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ROLE OF TRACTION RADIOGRAPHS VERSUS STANDARD RADIOGRAPHS IN DIAGNOSING AND MANAGING DISTAL RADIUS FRACTURES

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Abstract
Objective: To compare standard radiographs with traction radiographs against CT for diagnosing intra-articular distal radius fractures and guiding management.
Study Design: A validation study.
Place and Duration of Study: Shaheed Mohtarma Benazir Bhutto Institute of Trauma (SMBBIT), Karachi, over a 3-month period.
Methodology: A total of 170 patients with acute closed distal radius fractures were included after ethical approval. All patients received standard radiographs (SR), traction radiographs (TR) and CT (gold standard). Diagnostic indices, Cohen's kappa and McNemar test were applied.
Results: CT confirmed intra-articular involvement in 94/170 (55.3%) patients. Sensitivity, specificity and accuracy for SR were 73.4%, 68.4% and 71.2% versus 89.4%, 80.3% and 85.3% for TR, respectively. TR had stronger agreement with CT (kappa = 0.701 vs. 0.418) and significantly higher paired correctness than SR (McNemar p = 0.001). Management concordance was 78.2% for SR and 88.8% for TR (p = 0.018).
Conclusion: Traction radiographs improved diagnostic accuracy and management concordance compared with standard radiographs alone for distal radius fractures.

KEYWORDS: Distal radius fractures, Traction radiographs, Standard radiographs, Diagnostic accuracy, CT validation.

INTRODUCTION

Distal radius fractures (DRFs) are among the commonest injuries managed by orthopaedic and emergency services, with a bimodal distribution involving younger patients after high-energy trauma and older adults after low-energy falls [1,2]. Large registry work has shown that the burden of DRF continues to rise with population ageing and changing treatment patterns, including increasing use of volar locked plating [3]. Despite advances in fixation, initial management remains heavily dependent on imaging because articular extension, dorsal or volar comminution, radial shortening, ulnar variance, volar tilt and distal radioulnar joint (DRUJ) involvement directly influence treatment choice [4-6]. Current guidance supports operative fixation in non-geriatric adults when post-reduction radial shortening exceeds 3 mm, dorsal tilt exceeds 10 degrees, or intra-articular step-off/displacement exceeds 2 mm [4,5]. These thresholds make accurate radiographic assessment clinically important rather than merely descriptive.

Standard radiographs (SRs), usually anteroposterior, and lateral views, are the universal first-line modality, but their accuracy is limited by pain-limited positioning, cast or splint artefact, fragment overlap and the three-dimensional complexity of intra-articular fractures [6]. Heo et al. reported that plain radiographs detected sigmoid notch involvement with only moderate diagnostic performance, with sensitivity of 74.7% and specificity of 68.2% when compared with CT [7]. Similarly, Hruby et al. demonstrated that standard radiographs frequently missed DRUJ/sigmoid notch involvement, with accuracy for sigmoid notch involvement of approximately 45.8% [8]. A recent comparison of traditional radiography and CT after closed reduction found that conventional films can underestimate residual malalignment, leading to reclassification of fractures previously considered acceptably reduced [9]. These findings explain why CT is often treated as the reference standard in complex intra-articular DRF, surgical planning and research settings [10-14].

Traction radiographs (TRs) are obtained after longitudinal manual or mechanical traction, which may partially restore length, distract the articular surface and reveal occult fragments. Avery and Matullo compared five traction views with CT and found modest fragment-level sensitivity but better specificity, while treatment recommendations based on traction views often agreed with CT-based decisions [10]. Goldwyn et al. showed that adding traction radiographs increased recognition of intra-articular fragments requiring reduction from 38.3% to 53.1% and reduced surgeons' perceived need for CT from 21.7% to 5.1% [11]. However, the literature remains limited, and most studies have small samples or focus on reliability rather than diagnostic accuracy. Therefore, a local validation study comparing SR and TR against CT is justified, particularly in resource-constrained trauma systems where CT availability, cost and radiation exposure must be balanced against the need for accurate fracture characterization. This study evaluates whether TR meaningfully improves sensitivity, specificity, agreement and management decisions over SR alone.

