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Accuracy of Ottawa Ankle Rules for Predicting Fractures in Acute Ankle and Midfoot Injuries

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Abstract:

Introduction: The incidence of acute ankle and mid-foot injuries are one of the most common reasons for presenting to emergency department and orthopedics outpatient departments, but only a small percentage of patients approximately 14% have clinically significant fractures. However, these patients are almost always sent for radiography. The Ottawa ankle rules have been designed to reduce the number of unnecessary radiographs ordered for patients with acute ankle and midfoot injuries. Accuracy of "Ottawa ankle rules" for predicting fractures in patients with acute ankle and midfoot injuries and to assess the potential of these tests to reduce unnecessary x-rays.

Materials and methods: Study was conducted in the emergency department and department of orthopedics and traumatology in Madhesh institute of health sciences from April 2023 to April 2024. In this period 100 patients were included in this study, 50 patients in ankle and 50 patients in midfoot group. Outcome measures of this study were sensitivity, specificity, positive predictive value and negative predictive value of the Ottawa ankle rules.

Results: Sensitivity of the Ottawa ankle rules for predicting fractures was 100% for each two group (ankle and midfoot group), and 100% for combined ankle and midfoot group. Specificity of the Ottawa ankle rules for predicting fracture was 0.26(26%) for combined ankle and midfoot group, 0.24(24%) for ankle group and 29.27% for the midfoot group. The potential of Ottawa ankle rules to reduce unnecessary radiographs was calculated 23%.

Conclusions: Ottawa ankle rules are very accurate and highly sensitive tools for detecting fractures in acute ankle and midfoot injuries. Implementation of these rules would lead to significant reduction of radiographs, costs of treatment, radiation exposure and waiting time of patients in hospital.

Keywords: Accuracy; Ankle rules; Injuries; Midfoot.

INTRODUCTION

Ankle injuries are one of the commonest sports injuries and extremity complaints presenting to the emergency department [1]. Although generally benign, 20% or more of these injuries may have prolonged morbidity. It is thus incumbent on the emergency physician to diagnose accurately and treat appropriately those present with ankle injuries [2]. Nearly less than 15% of patient with blunt ankle injuries have significant fracture [3-7]. Traditionally physicians order radiography for virtually all ankle injuries and typically 85% of these examinations are negative for fracture [8-10]. The ankle radiographic series, along with cervical spine series, is one of the two most commonly ordered musculoskeletal radiology examinations in emergency departments [11]. So low-cost, high-volume tests, such as plane radiography, may contribute as much to rising health care cost as high technology, low volume procedure [12]. In Nepal there is no data pertaining to the amount of money spent in negative ankle radiography whereas University of Ottawa (Canada) estimated that US $500 million is spent annually on ankle radiographs in north America and suggested that some of the spent in negative radiographs could better used elsewhere in health care systems[10].

In the past there were no widely accepted guidelines to help physician to be more selective on their use of ankle radiography [3]. To address this clinical problem, Stiell IG et al conducted a multiphase project to develop and test decision rules for the use of radiography in acute ankle injuries [13]. In the 1st phase[14] they developed Ottawa ankle rules(OARs) by assessing 750 adult ankle injury patients prospectively for 32 clinical findings .One hundred of these patient were examined by two physicians to determine the reliability of findings by kappa analysis [15]. Rules were then derived by recursive partioning multivariate analysis. In the second phase [16], they refined and prospectively validated the rules in another 1485 patients. They demonstrated sensitivities of 100% for detecting clinically significant fractures for both malleolar and midfoot region and the potential for reducing use of radiography by 30% without missing clinically significant fractures. Fracture fragment 3mm or less (avulsion injuries) is treated no differently than severe sprains that is aggressive “RICE” (rest, ice, compression, elevation) regimen [14-16].

