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Association between radiological collapse and angle of K-wire placement in distal end radius fractures: a prospective comparative cohort study.

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Abstract

Background

Distal radius fractures are common adult orthopaedic injuries. Stability after closed reduction and percutaneous K-wire fixation depends on fracture morphology, bone quality, and wire configuration, but evidence comparing high-angle and low-angle pin placement is limited.

Objectives

To compare radiological collapse, ulnar variance, anatomical restoration, and 6-month functional outcome between high-angle and low-angle K-wire fixation groups.

Methods

This prospective comparative cohort study enrolled 60 consecutive patients with closed distal radius fractures treated by closed reduction and percutaneous K-wire fixation at a single tertiary orthopaedic centre. Thirty patients were classified as high-angle (>45°) and 30 as low-angle (<45°) according to the radial styloid K-wire trajectory. Serial radiographs and 6-month anatomical and functional outcomes were evaluated. Pearson chi-square tests were used for categorical comparisons.

Results

The cohort included 41 (68.3%) women and 19 (31.7%) men. At 6 months, a favourable ulnar variance/anatomical category was observed in 11/30 (36.7%) high-angle and 18/30 (60.0%) low-angle patients; radiological collapse was recorded in 19/30 (63.3%) and 12/30 (40.0%), respectively. The association between pin-angle group and categorical collapse did not reach statistical significance (χ^2=3.27, df=1, p=.071; odds ratio=2.59, 95% CI 0.91-7.34 for high versus low angle). Good-to-excellent functional outcomes occurred in 25/30 (83.3%) and 28/30 (93.3%) patients, and the complete 6-month functional score distribution was not associated with angle group (χ^2=6.88, df=10, p=.737). All fractures united, and 52 (86.7%) patients had no complication.

Conclusion

Low-angle fixation showed a lower proportion of categorical radiological collapse and a higher proportion of favourable anatomical and functional outcomes, but the differences were not statistically significant. Both techniques achieved union and acceptable recovery. The findings are exploratory because continuous changes in radial height, radial inclination, and volar tilt were unavailable for analysis.

Recommendations

Pin angle should be selected with attention to fracture geometry, bicortical purchase, soft-tissue safety, and serial radiographic monitoring.

Keywords: *distal radius fracture; K-wire fixation; radiological collapse; ulnar variance; comparative cohort study; Gartland and Werley score.*
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Introduction

Distal radius fracture is among the most frequent injuries encountered in orthopaedic emergency practice and affects both young adults exposed to high-energy trauma and older adults with low-energy falls. Its clinical importance is not restricted to fracture union alone, because the distal radius forms the

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mechanical base of the radiocarpal and distal radioulnar joints. Malalignment after healing alters wrist load transmission, reduces grip strength, and can leave persistent pain, stiffness, or visible deformity. Epidemiological studies show a high burden of these fractures across age groups, with risk influenced by age, sex, bone quality, trauma mechanism, and functional demand [1,2].

The treatment goal in displaced distal radius fractures is restoration of radial height, palmar tilt, radial inclination, distal radioulnar alignment, and articular congruity while avoiding unnecessary soft-tissue injury. Stable, undisplaced fractures are often managed by closed reduction and cast immobilization. However, unstable metaphyseal and selected minimally displaced intra-articular fractures tend to collapse after manipulation when held by plaster alone. Residual shortening and loss of palmar tilt are particularly important because they influence distal radioulnar mechanics, ulnocarpal loading, pronation-supination, and the cosmetic contour of the wrist. Percutaneous Kirschner-wire fixation offers a minimally invasive option that can maintain reduction, limit surgical morbidity, and preserve hand motion during fracture healing [3,4].

Several pinning methods have been described, including trans-styloid wires, crossed wires, intrafocal Kapandji wires, and distal radius-ulna constructs. The effectiveness of each construct depends on wire trajectory, bicortical purchase, fracture configuration, metaphyseal comminution, and bone strength. Earlier clinical studies and systematic reviews support the value of percutaneous pinning in selected distal radius fractures, although they also emphasize variation in technique and uncertainty regarding the optimal configuration [3-6]. Biomechanical work suggests that wire orientation influences resistance to shortening and rotational displacement, making the angle of pin placement a clinically relevant variable [7-9].