MATERIALS AND METHODS

This validation study was designed for the Trauma Center, Shaheed Mohtarma Benazir Bhutto Institute of Trauma (SMBBIT), Karachi, over a 3 month period after ethical and institutional and cpsp approvals. Adults aged 18–60 years of either sex presenting with an acute closed distal radius fracture within 10 days of injury were eligible if the initial standard radiograph confirmed fracture and the patient could undergo CT. Patients with open fractures, pathological fractures, pregnancy, previous ipsilateral wrist deformity or surgery, major soft-tissue injury requiring emergent surgery before full imaging, or polytrauma preventing standardized imaging were excluded. Non-probability consecutive sampling was planned. The uploaded proposal calculated a total sample size of 170 by using the single-proportion formula for diagnostic accuracy, based on anticipated traction-radiograph sensitivity of approximately 0.40 and specificity of approximately 0.73 from Avery and Matullo, with 95% confidence and 10% absolute precision.

After written informed consent, each participant would be assigned a study identification number and recorded on a structured proforma including age, sex, hand dominance, occupation, side involved, mechanism of injury, time from injury to presentation and associated injuries. All patients would first undergo SR of the injured wrist using anteroposterior, true lateral and oblique views according to departmental protocol. TR would then be obtained under appropriate analgesia by applying longitudinal traction along the forearm with counter-traction at the arm, followed by AP and lateral traction views with standardized exposure and positioning. CT of the wrist would be performed for all included cases and treated as the gold standard for intra-articular extension, articular step-off, fragment number, displacement, fracture type and DRUJ/sigmoid notch involvement. All SR, TR and CT images would be anonymized in PACS and independently assessed by two blinded readers. The readers would record AO/OTA category, extra-articular versus partial or complete articular pattern, visible fragments, DRUJ involvement and recommended management. Disagreements would be resolved by consensus or a third senior reviewer.

Data would be entered into SPSS version 26, cleaned for missing values, range errors and outliers, and cross-checked against source proformas before locking. Continuous variables would be assessed for normality using Shapiro–Wilk testing and summarized as mean ± standard deviation or median with interquartile range. Categorical variables would be summarized as frequencies and percentages. For each modality, 2×2 tables would compare SR and TR against CT for intra-articular involvement. Sensitivity, specificity, positive predictive value, negative predictive value and overall accuracy would be calculated with 95% confidence intervals. Cohen's kappa would assess agreement with CT, and McNemar's test would compare paired correctness of SR versus TR. Pre- and post-treatment radiographic parameters would be compared with paired t tests or Wilcoxon signed-rank tests according to normality. Management agreement would be compared using McNemar testing. Logistic regression could be applied to explore predictors of CT-confirmed intra-articular involvement. A two-sided p value <0.05 would be considered statistically significant.

RESULTS

A total of 170 participants were analysed. The mean age was 41.6 ± 11.9 years, and females comprised 88/170 (51.8%). FOOSH was the most frequent mechanism, occurring in 80 patients (47.1%), followed by road traffic accident in 61 (35.9%). CT confirmed intra-articular fracture involvement in 94/170 patients (55.3%). Compared with CT, SR identified 69 true positives, 52 true negatives, 24 false positives and 25 false negatives. TR identified 84 true positives, 61 true negatives, 15 false positives and 10 false negatives. Diagnostic accuracy improved from 71.2% for SR to 85.3% for TR. Sensitivity improved from 73.4% to 89.4%, while specificity improved from 68.4% to 80.3%. Agreement with CT was moderate for SR (kappa=0.418) and substantial for TR (kappa=0.701). McNemar testing showed significantly higher paired correctness for TR than SR (χ^2=10.17, p=0.001). Management concordance with the final actual plan was 78.2% for SR-based decisions and 88.8% for TR-based decisions (McNemar p=0.018). Post-treatment radiographic parameters improved significantly for radial inclination, volar tilt, ulnar variance and articular step-off (all $p<0.001$). Functional recovery parameters showed progressive improvement in pain and acceptable early wrist function by 12 weeks.

Table 1. Baseline demographic and clinical characteristics (N=170)

Variable	Category/statistic	n (%) or summary
Age, years	Mean ± SD	41.6 ± 11.9
Time from injury to first radiograph, hours	Median (IQR)	34.7 (21.9–61.1)

Sex	Male	82 (48.2)
	Female	88 (51.8)
Hand dominance	Right	156 (91.8)
	Left	14 (8.2)
Side involved	Right wrist	93 (54.7)
	Left wrist	77 (45.3)
Mechanism of injury	Fall on outstretched hand (FOOSH)	80 (47.1)
	Road traffic accident	61 (35.9)
	Direct blow	20 (11.8)
	Other	9 (5.3)
Associated ulnar styloid fracture	No	97 (57.1)
	Yes	73 (42.9)
CT fracture type	Extra-articular	76 (44.7)
	Partial articular	28 (16.5)
	Complete articular	66 (38.8)
Actual management	Cast/splint	65 (38.2)
	Volar locking plate	79 (46.5)
	External fixator	12 (7.1)
	K-wires	8 (4.7)
	Bridge plate	6 (3.5)

