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Research Article

Clinical usefulness of the Ottawa Ankle Rules in the overweight and obese population following an acute ankle injury: A prospective cross-sectional study

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ABSTRACT

Objective: The aim of this study was to determine the clinical usefulness of the Ottawa Ankle Rules (OAR) in overweight and obese patients compared to the general population.

Methods: In this prospective cross-sectional study, 935 adult patients (453 female, 482 male; mean age = 57.2 ± 20.9) admitted to the emergency department following an acute ankle injury (<3 days) secondary to low energy-trauma were included. All the patients were examined based on a standardized protocol, including age, Body-Mass Index (BMI), OAR, and presence of ankle fracture. As accuracy indicators, sensitivity, specificity, positive and negative predictive values of OAR were calculated.

Results: Of all patients, 790 (84.5%) were normal weighted, 107 (11.5%) were overweight, and 38 (4%) were obese. While OAR was negative in 58.8% of patients, 41.2% of patients met OAR. The sensitivity of OAR in the normal weighted population was significantly higher than obese and overweight groups ($P < 0.01$). The specificity of OAR in the normal weighted population was significantly lower than overweight and obese groups ($P < 0.01$). The accuracy of OAR in the overweight group was 82.7% and significantly higher compared with the normal weighted population (62.8%) ($P < 0.01$).

Conclusion: We do not recommend OAR as a screening tool to be used safely in patients with higher BMI because of its lower sensitivity in this population. In this specific patient population, these rules should be implemented carefully, and radiography should be evaluated meticulously not to miss a fracture.

Level of Evidence: Level IV, Cross Sectional Study

Introduction

Acute ankle injuries are among the most common injuries of the musculoskeletal system. They account for 25% of all injuries of the musculoskeletal system and 36% of all lower extremity injuries.[1] In most cases, patients with acute ankle injuries consult the emergency department or general practitioners to ascertain the pathology and treatment. Radiographic imaging of the foot or ankle after detailed physical examination is a part of diagnosis and treatment. However, approximately 15% of these patients are diagnosed with ankle fracture. Radiation exposure, cost, and time consumption are some disadvantages of unnecessary radiography.[2,3]

Stiell et al.[4] first introduced a guideline, the Ottawa ankle rules (OAR), in 1992 to reduce the costs of ankle radiographs and expedite patient care. They stated that the sensitivity of OAR is 100% in detecting both malleolar and mid-foot fractures without missing any fracture, and it can reduce radiography use by 30%. The OAR have high sensitivity and modest specificity. Despite these efforts and findings, over-imaging continues to be a major problem. The applicability of OAR in different age or sex groups, including pediatric and geriatric populations, has been extensively studied.[5,6]

Obesity is increasing in prevalence in North America, and being overweight or obese is associated with an increased risk of musculoskeletal problems. In a study that evaluated the relationship between ankle fracture and Body-Mass Index (BMI), the average BMI of patients with ankle fracture was higher than that of the general population across all age and gender categories. Obese patients are highly prone to severe ankle injuries and have increased complications compared with the normal population.[7] Thus, whether the accuracy of OAR in the overweight or obese population adequately screens these patients must be evaluated. We aimed to determine the efficacy of OAR in patients with high BMI and compare it with the general population. Thus, radiography may be required, and ankle fractures in populations with a high BMI can be precisely predicted by refining the OAR.

Materials and Methods

We evaluated 935 adult patients with acute ankle injuries admitted to the emergency department of our

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hospital for 6 months. In this prospective cross-sectional study, patients who met the following inclusion criteria were included: acute closed ankle injuries <3 days secondary to low-energy mechanism and >18 years. The exclusion criteria were as follows: chronic ankle injuries >3 days, <18 years, patients with BMI < 18.5, altered mental status, pregnancy, mid-foot injuries, injuries secondary to high-energy trauma, and major distracting injuries. Ethics approval for the study was obtained from the Clinical Research Ethics Committee of our hospital (approval number: 00128053094).

The following patient information were collected using a prospective chart by orthopedic surgeons in our hospital: age; sex; BMI; OAR findings for the ankle (for patients who were ≥55 years old, were unable to bear weight for four steps both immediately and at the time of evaluation, experienced bone tenderness at the posterior edge [6 cm] or inferior tip of the lateral malleolus, or had bone tenderness at the posterior edge or inferior tip of the medial malleolus); and imaging findings, such as the presence or absence of ankle fracture and fracture type (medial malleolus, lateral malleolus, bimalleolar, trimalleolar, and distal tibia fractures), after plain radiography of the ankle in anteroposterior and lateral views.

The BMI of the patients was calculated by determining their weight in kilograms divided by height in meter squared. Three groups were formed as follows: obese (BMI ≥ 30), overweight (BMI 25-29.9), and normal (BMI 18.5-24.9). Volunteer participants were informed in detail about the study and were free to refuse to participate. Written informed consents of volunteer participants were obtained after a detailed explanation of the study. The participants underwent AP, and lateral views of the ankle were evaluated to determine if radiography was necessary in accordance with the OAR to obtain accurate results.