Ankle is broadly defined to include the area usually involved in common twisting injuries and is subdivided into malleolar and mid foot zones. These zones correspond to areas that generally require assessment by a standard ankle radiography series (malleoalar zone) or foot radiography series (midfoot zone). Malleolar zone include distal 6 cm of tibia and fibula and talus and midfoot zone include navicular, cuboid, cuniforms, anterior process of calcaneus and base of fifth metatarsal. The body and the tuberosities of calcaneus were not included in this definition [14-17].

Since 1993, Ottawa ankle rules are validated in various countries including France, Span, Poland, Hong Kong, Greece, Netherlands, New Zealand, Iran, Australia,the USA, Italy, and the UK [18-29]. They are also validated in different medical set-ups. They are also validated among special groups of populations like children’s, armies and athletes [18-36]. However studies conducted in New Zeeland and Singapore concluded that Ottawa ankle rules were unacceptable in their populations due a high false-negative rate [37,38].

Though exact prevalence of ankle injuries is not available for our setup, yet ankle and midfoot injuries are common, mainly twisting ankle injuries. We are sending all cases for radiography and yield of radiography is very low. Till date we are not using any guidelines for screening such injuries. In view of the high prevalence of ankle injuries, the long waiting times in emergency departments for patients without severe trauma and low yield of x-ray, it was decided to carry out this study which would evaluate the accuracy Ottawa ankle rules in excluding (predicting) fractures of the ankle and mid foot region in our setup and would set a guideline for the need of x-ray for appropriate cases only there by help to reduce the cost of treatment , waiting time of patients , work load on radiology department and radiation hazards for both patients and radiology staff. Thus this study evaluate the accuracy of “Ottawa ankle rules” for predicting fractures in acute ankle and mid foot injuries.

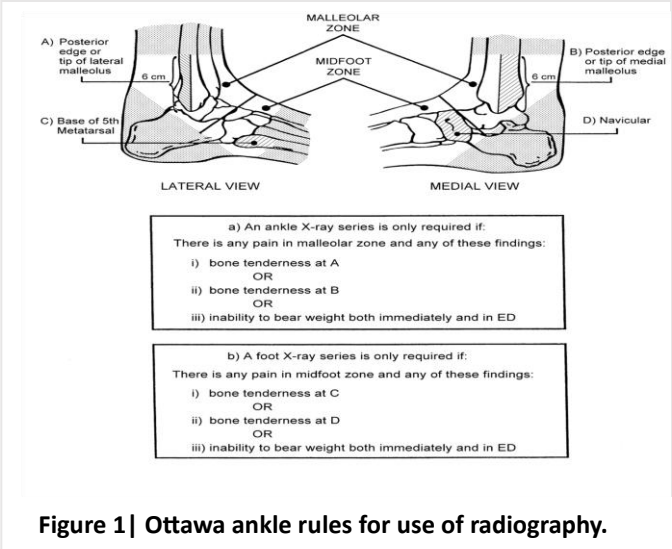

Figure 1| Ottawa ankle rules for use of radiography.

METHOD AND MATERIALS

Study design and setting

This is a prospective, observational study. It was conducted in Madhesh institute of health sciences from April 2023 to April 2024.

Participant, sample size and procedure

Acute ankle and mid-foot injuries (twisting injury, injury due to fall from height. All adult patients coming to this institute with complaints of ankle and mid-foot pain secondary to closed direct blow, due to road traffic accident) were include in this study. Patient less than 18 years of age, patients with isolated injuries of skin, referred from outside hospital with radiography, injuries more than 10 days old, unconscious patient, patient with previously symptomatic ankle, intoxicated patient, insensate leg, multiple injuries, open fractures, evidence of neurovascular compromise, patients with obvious ankle and foot deformities, pregnant women, and patients who do not gave consent were excluded from the study. Convenience sampling was used to select the patients. Due to limitation of time duration of study participants selected was 100 as more number of patients was not be possible reach. Out of 100 patients, 50 patients were in ankle group and 50 patients in foot group.

