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.

When almost every patient entering the emergency department with an ankle sprain undergoes radiography, even modest values for specificity may imply large reductions in the number of radiographs needed. The instrument is therefore calibrated towards high sensitivity, at the expense of specificity to some extent. We conducted a systematic review on the accuracy of the Ottawa ankle rules.

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).

We searched Medline and Premedline (Ovid version; 1990 to present), Embase (Datastar version; 1990-2002), CINAHL (Winspirs version; 1990-2002), and the Cochrane Library (2002, issue 2). We explored the Science Citation Index database (Web of Science by Institute for Scientific Information), entering reference 7 of this paper. The search had no language restrictions.

We selected studies in a two stage process. Firstly, all abstracts or titles found by the electronic searches were independently scrutinised by JS and LMB. If a paper's eligibility was disputed, the paper was obtained and scrutinised. Next, we obtained copies of eligible papers. We used a checklist to assess that criteria for inclusion had been met. Minimal requirements for inclusion were assessment of the Ottawa ankle rules and the possibility of constructing at least a 2×2 table specifying the false positive rate and the false negative rate. Disagreements on eligibility of studies were resolved by consensus.

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.

Editorial by Heyworth

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bmj.com 2003;326:417

Examples of the search strategy and details of the included studies 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

	Prospective data collection		Plus consecutive enrolment		Plus blinding		Plus radiography as reference standard in all patients		
Stratum	**Within 48 hours**	**After 48 hours**	**Within 48 hours**	**After 48 hours**	**Within 48 hours**	**After 48 hours**	**Within 48 hours**	**After 48 hours**	**All studies**
Ankle	0.01 (0.08 to 0.22)	0.09* (0.04 to 0.22)	—	0.08 (0.02 to 0.39)	—	0.07 (0.01 to 0.44)	—	—	0.08 (0.03 to 0.20)
2×2 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)
2×2 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)
2×2 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)
2×2 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).

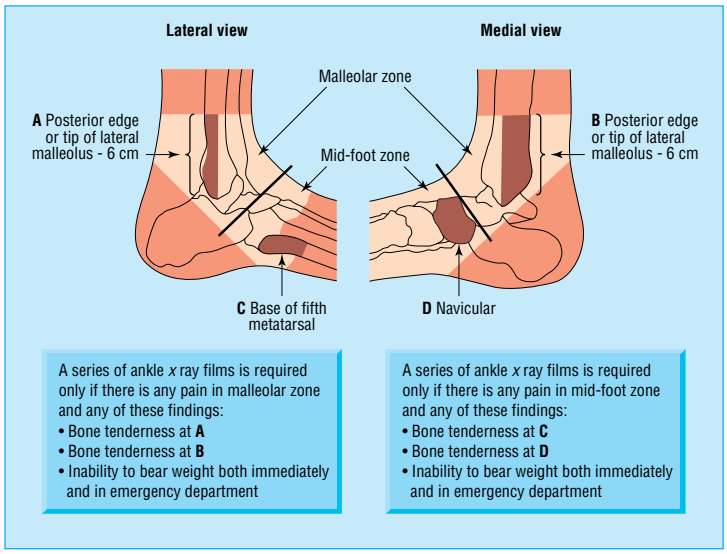

Fig 1 Ottawa ankle rules

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 (using the bootstrap) and in the pooled likelihood ratio of a negative result (using a random effects model)—that is, how many times more likely it is to find a negative result among people with a fracture (1 – sensitivity) than among those without (specificity). To investigate sources of variation in the negative likelihood ratios, we looked at this variable in analyses stratified by variables related to clinical subgroups and study design. We calculated the Spearman rank correlation to assess variation in diagnostic threshold. We tested heterogeneity of sensitivities and specificities using χ^2 tests, but the interpretation was hampered by small numbers of false negative results.[15] After inspection of the receiver operating characteristics plot we decided to pool sensitivities, but not specificities (fig 2). We analysed the data with Stata 7.0.

Results

We identified 1085 studies from the electronic search, and we obtained full papers for 116. The reference lists of these studies revealed 15 additional articles. Overall, we analysed 32 studies meeting our inclusion criteria.[7 16–46] Contact with the first authors of these studies yielded no additional data.

