

Validation of the Ottawa ankle rules

Experience at a community hospital

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ABSTRACT

OBJECTIVE To test the validity of a set of defined and tested rules for decisions on use of radiography for acute ankle injuries.

DESIGN Prospective survey.

SETTING Community hospital emergency department managing 42 000 visits annually.

PARTICIPANTS A non-consecutive sample of 318 adults and children presenting during 1 year was evaluated by 25 family physicians in part-time emergency practice.

INTERVENTIONS Participating physicians interpreted the Ottawa ankle rules for all enrolled patients and ordered radiographs in 96% of cases.

MAIN OUTCOME MEASURES Sensitivity of the Ottawa ankle rules to predict whether radiography is required for acute ankle injuries.

RESULTS Of the 318 cases, 22 incomplete records were excluded, leaving 259 records of adults and 37 records of patients younger than 16 accepted for analysis. Of 34 adult patients with identified fractures, only one was predicted by the rules not to require radiographs. Sensitivity of the rules was 0.971 (confidence interval [CI] 0.914 to 1.00), specificity was 0.302 (CI 0.242 to 0.362), positive predictive value was 0.174 (CI 0.120 to 0.228), and negative predictive value was 0.986 (CI 0.971 to 1.00). Radiography could have been reduced by 26.3% had the rules been applied. Of the 37 children, seven had fractures. All were properly identified by the rules. Radiography in this group could have been reduced by 22%.

CONCLUSIONS This study validates the Ottawa ankle rules and supports their use. Further research on how the rules apply to children is required.

RÉSUMÉ

OBJECTIF Vérifier la validité d'un ensemble de règles définies et reconnues qui facilitent la prise d'une décision éclairée concernant l'utilisation de la radiologie dans les cas de blessure aiguë de la cheville.

CONCEPTION Étude prospective.

CONTEXTE Service des urgences d'un centre hospitalier communautaire qui reçoit 42 000 visites annuellement.

PARTICIPANTS Vingt-cinq médecins de famille exerçant la médecine d'urgence à temps partiel ont évalué un échantillon non consécutif de 318 adultes et enfants qui avaient consulté au cours d'une période de 12 mois.

INTERVENTIONS Les médecins participants ont appliqué les règles d'Ottawa concernant la cheville à tous les patients inscrits et ont prescrit des radiographies dans 96% des cas.

PRINCIPALES MESURES DES RÉSULTATS Sensibilité des règles d'Ottawa à prédire le besoin d'obtenir des radiographies dans les cas de blessures aiguës de la cheville.

RÉSULTATS De ces 318 cas, on a exclu 22 dossiers incomplets, ce qui laissait pour l'analyse 259 dossiers d'adultes et 37 dossiers de patients de moins de 16 ans. Des 34 adultes chez qui on a identifié une fracture, un seul n'aurait pas nécessité de radiographie selon les règles. La sensibilité des règles fut de 0,971 (intervalle de confiance [IC] de 0,914 à 1,00), la spécificité de 0,302 (IC de 0,242 à 0,362), la valeur prédictive positive de 0,174 (IC de 0,120 à 0,228) et la valeur prédictive négative de 0,986 (IC de 0,971 à 1,00). L'application des règles aurait permis de réduire de 26,3 % l'utilisation des radiographies. Quant aux 37 enfants, sept étaient porteurs de fractures. Les règles les ont tous identifiés et leur application aurait réduit de 22 % l'utilisation de la radiologie.

CONCLUSIONS Cette étude confirme la validité des règles d'Ottawa concernant la cheville et confirme leur utilité. D'autres recherches sont nécessaires pour préciser l'application de ces règles chez les enfants.

