

Prospective Evaluation of the Ottawa Ankle Rules in a University Sports Medicine Center

With a Modification to Increase Specificity for Identifying Malleolar Fractures

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ABSTRACT

In a sports medicine center, we prospectively evaluated the Ottawa Ankle Rules over 1 year for their ability to identify clinically significant ankle and midfoot fractures and to reduce the need for radiography. We also developed a modification to improve specificity for malleolar fracture identification. Patients with acute ankle injuries (≤ 10 days old) had the rules applied and then had radiographs taken. Sensitivity, specificity, and the potential reduction in the use of radiography were calculated for the Ottawa Ankle Rules in 132 patients and for the new "Buffalo" rule in 78 of these patients. There were 11 clinically significant fractures (fracture rate, 8.3% per year). In these 132 patients, the Ottawa Ankle Rules would have reduced the need for radiography by 34%, without any fractures being missed (sensitivity 100%, specificity 37%). In 78 patients, the specificity for malleolar fracture for the new rule was significantly greater than that of the Ottawa Ankle Rules malleolar rule (59% versus 42%), sensitivity remained 100%, and the potential reduction in the need for radiography (54%) was significantly greater. The Ottawa Ankle Rules could significantly reduce the need for radiography in patients with acute ankle and midfoot injuries in this setting without missing clinically significant fractures. The Buffalo modification could im-

prove specificity for malleolar fractures without sacrificing sensitivity and could significantly reduce the need for radiography.

With the advent of managed health care and the impetus to measure clinical outcomes, "clinical practice guidelines" or "clinical decision rules" have been developed for a variety of medical problems.^{14,22} Stiell et al.¹⁸ have developed easy-to-use clinical decision rules called the Ottawa Ankle Rules (OAR) for the use of radiography for acute ankle injuries in the emergency department. The OAR have been prospectively applied in university and community hospital emergency department settings.^{12,13,15,20,21} In all but one of these studies,¹² the rules have significantly reduced the need for ankle and foot radiographs (by 19% to 29%) without missing any clinically significant (i.e., nonavulsion) fractures. The OAR were designed to minimize false-negative results. They are highly sensitive and appear to be superior to even experienced emergency department physicians' clinical suspicion for ankle fracture.^{13,19} In addition, the OAR significantly reduce emergency department waiting time and costs.^{1,15,20} It would thus be useful to test these decision rules in clinical sites other than the emergency department to evaluate their general applicability.

The one trial in which the OAR were not effective may have been limited by methodologic problems.¹² The evaluating physicians apparently were not provided with the complete set of final rules, nor were they given an accurate pictorial representation of them. Both of these criteria appear to be crucial to the effectiveness of the rules.¹⁷ To

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be effective, it is important that the rules be used exactly as they were in the original studies. For example, physicians must palpate the entire distal 6 cm of the fibula because some fractures will exit 5 or 6 cm proximal to its tip.²¹ Thus, properly taught and implemented, the OAR appear to satisfy the criteria for a valid clinical decision rule: They are a simple way to tell physicians when to initiate or when to avoid a medical intervention (radiography) within a specified medical context (the acutely injured ankle in the emergency department).

Given the high sensitivity of the OAR for ankle and midfoot fractures (93%¹³ to 100%¹⁸), it is not surprising that some emergency department studies have found very low specificity for this practice guideline (10%¹⁵ to 20%¹³). Expectations are high for intervention in the emergency department, and it is important to ensure that no clinically significant fractures are missed because patient contact is brief and followup can be unpredictable. The result is that approximately five of every six radiographs "approved" by the OAR in the emergency department are negative.¹⁸ While this may be acceptable and even necessary in the emergency department, where the rate of ankle and foot fractures can be 20% or greater,^{12,13,18} it may be less acceptable in settings where the fracture rate is appreciably lower. Fracture rates are lower in family practice offices¹⁶ (8.5%) and outpatient sports medicine centers⁸ (2.4%). Different fracture rates likely reflect an effect of study setting, i.e., injuries perceived to be more severe by patients are probably more often seen in the emergency department.¹⁶ If so, it may then be possible to modify or add to the OAR to formulate a clinical decision rule for the nonemergent outpatient setting that maintained high sensitivity (to detect all significant fractures) but with improved specificity to potentially reduce radiography use even more than in the emergency department setting.

