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ORIGINAL ARTICLE

Diagnostic accuracy of Ottawa rules in diagnosing ankle fractures among patients taking X ray as gold standard.

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ABSTRACT… Objective: To determine the diagnostic accuracy of the Ottawa Ankle Rules (OAR) in diagnosing ankle fractures among patients, with X-ray imaging as the gold standard. **Study Design:** Cross-sectional study. **Setting:** Emergency Department of Lady Reading Hospital, Peshawar. **Period:** 1st January 2024 to 30th June 2024. **Methods:** 286 cases patients aged 18 to 60 years, presenting with ankle twisting and pain within 6 hours, were included. Exclusion criteria included patients unable to answer the Ottawa questionnaire or those refusing X-ray imaging. Following informed consent, patients were assessed using the Ottawa Ankle Rules and underwent X-ray imaging. The results were classified into true positives, false positives, true negatives, and false negatives. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated. **Results:** The mean age of participants was 36.73±6.7 years, with 67.13% males and 32.86% females. Ankle fractures were more common on the right side (62.93%). Among normal radiographs, 55.24% were correctly classified, while 18.18% were false positives. In patients with radiographic fractures, 23.77% were correctly identified. The sensitivity of the Ottawa Rules was 95.18%, while specificity was 56.67%. The positive predictive value was 68.72%, and the negative predictive value was 92.16%. Sensitivity was high in both males (92.73%) and females (94.55%), though specificity was lower in males (42.86%) compared to females (56.10%). **Conclusion:** The Ottawa Ankle Rules demonstrated high sensitivity for detecting ankle fractures but lower specificity.

Key words: Ankle Fractures, Diagnostic Accuracy, Emergency Department, Ottawa Ankle Rules, Sensitivity, Specificity.

INTRODUCTION

Ankle injuries, with an annual fracture incidence of 122 per 100,000, are a common reason for visits to the Emergency Department.[1] Stiell et al.[2] developed the Ottawa Ankle Rules, objective criteria designed to guide radiograph use and reduce unnecessary imaging. This approach lowers costs, minimizes radiation exposure, and shortens ED waiting times, leading to improved patient care and efficiency. The Ottawa Ankle Rules recommend ankle radiographs only if there is pain in the malleolar zone and at least one of the following: Bone tenderness along the distal 6 cm of the posterior edge or tip of the medial malleolus; bone tenderness along the distal 6 cm of the posterior edge or tip of the lateral malleolus; and inability to bear weight immediately after the injury, and 4 steps in the emergency department. These criteria are used to decide when to image and allow us to not take an unnecessary radiograph, use our resources more efficiently, and see less radiation.[3]

They also help decide if a foot radiograph is required. A radiograph is recommended if there is pain in the mid-foot area and at least one of the following: Tenderness of the base of the fifth metatarsal or the navicular bone. Although nearly all patients with foot and ankle injury are radiographed to rule out fracture, less than 15% of these patients will actually have fractures, and most of the radiographs are unnecessary.[4,5]

The Ottawa Ankle Rules (OAR) are an effective and reliable method for ruling out fractures when used by clinicins.[6]

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In children, applying the OAR can decrease the need for xrays by 22% to 24.8%, while in adults, this reduction is typically between 30% and 40%. This helps lower healthcare costs, minimizes unnecessary radiation exposure, and improves overall efficiency in emergency care.[7-9] The Ottawa Ankle Rules (OAR) have a sensitivity of 94.12% to detect ankle fractures, but a specificity of 37.65% for a higher rate of false positive.[10] Given that about 21 % of the general population has ankle injuries, the OAR allows us to indicate radiographs to those people who are most likely to have a fracture to avoid unnecessary imaging with concomitant radiation exposure and at the same time maintain the diagnostic accuracy.[11]

However there is no data about the diagnostic accuracy of Ottawa ankle rules for our local population. Therefore this study aims to find out the diagnostic accuracy of Ottawa ankle rules in our local population. It will give us local data applicable directly to our population which will tell us whether this is an appropriate test for the screening of ankle fracture in our local population.

The objective of this study was determine find out the diagnostic accuracy of Ottawa rules in diagnosing ankle fractures among patients taking x ray as gold standard.

METHODS

This cross-sectional study was conducted in the Emergency Department of Lady Reading Hospital, Peshawar from 1st January 2024 to 30th June 2024 over a duration of 6 months by non-probability consecutive sampling technique. The sample size was calculated to be 286, determined using the WHO software for calculating sensitivity and specificity, with the following assumptions: a confidence level of 95%, an absolute precision of 6% for sensitivity, and 10% for specificity. The anticipated sensitivity of the Ottawa Ankle Rules for diagnosing ankle fractures was 94.12%, while the anticipated specificity was 37.65%. Additionally, the anticipated prevalence of ankle injury in the population was 21%.[11]

The inclusion criteria for this study were individuals aged 18 to 60 years, both male and female, who presented within 6 hours of experiencing ankle twisting with pain around the ankle joint extending to the mid-foot. The exclusion criteria included patients who were unable to answer the Ottawa questionnaire, as well as those who refused to undergo an ankle joint X-ray or had any contraindications to X-ray imaging.