Overall, 32 studies investigated the accuracy of the Ottawa ankle rules: 16 assessed the ankle,[7 16 18 26 28 30 31 33 34 37 39–43 46] 11 assessed the mid-foot,[7 16 18 28 30 33 40–43 46] and 10 investigated global accuracy, which included a combination of both assessments.[17 21–23 25 27 35 38 44 45]

The Ottawa ankle rules was developed to assist decision making in adults, but six studies reported on the accuracy of the instrument in children.[19 20 24 29 32 36] Several studies selectively included patients admitted to the hospital within 48 hours of a sprain instead of within one week.[21 24 31 36]

Pooled analyses

We excluded from the pooled estimates studies that collected data non-prospectively in addition to unknown blinding of the radiologist[17 37] and one abstract.[40] If studies compared the performance of dif-

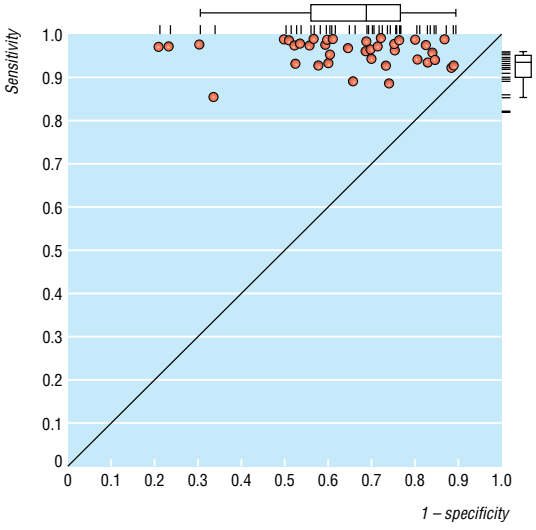

Fig 2 Receiver operating characteristics plot of all included studies (39 2×2 tables)

ferent specialties using the rules, we analysed only the data on doctors' judgments.[31 35] We also excluded from the pooled analysis data on modifications of the rules.[27 28 41 44]

Overall, 27 studies were available for the pooled analysis: 12 on assessment of the ankle (13 2×2 tables),[7 16 18 26 30 31 33 34 39 42 43 46] eight on assessment of the mid-foot (nine 2×2 tables),[7 16 18 30 33 42 43 46] 10 on assessment of both the ankle and the mid-foot (10 2×2 tables),[21–23 25 27 32 38 44 45] and six on assessment of the ankle or mid-foot in children (seven 2×2 tables).[19 20 24 29 32 36]

Among these 27 studies describing 15 581 patients, 47 patients (0.3%) had a false negative result. Table 2

Table 2 Description of 27 studies on diagnostic accuracy of Ottawa ankle rules (OARs). See appendix for description of all 32 studies