We performed a prospective evaluation of the potential of the OAR to reduce the use of radiography for acute ankle and midfoot injuries in a university-based community sports medicine center. We also present an addition to the OAR that, in this setting, improves specificity yet maintains excellent sensitivity for clinically significant fractures. This addition has the potential to reduce the use of radiography beyond that demonstrated in emergency department studies.

MATERIALS AND METHODS

The State University of New York (SUNY) at Buffalo Sports Medicine Institute is an outpatient facility located on the SUNY Buffalo campus that is staffed by fellowship-trained primary care and orthopaedic sports medicine physicians, physical therapists, and athletic trainers. Radiography and physical therapy are available on-site and the Institute provides comprehensive sports medicine care to Division I athletic teams, students, and the general community. It is a general sports medicine center treating the whole spectrum of athletic injuries in patients of all ages and abilities. The Institute does not have a foot and ankle specialty clinic to which the study participants were referred. Rather, most of the patients were evaluated by

the primary care physicians during the evening walk-in clinic, where patients may seek urgent care without an appointment.

The study included all persons (pediatric and adult) seen at the Institute between July 1, 1994, and July 1, 1995, with acute ankle or midfoot injuries (≤ 10 days old) who agreed to participate and who satisfied the inclusion criteria. Patients with ankle or midfoot pain due to any injury mechanism were eligible for inclusion. Exclusion criteria (per the studies of Stiell et al.¹⁸⁻²¹) included pregnancy, isolated skin injury, injury more than 10 days old, second evaluation for the same injury, an obviously deformed ankle or foot, or altered sensorium.²⁰ Approval for this study was obtained by the University at Buffalo Institutional Review Board on Human Experimentation and patients or their guardians signed informed consent forms.

A standard form was attached to each patient's chart during registration. On it were recorded epidemiologic data and the history questions, physical examination signs, and pictorial representation of the OAR²⁰ (Fig. 1). All patients were prospectively evaluated by one of the five authors, who included two fellowship-trained primary care sports medicine physicians (an internist and a family physician), a fellowship-trained sports medicine orthopaedic surgeon, and two primary care sports medicine fellows-in-training (a rehabilitation medicine and a family physician). Physicians were instructed in application of the OAR and in completing the forms.

Examinations were performed and all forms were completed before radiographs were taken. The ankle region was subdivided into malleolar and midfoot zones (Fig. 1). The decision rules were considered positive if tenderness was present at either the malleolar (A or B) or the midfoot (C or D) locations or if the patient could not bear weight both immediately after the injury and in the clinic.¹⁸ Weightbearing is defined as the ability to transfer weight twice onto each leg (a total of four steps), regardless of limping or some discomfort. Patients are encouraged to try to bear weight after the physician assesses bone tenderness and are never coerced. Most patients are willing to try and are surprised by their success. The rules were considered negative if there was no bony tenderness and the patient could ambulate either immediately after the injury or in the clinic. Physicians completed the forms, made their predictions according to the rules, and recorded their predictions. Radiographs were then obtained in all cases.

Physicians made treatment decisions after reading their own films. All radiographs were subsequently read by a radiologist who was blinded to the results of the rules.

A clinically significant fracture was defined as a bone fragment more than 3 mm in breadth¹⁸ or any other nonavulsion fracture requiring cast immobilization. Avulsion fractures 3 mm or less in breadth were considered not significant because they were treated no differently than severe sprains, that is, with an aggressive "RICE" regimen (rest, ice, compression, and elevation), functional splinting with an Aircast brace (Aircast, Summit, New Jersey) or