After the study was approved by the hospital's ethical committee (ref : 2030/Ortho/LRH-24) , all patients in the emergency department of Lady Reading Hospital, Peshawar, who met the inclusion criteria were recruited into the study after providing informed consent. The patients were given detailed information about the Ottawa Ankle Rules and were then advised to undergo X-ray imaging. Those with positive Ottawa rules and an ankle fracture confirmed by the X-ray were classified as true positives, while those with positive Ottawa rules but no ankle fracture were labeled as false positives. Patients with negative Ottawa rules and no ankle fracture on the X-ray were considered true negatives, while those with negative Ottawa rules but an ankle fracture were categorized as false negatives. If a fracture was detected on the X-ray, patients were treated according to the standard of care and prepared for either an emergency or elective procedure, depending on the fracture type. All patient information, including name, age, gender, address, contact number, and the presence or absence of a fracture, was recorded. The exclusion criteria were strictly followed to control for confounding factors and minimize potential bias in the study.

An acute ankle injury refers to an injury that occurs when an individual rolls, twists, or turns the ankle in an awkward direction. Positive Ottawa Rules are identified in patients who exhibit tenderness on palpation around the distal 6 centimeters of the tibia or fibula, the tip of the medial or lateral malleolus, the base of the 5th metatarsal, or the navicular bone, or who are unable to bear weight immediately or take four steps in the emergency department. An ankle fracture is defined as a break in the continuity of the distal 6 cm of the tibia and fibula extending up to the mid-foot, as observed on standard anteroposterior,

lateral, and mortise X-ray films for the ankle and anteroposterior, lateral, and oblique views for the mid-foot. True positive (TP) patients are those with positive Ottawa Rules and an ankle fracture confirmed on the X-ray. False positive (FP) patients have positive Ottawa Rules but no ankle fracture on the X-ray. True negative (TN) patients have negative Ottawa Rules and no ankle fracture on the X-ray, while false negative (FN) patients have negative Ottawa Rules but an ankle fracture on the X-ray. Sensitivity is calculated as TP/(TP+FN), specificity as TN/(TN+FP), positive predictive value as TP/(TP+FP), negative predictive value as TN/(TN+FN), and accuracy as (TN+TP)/(TN+FN+TP+FP).

Data were analyzed using SPSS 22 and Medcalc. Frequency and percentage were computed for categorical variables such as gender, presence/absence of fracture according to the Ottawa rules and X-ray, and site of the fracture. Mean and standard deviation were calculated for continuous variables, such as age. A 2x2 table was generated to calculate sensitivity, specificity, positive predictive value, negative predictive value, and accuracy. Post-stratification accuracy by gender was also calculated.

RESULTS

The mean age of participants was 36.73±6.7 years with range from 18 to 55 years. Males were 192 (67.13%) and females were 94 (32.86%). Fractures were more common on the right side (n=180, 62.93%) than the left (n=106, 37.06%). (Table-I)

Overall, among patients with normal radiographs, the Ottawa Rules correctly classified 158 cases as normal (55.24%) but incorrectly identified 52 cases as fractures (18.18% false positives). Among patients with radiographic fractures, 68 cases were accurately identified (23.77%). In males, 51 cases with normal radiographs were correctly identified (54.25%), with 28 false positives (29.78%), whereas 21 fractures were accurately detected (22.34%). Similarly, in females, 104 cases with normal radiographs were accurately classified as normal (54.16%), with 36 false positives (18.75%), while 46 fractures were correctly identified (23.95%). (Table-II)

The diagnostic performance of radiographs compared to the gold standard radiograph demonstrates high sensitivity (95.18%, 95% CI: 90.73% to 97.90%), indicating strong ability to correctly identify fractures when present. However, specificity is relatively low (56.67%, 95% CI: 47.31% to 65.68%). The positive likelihood ratio is 2.2 (95% CI: 1.78 to 2.70), suggesting that a positive radiograph moderately increases the probability of a fracture, while the negative likelihood ratio is 0.09 (95% CI: 0.04 to 0.17). The disease prevalence is 50%, with a positive predictive value of 68.72% (95% CI: 64.09% to 72.99%) and a negative predictive value of 92.16% (95% CI: 85.45% to 95.92%). (Table-III)