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Ankle injuries are frequently encountered in emergency departments. Almost all patients (>90%) are referred for ankle radiographic series,^{1,2} which are the second most commonly performed radiologic examinations in emergency departments.³ Radiography is used primarily to rule out clinically important fractures, even though fracture prevalence is generally lower than 15%.^{4,5} Reducing use of radiography would decrease patient irradiation and waiting times and save costs on this high-volume, low-technology procedure.⁶

Using less radiography, while desirable, has not been feasible. Although emergency physicians can decide on clinical grounds whether patients require radiography or not, they seldom make this decision for a variety of reasons, such as transient patient contact; high patient volumes; lack of follow up; fear of medicolegal repercussions; patient demand for radiography; and lack of clear, sound guidelines.⁶ Many studies have tried to formulate data for clinical guidelines, but have failed. Some used unreliable signs^{1,7} or variables that lacked clinical sense and were complicated to follow⁸ while others had contradictory results⁹ or methodologic flaws.^{2,4,5}

Recently, a group in Ottawa developed a simple set of clinical decision rules (the "Ottawa ankle rules")¹⁰ based on clinical evaluation.^{10,11} The rules were carefully defined, validated for interobserver variance, further refined, and then implemented at their centre.¹²

Their two rules are:

- if patients present with pain in the proximal area of the foot, radiography is required if they cannot bear weight immediately or for four steps in the emergency room or if they have tenderness in the navicular or the base of the fifth metatarsal; and
- if patients present with ankle pain, radiography is required if they cannot bear weight as above or have tenderness along the inferior tip or posterior portion of the distal 6 cm of either malleolus.¹²

At the start of the study, these rules had not been validated outside the authors' institution. The best test of validation is an independent evaluation at a separate site.¹³ This study aimed to test the validity of these rules in a common practice setting with family physicians in part-time practice at a community hospital emergency department. As a secondary interest,

Dr McBride is a family physician and part-time emergency physician in private practice. This study was presented, in part, at the College's 37th Annual Scientific Assembly in Quebec City in May 1995.

children were included to see whether the rules could be extrapolated to the pediatric population. We hoped validation would assuage physicians' anxiety and lead to widespread use of the rules.

METHODS AND MATERIALS

This study was conducted in a community hospital emergency department serving 42 000 patients annually. The department was staffed by two full-time emergency physicians (who were excluded from the study) and 25 part-time family physicians. None of the family physicians had emergency medicine certification.

Physicians were instructed about the Ottawa ankle rules at an in-hospital continuing medical education session. Study summaries and diagrams detailing the rules' use were posted in the emergency department.

Patients presenting non-consecutively with blunt ankle trauma were enrolled from July 1993 to July 1994. Exclusion criteria were pregnancy, open injuries, and presentation more than 1 week after injury. Non-consecutive enrolment occurred because, although the full-time physicians saw patients with ankle injuries, data were not collected on these patients.

Reception clerks attached a standard form to charts of patients presenting with blunt ankle trauma. The form asked physicians first to assess patients using the Ottawa ankle rules and to note marked swelling and the mechanism of injury, and then to feel free to otherwise assess, investigate, and treat at their discretion, including using radiography or not.

Forms were collected at the end of the enrolment period, and patient charts were inspected for presence of a radiologist's report. Type of series obtained and type of clinically significant fracture, if any, were noted. Fractures were considered significant and were included if the fragment measured more than 3 mm, as previously defined.¹⁰

Statistical analysis consisted of Student's *t* test and Fisher's exact test or χ^2 analysis. *P* values were two-tailed with confidence intervals of 95%. Sensitivity and specificity and negative and positive predictive values were calculated with 95% confidence intervals.

Approval for this study was obtained from the institution's Research Ethics Committee.

RESULTS

Of 318 patients initially enrolled, 37 were younger than 16 years, and their charts were analyzed separately. Of the 281 eligible adult patients, 12 had charts

Table 1. Characteristics of the 259 adult patients by fracture and no fracture groups