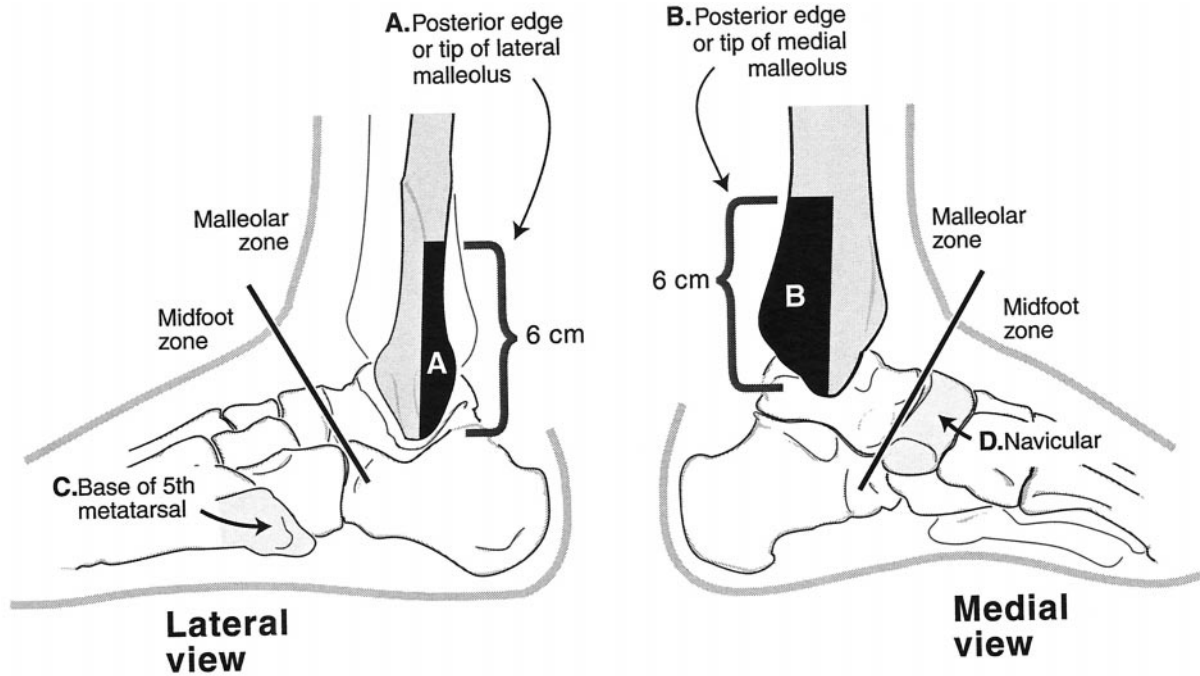


Figure 1. The Ottawa Ankle Rules are positive, and radiography is indicated, if there is bone tenderness at A or B (ankle series) or C or D (foot series) or if there is inability to bear weight both immediately after injury and during examination (four steps, regardless of limping). The malleolar tenderness rule involves palpation along the posterior borders of the malleoli. (Adapted from Stiell et al.¹⁹)

lace-up brace, early ambulation, and rehabilitation exercises.

Patients were usually followed up by their physician, but some had followup with Institute physical therapists or athletic trainers. At the end of each month during the

study, the senior author (JJL) reviewed all charts for completeness of forms, correct interpretation of the rules, correlation of radiographic interpretation between treating physician and the radiologist, and patient followup. Those patients who had not had at least one follow-up visit

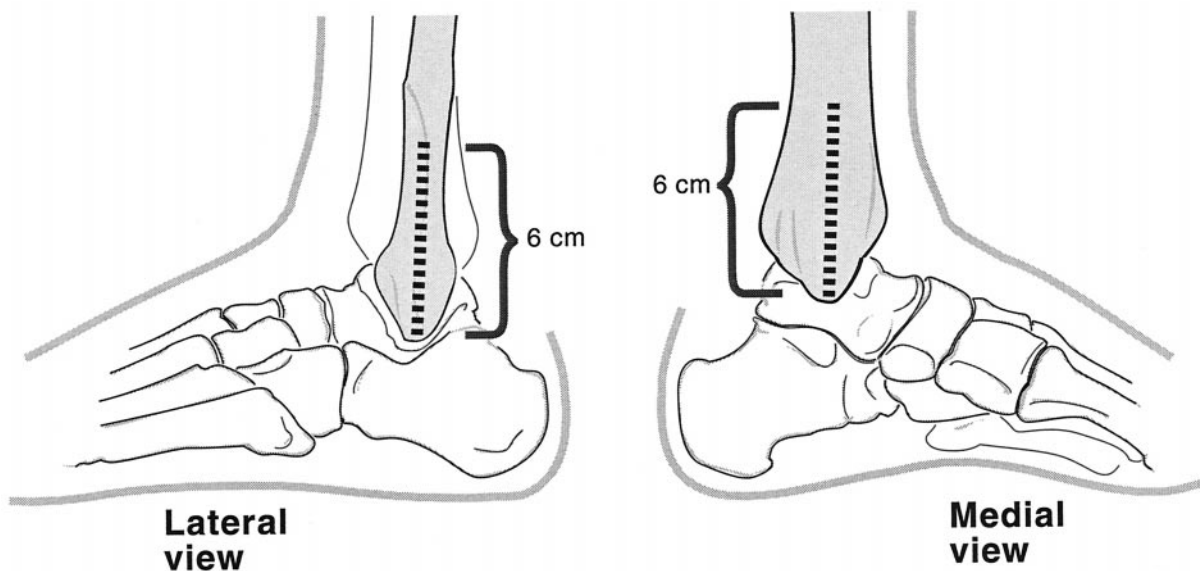


Figure 2. The Buffalo modification for malleolar tenderness moves the area of palpation to over the crests or midportions of the malleoli, away from the ligamentous attachments. The remainder of the OAR are otherwise the same.

