

Accuracy of Ottawa ankle rules to exclude fractures of the ankle and mid-foot: systematic review

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Abstract

Objective To summarise the evidence on accuracy of the Ottawa ankle rules, a decision aid for excluding fractures of the ankle and mid-foot.

Design Systematic review.

Data sources Electronic databases, reference lists of included studies, and experts.

Review methods Data were extracted on the study population, the type of Ottawa ankle rules used, and methods. Sensitivities, but not specificities, were pooled using the bootstrap after inspection of the receiver operating characteristics plot. Negative likelihood ratios were pooled for several subgroups, correcting for four main methodological threats to validity.

Results 32 studies met the inclusion criteria and 27 studies reporting on 15 581 patients were used for meta-analysis. The pooled negative likelihood ratios for the ankle and mid-foot were 0.08 (95% confidence interval 0.03 to 0.18) and 0.08 (0.03 to 0.20), respectively. The pooled negative likelihood ratio for both regions in children was 0.07 (0.03 to 0.18). Applying these ratios to a 15% prevalence of fracture gave a less than 1.4% probability of actual fracture in these subgroups.

Conclusion Evidence supports the Ottawa ankle rules as an accurate instrument for excluding fractures of the ankle and mid-foot. The instrument has a sensitivity of almost 100% and a modest specificity, and its use should reduce the number of unnecessary radiographs by 30-40%.

Introduction

The number of acute ankle sprains managed by lay people at sporting activities is unknown; however, general practitioners frequently encounter such injuries.¹ The management of ankle sprains is daily routine at emergency departments, and although most patients undergo radiography, fracture of the ankle or mid-foot occurs in less than 15%.²⁻⁶ This small yield triggered the development of the Ottawa ankle rules in 1992.⁷ This instrument consists of a questionnaire for assessment of the ankle and foot.⁸ The ankle assessment covers the ability to walk four steps (immediately after the injury or at the emergency department) and notes localised tenderness of the posterior edge or tip of either malleolus (four spots). The mid-foot assessment

covers the ability to walk and notes localised tenderness of the navicular or the base of the fifth metatarsal (fig 1). The instrument is designed to rule out fractures of the malleolus and the mid-foot. It has been validated and modified in several clinical settings. We conducted a systematic review on its accuracy.

Methods

We focused on studies in which the Ottawa ankle rules was used to diagnose fractures of the ankle or mid-foot. We electronically searched databases, checked the reference lists of included studies, and contacted experts and authors in the specialty (see appendix on bmj.com for examples of the search strategy).

We searched Medline and Premedline (1990 to present), Embase (1990-2002), CINAHL (1990-2002), and the Cochrane Library (2002, issue 2). We used the Science Citation Index database to identify studies citing reference 7 of this paper. The search had no language restrictions.

All abstracts or titles found by the electronic searches were independently scrutinised by JS and LMB. We then obtained copies of eligible papers. Minimal requirements for inclusion were assessment of the Ottawa ankle rules and the possibility of constructing at least a 2×2 table specifying the true positive rate and the true negative rate.

Methodological quality and statistical analysis

EK and LMB independently assessed the methods of data collection, patient selection, blinding and prevention of verification bias, and description of the instrument and reference standard.⁹⁻¹⁴ Disagreements were resolved by consensus. We calculated several pooled estimates of the negative likelihood ratio by successively increasing the number of methodological criteria required (table 1).

We calculated sensitivities, specificities, likelihood ratios, and their standard errors. Because the Ottawa ankle rules is calibrated towards high sensitivity, we were particularly interested in the pooled sensitivity and in the pooled likelihood ratio of a negative result—that is, how many times more likely it is to find a negative result among people with a fracture ($1 - \text{sensitivity}$) than among those without (specificity). After inspection of the receiver operating characteristics plot we decided to pool sensitivities, but not specificities, by using bootstrapping (fig 2).



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Examples of the search strategy appear on bmj.com

Table 1 Pooled likelihood ratios (95% confidence intervals; random effects) of negative result with Ottawa ankle rules for subgroups of increasing complexity of methodological quality

Stratum	Prospective data collection		Plus consecutive enrolment		Plus blinding		Plus radiography as reference standard in all patients		All studies
	Within 48 hours	After 48 hours	Within 48 hours	After 48 hours	Within 48 hours	After 48 hours	Within 48 hours	After 48 hours	
Ankle	0.01 (0.08to0.22)	0.09* (0.04to0.22)	—	0.08 (0.02to0.39)	—	0.07 (0.01to0.44)	—	—	0.08 (0.03to0.20)
2x2 tables	n=1	n=12		n=5		n=4			n=13
Mid-foot	—	0.07* (0.03 to 0.21)	—	0.08 (0.01 to 0.77)	—	0.08 (0.003 to 1.74)	—	—	0.07 (0.03 to 0.21)
2x2 tables		n=9		n=4		n=3			n=9
Combined	—	0.21* (0.12 to 0.38)	—	0.26 (0.13 to 0.51)	—	0.29 (0.12 to 0.71)	—	0.42 (0.21 to 0.81)	0.21 (0.12 to 0.38)
2x2 tables		n=10		n=6		n=4		n=1	n=10
Children	0.08 (0.02 to 0.29)	0.06 (0.02 to 0.25)	0.10 (0.01 to 1.64)	—	0.10 (0.01 to 1.64)	—	—	—	0.07 (0.03 to 0.18)
2x2 tables	n=4	n=3	n=1		n=1				n=7

*Larger negative likelihood ratios in studies testing Ottawa ankle rules in mixed populations (ankle and mid-foot versus combined: P<0.001).