Patients of acute ankle and mid foot injuries fulfilling inclusion criteria were included in this study after taking informed written consent. Cases were evaluated using Ottawa ankle rules. Intensity pain was assessed by using verbal rating scale. History was taken regarding inability to bear weight immediately after injury. Tenderness was evaluated first over the areas mentioned above after that weight bearing ability was assessed. Weight bearing was described as the ability to transfer weight twice onto each leg (a total of four steps) regardless of limping or discomfort. Clinical diagnosis was reached and recorded in Proforma. Radiograph was made only after clinical diagnosis was made for both Ottawa ankle rules negative and Ottawa ankle rules positive cases. X-ray order for ankle was AP, LAT and mortise view. For foot AP, LAT and oblique view was ordered. The x-ray were evaluate, fracture fragment more than 3mm breadth were considered as clinically significant fracture and record in Proforma. Patient was followed up in 5 days and 10 days.

For data collection proforma was designed which is attached to page. All information's regarding patient e.g. age, sex, date, time since injury, mechanism of injury, swelling, presence of ecchymosis, tenderness, inability to bear weight, result of Ottawa ankle rules and x-ray findings were entered in Proforma by orthopedics faculty involved in evaluating the patient and proforma was collect same or next day.

Definition of outcomes

Ottawa ankle rules positive for ankle group:

Patient in ankle group was considered as Ottawa ankle rule positive if there were pain near the malleoli and either inability to weight-bear immediately after the injury and to take four steps in the Emergency department, OPD or bony tenderness at the posterior edge of the distal 6 cm or at the tip of either the lateral or medial malleolus.

Ottawa ankle rule negative for ankle group

Patient in ankle group was considered as Ottawa ankle rule negative if there were pain near the malleoli but neither fulfilling the weight bearing criteria (were able to bear weight either immediately after the injury or able to take four steps in the Emergency department or able to bear weight at both places immediately after injury and in Emergency department) nor there were bony tenderness at the posterior edge of the distal 6 cm or at the tip of either the lateral or medial malleolus.

Ottawa ankle rules positive for midfoot group

Patients in foot group was considered Ottawa ankle rule positive if there were pain in the midfoot zone and either inability to weight bear immediately after the injury and inability to take four steps in the Emergency department or bony tenderness over the navicular or the base of the fifth metatarsal.

Ottawa ankle rule negative for midfoot group

Patients in foot group was considered Ottawa ankle rule negative if there were pain in the midfoot zone but not fulfilling weight bearing criteria (were able to bear weight either immediately after the injury or able to take four steps in the Emergency department or able to bear weight at both places immediately after injury and in Emergency department) nor there were bony tenderness over the navicular or the base of the fifth metatarsal.

X-ray positive (clinically significant fractures)

X-ray with fracture fragment more than 3mm breadth was considered as a positive radiological outcome or clinically significant fracture

X-ray negative (no fractures or clinically insignificant fracture)

X-ray with no fracture or fracture fragment measuring 3mm or less as considered as a negative radiological outcome or clinically insignificant fracture.

Statistical analysis and data management

All data were entered and analyzed using SPSS version 16. Patients were divided into two groups Ottawa ankle rule positive and Ottawa ankle rule negative groups. After x-ray evaluation they were further divide into four groups true and false positive, true and false negative and 2 by 2 tables were prepared. Outcome of Ottawa ankle rules were analyzed by calculating sensitivity, specificity, positive and negative predictive values and percentage of x-ray that could be saved by application of Ottawa ankle rules. All these above-mentioned parameters were calculated separately for ankle and mid-foot groups and for combined ankle and midfoot groups.

Clinical variables were assessed for association with significant fractures in the ankle and foot radiographic series, separately, by the Pearson chi square test. Amount of x-rays that can be reduce when Ottawa ankle rule was applied was calculated.

Ethical Consideration

For the purpose of the study, ethical approval was obtained. Permission from the patients of the hospital was also obtained.