Study	No of patients	Specification	Prospective data collection	Exclusion of patients <18 years	Mean age	Consecutive enrolment	Blinding of radiologist	Radiography in all patients
Ankle assessment								
Aginaga et al 1999[16]	463	Doctors applied OARs in adults in regional hospital in Spain	Yes	Yes	37.1	Not reported	Yes	No
Auleley et al 1998[18]	130	Compared radiography request rates between senior house officers and nurse practitioners using OARs in adults in university hospital in France	Yes	Yes	34	Yes	Yes	No
Kerr et al 1994[26]	350	OARs applied in convenience (not otherwise specified; easy to approach) sample of adults in four hospitals (two university, one community, and one provincial) in New Zealand. Mid-foot injuries not assessed	Yes	Not reported	Not reported	No	Not reported	No
Lucchesi et al 1995[30]	422	OARs in convenience sample of adults in suburban community teaching trauma centre in United States	Yes	Yes	35	Yes	Yes	No
Mann et al 1998[31]	700	Compared radiography request rates between senior house officers and nurse practitioners applying OARs in patients enrolled within 48 hours after injury to large accident and emergency department in United Kingdom. No mid-foot assessment	Yes	No	Not reported	Not reported	Not reported	Yes
Papacostas et al 2001[33]	79	OARs in athletes and people engaged in sport at least three times a week, injured during sports activities attending district general hospital and sports injuries clinic in Greece	Yes	Yes	29	Not reported	Yes	Yes
Perry et al 1999[34]	577	OARs assessed in urban teaching hospital in United Kingdom. No mid-foot assessment	Yes	Yes	Not reported	No	Yes	Yes
Singh-Ranger and Marathias 1999[39]	18	Compared conventional ordering of radiography to use of OARs in district general hospital in United Kingdom. No mid-foot assessment reported	Yes	No	Not reported	Yes	Not reported	Yes
Stiell et al 1992[7]	689	Development of OARs in two university hospital emergency departments in Canada	Yes	Yes	35.1	Not reported	Yes	No
Stiell et al 1993[42]	1032	OARs applied in adults attending one of two university hospital emergency departments in Canada. Refinement of 1992 rules	Yes	Yes	35	Not reported	Yes	No
Stiell et al 1993[42]	453	OARs applied in adults attending one of two university hospital emergency departments in Canada. Validation of refined rules	Yes	Yes	36	Not reported	Yes	No
Stiell et al 1994[43]	565	Implementation study of OARs using refined 1993 OARs. OARs applied on adults attending university hospital in Canada	Yes	Yes	36	Yes	Yes	No
Yuen et al 2001[46]	467	OARs applied in Chinese population of district hospital of Hong Kong	Yes	No	37	Yes	Yes	Yes
Foot assessment								
Aginaga et al 1999[16]	197	Doctors applied OARs on adults in regional hospital in Spain	Yes	Yes	37.1	Not reported	Yes	No
Auleley et al 1998[18]	130	Compared radiography request rates between senior house officers and nurse practitioners using OARs	Yes	Yes	34	Yes	0	No
Lucchesi et al 1995[30]	150	OARs applied on convenience sample of adults of suburban community teaching trauma centre in United States	Yes	Yes	35	Yes	Yes	No
Papacostas et al 2001[33]	43	OARs in athletes and people engaged in sport at least three times a week, injured during sports activities attending district general hospital and sports injuries clinic in Greece	Yes	Yes	29	Not reported	Yes	Yes

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Table 2 Description of 27 studies on diagnostic accuracy of Ottawa ankle rules (OARs). See appendix for description of all 32 studies—*continued from previous page*