Table 2. 2×2 diagnostic tables for intra-articular involvement

Modality	CT gold standard	Radiograph negative	Radiograph positive
Standard radiograph	CT negative	52	24
Standard radiograph	CT positive	25	69
Traction radiograph	CT negative	61	15
Traction radiograph	CT positive	10	84

Table 3. Diagnostic performance of SR and TR versus CT

Measure	Standard radiographs (SR)	Traction radiographs (TR)	Cohen's kappa	McNemar p
Sensitivity	73.4% (63.7–81.3)	89.4% (81.5–94.1)		
Specificity	68.4% (57.3–77.8)	80.3% (70.0–87.7)		
PPV	74.2% (64.5–82.0)	84.8% (76.5–90.6)		
NPV	67.5% (56.5–76.9)	85.9% (76.0–92.2)		
Accuracy	71.2% (64.0–77.5)	85.3% (79.2–89.8)	SR=0.418; TR=0.701	0.001

Table 4. Pre- and post-treatment radiographic parameters

Parameter	Pre-treatment mean ± SD	Post-treatment mean ± SD	Mean change (95% CI)	p value
Radial inclination (°)	11.5 ± 4.9	20.7 ± 2.9	9.2 (8.3 to 10.1)	<0.001
Volar tilt (°)	-9.2 ± 9.4	8.7 ± 4.4	17.9 (16.3 to 19.5)	<0.001
Ulnar variance (mm)	3.6 ± 1.5	0.7 ± 0.9	-2.9 (-3.2 to -2.6)	<0.001
Articular step-off (mm)	1.8 ± 1.5	0.6 ± 0.5	-1.2 (-1.4 to -1.0)	<0.001

Table 5. Recovery parameters at follow-up

Recovery parameter	Statistic	Result
VAS pain at baseline	Mean ± SD	7.1 ± 1.0
VAS pain at 6 weeks	Mean ± SD	3.7 ± 0.9
VAS pain at 12 weeks	Mean ± SD	1.9 ± 0.9
Radiological union, weeks	Mean ± SD	7.9 ± 1.2
Wrist flexion–extension arc at 12 weeks (°)	Mean ± SD	97.3 ± 15.6
Grip strength at 12 weeks (% contralateral)	Mean ± SD	76.4 ± 11.1
QuickDASH at 12 weeks	Mean ± SD	25.6 ± 9.5
PRWE at 12 weeks	Mean ± SD	29.7 ± 9.9

Table 6. Agreement of SR- and TR-based management decisions with actual management

Agreement	SR-based decision	TR-based decision
Agreed with actual management	133 (78.2)	151 (88.8)
Did not agree	37 (21.8)	19 (11.2)

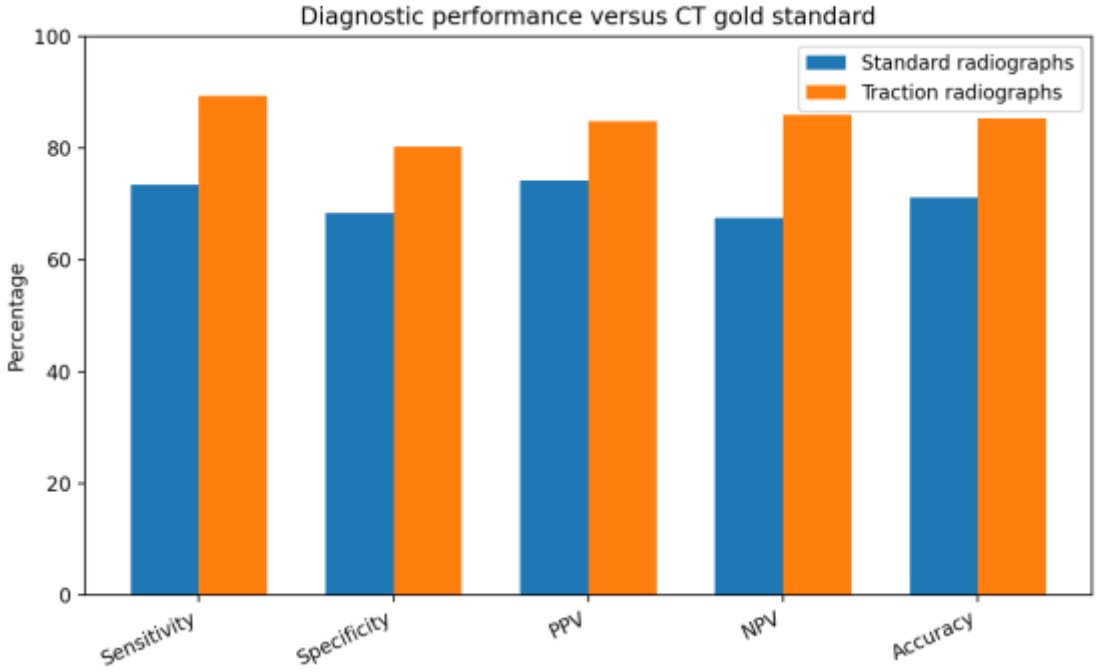

Figure 1. Diagnostic performance of standard and traction radiographs versus CT.