were contacted by phone. To gauge consistency in application and interpretation of the rules, the senior author blindly evaluated the performance of the two fellows in 72 of 132 patients for the OAR and in 50 of 78 patients for the new rule. The percentage of patients correctly identified as rule-positive or rule-negative was calculated for each physician.

At the end of the 3rd month of the study, we observed that the majority of the films that would have been “approved” by the OAR for evaluation of malleolar zone pain were negative for fracture. We therefore modified the protocol (but not the OAR) by adding to the physical examination and to the data form tenderness over the midportion or crest of the bone from the tip of each malleolus to 6 cm proximal (Fig. 2). Theoretically, this examination preserves the ability to identify tenderness due to a fracture (which goes through the middle of the bones) while minimizing palpable tenderness at the ligamentous attachments to the posterior edges of the malleoli.⁴ This new rule was then prospectively evaluated for its ability to predict malleolar zone fractures and for its potential effect on the use of radiography separately from the OAR malleolar zone tenderness rule (which is palpation along the posterior border of the malleolus and its inferior tip). All physicians were instructed in the new examination technique and a single line was added to the data form.

Cost savings were calculated based on a charge of \$37.60 for ankle radiography and \$38.15 for foot radiography (professional, technical, and film costs).

Statistical Analysis

For the 132 patients, 2 by 2 contingency tables were created to calculate sensitivity and specificity (with 95% confidence intervals) for fracture identification for the OAR. Potential reduction in the use of radiography was also calculated. For the 78 patients with malleolar zone pain (isolated or in combination with midfoot pain) who were examined after introduction of the new rule, contingency tables were created to calculate sensitivity and specificity for both the OAR and the new rule separately and for the OAR in combination with the new rule. McNemar’s test for correlated proportions (SPSS for Windows, release 6.1.2; SPSS, Inc., Chicago, Illinois) was used to compare the specificity of the new rule with that of the OAR malleolar tenderness rule in the 78 patients. Potential reductions in the use of radiography for both rules were also calculated.

We estimated that 10 patients per month would be enrolled in the study. The estimated sample size of 120 patients in 1 year was sufficient to assure that a 95% confidence interval on the specificity of the OAR would have a width of less than 30% for any fracture rate up to 20%. When the new rule was introduced for testing, we estimated that at least 60 more patients would have to be enrolled in the study. The power of the sample size for comparing the two rules using McNemar’s test depends only on the number of disagreements between the two rules. Such a test, at a significance level of 0.05, has the power of 80% for detecting an advantage when there is a

TABLE 1
Anatomic Distribution of Fractures in 132 Patients

Fracture	No. of patients
Proximal 5th metatarsal	4
Salter I distal fibular physis	1
Nondisplaced distal fibula	4
Large avulsion distal fibula	1
Displaced distal fibula	1
Total	11

probability of at least 60% that the disagreement will be in one direction, for all circumstances in which the number of disagreements in the sample is at least 15.

RESULTS

One hundred thirty-five pediatric and adult patients were enrolled during the study period. All forms were completed satisfactorily, and the physicians accurately interpreted the rules in 98% of the cases (in three cases the rules were incorrectly considered positive when the patient could not bear weight in the examination room, even though weightbearing was possible immediately after injury). The high compliance with data collection and the accurate interpretation of the rules are attributed to the ease of completing the data form and the training and motivation of the physicians to use the rules effectively. After chart review, three patients were excluded because their injuries did not meet the study criteria (in each case the injury had occurred more than 10 days before the examination). One hundred forty-four radiographic series were obtained in 132 patients (128 of the ankle, 16 of the midfoot). The age range of the 132 patients was 12 to 68 years, with a mean of 23.4 years, a median of 21 years, and a mode of 19 years. Thirty-three percent of the patients (N = 44) were female and 18% (N = 24) were children (≤17 years old). There were 15 black (11%) and 12 Asian (9%) patients. Fifty-six percent of cases (N = 74) involved the left ankle.