CHARACTERISTICS	NO FRACTURE N = 225	FRACTURE N = 34	STATISTICAL SIGNIFICANCE
Mean age (SD) Age range	30.90 (\pm 12.27) 16 to 71	41.21 (\pm 17.87) 16 to 78	$t = 2.419 P < 0.10$
Male to female ratio	123:102	13:21	$\chi^2 = 3.197 P < 0.10$
Mechanism			NS
• Twist	179 (79.6%)	27 (79.4%)	
• Blow	14 (6.2%)	2 (5.9%)	
• Motor vehicle accident	3 (1.3%)	1 (2.9%)	
• Fall	9 (3.9%)	2 (5.9%)	
• Other*	20 (8.9%)	2 (5.9%)	
Clinical factors†			
• Cannot bear weight	71 (31.5%)	20 (58.8%)	
• Tender malleoli	134 (59.6%)	23 (67.6%)	
• Tender navicular or fifth metatarsal	33 (14.7%)	11 (32.3%)	
• Swelling with or without other signs	107 (47.6%)	19 (55.9%)	
• Weight bearing with no bony tenderness	68 (30.2%)	1 (2.9%)	

SD – standard deviation, NS – nonsignificant.

*Hyperextension or hyperflexion of foot, or unknown mechanism.

†Some patients met several criteria, so numbers do not add up to total.

with incomplete data and were excluded. Ten had no radiography, 212 had ankle series, 25 had foot series, and 22 had foot and ankle series, resulting in a 96% radiography rate. We analyzed the charts of the 259 patients who had radiography.

Patient characteristics are noted in **Table 1**. A statistical difference was noted in the ages of the fracture and nonfracture groups. The fracture group had an older mean age ($t = 2.419$, $P < 0.01$) and had proportionately more women in it (this difference was not significant [$\chi^2 = 3.197$, $P < 0.10$]). Mechanisms of injury were similar in both groups.

Of the 259 patients included for analysis, 34 had fractures. Fracture characteristics are shown in **Table 2**. The fracture rate was 13.1%, which is comparable to rates at other centres.^{4,5}

Performance of the Ottawa ankle rules is demonstrated in **Table 3**. The fracture not predicted by the rules occurred in a 62-year-old man who suffered an isolated, undisplaced posterior malleolar fracture ("curbstone fracture") that required plaster immobilization. The mechanism of injury was a sudden hyperextension of the foot. Use of the rules could have reduced radiography by 26.3%.

If inability to bear weight is considered separately as the sole criterion, sensitivity declines (0.588) as specificity increases (0.684). When swelling is

evaluated alone, similar results are obtained (sensitivity 0.559, specificity 0.524).

Table 4 shows characteristics of the 37 pediatric patients. A preponderance of male patients in the fracture group was noted. All pediatric patients had radiographic investigation (32 ankle views, three foot views, two ankle and foot) for a 100% radiography rate. Fracture types are presented in **Table 5**. The fracture rate was 18.9%. **Table 6** shows the rules' performance; use of the rules could have reduced the number of radiographic examinations by eight (21.6%).

DISCUSSION

This study attempted to validate the Ottawa ankle rules using family physicians not certified in emergency medicine. The study was performed at an institution removed from the original site with clinicians inexperienced with the rules. The study design was deliberately very loose to replicate as much as possible the everyday practice of our institution's family physicians.

Despite these potential weaknesses, the rules performed well. Although sensitivity was not 100%, the rules performed well enough to be clinically useful and valid. The rules were easy to learn and apply. The one fracture missed in this study (isolated posterior malleolus) is one of the more difficult fractures

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Table 2. Anatomic distribution of the 34 fractures seen in 259 adults with blunt ankle trauma

FRACTURE TYPE	NO. OF PATIENTS
ANKLE	
Lateral malleolus	9
Medial malleolus	4
Bimalleolar (lateral and medial)	3
Fibula (distal spiral)	3
Posterior malleolus alone	2
Posterior and medial malleoli	1
FOOT	
Base of fifth metatarsal	7
Shaft of fifth metatarsal	3
Navicular	1

to identify. One other patient with the same diagnosis in this study was correctly identified by the rules as requiring radiography.

In three other trials with a total of 33 patients with isolated posterior malleolar fractures,^{11,14,15} the Ottawa ankle rules misclassified three patients. Extra caution or routine radiography might be necessary for patients presenting with ankle pain and a hyperplantar flexion mechanism of injury. All patients should be instructed to return for reassessment if the pain or ability to bear weight have not improved in 7 days. Caution in applying the Ottawa ankle rules should also be considered when altered sensation is a problem, such as with drug or alcohol intoxication, head injury, multiple trauma, or neurologic deficits causing decreased sensation.

