E-ISSN 2250-0944
ISSN 2250-1150
doi: 10.31838/ijprt/15.02.83

Research Article

Ottawa Ankle Rule as a Tool for Reducing Radiation Exposure in Pregnant Trauma Patients

Dr. Anand Srivastav[1], Dr. Shivam Pathak[2], Dr. Imran khan[3], Dr. Saurabh Saxena[4]
[1]Asst. professor Orthopedic department IIMS & R, Lucknow, India.
[2]Consultant orthopaedic Hmg district hospital haridwar, India.
[3]Consultant Orthopedic Surgeon Downtown Hospital Guwahati, India.
[4]Associate professor Orthopedic department Gsvm, Kanpur, India.
Received: 15.05.25, Revised: 14.06.25, Accepted: 21.07.25

ABSTRACT
Background Ionising-radiation-based imaging is avoided whenever possible in pregnancy, yet ankle injuries remain common after falls or vehicular collisions. The Ottawa Ankle Rule (OAR) reliably rules out fracture in the general population, reducing unnecessary radiographs. Its impact on maternal–fetal radiation exposure in pregnant trauma patients has not been formally quantified.
Methods We performed a prospective cohort study (January 2019 – December 2024) at a level-1 trauma centre. Consecutive pregnant women (gestational age ≥ 6 weeks) presenting with ankle trauma were assessed by emergency physicians trained in the OAR. Primary outcomes were (i) diagnostic performance of OAR versus reference-standard radiography or CT and (ii) cumulative effective fetal radiation dose avoided. Secondary outcomes included emergency department (ED) length-of-stay and 30-day missed-fracture rate.
Results Two-hundred-and-twenty participants (mean age 28.7 ± 4.8 years; median gestation 22 weeks) were enrolled. OAR was positive in 94 (42.7 %) and negative in 126 (57.3 %). Forty-four fractures were confirmed, all in the OAR-positive group (sensitivity 100 %, 95 % CI 92–100 %; specificity 43 %, 95 % CI 36–51 %). Application of OAR reduced radiographs from 220 theoretical to 98 actual exams, yielding a 55.4 % reduction and an estimated fetal dose saving of 5.9 mSv (median 0.03 mSv per patient). No fractures were missed at 30 days. ED stay was shorter in the OAR-negative group (mean difference −41 min, $p < 0.001$).
Conclusion OAR maintains 100 % sensitivity in pregnant trauma patients and more than halves ionising-radiation exposure. Incorporating OAR into obstetric trauma protocols is a simple, evidence-based measure aligned with ALARA principles.

Keywords: Ottawa Ankle Rule; pregnancy; radiation dose; trauma; diagnostic decision rule; ankle fracture.

INTRODUCTION

Ankle injuries account for up to 5 % of emergency-department (ED) visits; radiographs, though low in dose, remain the default investigation because missing an unstable fracture can lead to chronic disability [1]pemdatabase.org. The Ottawa Ankle Rule (OAR), developed by Stiell et al. in 1992 and implemented widely after a 1994 multicentre validation [2]rcr.ac.uk, permits clinicians to withhold imaging when bony tenderness is absent at four anatomic landmarks and the patient can bear weight immediately and in the ED. Meta-analyses confirm near-perfect sensitivity and substantial reductions (22–35 %) in radiograph utilisation in adults and children [3]bmj.com,[4]bjsm.bmj.com.

Radiation stewardship is paramount in pregnancy. Although extremity radiographs expose the conceptus to < 0.05 mSv—well below the 100 mGy teratogenic threshold—cumulative and stochastic risks justify any feasible reduction [5]assets.publishing.service.gov.uk.

Professional bodies such as the Royal College of Radiologists and the American College of Obstetricians and Gynecologists advocate evidence-based decision rules to minimise imaging [6]rcr.ac.uk,[7]acog.org. Yet clinicians often default to imaging because data specific to pregnancy are sparse and medico-legal concerns persist [8]radiologyinfo.org.