RESULTS

Patient characteristics

Hundred eligible patients with acute ankle and midfoot injuries were included in this study. Fifty patients were included in ankle group and fifty patients were included in midfoot group. All patients underwent x-ray evaluation, giving 100 % radiography rate. Mean age was 33.66 hours and 31.74 yrs in ankle and midfoot groups respectively. Female preponderance was seen in ankle group, male in midfoot group. Mean time of arrival to hospital (time since injury) was 24 hours in ankle group and 31.74 hours in midfoot group. Right sided was more affected in ankle and left sided midfoot groups. Some amount of swelling was present in all patients both in ankle and midfoot groups. Ecchymosis was present in 11 cases in ankle group and 3 cases ecchymosis in midfoot group. Twisting mechanism was the commonest cause of ankle and midfoot injuries. Among 50 patients in ankle group 39 patients were diagnosed as OARs positive. Among 50 patients in midfoot group 38 patients were diagnosed as Ottawa ankle rules positive. Five (10%) patients had clinically significant fracture in ankle group. Nine (18%) patients had clinically significant fractures in midfoot group that was relatively higher in comparison to ankle group (Table 1).

Fracture pattern

In this study total 14 fractures were detected by x-ray evaluation. 14 clinically significant fractures (including both ankle and midfoot groups) were detected. Five clinically significant fractures (5%) were detected in ankle groups. Nine clinically significant fractures (18%) were detected in midfoot groups (Table 2).

Table 2| Fracture pattern among patients

Total no. of fracture cases	14 cases
Significant fracture(>3mm)	14 cases
Insignificant fracture(<3mm)	0 case
Lateral malleolus fracture	4
Medial malleolus fracture	1
Base of 5th metatarsal fracture	8
Navicular fracture	1

Table 1|Patient characteristics

Patient characteristics	Ankle group	Foot group
Total no. of cases	50	50
Age(mean)	33.66(SD 13.113)	31.74(SD 10.156)
Sex(male/female)	16/34	20/30
Time since injury	Mean:24 hrs Range:1 hrs to 220 hrs	Mean:31.44 hrs Range:1 hrs to 190 hrs
Side affected(R/L)	27/23	24/26
Swelling	Mild:29 Moderate:21	Mild:37 Moderate:13
Ecchymosis present in	11 cases (22%)	3 cases (6%)
Mechanism of injury	Twisting 39(78%) Fall from height 8(16%) RTA 2(4%) Direct blow 1(2%)	Twisting 42(84%) Fall from height 0 case RTA 0 case Direct blow 8(16%)
Inability to bear weight among OARs positive cases	After injury:1 case In ER:7 cases At both place:16 cases	After injury:4 cases In ER:0 case At both place:5 cases
Inability to bear weight among OARs negative cases	After injury, ER and both places 0 case	After injury 3 cases
Tenderness present	Total 38 cases At tip of malleolus 14 cases. (Lateral side 13 cases and both sides 1 case.) At posterior edge 24 cases (Lateral side 20 cases, medial side 2 cases and both side 2 cases.)	Total 36 cases At the base of 5th metatarsal 30 cases. At navicular 6 cases.
OARs positive cases	39	38
Clinically significant fractures	5(10%)	9(18%)

Table 3 |Outcome of OAR in ankle group, mid-foot group and combined group									
Ottawa Ankle Rules (OAR)	Ankle group			Mid-foot group			Combined Group		
	Total no. of cases	X-ray positive cases	X-ray negative cases	Total no. of cases	X-ray positive cases	X-ray negative cases	Total no. of cases	X-ray positive cases	X-ray negative cases
Positive cases	39	5	34	38	9	29	77	14	63
Negative cases	11	0	11	12	0	12	23	0	23
Total no of cases	50	5	45	50	9	41	100	14	86

Outcome of Ottawa ankle rules

Ottawa Ankle Rules in ankle group, mid-foot group and overall group shown in Table 3. On clinical examination out of 50 patients. In ankle group, 39 patients were positive for Ottawa ankle rules in which only 5 had clinically significant fracture as shown by x-ray. Out of 11 Ottawa ankle rules negative cases none had clinically significant fracture. Similarly, on clinical examination 38 patients were positive according to Ottawa ankle rules in foot group. On x-ray examination out of 38 Ottawa ankle rules positive cases only 9 patients had clinically significant fracture (> 3mm in breadth). On clinical diagnosis 12 patients were Ottawa ankle rules negative and on x-ray examination none of them had clinically significant fracture. Among all 100 patients, 77 patients were diagnosed as Ottawa ankle rules positive in which 14 had clinically significant fracture whereas out of 100 patients, 23 patients were diagnosed as Ottawa ankle rules negative among these 23 patients none had clinically significant fracture.