Four other validation studies have been performed in a variety of settings,^{14,17} along with two other validation studies by the original group^{11,12} (Table 7). Only one independent site assessment, a small study conducted by board-certified emergency physicians,¹⁴ has achieved the sensitivity of the original group.

A multicentre New Zealand study involving emergency physicians achieved the poorest sensitivity.¹⁷ However, this study seems to have several flaws. How the Ottawa ankle rules were applied is not specified nor is it clear whether the staff were instructed on proper use of the rules. The authors concluded that the rules were unacceptable due to low sensitivity.

Similar results were obtained by American emergency physicians at a community teaching hospital.¹⁴

Table 3. Performance of the Ottawa ankle rules

DECISION RULES	FRACTURE (N = 34)	NO FRACTURE (N = 225)
Positive	33	157
Negative	1	68

Sensitivity (95% CI) 0.971 (0.914-1.00)

Specificity (95% CI) 0.302 (0.242-0.362)

Positive predictive value (95% CI) 0.174 (0.120-0.228)

Negative predictive value (95% CI) 0.986 (0.971-1.00)

Despite a sensitivity nearly identical to that found in New Zealand, these investigators favoured implementing the rules as guidelines, provided patients were adequately instructed on care and consequences.

Stiell and coworkers did three validation studies. The first two were performed to help refine the rules and apply them prospectively at their own institution.^{11,12} Both studies achieved sensitivities of 1.0 in the subgroup of patients involved. The third was a large multicentre¹⁵ trial to introduce the rules and reduce radiography. This involved training 200 physicians of varying experience (house officers, family physicians, emergency physicians) to use the rules at both community and teaching hospitals. A reduction in radiography of 26% was obtained with a sensitivity approaching 1.0.

None of the above studies were conducted primarily by family physicians without emergency certification. Our study fills this gap, validating the Ottawa ankle rules just in this group. While the rules have not been formally validated in family practice offices, one recent study has supported their use in this venue.¹⁸

It is interesting to note the high sensitivities in the three studies by the original group,^{11,12,15} compared with all other validation studies.^{14,16,17} The surprise is not in sensitivities of less than 100%, but that some validation studies have come so close; sensitivity tends to drop when a rule is subjected to the vagaries of the real world.¹⁹

The discrepancy appears to be a factor of education and correct implementation. Studies that specified how the rules were to be taught included the large multicentre trial¹⁵ and our study. Both performed well. In other studies the authors did not specify how the rules were taught to physicians and the rules tended to perform less well. In the study that analyzed why fractures were missed, the rules were applied incorrectly in eight of the 16 missed fractures.¹⁵

Is it necessary for the sensitivity to be 1.0? For a cost-benefit analysis, it is not.²⁰ That study assessed

Table 4. Characteristics of the 37 pediatric patients by fracture and no fracture groups

CHARACTERISTICS	NO FRACTURE N = 30	FRACTURE N = 7	STATISTICAL TESTS
Mean age (SD) Age range	13.23 (\pm 1.30) 9 to 15	12.86 (\pm 1.34) 11 to 14	NS
Male to female ratio	12:18	5:2	Fisher's exact $P = 0.114$
Mechanism*			Fisher's exact $P = 0.323$
• Twist	24	5	
• Blow	1	1	
• Motor vehicle accident	0	0	
• Fall	1	0	
• Other†	4	1	
Clinical factors‡			
• Cannot bear weight	14	3	
• Tender malleoli	20	4	
• Tender navicular or fifth metatarsal	2	2	
• Swelling with or without other signs	9	3	
• Weight bearing with no bony tenderness	8	0	

SD – standard deviation, NS – nonsignificant.

*For statistical comparison, mechanisms were collapsed into two groups: twist and all others.

†Hyperextension or hyperflexion of foot, or unknown mechanism.