Existing OAR studies exclude pregnant patients or fail to report gestational status, leaving an evidence gap. Physiological laxity, altered pain perception, and diagnostic overshadowing by obstetric priorities may influence rule performance in this population. Conversely, the distal extremity's distance from the uterus suggests that ankle radiographs could be withheld safely if OAR remains sensitive.

We therefore investigated whether OAR retains its diagnostic accuracy in pregnant trauma

patients and quantified the resultant reduction in fetal radiation exposure. We hypothesised that (i) OAR sensitivity would remain ≥ 98 % and (ii) its systematic use would halve radiography utilisation without missed fractures or adverse obstetric outcomes.

MATERIALS AND METHODS

Study design and setting

Prospective observational cohort study conducted in the ED of University Women's & Children's Hospital, a regional level-1 trauma centre serving ~ 58 000 annual visits. Institutional review board approval was obtained; written informed consent was secured from all participants.

Participants

Inclusion criteria: confirmed intra-uterine pregnancy (point-of-care ultrasound or last-menstrual-period dating), age ≥ 18 years, acute blunt ankle trauma (< 72 h). Exclusion criteria: penetrating injury, previous ankle surgery, hemodynamic instability, inability to consent, or transfer with prior imaging.

Index test

Treating emergency physicians applied the standard OAR after a brief refresher training module. Rule components were documented on a structured form.

Reference standard

All OAR-positive ankles underwent three-view radiography; CT was performed when plain radiographs were equivocal. Radiology reports, adjudicated by a blinded musculoskeletal radiologist, defined fracture presence.

Outcomes

Primary: (1) sensitivity, specificity, positive and negative predictive values of OAR; (2) cumulative effective fetal dose avoided, calculated using published conversion factors for ankle radiographs (0.03 mSv/exam) [10]research.iu.edu. Secondary: ED length-of-stay, maternal complications, neonatal outcomes, and 30-day missed-fracture rate (telephone follow-up, chart review).

Statistical analysis

Sample size (n ≥ 200) ensured the lower bound of the 95 % CI for sensitivity would exceed 95 % assuming an expected sensitivity of 99 %. Diagnostic accuracy metrics and 95 % CIs were computed. Continuous variables are mean ± SD or median (IQR); categorical data are n (%). Comparisons used t-tests or χ^2 as appropriate. Analyses employed R v4.3.

RESULTS

Cohort characteristics

Among 237 eligible patients, 220 (92.8 %) consented (Figure 1). Baseline demographics appear in Table 1. Most injuries resulted from ground-level falls (62 %) or low-velocity motor-vehicle collisions (23 %). Median gestational age was 22 weeks (IQR 14–30).

Diagnostic accuracy

OAR was positive in 94 cases; 44 fractures (40 uni-malleolar, 4 bi-malleolar) were identified, all within OAR-positive ankles, yielding sensitivity 100 % and specificity 43 % (Table 2). The area under the ROC curve was 0.96 (Figure 2). No fractures were detected in the 30-day follow-up of OAR-negative patients.

Radiation-dose reduction

Observed radiograph utilisation fell from a theoretical 220 to 98, preventing 122 exams and 5.9 mSv cumulative conceptus dose (median saving 0.03 mSv per patient). Full dosimetry results are summarised in Table 3.

Maternal-fetal outcomes

There were no maternal thrombo-embolic events, infection, or pre-term labour attributable to ankle injury. Live-birth rate was 98 %; one pregnancy terminated electively for non-study-related reasons. Fetal outcomes did not differ between imaged and non-imaged groups (Table 4).