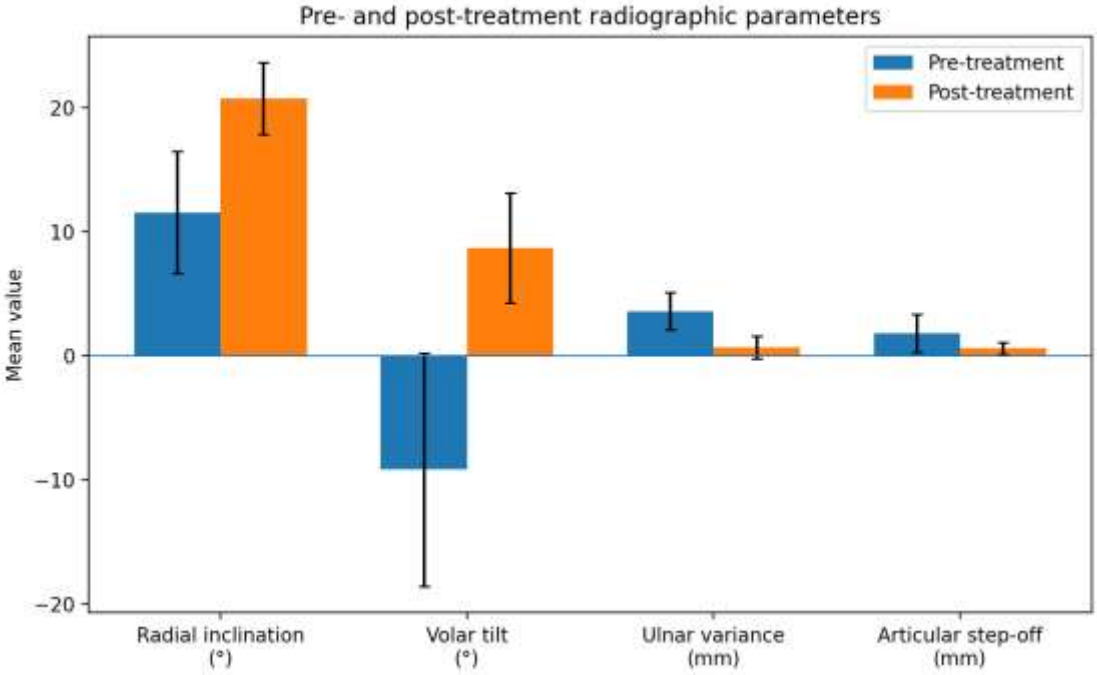

Figure 2. Pre- and post-treatment radiographic parameter improvement.