Four patients (one with a nondisplaced distal fibular fracture) were lost to followup because they moved out of state within 1 week to 1 month of the initial visit. All others were back to normal activities, except three patients who reinjured the same ankle within 3 weeks (all made a full recovery) and five patients with persistent symptoms for 5 to 9 months (all of whom eventually improved by the end of the study, except one patient who required arthroscopic debridement of an anterolateral im-

TABLE 2
Performance of the OAR for Identifying Fractures in 132 Patients with Acute Ankle and Midfoot Injuries^a

OAR	Fracture	No fracture	Totals
Positive	11	76	87
Negative	0	45	45
Totals	11	121	132

^a Sensitivity, 100% (72%, 100%); Specificity, 37% (29%, 46%). Values in parentheses are 95% confidence intervals.

TABLE 3
Comparison of OAR and New Buffalo Rule for Identifying Fractures in 78 Patients with Malleolar Pain^a

Rule	Fracture	No fracture	Totals
OAR			
Positive	7	41	48
Negative	0	30	30
Total	7	71	78
New rule			
Positive	7	29	36
Negative	0	42	42
Total	7	71	78

^a For OAR: sensitivity, 100% (59%, 100%); specificity, 42% (31%, 55%). For the new rule: sensitivity, 100% (59%, 100%); specificity, 59% (47%, 71%). Values in parentheses are 95% confidence intervals.

pingement lesion). All of these patients had follow-up radiographs within 2 days to several weeks after initial evaluation, and none was found to have a fracture.

There were 11 clinically significant fractures in 132 patients, for a fracture incidence of 8.3% per year. There were seven fractures in the malleolar zone and four in the midfoot zone (all at the base of the 5th metatarsal). Table 1 lists the anatomic details of the fractures.

For the OAR, the blinded review of the physical examination and rule interpretation of the fellows showed that Fellow 1 was correct in 96% (27 of 28) of cases when interpreting the rules as positive and in 100% (14 of 14) of cases when interpreting the rules as negative. Fellow 2 was correct in 90% (18 of 20) of positive cases and in 70% (7 of 10) of cases interpreted as negative. For the new Buffalo rule, Fellow 1 was correct in 92% (12 of 13) of positive cases and 100% (17 of 17) of negative cases. Fellow 2 was correct in 88% (7 of 8) of cases interpreted as positive and in 89% of (8 of 9) of cases interpreted as negative. In no instance was a clinically significant fracture present when the OAR or the Buffalo rule were interpreted as falsely negative. Thirteen patients (10%) were evaluated by the orthopaedic surgeon and 119 patients (90%) by the primary care physicians. The orthopaedic surgeon interpreted the rules correctly (i.e., whether a radiograph would have been indicated) in all 13 patients, but it was not possible to ascertain whether the examination was done properly because he was not directly supervised.

Table 2 shows the performance of the OAR in evaluating for the presence of fractures in all 132 patients. Use of the decision rules would have reduced the use of ankle and

TABLE 4
Comparison of the OAR and the New Buffalo Rule in 71 Patients with No Malleolar Fracture

New rule	OAR		Totals
	Positive	Negative	
Positive	24	5	29
Negative	17	25	42
Totals	41	30	71

TABLE 5
Sensitivity and Specificity for Malleolar Fracture in 78 Patients When Both Rules are Positive^a

Both rules positive	Malleolar fracture		Totals
	Yes	No	
Yes	7	24	31
No	0	47	47
Totals	7	71	78

^a Sensitivity, 100% (59%, 100%); Specificity, 66% (54%, 77%). Values in parentheses are 95% confidence intervals.

foot radiographs by 34% without any clinically significant fractures being missed.

Beginning with Case 43, the new rule for malleolar tenderness was included. After this point, 78 patients were seen with either isolated malleolar pain ($N = 74$) or malleolar pain in combination with midfoot pain ($N = 4$). Table 3 shows the data for this subgroup of patients and the comparison between the results using the original OAR and the results with the new Buffalo malleolar tenderness rule for predicting malleolar ankle fracture.