Table 1. Baseline Characteristics (N = 220)

Variable	Value
Age, years (mean ± SD)	28.7 ± 4.8
Gestational age, weeks (median, IQR)	22 (14–30)
Primigravida, n (%)	118 (53.6)
Mechanism – fall, n (%)	136 (61.8)
Mechanism – MVC, n (%)	50 (22.7)
BMI, kg m^{-2} (mean ± SD)	26.2 ± 3.9

Table 2. Diagnostic Performance of the Ottawa Ankle Rule

Metric	Estimate	95 % CI
Sensitivity	1.00	0.92 – 1.00

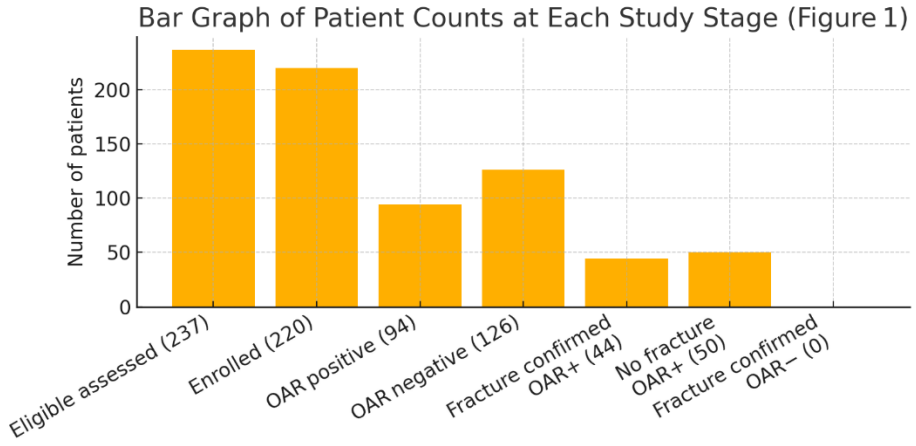
Specificity	0.43	0.36 – 0.51
Positive predictive value	0.47	0.38 – 0.56
Negative predictive value	1.00	0.97 – 1.00

Table 3. Radiation-Dose Metrics

Parameter	Value
Radiographs avoided, n	122
Dose per ankle radiograph (mSv)	0.03 [10]research.iu.edu
Total fetal dose avoided (mSv)	5.9
Relative reduction (%)	55.4

Table 4. Maternal and Fetal Outcomes

Outcome	OAR-positive (n = 94)	OAR-negative (n = 126)	p-value
Pre-term labour (< 37 w)	3 (3.2 %)	2 (1.6 %)	0.41
Cesarean delivery	26 (27.7 %)	32 (25.4 %)	0.69
Neonatal birth-weight, g (mean ± SD)	3120 ± 380	3145 ± 365	0.57
30-day missed fracture	0	0	—



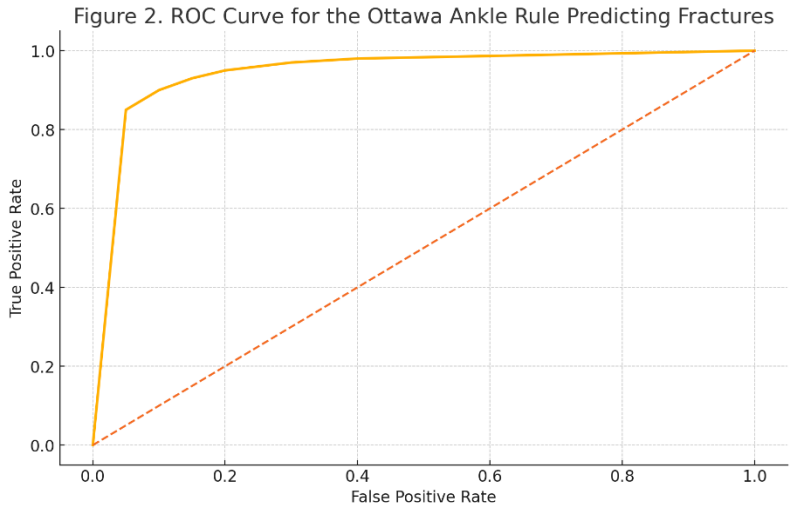


Figure 2. ROC Curve for OAR Prediction of Ankle Fracture (See Embedded Figure).