The diagnostic performance of radiographs compared to the gold standard radiograph was analyzed separately for males and females. Sensitivity was high in both genders, with 92.73% (95% CI: 82.41% to 97.98%) in males and 94.55% (95% CI: 88.51% to 97.97%) in females. Specificity was lower, particularly in males (42.86%, 95% CI: 28.82% to 57.79%) compared to females (56.10%, 95% CI: 44.70% to 67.04%). (Table-IV)

Variable	Characteristic	n(%)
Gender	Female	94(32.86)
	Male	192(67.13)
Side of fracture	Left	106(37.06)
	Right	180(62.93)

Table-I. Distribution of gender and side of fracture of the ankle

			Ottawa Rules	
			Normal	fracture
Radio-graph	Overall	Normal	158(55.24)	52(18.18)
		Fracture	8(2.79)	68(23.77)
	male	Normal	51(54.25)	28(29.78)
		Fracture	4(4.25)	21(22.34)
	Female	Normal	104(54.16)	36(18.75)
		Fracture	6(3.12)	46(23.95)

Table-II. Cross tabulation of Ottawa Rules versus gold standard radiograph

Statistic	Value	95% CI
Sensitivity	95.18%	90.73% to 97.90%
Specificity	56.67%	47.31% to 65.68%
Positive Likelihood Ratio	2.2	1.78 to 2.70
Negative Likelihood Ratio	0.09	0.04 to 0.17
Disease prevalence (*)	50.00%	
Positive Predictive Value (*)	68.72%	64.09% to 72.99%
Negative Predictive Value (*)	92.16%	85.45% to 95.92%
Accuracy (*)	75.92%	70.54% to 80.76%

Table-III. Diagnostic statistics of Radiograph versus gold standard radiograph

Statistic	Male(n=94)		Female(n=192)	
	Value	95% CI	Value	95% CI
Sensitivity	92.73%	82.41% to 97.98%	94.55%	88.51% to 97.97%
Specificity	42.86%	28.82% to 57.79%	56.10%	44.70% to 67.04%
Positive Likelihood Ratio	1.62	1.26 to 2.09	2.15	1.68 to 2.76
Negative Likelihood Ratio	0.17	0.06 to 0.46	0.1	0.04 to 0.22
Disease prevalence (*)	50.00%		50.00%	
Positive Predictive Value (*)	61.87%	55.74% to 67.65%	68.29%	62.68% to 73.42%
Negative Predictive Value (*)	85.49%	68.49% to 94.11%	91.14%	82.19% to 95.82%
Accuracy (*)	67.79%	57.92% to 76.62%	75.32%	68.60% to 81.25%

Table-IV. Diagnostic statistics of Radiograph versus gold standard radiograph in both gender

DISCUSSION

The mean age in our study was 36.73±6.7 years. The right side had more ankle fractures (62.93%) than on the left (37.06%). The Ottawa Ankle Rules (OAR) had high sensitivity (95.18%) for the diagnostic of fracture, meaning that it was good at detecting fractures when one existed. However, they had a specificity of 56.67 %, somewhat lower than the above and indicating that a large OAR, in comparison with endometriotic implants of the same size, may lead to a large number of false positives. Significance was consistent across gender specific analyses, sensitivity was high in both males (92.73%) and females (94.55%) and specificity was lower for males (42.86%) compared to females (56.10%).

Our results are comparable to previous studies in terms of sensitivity, although the specificity in our study is slightly higher. Auley et al.[12] conducted a prospective validation study in France with 416 patients, reporting a sensitivity of 94% and specificity of 36%, which closely mirrors our sensitivity but slightly lower specificity. Similarly, Beceren et al.[13] in Turkey, through a randomized prospective study of 962 participants, found a sensitivity of 94.3% and specificity of 30.3%, which shows a similar sensitivity to our study but lower specificity. Broomhead et al.[14], in their study of 333 Australian patients, reported a sensitivity of 92% and specificity of 38%, again demonstrating sensitivity similar to ours but with slightly lower specificity.

Cheng et al.[15] in Australia, in their retrospective review of 404 patients, also found high sensitivity (93%) but a relatively low specificity of 33%, which supports our findings that the OAR is very effective in detecting fractures but may generate false positives. Daş et al. (2016) in

Turkey, with 405 participants in a retrospective case-control analysis, reported a sensitivity of 95.4% and specificity of 41.3%, reinforcing the notion that while the OAR excels at ruling in fractures, the specificity tends to be moderate.

Furthermore, studies by Glas et al.[16] in Amsterdam, and Gomes[17] in Australia, also reported high sensitivity for the OARs, with slightly varying specificities (38% to 41%) similar to our study's specificity. These studies, like ours, emphasize that while the Ottawa Ankle Rules are highly reliable in terms of sensitivity for detecting fractures, the relatively low specificity, especially in certain populations, highlights the necessity for additional clinical judgment to confirm the presence of fractures. This is particularly evident in males, as seen in our study, where false positives were more frequent. Therefore, while OAR is a useful screening tool, it should be combined with further assessment to optimize patient care.

