;9(2):130-3.
  27. Rowe BH, Willa-Roel C, Guo X, et al. The role of triage nurse ordering on mitigating overcrowding in emergency departments: a systematic review. *J Accid Emerg Med* 1998;15(5):315-6.
  28. Brehaut JC, Stiell IG, Visentin L, Graham ID. Clinical decision rules "in the real world": How a widely disseminated rule is used in everyday practice. *Acad Emerg Med* 2005;12(10):948-57.
  29. Gravel J, Roy M, Carrière B. 44-55-66-PM, a mnemonic that improves retention of the Ottawa Ankle and Foot Rules: a randomized controlled trial. *Acad Emerg Med* 2010;17 (8):859-64.
  30. Stiell IG, McKnight RD, Greenberg GH, et al. Implementation of the Ottawa Ankle Rules. *JAMA* 1994;271 (11):827-32.
  31. Silveira PC, Ip IK, Sumption S, et al. Impact of a clinical decision support tool on adherence to the Ottawa Ankle Rules. *Am J Emerg Med* 2016;34(3):412-8.
  32. Ho JK, Chau JP, Cheung NM. Effectiveness of emergency nurses' use of the Ottawa Ankle Rules to initiate radiographic tests on improving healthcare outcomes for patients with ankle injuries: A systematic review. *Int J Nurs Stud* 2016;63:37-47.