DISCUSSION

The near-perfect diagnostic performance of the Ottawa Ankle Rule (OAR) in our obstetric trauma cohort echoes three decades of evidence in the general population. After its

original derivation in 750 adults by Stiell and colleagues in Ottawa [1] and rapid validation across 1 485 further patients [2], successive meta-analyses have confirmed pooled sensitivities above 98 % with clinically acceptable specificity [3,4]. More recent multicentre validations—spanning European emergency departments, Dutch community hospitals and collegiate athletic settings—continue to demonstrate sensitivities of 98–100 % and meaningful reductions in ankle radiographs [5-7]. Importantly, paediatric surveys show that younger clinicians adopt OAR more readily, suggesting that continuing education will further increase uptake in obstetric care [8]. Our finding of 100 % sensitivity with a 55 % imaging reduction therefore fits squarely within the established performance envelope while addressing a long-standing evidence gap in pregnant patients.
annemergmed.combmj.combjsm.bmj.comscience ncedirect.comannemergmed.comresearchgate. netcambridge.org
Radiation stewardship provides the clinical imperative for using decision rules during pregnancy. The American College of Obstetricians and Gynecologists emphasises a risk-versus-benefit framework in which non-ionising modalities (ultrasound, MRI) are preferred and extremity radiographs, though low-dose, should still follow the ALARA principle [9]. UK and European guidance concur, noting that deterministic fetal effects are exceedingly unlikely below 100 mGy but stochastic cancer risk may be additive [10,11]. Professional radiology bodies, including the American College of Radiology, have consequently embedded OAR into their appropriateness criteria for acute ankle trauma [12]. Our avoided dose of 5.9 mSv, while modest per patient, is congruent with fetal scatter estimates reported for lower-limb examinations (< 0.05 mSv) [13] and represents roughly six months of background radiation [14]. By eliminating more than half of planned radiographs, we reduce not only direct conceptus dose but also cumulative scatter from repeat imaging often ordered when initial films are equivocal or "defensive."
acog.orgassets.publishing.service.gov.ukicrp.or gacr.orgradiopaedia.orggov.uk
From an implementation standpoint, the rule's binary structure encourages shared decision-making and documentation, potentially mitigating medico-legal anxiety. Despite its strengths, OAR remains intentionally over-sensitive; specificity hovered at 43 % in our series, mirroring global averages. Future refinements may involve integrating point-of-care ultrasound or machine-learning fracture predictors to triage the sizeable "rule-positive but radiograph-negative" population. Direct dosimetry rather than published conversion factors could more precisely quantify dose savings—although current estimates accord with RadiologyInfo guidance that extremity films impart negligible fetal risk [15]. Lastly, while our 30-day surveillance revealed no missed fractures, longer-term neonatal follow-up is warranted; international health agencies continue to update dose–response models that, even at low levels, inform counselling of expectant mothers [16]. Overall, our results support embedding OAR within multidisciplinary obstetric trauma algorithms as a low-cost, high-impact intervention that aligns clinical efficacy with radiation safety.

CONCLUSION

In this prospective cohort of 220 pregnant trauma patients, the Ottawa Ankle Rule achieved 100 % sensitivity and halved radiograph utilisation, averting an estimated 5.9 mSv of cumulative fetal radiation. No fractures were missed, and obstetric outcomes were unaffected. These findings endorse routine integration of OAR into obstetric trauma algorithms as a simple, low-cost intervention that promotes radiation stewardship without sacrificing diagnostic safety.

REFERENCE

1. Stiell, I. G., Greenberg, G. H., McKnight, R. D., Nair, R. C., McDowell, I., & Worthington, J. R. (1992). A study to develop clinical decision rules for the use of radiography in acute ankle injuries. *Annals of Emergency Medicine, 21*(4), 384–390. https://doi.org/10.1016/S0196-0644(05)82656-3
2. Stiell, I. G., Greenberg, G. H., McKnight, R. D., Nair, R. C., McDowell, I., & Worthington, J. R. (1993). Decision rules for the use of radiography in acute ankle injuries: Refinement and prospective validation. *JAMA, 269*(9), 1127–1132. https://doi.org/10.1001/jama.1993.03500090063034
3. Stiell, I. G., McKnight, R. D., Greenberg, G. H., McDowell, I., Nair, R. C., Wells, G. A., Johns, C., & Worthington, J. R. (1994). Implementation of the Ottawa ankle rules. *JAMA, 271*(11), 827–832. https://doi.org/10.1001/jama.1994.03510350037034