Performance of Ottawa ankle rules in ankle group, mid-foot group and combined group

In ankle group sensitivity Ottawa ankle rules was 1(100%), specificity, positive predictive value, negative predictive value was 0.24(24%), 0.12(12%) and 1(100%) respectively. There were no false negative cases. X-ray that could be saved were calculated to be 22%. In mid-foot group, sensitivity for Ottawa ankle rules were 1(100%), specificity 29.27%, positive predictive value, negative predictive value were 23.68% and 1(100%) respectively. There were no false negative cases X-ray that could be saved were calculated to be 24%. Further, Overall sensitivity of Ottawa ankle rules was 1 (100%), specificity, positive predictive value, negative predictive value were 0.26(26.74%), 0.18(18.18%), and 1(100%) respectively. There were no false negative cases. X-ray that could be saved were calculated to be 23% (Table 4)

Association of different variables with significant fracture group in ankle group:

In the ankle group Swelling, inability to bear weight, tenderness (either tip or posterior edge) and tenderness at posterior edge were found to be associated with clinically significant fracture with p value <0.05 (Table 5).

Table 4| Performance of OARs in ankle group mid-foot group and combined group			
Performance of OAR	Ankle group	Mid-foot group	Combined group
Sensitivity	1(100%)	1(100%)	100%
Specificity	0.24(24%)	29.27%	26.74%
Positive predictive value	0.12(12%)	23.68%	18.18%
Negative predictive value	1(100%)	100%	1(100%)
X-ray that could be saved	22%	24%	23%

Association of different variables with significant fracture group in midfoot group

Individual clinical variables were assessed for association with significant fracture group by the Pearson chi square test with 1*df*. In midfoot group inability to bear weight at both places and tenderness were associated with clinically significant fracture with p values <0.05 (Table 6).

DISCUSSIONS

Several studies have been performed since 1981 to develop clinical decision-making rules regarding need of radiological evaluation in patients with acute ankle and mid-foot injuries [5,7,9,13,18-38]. The Ottawa ankle rules were designed, reviewed and validated by its Canadian inventors, and used in various clinical settings. Their simplicity in application and memorization has made them a very powerful tool to decrease radiology department referrals and to save cost and time. In addition, these rules have been successfully and favorably validated in France, Span, Poland, Hong Kong, Greece, Netherlands, New Zealand, Iran, Australia, the USA, Italy, and the UK [18-29]. Without evaluation, however, even well-defined decision-making rules are not suitable for application in all clinical settings due to difference in patient characteristics, different clinical settings and difference in behavior of treating physicians. Moreover, some study results [37,38] have rejected the generalizability of the Ottawa ankle rules, although these studies had considerable methodological errors or did not use real Ottawa ankle

Table 5| Significant of clinical variables among fracture and no fracture group in ankle group.			
	Fracture group	No fracture group	P-value
Total no. of cases	5	45	
Age (years, mean +SD)	32±8.69	33.84±13.57	NS
Male: Female ratio	0:5	16:29	NS
Time since injury mean	13.40hrs	25.51hrs	NS
Side(R/L)	4:1	23:22	NS
Swelling grade	Mild 1 case Moderate 4 cases	Mid 28 cases Moderate 17 cases	<0.05
Ecchymosis	Present 2 cases Absent 3 cases	Present 9 cases Absent 36 cases	NS
Mechanism of injury	Twisting 1 case Fall from height 1 RTA 1 case	Twisting 36 case Fall from height 7 RTA 1 case Direct blow 1 case	NS
Inability to bear weight	After injury 1 case In ER 5 cases At both places 5 cases Total 5 cases	After injury 2 cases In ER 7 cases At both places11 cases Total 20 cases	<0.05
Tenderness	Total 5 cases Tip of malleolus 0 Edge of malleolus 5 cases	Total 33 cases Tip of malleolus 14 Edge of malleolus 19 cases	<0.05