Of the 71 patients who had no malleolar fracture, there were 12 fewer false-positive results (29 versus 41) with the new rule, so the point estimate of specificity is higher (59% versus 42%). However, there is some overlap in the confidence intervals. To determine whether the specificity is significantly higher with the new rule, a 2 by 2 table for the 71 patients with no fracture is presented in Table 4. McNemar's test for correlated proportions indicates that the new rule has significantly greater specificity for fracture than the OAR malleolar tenderness rule ($P < 0.02$). Note that there were no fractures in the 17 cases where the OAR were positive and the new rule was negative.

The OAR would have led to radiographs for 48 of the 78 patients (62%), and the new rule would have led to radiographs for 36 of the 78 patients (46%). This is a 25% reduction in radiography for the new rule over the potential reduction using the OAR. If we add to Table 4 the seven fractures successfully identified by both rules and use McNemar's test, there is a statistically significant decline in radiography use for the new rule compared with that using the OAR ($P < 0.02$).

Table 5 shows that when both rules are positive for fracture, the point specificity for fracture increases to 66% and sensitivity is maintained at 100%. Table 6 shows that when either rule is positive (i.e., they do not agree), the

TABLE 6
Sensitivity and Specificity for Malleolar Fracture in 78 Patients When Either Rule is Positive^a

Either rule positive	Malleolar fracture		Totals
	Yes	No	
Yes	7	46	53
No	0	25	25
Totals	7	71	78

^a Sensitivity, 100% (59%, 100%); Specificity, 35% (24%, 46%). Values in parentheses are 95% confidence intervals.

point specificity decreases to 35% and sensitivity remains at 100%.

DISCUSSION

Ankle injuries are the most common reason for time loss in all of sports.⁸ Most ankle and foot injuries occur by an inversion mechanism⁶ and, although most are not fractures,⁸ radiographs are often routinely obtained to rule out a fracture.¹⁶ The restructuring of the health care delivery system in the United States has forced physicians to examine the appropriateness of many routine medical practices, and some diagnostic testing has been criticized for being excessive and unjustified.¹¹

Diagnostic tests are most useful when their results will alter treatment. A lower incidence of a clinical condition (e.g., a fracture) means that a diagnostic test (e.g., radiography) will have a lower yield if employed routinely. The diagnostic test in this setting may therefore be influenced by a clinical decision rule. Clinical decision rules can provide an objective, reproducible method to obtain the patient's pretest probability of disease or injury and can help make diagnostic tests more accurate.²² Ultimately, this could help clinicians cope with the uncertainties of clinical practice and improve the cost-effectiveness of their decision-making.

The only study to date that prospectively documented the ankle and foot fracture rate in patients seen at a private family practice office¹⁶ identified a significantly lower yearly rate (8.5%) compared with the median rate of similar fractures reported from some emergency departments (13% to 20% or greater).^{5, 13, 18, 20} Because patients with acute ankle injuries who are seen at nonemergency outpatient facilities have a lower pretest probability of disease (fracture), ankle radiography might be well suited to the predictions of clinical decision rules.

Clinical decision rules will improve the cost-effectiveness of medical care only if they are both easy to use and valid.¹⁴ Validity, the degree to which we can trust that guidelines will help physicians "decide" correctly, is best established in clinical trials. The OAR are straightforward; have been found easy to use^{13, 21}; and, in prospective emergency department trials of thousands of patients,^{20, 21} have been successful in saving resources without missing any clinically significant fractures. Cost-effectiveness analysis indicates that using the OAR in the emergency department would save a significant amount of money, even accounting for some misdiagnosis and potential litigation.¹ It is therefore reasonable to consider that these decision rules might have significant economic impact in the nonemergent outpatient setting, where fracture rates are lower (yet radiography use is very high) and close followup could minimize any adverse consequences of false-negative results from the guidelines.

Sports medicine practitioners are beginning to embrace the concept of evidence-based medicine,⁹ which advocates the application of research evidence and the insights of systematically recorded clinical experience to patient's problems. Useful clinical decision rules are one way to make the approach to sports medicine clinical practice more objective.

We found that the OAR would be particularly useful for the evaluation of acute ankle and midfoot injuries in our clinic, a university-based community sports medicine center with a walk-in clinic enabling rapid evaluation of urgent musculoskeletal problems. Because this was a validation study and not a controlled trial of the implementation of the OAR to measure actual changes in physician use of radiography and in patient care outcome, we can only predict what effect these decision rules would have had. Had they been employed during the academic year 1994 to 1995, radiography for the evaluation of acute ankle injury would have declined by at least a third without missing any clinically significant fractures and without any adverse effects on patient care. This would have saved our center more than \$2000 over the year and would have improved patient flow through our busy clinic. Multiplied by many similar clinics over several years, the savings would be substantial.