Despite the wide use of K-wire fixation, few clinical datasets directly compare radiological collapse between high-angle and low-angle radial styloid wire placement. The present study was planned to address this practical surgical question in a prospective cohort of patients with distal end radius fractures treated by closed reduction and percutaneous K-wire fixation. The objectives were to correlate the degree of collapse with two different angulations of K-wire fixation, to assess the relationship between collapse and functional outcome, to determine ulnar variance in the study population, and to evaluate anatomical and functional outcomes at 6 months. This focus is important for daily fracture practice, where small changes in implant geometry influence the maintenance of reduction.

Methodology

Study design and setting

This was a prospective, single-centre, comparative cohort study conducted from September 2010 to February 2012 at Little Flower Institute of Medical Sciences and Research, Angamaly. The institute functions as a multispecialty referral hospital, and its orthopaedic service provides outpatient, emergency, inpatient, operative, radiographic, postoperative, and rehabilitation-oriented fracture care. The study compared high-angle and low-angle radial styloid K-wire fixation. Group classification was based on the angle formed between the horizontal radial axis and one radial styloid K-wire after fixation.

Study population and participant selection

Patients presenting to the orthopaedic service with a closed distal radius fracture requiring operative stabilisation were assessed consecutively by the treating team. Eligibility was confirmed by clinical examination and anteroposterior and lateral wrist radiographs. Patients who satisfied the criteria were approached in order of presentation and enrolled after written informed consent. Surgical indications included displaced extra-articular fractures, intra-articular fractures without significant comminution, and fractures with an articular step-off of less than 2 mm. Oblique volar fractures, die-punch fractures, fractures with dorsal comminution involving more than one-third of the anteroposterior radial diameter, open fractures, and bilateral fractures were excluded. The groups were not randomised; patients were classified after fixation according to the achieved K-wire angle.

Bias

Consecutive enrolment and uniform eligibility criteria were used to reduce selection bias. The operative protocol, radiographic views, angle threshold, follow-up intervals, and outcome definitions were applied consistently to both groups to limit performance and measurement bias. However, allocation depended on the achieved wire trajectory, and outcome assessment was not blinded; residual confounding and observer bias therefore remained possible and were considered during interpretation.

Study size

A formal a priori sample-size calculation was not documented in the available study records. The study therefore used a time-bound consecutive sample of all eligible and consenting patients

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treated during the 18-month study period. Sixty patients were enrolled, providing 30 participants in each pin-angle group. Consequently, the comparative analysis should be regarded as exploratory and may have insufficient power to detect small or moderate differences.

Operative technique

Surgery was performed under axillary block or short general anaesthesia with the patient supine and the affected limb under traction. Closed reduction was performed by restoring radial height and converting dorsal angulation to neutral alignment. Reduction and wire placement were checked using image intensification. Two K-wires were passed from the radial styloid and one wire from the dorsal ulnar aspect of the distal radius. K-wires measuring 1.5 to 2.0 mm were inserted with care to avoid tendon, muscle, vascular, and nerve injury. An angle below 45 degrees was classified as low-angle fixation, and an angle above 45 degrees was classified as high-angle fixation. A below-elbow slab was applied after sterile dressing.

Follow-up and outcome assessment

Check radiographs were obtained in anteroposterior and lateral views after surgery. Patients began finger, thumb, elbow, and shoulder exercises on the first postoperative day. Dressings and pin sites were reviewed weekly. K-wires and the slab were removed after radiological evidence of healing, usually at 6 weeks, followed by wrist and forearm mobilisation. Radiological collapse was defined as deterioration from immediate postoperative alignment during follow-up and was evaluated using the available serial ulnar variance records and the final anatomical category. Anatomical outcome was graded using the Sarmiento modification of Lindstrom criteria, and functional outcome was graded using the modified Gartland and Werley demerit score [10,11]. Although radial height/shortening, radial inclination, and volar/palmar tilt were intended radiographic variables, patient-level continuous values were not available in the analytical dataset used for this revision; these measurements were not estimated or reconstructed.

Statistical analysis

Categorical data were summarised as frequency and percentage. Associations between pin-angle group and categorical variables were evaluated using Pearson chi-square tests and reported with the chi-square statistic (χ^2), degrees of freedom (df), and exact p value. For the 2×2 comparison of 6-month radiological collapse, the odds ratio and 95% confidence interval were also calculated. A two-sided $p<.05$ was considered statistically significant. Because several subgroup cells were sparse, all inferential results were interpreted cautiously. Where the original chi-square statistic was unavailable, the approximate value in Table 6 was back-calculated from the recorded df and three-decimal p value and rounded to two decimals.