Table 6| Significant of clinical variables among fracture and no fracture group in mid-foot group.			
	Fracture group	**No fracture group**	**P-value**
Total no. of cases	9	41	
Age(years, mean +SD)	35.67±9.38	30.88±10.22	NS
Male: Female ratio	3:6	17:24	NS
Time since injury mean	47hrs	28.02hrs	NS
Side(R/L)	5:4	19:22	NS
Swelling grade	Mild 8 cases Moderate1 case	Mild 29 cases Moderate12 case	NS
Ecchymosis	Present 2	Present1	
Mechanism of injury	Twisting 8 cases Direct blow 1 case	Twisting 34 cases Direct blow 7 case	NS
Inability to bear weight	After injury 3 case In ER 3 cases At both places 3 cases Total 3 cases	After injury 9 case In ER 2 cases At both places 2 cases Total 9 cases	<0.05
Tenderness	9 cases	27 cases	<0.05

rules [16]. Therefore, considering the differences in patient characteristics, clinical set-up and also in physicians' behavior, evaluation of the Ottawa ankle rules was considered in this study. In this study total 100 patients were included, 50 patients in ankle group and 50 patients in mid-foot group. All patients underwent radiological evaluation. Giving 100% radiography rate.

Patients those were 18 years of age or above were included in this study. Patients less than 18yrs of age were not included in this study. Because this study was evaluating the refined Ottawa ankle rules developed by Stiell et al[16] , they validated this rule for adult patients only (>18 years of age or above). Another reason for not including patients those were less than 18yrs of age was fracture pattern, in this age group there may be displaced epiphyseal injury that may not be visible in x-ray and according to Ottawa ankle rule they will be classified as clinically insignificant fracture but they require treatment in the form of cast immobilization. Patients mean age was 33.33yrs in ankle and 31.74yrs in midfoot group. In ankle group 54% of patients and in midfoot group 54% of patients were 18 to 30 yrs of age. Prevalence of ankle and midfoot injuries were highest in this age group (18 to 30 yrs). People of this age group (18 to 30 yrs) are more active and they are involved more in sports activity this may be the probable reason for highest prevalence of ankle and midfoot injuries in this age group. In study by Yazdani et al in Iran[25], they found most patients were less than 30 yrs of age. In present study prevalence of ankle and midfoot injuries were least common in patients above 60 yrs of age. People from this age group are relatively less active than younger age group, probable this may be the reason for lowest prevalence of ankle and midfoot injuries among patients above 60 yrs of age.

In this study in ankle and midfoot injuries were more common in females. Maximum number of patients were from urban area. There is trend to put high heel wear among urban ladies that might have predisposed them for ankle injury and probably this may be the reason females had injured their ankle more than males.

Patients those who presented 10 days after injury were not included in this study. Because this study was evaluating only acute ankle and midfoot injuries and this was one of the exclusion criteria in original study

conducted by Stiell et al. Mean time of arrival of patients to hospital in ankle group was 29 hours and in midfoot group was 36.7 hours. This shows that in both groups patients has presented on second day after inury that appears to be relatively late presentation. This could be due to delayed treatment seeking attitude of people in our society and also due to misbelieve that ankle injury heals by itself. In study from France by Auleley GR et al most patients presented to the emergency department with in the day of injury [18].

In this study ankle group had 54% on right side and 46% in left side, in midfoot group 48% left side and 52% in right side injury. No previous study has been found regarding side predominance in ankle and midfoot injuries. In this study slight right, sided predominance has been found, probably right limb being dominant limb. Where midfoot injuries were more common on left side.

In this study in both ankle and midfoot groups some amount of swelling was present in every case. In ankle group swelling was significantly association with fractures but in mid foot group there was no association between swelling and fractures. In study by IG Stiell et al association between fracture and swelling was not significant both in ankle and mid foot groups [14,16].