The limitations of this study deserve comment. First, a relatively small number of clinically significant fractures were identified (11 of 132 cases). There were some (nine) nonsignificant avulsion fractures, but these were treated no differently than soft tissue injuries. Nevertheless, our fracture rate of 8.3% is greater than that retrospectively reported in a similar sports medicine center setting (2.4%)⁸ and is almost identical to the fracture rate in a prospective study in a family practice office setting (8.5%).¹⁶ These rates are lower than those reported in emergency department studies and reflect, we believe, the nature of patients presenting to sports medicine centers and private offices. None of our patients had an obviously deformed joint because most were injured during sports and had not been involved in high-impact trauma (such as a car accident or high altitude fall).

Second, midfoot fractures other than those at the base of the 5th metatarsal were not identified. This may represent a Type II error given the relatively small number of patients in this study. Fractures at the base of the 5th metatarsal are commonly seen midfoot fractures in sports medicine centers.^{3, 7} However, the rate of clinically significant midfoot fractures other than those of the 5th metatarsal has been reported to be less than 1% (0.86%) in over 17,000 emergency department patients.¹⁸⁻²¹ These fractures are therefore rare, and in our subsequent (and others'¹⁹) experience are detected by the OAR.

The strengths of this study are its prospective nature and its evaluation of the decision rules in a new clinical setting.²³ The rules were used by sports medicine physicians who are comfortable with joint evaluation, who performed the examination and interpreted the rules very uniformly, and who followed up with most of the patients. In addition, we included older pediatric patients (age range, 12 to 17 years; $N = 24$), one of whom had a distal fibular Salter I growth plate fracture that was identified by the OAR. A study of the OAR in younger patients in a pediatric emergency department (mean age, 12 years; $N = 71$) suggested that radiography use could be reduced by 25% without missing any fractures.² These results and ours suggest that the OAR merit further study in pediatric patients.

We did not begin this study intending to modify or add

to the OAR. However, given the large percentage of negative radiographs for malleolar fractures, we considered if specificity for this location could be enhanced in our clinical situation. Therefore, in addition to palpation along the posterior malleolar edges (per the OAR), we palpated over the crest of the bones in the midportion of each malleolus (Fig. 2) and made this a separate data entry. The new palpation location did not include the anterior edge of the lateral malleolus, where tenderness from injury to the anterior talofibular ligament is typically found.¹⁸

Our data show that this simple alteration would potentially reduce the use of radiography in patients with malleolar pain an additional 25% beyond that using the OAR malleolar examination rule. In 78 patients with malleolar pain who were seen after the protocol modification, the new rule would have led to radiographs for 36 patients (46%), compared with 48 patients (62%) for the OAR. No fractures would have been missed. The new Buffalo rule had fewer false-positive results and was therefore more specific. If the OAR were amended to "advise" a radiograph when the new rule indicated midmalleolar tenderness, the point specificity for fracture would increase from 42% to 59%, sensitivity would remain 100%, and ankle radiography could be reduced by 54%. If radiographs were to be obtained when either rule was positive (i.e., they did not agree), sensitivity would be preserved but specificity would decline from 42% (OAR alone) to 35% (OAR with Buffalo modification), and the potential reduction in radiography use would be less than that using the OAR alone (in 132 patients). Thus, in our setting, modifying the OAR by substituting the Buffalo malleolar rule for its malleolar rule would theoretically maintain excellent sensitivity, significantly increase specificity, and reduce the pretest probability of malleolar fracture enough to forego ankle radiography in 5 of 10 acute cases. Projected over 1 year, the OAR with the Buffalo modification would have saved us more than \$3000 in ankle joint radiography. This is a potential savings of over \$1000 beyond that using the OAR unmodified.

There were no fractures in the 17 cases where the OAR malleolar rule was positive but the Buffalo rule was negative. We hypothesize that the midline palpation locations (Fig. 2) are more specific for fracture because they are farther away from the ligamentous attachments to the posterior malleolar edges.⁴ Stiel et al.¹⁹ stated that had they eliminated tenderness at the tip of the lateral malleolus, OAR specificity would have increased significantly but at the cost of reduced sensitivity. This was unacceptable. The Buffalo rule, however, improves fracture specificity without reducing sensitivity and adds no extra time to the physical examination. If the usefulness of a clinical guideline depends on it being as specific as possible,¹⁴ improving the accuracy of the parameters that define it (here, the physical examination) makes sense.