Statistical analysis

Mean, standard deviation, median, minimum, maximum value frequency, and percentage were used for descriptive statistics. The sensitivity, specificity, Positive Predictive Value (PPV), and Negative Predictive Value (NPV) of OAR were calculated to determine accuracy. To detect significant differences between groups according to accuracy parameters, we applied *z* statistics. Statistical Package for Social Sciences (SPSS) version 26.0 was used for statistical analyses (IBM SPSS Corp., Armonk, NY, USA).

Results

We included 935 adult patients in this study with an average (±standard deviation) age of 57.2 ± 20.9. A total of 48.4% ($n = 453$) and 51.6% ($n = 482$) of patients were females and males, respectively. A total of 84.5%, 11.5%, and 4% of patients were normal in weight, overweight, and obese, respectively. OAR was negative in 58.8% of patients, and 41.2% of patients met OAR.

Fractures were detected in 11.8% of all population. Lateral malleolus fracture (9%) was the most common type of ankle fracture among the patients admitted to our emergency room with low-energy ankle fracture. The rates of medial malleolus, bimalleolar, distal tibia, and trimalleolar fractures were 1.4%, 1.0%, 0.2%, and 0.2%, respectively. Injury rates among normal, overweight, and obese populations are shown in Figure 1.

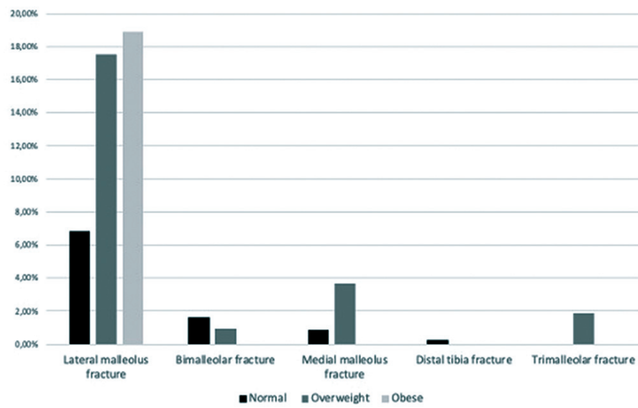

Figure 1. Rates of fracture types in normal, overweight, and obese populations.

In the general population, OAR displayed 80.7% sensitivity and 63.9% specificity. PPV and NPV were 22.7% and 96.1%, respectively. The accuracy of OAR in all the patients was 65.8%.

The sensitivity of OAR was 93.4% (95% confidence interval [CI], 0.68-1.00) in the normal-weight population but was 53.8% (95% CI, 0.29-0.76) and 42.8% (95% CI, 0.34-0.46) in the overweight and obese groups, respectively. This difference was statistically significant between the normal and overweight groups ($P < 0.01$). The sensitivity of OAR in the normal-weight population was significantly higher than that in the obese group ($P < 0.01$). No statistically significant difference was found between the overweight and obese groups ($P > 0.05$).

The specificity of OAR in the normal-weight population was 59.5% (95% CI, 0.25-0.79), which was significantly lower than that in the overweight (93.9%) and obese groups (86.2%) ($P < 0.01$). No statistically significant difference was found between the specificities of OAR in the overweight and obese groups ($P > 0.05$).

The PPV of OAR in the normal-weight population was 19.7% (95% CI, 0.12-0.37). The PPVs of OAR were 73.6% (95% CI, 0.58-0.80) and 42.8% (95% CI, 0.38-0.59) in the overweight and obese groups, respectively. The PPV of OAR in the overweight population was significantly higher compared with those in the normal-weight and obese groups ($P < 0.01$). The PPV of OAR in the obese group was significantly higher than that in the normal-weight group ($P < 0.05$).

The NPVs of OAR in the normal-weight, overweight, and obese groups were 98.8%, 86.5%, and 86.2%, respectively. The NPV of OAR in the normal-weight population was significantly higher than that in the overweight and obese groups ($P < 0.01$). No statistically significant difference was found between the NPVs of OAR in the overweight and obese groups ($P > 0.05$).

The accuracy of OAR in the overweight group was 82.7%, which was significantly higher compared with that in the normal-weight population (62.8%; $P < 0.01$). The accuracy of OAR in the obese group was 75.6% and revealed no statistically significant difference compared with that in the overweight group ($P > 0.05$). The accuracy of OAR in the obese group was significantly higher than that in the normal-weight population ($P < 0.05$).

HIGHLIGHTS

- OAR had lower sensitivity and higher specificity in overweight and obese population compared to normal weighted patients.
- When high fracture risk is considered to be related with obesity, OAR is not a convenient screening tool for these patient groups.
- OAR in general population had lower sensitivity than literature.