In ankle group there were 11 patients with ecchymosis and in midfoot group 3 had ecchymosis. Most of the ankle injuries are ligamentous injuries ranging from mild to severe grade. In partial or complete ligamentous injury there may be ecchymosis. Whereas in foot injuries ligamentous injuries are relatively less in comparison to ankle injuries that may be the probable reason for ecchymosis to be present in ankle group only. In this study there was no association between ecchymosis and fractures. Similar result was found in study conducted by Stiell et al [14,16].

In present study most common mechanism of injury was twisting. This result was similar to several other studies worldwide [13,14,16,18-38]. In ankle group among Ottawa ankle rule positive cases 16 patients were not able to bear weight at both places (after injury and emergency department) whereas in midfoot group only 5 patients were not able to bear at both places. In this study in both groups inability to bear weight at both places was significantly associated with fractures. In study by IG Stiell et al. they found that there was significant association between inability to bear weight and ankle fractures but there was no association between inability to bear weight and midfoot fractures [14-16].

In ankle group among Ottawa ankle rule positive patients tenderness was present in 38 cases. In midfoot group among Ottawa ankle rule positive patients tenderness was present in 36 cases. In both ankle and midfoot groups there was significant association between tenderness and fractures . In study by IG Stiell et al. they found that there was significant association between tenderness and fractures [14,16].

In this study total 14 fractures were detected by x-ray, out of which 14 were clinically significant. Overall rate of fracture was 14 %. In study by Auleley GR et al. fracture rate was 17.1% [18]. In study by Yazdani et al fracture rate was18.5% [25].

In this study, sensitivity of Ottawa ankle rule was calculated 100 % for ankle, midfoot and for combined ankle and midfoot groups. That means in all three groups, all patients with clinically significant fracture were picked up by Ottawa ankle rules and none of the clinically significant fractures were missed. Specificity was calculated 24% for ankle group, 30% for midfoot group and 36% for combined ankle and midfoot group. Specificity of Ottawa ankle rules appears to moderate, about two third of cases were diagnosed as false positive. Positive predictive value (PPV) was calculated 13% for ankle group, 24% for midfoot group and 19% for combined ankle and midfoot group. Negative predictive value (NPV) was calculated 100% for ankle, midfoot and for combined ankle and midfoot group. That means chances of getting clinically significant fractures in patients those who were diagnosed as Ottawa ankle rule negative was zero. In this study, clinically significant fractures were not missed. 14 patients (14%) had clinically significant fracture. With application of Ottwa ankle rules, possible reduction in the need for radiography was calculated to be about 23%. This figure shows that approximately one third unnecessary x-rays could be avoided with application of Ottawa ankle rules. Results of present study were comparable to other studies.

Result of present study is similar to those of Stiell et al. [16] They demonstrated sensitivities of 10 for detecting clinically significant fractures for both malleolar and midfoot region and the potential for reducing use of radiography by 30% without missing clinically significant fractures.

Present study is similar to study conducted by Shahram Yazdani et al in Iran [25]. They found sensitivity of the Ottawa ankle rules 100% for each of the two zones(ankle and midfoot), and 100% for both zones combined. Specificity of the Ottawa ankle rules for detecting fractures was 40.50% for both zones, 40.50% for the malleolar zone, and 56.00% for the midfoot zone. Implementation of the Ottawa ankle rules had the potential for reducing radiographs by 33%. Difference is that specificity was higher in their study than present study whereas potential to reduce x-ray was slightly higher (33 % versus 31%).

Papacostas E et al [22] validated Ottawa ankle rules protocol in Greek athletes. This study is similar to our study in several aspects. examination were performed by orthopedic residents or sports medicine doctors. 122 patients were included in this study. The sensitivity of

the Ottawa ankle rules in predicting fractures in both the malleolar and midfoot zones was 100%. The negative predictive value for each of these areas was also 1.0. Specificity was estimated to be 0.3(30%) for ankle fractures and 0.49(49%) for midfoot fractures. Positive predictive values were 0.16 and 0.28 respectively. Nine ankle and eight midfoot fractures were detected. A possible reduction of up to 28.7% was found in the need for radiography. These values are almost similar to result of present study. Difference from present series is the group of patients included in the study. Their study included only athletes but present study was conducted in general population.