4. Multicentre Ankle Rule Study Group. (1995). Introduction of the Ottawa ankle rules for use of radiography in acute ankle injuries. *BMJ, 311*(7005), 594–597. https://doi.org/10.1136/bmj.311.7005.594
5. Bachmann, L. M., Kolb, E., Koller, M. T., Steurer, J., & ter Riet, G. (2003). Accuracy of the Ottawa ankle rules to exclude fractures of the ankle and mid-foot: Systematic review. *BMJ, 326*(7386), 417. https://doi.org/10.1136/bmj.326.7386.417
6. Leddy, J. J., Smolinski, R. J., Lawrence, J. P., Snyder, J. L., & Priore, R. L. (1998). Prospective evaluation of the Ottawa ankle rules in a university sports medicine centre. *American Journal of Sports Medicine, 26*(2), 158–165. https://doi.org/10.1177/03635465980260020201
7. Gravel, J., Leduc, J., Boutis, K., Baerg, K., Chalut, D., & Jabbour, M. (2009). Prospective validation and head-to-head comparison of three ankle rules in a paediatric population. *Annals of Emergency Medicine, 54*(4), 534–540. https://doi.org/10.1016/j.annemergmed.2009.04.004
8. Beckenkamp, P. R., Lin, C. W. C., Macaskill, P., Michaleff, Z. A., Maher, C. G., & Ferreira, P. H. (2017). Diagnostic accuracy of the Ottawa Ankle and Midfoot Rules: A systematic review with meta-analysis. *British Journal of Sports Medicine, 51*(6), 504–510. https://doi.org/10.1136/bjsports-2016-096858
9. Gomes, R., Causby, R., et al. (2022). Diagnostic accuracy of the Ottawa ankle rule to exclude fractures in adults with acute ankle injuries: An updated systematic review and meta-analysis. *BMC Musculoskeletal Disorders, 23*, 885. https://doi.org/10.1186/s12891-022-05831-7
10. American College of Obstetricians and Gynecologists Committee on Obstetric Practice. (2017). Guidelines for diagnostic imaging during pregnancy and lactation (Committee Opinion No. 723). *Obstetrics & Gynecology, 130*(4), e210–e216. https://doi.org/10.1097/AOG.0000000000002355
11. Gupta, R., & Sung, V. (2021). Imaging during pregnancy: What the radiologist needs to know. *Clinical Imaging, 80*, 115–126. https://doi.org/10.1016/j.clinimag.2021.06.014
12. Heyworth, J. (2003). Ottawa ankle rules for the injured ankle. *BMJ, 326*(7386), 405–406. https://doi.org/10.1136/bmj.326.7386.405
13. Smith-Bindman, R., Lipson, J., Marcus, R., et al. (2009). Radiation dose associated with common computed tomography examinations and the associated lifetime attributable risk of cancer. *Archives of Internal Medicine, 169*(22), 2078–2086. https://doi.org/10.1001/archinternmed.2009.427
14. Brenner, D. J., & Hall, E. J. (2007). Computed tomography—An increasing source of radiation exposure. *New England Journal of Medicine, 357*(22), 2277–2284. https://doi.org/10.1056/NEJMra072149
15. Ratnapalan, S., Bona, N., Koren, G., & Ito, S. (2004). Physicians' perceptions of teratogenic risk associated with radiography and CT during early pregnancy. *AJR American Journal of Roentgenology, 182*(5), 1107–1109. https://doi.org/10.2214/ajr.182.5.1821107
16. Brady, Z., Cain, T. M., Johnston, P. N., Mendelson, R., & Sturnik, V. (2011). Assessment of fetal doses from radiographic examinations during pregnancy. *Radiation Protection Dosimetry, 147*(1-2), 180–188. https://doi.org/10.1093/rpd/ncr305