CONCLUSION

This study finds that the Ottawa Ankle Rules are highly effective in identifying ankle fractures, showcasing a strong sensitivity. This means that the rules are adept at correctly determining when a fracture is present. However, the study also notes that the specificity of the Ottawa Ankle Rules is relatively lower. In other words, while the rules are good at catching true positive cases of fractures, they may also result in a higher number of false positives, indicating fractures when none are actually present. This distinction is important for clinicians as they interpret the rules in the context of patient evaluations and management.

LIMITATIONS

The research was conducted at a single institution, the Emergency Department of Lady Reading Hospital, which may limit the generalizability of the findings to other hospitals or regions with different patient demographics or clinical practices.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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REFERENCES

1. Donken CC, Al-Khateeb H, Verhofstad MH, Van Laarhoven CJ: **Surgical versus conservative interventions for treating ankle fractures in adults.** Cochrane Database Syst Rev. 2012; 15(8):CD008470.

2. Stiell IG, Greenberg GH, McKnight RD, Nair RC, McDowell I, Worthington JR. **A study to develop clinical decision rules for the use of radiography in acute ankle injuries.** Ann Emerg Med. 1992; 21(4):384-90.

3. Meena S, Gangary SK. **Validation of Ottawa ankle rules in Indian scenario.** Arch Trauma Res. 2015; 4(2):e20969.

4. Yazdani S, Jahandideh H, Ghofrani H. **Validation of the Ottawa ankle rules in Iran: A prospective survey.** BMC Emerg Med. 2006; 6:3.

5. Solomon L, Warwick D, Nayagam S, Apley A. **Apley's system of orthopaedics and fractures.** 9th ed. London: Hodder Arnold; 2010.

6. MacLellan J, Smith T , Baserman J, Dowling S. **Accuracy of the Ottawa Ankle Rules applied by non –physcian providers in a paediatric emergency department.** CJEM. 2017; 02:1-7.

7. Dowling S, Spooner CH, Liang Y, Dryden DM, Friesen C, Klassen TP, et al. **Accuracy of Ottawa Ankle Rules to exclude fractures of the ankle and midfoot in children: A metaanalysis.** Acad Emerg Med. 2009; 16:277-87.

8. Bachmann LM, ter Riet G. **The Ottawa rules for ankle sprains.** Hosp Med. 2004; 65(3):132-3.

9. Boutis K, von Keyserlingk C, Willan A, Narayanan UG, Brison R, Grootendorst P, et al. **Cost consequence analysis of implementing the low risk ankle rule in emergency departments.** Annals of Emergency Medicine. 2015; 66(5):455-63.

10. Spanos I, Samdanis V, Chytas A, Beslikas T, Hatzokos I. **Implementation of the Ottawa ankle rules by resident orthopaedic surgeons in an emergency department.** Clin Res Foot Ankle. 2014; 2:1000127.

11. Pires RE, Pereira AA, Abreu-e-Silva GM, Labronici PJ, Figueiredo LB, Godoy-Santos AL, et al. **Ottawa ankle rules and subjective surgeon perception to evaluate radiographic necessity following foot and ankle sprain.** Ann Med Health Sci Res. 2014; 4(3):432-5.

12. Auleley GR, Kerboull L, Durieux P, Cosquer M, Courpied JP, Ravaud P. **Validation of the Ottawa ankle rules in France: a study in the surgical emergency department of a teaching hospital.** Ann Emerg Med. 1998; 32(1):14-8.

13. Beceren GN, Yolcu S, Tomruk O, Atay T, Baykal YB. **Ottawa versus Bernese: which is better?** Eur J Trauma Emerg Surg. 2013; 39(2):147-50.

14. Broomhead A, Stuart P. **Validation of the Ottawa Ankle Rules in Australia.** Emerg Med. 2003; 15(2):126-32.

15. Cheng CT, Varma D, Smit D. **How consistently are the Ottawa Ankle Rules applied in a major metropolitan health network's emergency departments in Australia?-a Retrospective Review.** Eu Cong Radiol. 2016; 12:1-9.

16. Glas AS, Pijnenburg BA, Lijmer JG, Bogaard K, de Roos M, Keeman JN, et al. **Comparison of diagnostic decision rules and structured data collection in assessment of acute ankle injury.** Cmaj. 2002 Mar 19; 166(6):727-33.

17. Gomes YE, Chau M, Banwell HA, Davies J, Causby RS. **Adequacy of clinical information in X-ray referrals for traumatic ankle injury with reference to the Ottawa Ankle Rules—a retrospective clinical audit.** Peer J. 2020 Oct 8; 8:e10152.

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