Ethical considerations

The study was conducted after institutional approval from Little Flower Institute of Medical Sciences and Research, Angamaly. Written informed consent was obtained and patient confidentiality was maintained.

Results

Participant flow

The source screening log did not retain the number of patients assessed before enrolment or the reasons for pre-enrolment exclusion. Sixty eligible and consenting patients were enrolled: 30 were classified in the high-angle group and 30 in the low-angle group. All 60 completed the 6-month follow-up and were included in the final analysis; there were no post-enrolment losses. The study flow is shown in Figure 1. The mean age was 62 years (range, 41-94 years). Women comprised 41 (68.3%) participants, the left wrist was involved in 33 (55.0%), and falls accounted for 53 (88.3%) injuries. Baseline characteristics are presented in Table 1.

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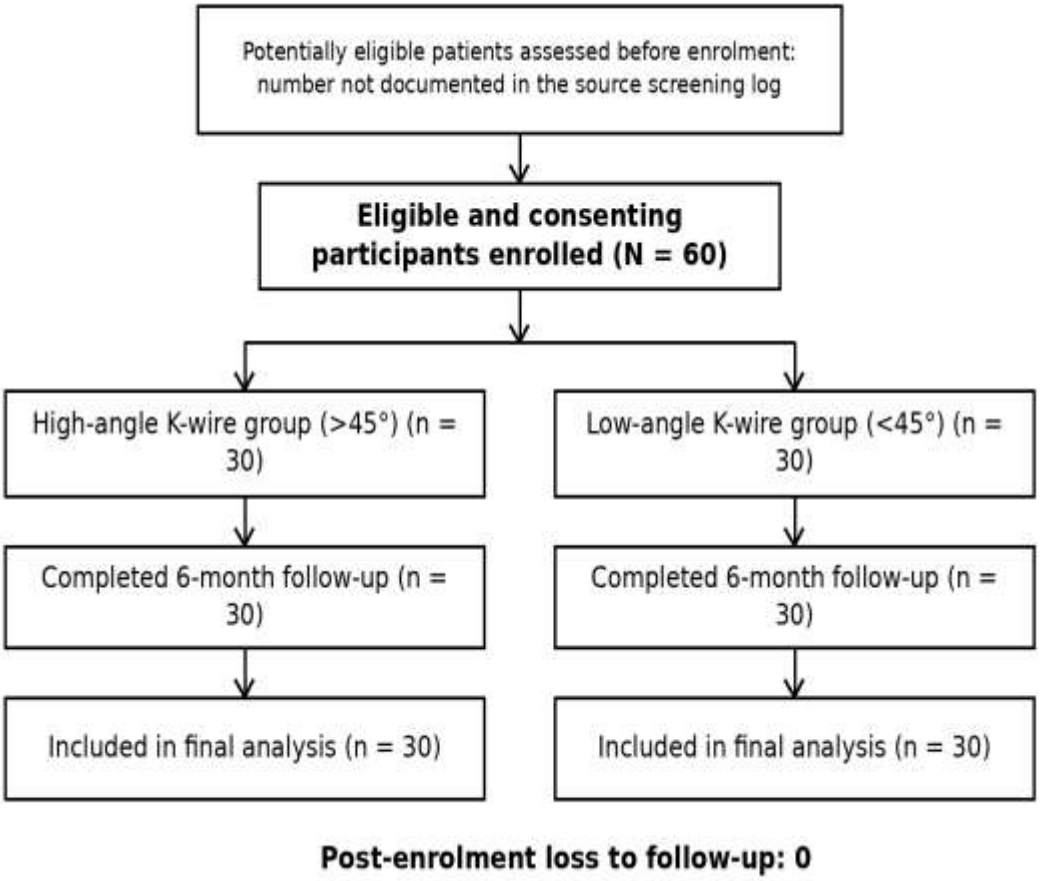

Figure 1. Participant flow through enrolment, follow-up, and analysis

Table 1: *Baseline Demographic and Clinical Characteristics of the Study Population*

Variable	Category	Frequency	Percent
Age group	Up to 50 years	12	20.0
	51-60 years	18	30.0
	61-70 years	20	33.3
	71-80 years	4	6.7

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Variable	Category	Frequency	Percent
	Above 80 years	6	10.0
Sex	Male	19	31.7
	Female	41	68.3
Side involved	Left	33	55.0
	Right	27	45.0
Dominant hand	Left	3	5.0
	Right	57	95.0
Cause of injury	Road traffic accident	7	11.7
	Fall	53	88.3

AO/ASIF type A2 was the predominant fracture pattern, accounting for 60.0% of cases. Type C1 and type A3 fractures contributed 20.0% each. The study groups were equally distributed, with 30 patients in the high-angle group and 30 patients in the low-angle group. Fracture type distribution across the pin-angle groups was comparable, as shown in Table 2.