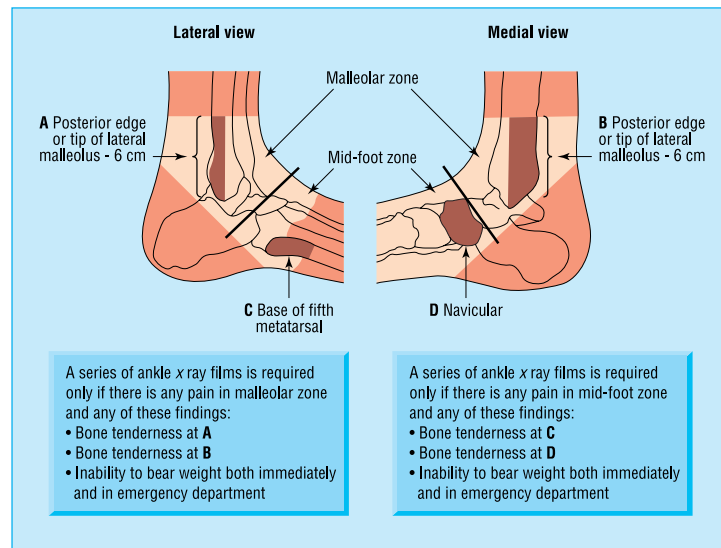


Fig 1 Ottawa ankle rules

Table 2 Pooled sensitivity (bootstrapped) and distribution of specificity in 27 studies (39 2x2 tables) of Ottawa ankle rules in diagnosis of ankle fractures. Values are percentages

Category	Sensitivity (95% CI)	Median specificity (interquartile range)
All studies (n=39)	97.6 (96.4 to 98.9)	31.5 (23.8-44.4)
Type of assessment:		
Ankle (n=15)	98.0 (96.3 to 99.3)	39.8 (27.9-47.7)
Foot (n=10)	99.0 (97.3 to 100)	37.8 (24.7-70.1)
Combined (n=14)	96.4 (93.8 to 98.6)	26.3 (19.4-34.3)
Population:		
Children (n=7)	99.3 (98.3 to 100)	26.7 (23.8-35.6)
Adults (n=32)	97.3 (95.7 to 98.6)	36.6 (22.3-46.1)
Prevalence of fracture:		
<25th centile (n=7)	99.0 (98.3 to 100)	47.9 (42.3-77.1)
25th-75th centile (n=22)	97.7 (95.9 to 99.0)	30.1 (23.8-40.1)
>75th centile (n=10)	96.7 (94.2 to 99.2)	27.3 (15.5-40.0)
Time to referral (hours):		
≤48 (n=5)	99.6 (98.2 to 100)	27.9 (24.7-31.5)
>48 (n=34)	97.3 (95.9 to 98.5)	36.6 (19.9-46.8)

Results

We identified 1085 studies. Thirty two studies investigated the accuracy of the Ottawa ankle rules: 16 assessed the ankle, 11 assessed the mid-foot, and 10 investigated global accuracy, which included a combi-

nation of both assessments (see bmj.com). The Ottawa ankle rules was developed to assist decision making in adults, but six reports reported on the accuracy of the instrument in children.

Pooled analyses

Overall, 27 studies were available for the pooled analysis: 12 on assessment of the ankle (13 2x2 tables), eight on assessment of the mid-foot (nine 2x2 tables), 10 on assessment of both the ankle and the mid-foot (10 2x2 tables), and six on assessment of the ankle or mid-foot in children (seven 2x2 tables).

Among these 27 studies describing 15 581 patients, 47 (0.3%) had a false negative result. The study characteristics stratified by ankle, mid-foot, or combined assessment are detailed on bmj.com.

Sensitivity and specificity

Table 2 shows the pooled sensitivities and the distribution of specificities stratified by several characteristics. Sensitivities were consistently high but ranged from 99.6% in studies on application of the rules within 48 hours of injury to 96.4% in studies of combined assessment. The specificities ranged from 47.9% in studies with a prevalence of fracture below the 25th centile of all studies to 26.3% in studies of combined assessment.