‡Some patients met several criteria, so numbers do not add up to total.

savings in patient waiting time and in radiography costs against the potential costs of litigation for missed fractures. Assuming a sensitivity of 0.985, nearly \$0.75 million could be saved for every 100 000 patients with ankle injuries assessed. From a human standpoint, if patients were counseled about proper care, follow up, and possible consequences, most would likely be satisfied.¹³

Application to children

It was thought that the Ottawa ankle rules could be extrapolated for use in children. Previous studies in children with acute ankle injuries had identified similar clinical characteristics including localized tenderness below the lateral malleolus,² inability to bear weight, bone point tenderness,²¹ and pain with motion or bearing weight.^{22,23}

Application of the Ottawa ankle rules to the 37 children in our study predicted all of the fractures. Had the rules been applied, radiography could have been reduced by 22% (roughly equivalent to the adult group). This group did not contain many young children; the youngest was 9 years and only five were younger than 12 years, when growth plate injuries become more of a problem.

Another small study of 71 children ranging in age from 3 to 18 years, of whom 14 had fractures, also revealed a sensitivity of 1.0 for the Ottawa ankle rules.²⁴ Despite the encouraging success in that study and our study, several caveats should be noted. Children have different injury patterns from adults due to more pliable soft tissues and inherent weakness of the growth plate. Young children might not cooperate for an examination, refusing to bear weight for reasons other than pain. Thus, the rules might not be directly applicable to children.

Biases and limitations

Our study might have several biases. In the adult patients, the fracture group was older and had a higher proportion of women than the nonfracture group. A plausible biologic explanation would be osteopenia, a condition more common among older and female patients. This is further supported by both groups having similar proportions of mechanism of injury. Selection bias could have occurred from non-consecutive patient enrolment. This does not appear to have been a problem, as our study population overall is similar to that of previous studies in age, sex, and mechanism of injury.^{5,10,11}

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Table 5. Anatomic distribution and type of fracture seen in pediatric study patients

FRACTURE TYPE	NO. OF PATIENTS
ANKLE	
Lateral malleolus, Salter I	2
Lateral malleolus	1
Medial malleolus	1
Tibia, Salter IV	1
FOOT	
Fifth metatarsal	2

Table 6. Performance of the Ottawa ankle rules

DECISION RULES	FRACTURE (N = 7)	NO FRACTURE (N = 30)
Positive	7	22
Negative	0	8

Sensitivity (95% CI) 1.0 (0.874-1.0)

Specificity (95% CI) 0.267 (0.141-0.393)

Positive predictive value (95% CI) 0.241 (0.115-0.367)

Negative predictive value (95% CI) 1.0 (0.874-1.0)

Table 7. Studies on the performance of the Ottawa ankle rules

STUDY	PATIENTS ENROLLED	FRACTURES PREDICTED	FRACTURES NOT PREDICTED	SENSITIVITY
Pigman et al (1994) ¹⁶	71	9	0	1.0
Kerr et al (1994) ¹⁷	350	70	5	0.93
Lucchesi et al (1995) ¹⁴	484	115	7	0.94
Stiell et al (1995) ¹⁵	6489	1066	16	0.99
Present study	259	33	1	0.97
Stiell et al (1993) ¹¹	453	93	0	1.0
Stiell et al (1994) ¹²	593	69	0	1.0

Limitations of this study include failure to account for patient and physician attitudes, lack of demonstration of effectiveness, and failure to assess interobserver agreement in clinical findings. Implementing clinical decision rules can be difficult if neither patient nor physician believes they are effective. However, a previous study does show patient satisfaction¹³ and, with the use of guidelines, physicians may implement these rules.⁶ This issue was beyond the scope of this study. Finally, a previous study has assessed interobserver reliability of clinical findings.^{10,16}

Conclusion

It appears that a simple set of clinical decision rules for radiography of acute ankle injuries in adults can be widely applied. More specifically, family physicians who do not have emergency medicine qualifications can easily and safely apply the Ottawa ankle rules to identify patients who do not require radiography. This can reduce costs, patient irradiation, and patient waiting times. ✦

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