Study	No of patients	Specification	Prospective data collection	Exclusion of patients <18 years	Mean age	Consecutive enrolment	Blinding of radiologist	Radiography in all patients
Stiell et al 1992[7]	689	Development of OARs in two university hospital emergency departments in Canada	Yes	Yes	35.1	Not reported	Yes	No
Stiell et al 1993[42]	1032	OARs applied in adults attending one of two university hospital emergency departments in Canada. Refinement of 1992 rules	Yes	Yes	35	Not reported	Yes	No
Stiell et al 1993[42]	453	OARs applied in adults attending one of two university hospital emergency departments in Canada. Validation of refined rules	Yes	Yes	36	Not reported	Yes	No
Stiell et al 1994[43]	565	Implementation study of OARs using refined 1993 OARs. OARs applied on adults attending university hospital in Canada	Yes	Yes	36	Yes	Yes	No
Yuen et al 2001[46]	467	OARs applied in Chinese population of district hospital in Hong Kong	Yes	No	37	Yes	Yes	Yes
Combined assessment								
Chandra and Schafmayer 2001[21]	397	OARs applied in adults attending city hospital in Germany	Yes	Yes	Not reported	No	Not reported	Yes
Garces et al 2001[22]	494	OARs in two community hospitals in Spain	Yes	Yes	35.6	Not reported	Not reported	Yes
Glas et al 2002[23]	647	Compared OARs and Leiden ankle rule assessed in adults of mid-sized teaching hospital in Netherlands.	Yes	Yes	35	Yes	Yes	Yes
Keogh et al 1998[25]	262	Compared current local guidelines with OARs in patients >16 years attending teaching hospital in United Kingdom	Yes	No	32	Yes	Yes	No
Leddy et al 1998[27]	78	OARs applied in patients >12 years, attending university based community sports medical centre in the United States	Yes	No	23.4	Yes	Yes	No
McBride 1997[32]	259	OARs applied in adults attending common practice with family doctors in community hospital in Canada	Yes	No	30.9	No	Not reported	Yes
Pigman et al 1994[35]	71	OARs used by attending doctors and triage nurses at community and university hospital in United States	Yes	No	35	Yes	Yes	No
Salt and Clancy 1997[38]	324	OARs used by triage nurses at university hospital in United Kingdom. Radiography performed on discretion of treating doctor	Yes	Yes	Not reported	Yes	Not reported	No
Tay et al 1999[44]	488	OARs in Asian population (Chinese, Malay, and Indian) attending large teaching hospital in Singapore	Yes	No	Not reported	Yes	No	Yes
Verma et al 1996[45]	911	OARs applied in adults attending level 1 trauma centre in Cincinnati, United States	Yes	Yes	Not reported	Not reported	No	No
Children								
Boutis et al 2001[19]	607	Clinical examination compared with OARs to identify high risk diagnoses in children attending one of two urban, university affiliated paediatric emergency departments in Canada	Yes	No	12.5	No	Yes	Yes
Chande 1995[20]	68	OAR applied in children enrolled within 48 hours after injury at University Hospital of Cleveland, United States	Yes	No	12	Yes	Yes	No
Karpas et al 2002[24]	186	Paediatric emergency department nurses applying OARs within 48 hours after injury in children attending tertiary care facility in United States	Yes	No	13	No	Yes	Yes
Libetta et al 1999[29]	761	OARs applied in children >1 year old, attending large teaching hospital in United Kingdom	Yes	No	11	Not reported	Not reported	No
McBride 1997[32]	37	OARs applied in children attending common practice with family doctors in community hospital in Canada	Yes	No	13.2	No	Not reported	Yes
Plint et al 1999[36]	559	OARs applied in children attending one of two specialist tertiary care units in Canada within 48 hours after injury. Ankle assessment	Yes	No	12.6	Not reported	Yes	Yes
Plint et al 1999[36]	205	OARs applied in children attending one of two specialist tertiary care units in Canada within 48 hours after injury. Foot assessment	Yes	No	12.6	Not reported	Yes	Yes

shows the studies' characteristics stratified by ankle, mid-foot, or combined assessment.

Sensitivity and specificity

Table 3 shows the pooled sensitivities and the distribution of specificities stratified by several characteristics. Sensitivities were consistently high but ranged from 99.6% (95% confidence interval 98.2% to 100.0%) in studies on application of the rules within 48 hours of injury to 96.4% (93.8% to 98.6%) in studies of combined assessment. The specificities ranged from 47.9% (interquartile range 42.3%-77.1%) in studies with a prevalence of fracture below the 25th centile of all studies to 26.3% (19.4%-34.3%) in studies of combined assessment.

Negative likelihood ratio

Table 4 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.

Table 5 shows the likelihood ratios for three criteria believed to affect the accuracy of diagnosis. 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.

Table 1 shows pooled negative likelihood ratios stratified for delay of patients being assessed (within or after 48 hours) and according to the quality items prospective data collection, enrolment of consecutive patients, blinding of assessor of radiographs, and definite diagnosis with radiography in all patients. Data on the use of the Ottawa ankle rules within 48 hours in adults are scarce. In children, the pooled negative likelihood ratio was 0.07, which seems low enough to be useful, although the evidence is sparse and the confidence interval correspondingly wide. The pooled likelihood ratios for assessment of the ankle and mid-foot are similar irrespective of methodological quality. Nevertheless, the estimates further towards the right side of the table are more likely to be valid.

Table 3 Pooled sensitivity (bootstrapped) and distribution of specificity in 27 studies (39 2×2 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)

Table 4 Pooled likelihood ratios (random effects) for negative result using Ottawa ankle rules in 27 studies (39 2×2 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 h (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 prevalence 7.9% in lower quartile, 12.7% in middle quartile, and 20.6% in upper quartile.