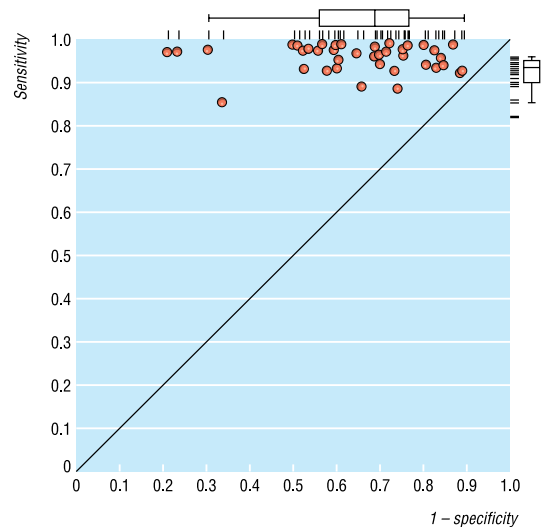


Fig 2 Receiver operating characteristics plot of all included studies (39 2x2 tables)

Negative likelihood ratio

Table 3 shows pooled negative likelihood ratios for clinical subgroups and probabilities of fracture after a negative result, assuming a 15% prevalence of fracture. The post-test probability of fracture was lowest in those studies with prevalences below the 25th centile of all studies (0.7%, 0.35% to 1.90%) and highest in those studies with prevalences above the 75th centile of all studies (3.74%, 1.73% to 8.26%). As the pretest probability of fracture increases, the pooled negative likelihood ratio gets worse. In studies assessing the Ottawa ankle rules in children, the probability of fracture after a negative result was 1.22% (0.53% to 3.08%). A worse negative likelihood ratio was found in the studies that assessed both the ankle and the mid-foot. The features of ideal study design, such as consecutive entry and applying a radiography reference standard in all patients, were associated with slightly worse likelihood ratios. Meta-regression analyses did not show these differences to be significant.

Discussion

Less than 2% of patients in most subgroups who were negative for fracture of the ankle or mid-foot according to the Ottawa ankle rules actually had a fracture. Since the Ottawa ankle rules is an instrument that is calibrated towards high sensitivity, we were particularly interested in the pooled sensitivity and the pooled likelihood ratio of a negative result. Specificity, however, is an indicator of the number of unnecessary radiographs that may be avoided with this decision rule. The variability in the specificities, which ranged from 10% to 79%, is surprising.^{15 16} The subtlety of palpation technique might explain some of the large variation in false positive rates—the percentages of patients who apparently indicated pain (or were unable to walk four steps) but had no fracture.

The Ottawa ankle rules was developed to avoid unnecessary radiography. One study found that although clinicians widely recognised the test as a decision tool, its use and the change of clinical behaviour was limited.¹⁷ Clinicians aim to minimise the number of missed fractures and would therefore maximise sensitivity at all costs. Immediate access to radiography may further trigger requests for radiographs. So far the usefulness of the Ottawa ankle rules as a decision tool in the primary care setting has not been assessed. Dissemination among general practitioners and people supervising sport activities may therefore be pertinent.

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Table 3 Pooled likelihood ratios (random effects) for negative result using Ottawa ankle rules in 27 studies (39 2x2 tables) on accuracy of the instrument in diagnosing ankle fractures. Probabilities of fracture after negative testing are calculated assuming 15% prevalence of fracture

Category	Negative likelihood ratio (95% CI)	P value for heterogeneity	Fracture probability (%) (95% CI)
All (n=39)	0.10 (0.06 to 0.16)	<0.001	1.73 (1.05 to 2.75)
Ankle assessment (n=15)*	0.08 (0.03 to 0.18)	<0.001	1.39 (0.53 to 3.08)
Foot assessment (n=10)†	0.08 (0.03 to 0.20)	0.14	1.39 (0.53 to 3.41)
Combined assessment (n=14)‡	0.17 (0.10 to 0.30)	0.04	2.91 (1.73 to 5.03)
Children (n=7)	0.07 (0.03 to 0.18)	0.9	1.22 (0.53 to 3.08)
Adults (n=32)	0.11 (0.06 to 0.18)	<0.001	1.90 (1.05 to 3.08)
Fracture prevalence§:			
Lower fourth (n=7)	0.04 (0.02 to 0.11)	0.97	0.70 (0.35 to 1.90)
Middle fourths (n=22)	0.09 (0.05 to 0.16)	0.001	1.56 (0.87 to 2.75)
Upper fourth (n=10)	0.22 (0.10 to 0.51)	0.007	3.74 (1.73 to 8.26)
Ottawa ankle rules applied ≤48 h (n=5)	0.06 (0.02 to 0.19)	0.65	1.05 (0.35 to 3.24)
Ottawa ankle rules applied >48 hrs (n=34)	0.11 (0.07 to 0.18)	<0.001	1.90 (1.22 to 3.08)

*Two reports on children.

†One report on children.

‡Four reports on children.

§Median prevalences 7.9% in lower fourth, 12.7% in middle fourth, and 20.6% in upper fourth.

What is already known on this topic

Although most patients with ankle sprains who present to emergency departments undergo radiography, less than 15% have a fracture

The Ottawa ankle rules is a clinical decision aid designed to avoid unnecessary radiography

What this paper adds

The Ottawa ankle rules is highly accurate at excluding ankle fractures after sprain injury

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