Study done by Leddy JJ et al. [27] had similar result as present study. Leddy JJ et al implemented the OAR. With a modification to improve the specificity for identifying malleolar fractures (the "Buffalo rule"). they found sensitivity 100% that was similar to our study. Specificity and potential reduction in x-ray were 37% and 34% respectively these values are close to present study. With modified OAR specificity had increased significantly for malleolar group from 42% to 59%. Difference from our study is that they included children (<18 yrs) which comprises 18% of total number of patients.

Study from Singapore by Tay SY et al[38] in our Asian population, calculated sensitivity and specificity of the OAR for predicting the presence of fracture 0.9 and 0.34 respectively (61 fractures were picked up out of 68) But when the rules were modified to cast a wider screening net, sensitivity improved to 0.99 (67 fracture were picked up out of 68) They concluded that Ottawa ankle rule are not applicable to Asian population because of inadequate sensitivity but when modified become acceptable and can reduce the number of x-ray studies requested by 28%.[39] But flaws with this study were ,they included patients aged 12–18 years, a group for which the refined Ottawa ankle rule were never designed or validated. Of the seven clinically significant fractures missed, one was the base of the first metatarsal which is not included in the ankle or midfoot zones of the OAR. For the six other fractures, all patients were unable to recall whether they were able to weight-bear immediately after the injury, making the application of the Ottawa ankle rule in these six patients unreliable.

Present study faced some limitations. The relatively low number of cases made it difficult to generalize the results to other medical centers and the entire Nepalese population. In this study patients were evaluated by orthopedic residents and consultants only. Not all the patients with ankle injuries that presented during this time period were enrolled. Enrollment was based on willingness of patient relatives' patient them self and cooperation of on duty doctors.

In addition to limitations application of Ottawa ankle rule s have some limitations. Would all physicians agree to treat their patients without taking a radiograph? Would they take the legal responsibility in case of a possible fracture? Some studies showed that even after attending a one-hour training program on the Ottawa ankle rules and despite having a very good opinion towards the subject, physicians did not use the Ottawa ankle rules.[40]

CONCLUSIONS

Twisting injury was found to be most common mechanism of ankle and midfoot injuries. Ankle and midfoot injuries were found to be more common in young adults. Tenderness and inability to bear weight were two clinical variables those were found to be significantly associated with clinically significant fractures in ankle and mid foot region. To conclude Ottawa ankle rules are the accurate and highly sensitive tools to predict fractures in patients with acute ankle and midfoot injuries. When Ottawa ankle rules are applied to screen the patients of acute ankle and midfoot injuries for the need of radiography chances of missing clinically significant fractures among Ottawa ankle rules negative patients is almost zero. Ottawa ankle rules have potential advantage to reduce significant amount of unnecessary x-rays. Therefore, application of Ottawa ankle rules in our setup can reduce health care costs, unnecessary radiation exposure and save time of both patients and hospital staffs. Further, application of Ottawa ankle rules will help in development of skill and attitude among Doctors regarding clinical evaluation of patients and they will spend more time in examining patients rather than writing radiological requisition.

RECOMMENDATION

Ottawa ankle rules should be used by orthopedics residents and consultants for clinical decision-making regarding need for radiological evaluation in adult patients with acute, ankle and midfoot injuries. This study was conducted in single center with relatively small sample size and cases were evaluated by orthopedics residents and consultants only therefore further studies are required with large sample, in hospitals of different levels including community health centres and by doctors of different levels of clinical skill and expertise. Our study sample was small and the study was done in only one centre. Patients were evaluated by residents and consultants only.

ADDITIONAL INFORMATION AND DECLARATIONS

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Data Availability: Data will be available upon request to corresponding authors after valid reason.

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