Table 5 Methodological criteria that could affect accuracy of diagnosis of ankle or mid-foot fracture. All studies were prospective

Criterion	Negative likelihood ratio (95% CI)	P value for heterogeneity	Fracture probability (%) (95% CI)
Type of entry to study:			
Consecutive (n=16)	0.13 (0.06 to 0.26)	0.001	2.24 (1.05 to 4.39)
Arbitrary or unknown (n=23)	0.09 (0.05 to 0.16)*	0.85	1.56 (0.87 to 2.75)
Gold standard applied:			
All patients (n=17)	0.16 (0.09 to 0.26)	0.001	2.75 (1.56 to 4.39)
Not all patients (n=22)	0.08 (0.04 to 0.15)†	0.03	1.39 (0.70 to 2.58)
Blinding of radiologist:			
Yes (n=27)	0.08 (0.05 to 0.15)	<0.001	1.39 (0.87 to 2.58)
No or unknown (n=12)	0.15 (0.07 to 0.31)‡	0.002	2.58 (1.22 to 5.19)

*Consecutive *v* arbitrary or unknown, P=0.49 (meta-regression analysis testing).
†All patients *v* not all patients, P<0.001 (metal-regression analysis testing).
‡Yes *v* no or unknown, P=0.29 (meta-regression analysis testing).

Discussion

We summarised the accuracy of the Ottawa ankle rules for excluding fractures of the ankle and mid-foot in patients presenting to emergency departments with an acute ankle sprain. Less than 2% of patients in most subgroups who were negative for fracture according to the Ottawa ankle rules actually had a fracture.

As 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.[35 42]

We hypothesise that differences in clinical skills, interpretation of the test, and experience of staff

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

performing the test influenced the accuracy of the Ottawa ankle rules. Only a few studies reported particulars of staff performing the test, stating, for instance, the number of years worked at a trauma emergency department. In addition, the expression of pain, which is crucial for the interpretation of the test, may have a cultural dimension. This could result in a higher false positive rate among patients with a relatively vivid expression of pain or a higher false negative rate among stoical individuals, unless the clinician shares the patient's cultural background. 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. The economic aspect of the test may be more complex. An obvious requirement of saving costs by means of the test is its application in clinical practice. A study on techniques for dissemination investigated the impact on requests for radiography of the ankle and foot in clinical practice after use of the instrument.[47] The study found that although clinicians widely recognised the test as a decision tool, its use and the change of clinical behaviour was limited. Clinicians aim to minimise the number of missed fractures and would therefore maximise sensitivity at all costs. Fear of a bad professional reputation or litigation might be an explanation. In contrast, a health insurer would be interested in the optimal balance between sensitivity and specificity of the instrument. Therefore, the practical question from the health authorities' point of view is, how should the instrument behave in order that clinicians will use it? Suppose, for example, that a sensitivity of 92% with a specificity of 85% maximised cost effectiveness. Suppose also that clinicians simply refuse to use the instrument at such a low sensitivity. In that case, it may be more useful to design the instrument such that, for example, 90% of clinicians will use it. To do this calculation would require knowing the distribution of the minimal sensitivities that the relevant clinicians are prepared to work with. Then the optimal cut-off point for sensitivity at which just enough clinicians would actually use it to make the test cost effective could be calculated.

Immediate access to radiography may further trigger requests for radiographs. So far the usefulness of the Ottawa ankle rules as a decision tool in primary care has not been assessed. Dissemination among general practitioners and people supervising sports activities may therefore be pertinent.

We thank Pius Estermann (information specialist, University Hospital Zurich) for doing the literature searches and Afina Glas and Patrick Bossuyt (department of clinical epidemiology and biostatistics, University of Amsterdam) for commenting on an earlier draft.

Contributors: LMB and JS initiated the project. LMB, MTK, EK, and JS screened and extracted the data. LMB and MTK cross checked the extracted data. LMB and GtR analysed the data. All authors participated in discussing the results and in writing the paper. LMB will act as guarantor for the paper.

Funding: None.

Competing interests: None declared.

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(Accepted 2 December 2002)