We found the OAR and the Buffalo modification to be easy to use. The senior author blindly evaluated the accuracy of the interpretations of the fellows-in-training and had to correct only a small percentage of them. Most of the mistakes were made early on, and the physicians became quite accurate as they used the rules repeatedly. The

orthopaedic surgeon and family physicians alike interpreted the rules correctly. Thus, these decision rules are easy to learn and, in our hands, yielded consistent, reproducible interpretations.

The Buffalo rule was evaluated in predominantly younger sports-injured patients who likely have different expectations for radiography (lower than in the emergency department) and for whom regular followup is routine. Decision rules may be tailored to the characteristics of the patients used to create them,²² and therefore this new rule may not be applicable to other patients (for example, older or nonsports trauma patients).

Valid, clinically tested decision rules are, in a sense, meant to supplant intuitive clinical judgment under certain conditions. However, it is unlikely they can be detailed enough to cover the myriad of clinical variations. For example, if a grossly swollen ankle prevented proper palpation of the malleolus, thus rendering interpretation of the physical examination inadequate, then the rules should be discarded and radiographs obtained according to the physician's discretion. Patients whose pain or ability to bear weight does not improve within 2 to 3 days should have radiographs. These decision rules are for *acute* injuries (≤ 10 days old) and do not apply to injuries more than 10 days old, repeat injuries, ankles with chronic or worsening symptoms, or patients in whom clinical assessment is difficult (altered mentation, intoxication, reduced lower extremity sensation, or language barrier).¹⁸ In these situations, radiographs should be obtained.

None of our patients with persistent problems was subsequently found to have a fracture, and all had recovered fully by the end of the study. One patient had arthroscopic debridement for anterolateral impingement syndrome. This was not identified by the rules because it is not a bony injury but a rare sequela of soft tissue injury. These decision rules are meant to evaluate the ankle region (the ankle joint, the navicular, and base of the 5th metatarsal bones) after injuries that usually involve a twisting mechanism. Other injuries, such as a Lisfranc sprain or fracture, are not within the purview of these rules and should be evaluated radiographically based on physician discretion. One of our injuries was a Maisonneuve fracture that was detected by the rules. This is a severe injury that typically involves the medial and lateral ankle ligaments in association with a proximal fibular fracture. Most patients cannot bear weight and have bimalleolar tenderness, therefore the rules should function well in this situation. The one situation where the rules may fail is the acute osteochondral fracture of the talar dome. However, this will be persistently symptomatic and should be identified by follow-up radiography.

We believe that, when properly applied, these rules will not jeopardize care, but there may be sociologic or behavioral factors that limit their routine application. For example, patients may demand tests or may in some instances benefit psychologically from learning of a negative result. Also, some physicians may be uncomfortable using quantitative estimates of probability.²² In addition, there are racial differences in bone density and susceptibility to

fracture that may affect the generalizability of these rules to black patients, who have larger, denser bones than white or Asian patients.¹⁰ The influence of race on the validity of these rules is a fertile area for further research.

Sports medicine physicians must now find ways to compete on the basis of the quality as well as the cost of medical care.¹¹ Decision rules, such as the OAR, which have been validated in large, well-designed clinical trials can help physicians direct resources to high-risk patients. Our results suggest that the OAR can help provide cost-effective, quality care in the nonemergency department setting. In relatively younger patients, the Buffalo modification appears to improve specificity yet maintain the excellent sensitivity of the OAR for clinically significant malleolar fractures. Judicious use of large-volume, relatively low-cost procedures such as radiographs may save substantial resources.^{1,21} Moreover, with the development of advanced computer-based medical information systems, clinical decision rules may become an integral part of patient care by providing physicians with point-of-decision assistance,²² i.e., should the physician watch and wait, perform a test, or treat without testing? Even so, clinical decision rules will be accepted only if they are simple to use, specific, and valid, and if they are used to inform medical decision-making by, and not to enforce medical decisions on, physicians.¹¹ Our results suggest that the OAR, and the Buffalo modification presented here, could help sports medicine physicians make appropriate medical decisions and conserve resources without compromising the care of their athlete-patients.

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