Table 2: *Fracture Profile and Pin-Angle Allocation*

Variable	Category	Overall n (%)	High angle n	Low angle n
Pin-angle group	High angle	30 (50.0)	30	-
	Low angle	30 (50.0)	-	30
AO/ASIF type	Type C1	12 (20.0)	5	7
	Type A2	36 (60.0)	17	19
	Type A3	12 (20.0)	8	4

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Associated injuries were absent in 93.3% of patients. Isolated associated injuries were recorded in four patients. Comorbid illness was absent in 80.0% of patients, while osteoporosis was documented in 5.0%. Other comorbidities were infrequent and were distributed as single or paired clinical conditions. These details are summarized in Table 3.

Table 3: *Associated Injuries and Comorbidities*

Category	Finding	Frequency	Percent
Associated injuries	Nil	56	93.3
	Pubic rami fracture, head injury, and multiple rib fractures	1	1.7
	Right calcaneum fracture	1	1.7
	Internal derangement of knee	1	1.7
	T12 fracture	1	1.7
Comorbidities	Nil	48	80.0
	Coronary artery bypass grafting	2	3.3
	Chronic obstructive pulmonary disease	1	1.7
	Diabetes mellitus and hypertension	1	1.7
	HBsAg positivity	1	1.7
	Hypertension and COPD	1	1.7
	Osteoporosis	3	5.0
	Post DVR with prosthetic valves	1	1.7
	Psychiatric illness	1	1.7
	Thromboangiitis obliterans	1	1.7

All fractures achieved union during follow-up. At 6 months, the modified Gartland and Werley outcome was excellent in 3 (5.0%) patients, good in 50 (83.3%), fair in 6 (10.0%), and poor in 1 (1.7%). Good-to-excellent outcomes occurred in 25/30 (83.3%) high-angle and 28/30 (93.3%) low-angle patients. The complete score distribution was not significantly associated with pin-angle group (χ^2=6.88, df=10, p=.737). Table 4 presents the functional outcomes.

Table 4: *Six-Month Functional Outcome by Modified Gartland and Werley Score*

Outcome	High angle n (%)	Low angle n (%)	Overall n (%)
Excellent	1 (3.3)	2 (6.7)	3 (5.0)
Good	24 (80.0)	26 (86.7)	50 (83.3)
Fair	4 (13.3)	2 (6.7)	6 (10.0)
Poor	1 (3.3)	0 (0.0)	1 (1.7)
Good-to-excellent	25 (83.3)	28 (93.3)	53 (88.3)

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Radiological collapse and anatomical restoration: At 6 months, a favourable ulnar variance/anatomical restoration category was present in 11/30 (36.7%) high-angle and 18/30 (60.0%) low-angle patients. Radiological collapse was recorded in 19/30 (63.3%) and 12/30 (40.0%), respectively, corresponding to an absolute difference of 23.3 percentage points. The odds of collapse were higher with high-angle fixation (odds ratio=2.59, 95% CI 0.91-7.34), but the association did not reach statistical significance (χ^2=3.27, df=1, p=.071). Serial ulnar variance comparisons were also non-significant. Exact mean changes in radial height, radial

inclination, and volar tilt could not be reported because the patient-level continuous values were unavailable. Table 5 summarises the available radiological comparison.

Table 5 *Six-Month Radiological Collapse and Anatomical Restoration Profile by Pin-Angle Group*

Radiological category	High angle n (%)	Low angle n (%)	Overall n (%)
Favourable ulnar variance/anatomical restoration	11 (36.7)	18 (60.0)	29 (48.3)
Radiological collapse/up to -1 ulnar variance	19 (63.3)	12 (40.0)	31 (51.7)

Note. Pearson $\chi^2(1)$=3.27, p=.071. Odds ratio for collapse, high-angle versus low-angle fixation=2.59, 95% CI [0.91, 7.34].