Discussion

OARs were designed to reduce the number of unnecessary foot or ankle radiographs in patients who presented to the emergency room with ankle injuries. Beckenkamp et al.[8] stated in their meta-analysis that the sensitivity of OAR ranges from 99.4% to 99.8%, whereas the specificity is between 35.3% and 42.3%. We determined that the sensitivity of OAR in the entire cohort was 80.7%, and the specificity was 63.9%. We explained that the higher specificity of OAR in the general population in our study was due to the immediate evaluation of patients in the emergency room. Chronic cases with ankle sprain or ligamentous injuries who presented to the clinic after several weeks were not included. All examinations were performed only by orthopedic surgeons, and this factor may have caused the high specificity of OAR in our study. Furthermore, the overweight and obese populations showed discrepancies in the sensitivity and specificity of OAR. This factor may have contributed to the change in sensitivity and specificity of OAR in the general population. Vosseller et al.[9] found the peak incidence of ankle sprains in the age group between 18 and 34 years, which is consistent with the literature. The average age of patients included in our study was 57.2 ± 20.9 years old, which was higher than the average. This discrepancy may also be another possible reason for higher specificity of OAR in our study.

A study that investigated a 10-year epidemiology of ankle injuries showed that male predominance was 57.6%.[10] We found in our study that 51.6% of the population was male, which was comparable with the literature. Lateral malleolus fracture is the most common type of ankle fracture after a low-energy mechanism.[11,12] In our study, 9% of the population who presented to the emergency room with low-energy mechanism ankle injury had lateral malleolus fractures. This finding was also consistent with the literature.

In a retrospective study with 491 patients, Murphy et al.[6] stated that 80% of the patients met OAR and 67.9% displayed fracture. Furthermore, in a meta-analysis, they found increased sensitivities after the application of OAR within 48 h after injury.[3] In our study, 41.2% of patients who presented to our emergency room with ankle injury were OAR positive. This result may be due to our study being a prospective study and that examinations were performed by orthopedic staff. Approximately 11.8% of the population was fracture positive in our study. We excluded patients admitted to the hospital 3 days after low-energy mechanism ankle trauma, given that the exclusion criteria of a previous study was >7 days after trauma.

This study aims to compare the efficacy of OAR in normal-weight, overweight, and obese populations. Significant differences were found between the sensitivity and specificity of OAR between the normal-weight and the other groups. The sensitivities of OAR in the normal-weight, overweight, and obese groups were 93.4%, 53.8%, and 42.8%, respectively. This difference could be related to the inconsistencies in pain perceptions among these patient groups. In a study from the UK, Perry et al. found that PPV was 17.98% and the NPV was 98.39% and concluded that OAR should not replace clinical judgment and experience.[13] We found significantly higher PPV and lower NPV in higher BMI groups than in the normal-weight population in our study. Given these findings, we determined that OAR is not an appropriate screening tool for overweight and obese groups because of significantly lower sensitivity rates. The number of missed fractures will be a major problem in these groups if we use OAR, even if examiners are orthopedic surgeons. If the first examination is generally conducted by general practitioners, the number of missed fractures would increase. Given these factors, another screening test for ankle injuries to detect radiography is necessary for overweight and obese populations. Thus, a refined version of OAR is needed for a population with a high BMI to improve the sensitivity of the test for these patients.

We found significantly higher specificity rates of OAR in the overweight and obese populations than in the normal-weight patients. The higher specificity of OAR in the overweight and obese groups compared with that in the normal population may be caused by the higher incidence of ankle fracture in patients with higher BMI after low-energy mechanism ankle injury. Bergkvist et al.[14] reported that ankle fracture was significantly related to obesity in 20- to 80-year-old patients. Thus, overweight and obese patients with ankle injury probably have a higher risk of ankle fracture than the normal-weight population. We also detected a higher incidence of lateral malleolus fracture in the overweight and obese patients than in the normal-weight patients. Furthermore, when OAR was used as a screening tool, these results seemed acceptable.

The accuracies of OAR in the overweight and obese groups were 82.7% and 75.6%, respectively, which were significantly higher than those in normal-weight patients. We believe that OAR may still be useful in patient groups with a high BMI. These findings are probably due to reduced patient numbers in the overweight and obese populations compared with those in normal-weight patients, which is one of the limitations in our study. Another limitation of our study is that we evaluated patients who presented with low-energy mechanism ankle injury. Our study also has other limitations. This study was performed in a local hospital in a specific geographical area. This factor could be a reason for differences in perception of pain, and the results may not be representative of the general population. Five types of ankle fracture were included, and other major problems, such as isolated syndesmotic injuries, were not included. Based on our knowledge, this study is the first and the only study that compared the efficacy of OAR in normal-weight, overweight, and obese patients. Given the limitations and some crucial findings of our study, future studies must be performed to refine the OAR in these patients with high BMIs. In conclusion, we do not recommend OAR as a screening tool in overweight and obese patient groups. We believe that OAR should be refined to be used safely in this population.

Ethics Committee Approval: Ethics committee approval was received for this study from the Local Ethical Committee of Ağrı Training and Research Hospital (22.10.2020-13).

Informed Consent: Informed written consent was obtained from the participants.

Author Contributions: Concept - H.Ö., S.Y.; Design - H.Ö., S.Y.; Supervision - H.Ö., S. Y.; Materials - H.Ö., S.Y.; Data Collection and/or Processing - H.Ö., S.Y.; Analysis and/or Interpretation - H.Ö., S.Y.; Literature Review - H.Ö., S.Y.; Writing - H.Ö., S.Y.; Critical Review - H.Ö., S.Y.

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