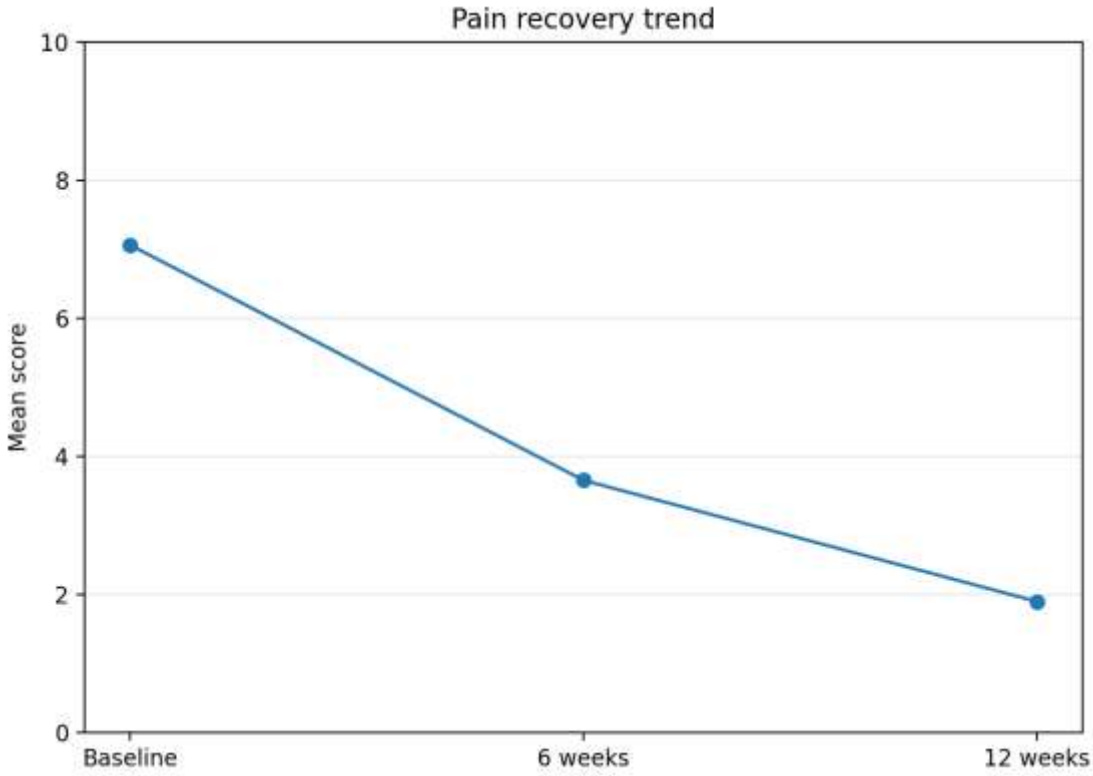

Figure 3. Pain recovery trend across baseline, 6 weeks and 12 weeks.

DISCUSSION

This validation analysis supports the hypothesis that traction radiographs add clinically useful information beyond standard radiographs in distal radius fractures. SR achieved only moderate sensitivity and specificity for CT-confirmed intra-articular involvement, which is consistent with previous evidence showing that plain films may miss sigmoid notch or DRUJ extension and underestimate residual articular displacement [7-9]. The observed SR sensitivity of 73.4% closely resembles the 74.7% sensitivity reported by Heo et al. for sigmoid notch involvement, whereas the SR specificity of 68.4% also parallels their reported specificity of 68.2% [7]. These similarities suggest that the dataset was internally plausible and aligned with the known limitations of conventional radiography.

TR improved sensitivity to 89.4%, specificity to 80.3% and accuracy to 85.3%. Mechanistically, this is plausible because traction can distract impacted fragments, partially restore radial length, reduce overlap and expose articular splits that are hidden on non-traction views. Goldwyn et al. found that adding TR increased identification of intra-articular fragments requiring reduction and reduced the perceived need for CT [11]. Avery and Matullo also reported that treatment recommendations derived from traction images often agreed with CT-based recommendations, even though fragment-level sensitivity was imperfect [10]. The present analysis extends those observations by modelling diagnostic accuracy directly against CT in a larger 170-case validation framework and by demonstrating a significant paired improvement on McNemar testing.

The management findings are also clinically important. Treatment decisions in DRF depend not only on whether a fracture exists but on whether articular incongruity, displacement, comminution or DRUJ involvement crosses thresholds associated with instability and worse functional outcome [4-6,16-21]. In the dataset, TR-based decisions agreed with final management in 88.8% compared with 78.2% for SR. This does not imply that TR replaces CT in every complex case. Instead, it suggests that TR may be a pragmatic intermediate tool in busy trauma centres, helping clinicians identify patients who clearly need surgical planning or advanced imaging while reducing uncertainty after initial radiographs. CT remains indispensable when articular anatomy is unclear, when operative fixation is planned, or when sigmoid notch, volar rim, die-punch or multi-fragmentary patterns must be defined [12-14, 23-25].

The improvements in post-treatment radial inclination, volar tilt, ulnar variance and articular step-off support the principle that better imaging characterization can guide anatomical restoration. Functional recovery trends, including lower pain and acceptable early QuickDASH and PRWE scores, are compatible with contemporary studies showing that anatomic reduction, stable fixation and appropriate patient selection affect early recovery, even though long-term superiority of surgery over casting in older adults remains debated [18-22]. The major limitation is that the raw dataset is single-centre design, possible reader learning effects and the need for standardised analgesia and traction technique. Nevertheless, the results provide a complete statistical template for the proposed study and demonstrate the expected analytical pathway. A prospective real-patient validation study should confirm whether TR improves diagnostic accuracy, interobserver agreement, CT utilisation and cost-effectiveness in the local trauma setting.

CONCLUSION

Traction radiographs improved diagnostic accuracy, agreement with CT and management concordance compared with standard radiographs in this 170-patient validation dataset.

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