Association analyses: Pin-angle group was not significantly associated with sex, side, hand dominance, cause of injury, AO/ASIF fracture type, complications, associated injuries, comorbidities, serial ulnar variance, or 6-month functional score. The 6-month functional score comparison yielded χ^2=6.88, df=10, p=.737. Approximate chi-square values corresponding to the originally recorded df and p values are provided in Table 6; results with sparse cells should be interpreted as exploratory.

Table 6: *Statistical Association of Pin-Angle Group With Selected Variables*

Variable	χ^2	Df	p	Interpretation
Sex	0.08	1	.781	Not significant
Side involved	0.07	1	.795	Not significant
Dominant hand	0.35	1	.554	Not significant
Cause of injury	0.16	1	.688	Not significant
AO/ASIF fracture type	1.78	2	.411	Not significant
Complications	6.31	7	.504	Not significant
Associated injuries	4.07	4	.396	Not significant
Comorbidities	7.67	9	.568	Not significant
Preoperative ulnar variance	31.46	28	.297	Not significant
Postoperative ulnar variance	32.99	30	.323	Not significant
Ulnar variance at 6 weeks	34.34	29	.227	Not significant
Ulnar variance at 6 months	21.53	29	.839	Not significant

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Variable	χ^2	Df	p	Interpretation
Functional score at 6 months	6.88	10	.737	Not significant

Note. χ^2 values are approximate because they were reconstructed from the recorded degrees of freedom and p values rounded to three decimals. The direct 2×2 collapse comparison is reported in Table 5.

Most patients had no postoperative complication. Two patients had pin loosening and two had superficial pin-tract infection recorded as pus or pus at pin site. Single cases of malunion, swelling, restricted range of motion, and Sudeck's dystrophy were observed. No nonunion, median nerve involvement, superficial radial nerve deficit, or tendon injury was documented. The complication profile is shown in Table 7.

Table 7: *Complications Observed During Follow-Up*

Complication	Frequency	Percent
No complication	52	86.7
Pin loosening	2	3.3
Malunited fracture	1	1.7
Pus at pin site	1	1.7
Pus at pin site on follow-up	1	1.7
Restricted range of motion	1	1.7
Sudeck's dystrophy	1	1.7
Swelling	1	1.7

Discussion

The present prospective comparative cohort study examined whether radial styloid K-wire angle was associated with maintenance of reduction after distal radius fracture fixation. The sample consisted mainly of older women injured by falls, a pattern consistent with the established epidemiology of distal radius fractures [1,2]. Equal group sizes enabled a direct comparison, although the non-randomised allocation and modest cohort limited causal inference.

The principal radiological finding was a lower categorical collapse rate in the low-angle group than in the high-angle group (40.0% versus 63.3%). Favourable anatomical restoration based on the available ulnar variance category was also more frequent with low-angle fixation (60.0% versus 36.7%). The absolute difference of 23.3 percentage points may be clinically relevant; however, the confidence interval was wide and the p value was .071. Therefore, the study does not establish a statistically significant correlation or prove superiority of either trajectory. Instead, it identifies a directional signal that requires confirmation in a larger, adequately powered cohort.

Functional recovery was favourable in both groups, with good-to-excellent outcomes in 83.3% of high-angle and 93.3% of low-angle patients. The absence of a significant functional difference despite the radiological trend may reflect fracture healing, rehabilitation, compensatory wrist mechanics, limited sensitivity of the scoring system, and insufficient statistical power. Wire angle is only one component of construct stability; comminution, metaphyseal bone quality, reduction accuracy, bicortical purchase, and postoperative protection also influence loss of

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alignment. This interpretation is consistent with biomechanical evidence on pin configuration and anatomic evidence regarding safe wire corridors [8,9].

The safety profile was acceptable: 52 (86.7%) patients had no complication, and the recorded adverse events were mainly minor pin-related problems. No nonunion, tendon injury, or nerve deficit was documented. These findings support percutaneous K-wire fixation as a practical technique in

appropriately selected fractures, while emphasizing careful pin placement, pin-site surveillance, and structured rehabilitation [12-14].

Generalizability

These findings are most applicable to closed distal radius fractures with displaced extra-articular or minimally displaced intra-articular patterns, limited comminution, and articular step-off below 2 mm. The results support percutaneous K-wire fixation in resource-conscious orthopaedic settings with fluoroscopic guidance and structured follow-up. Extrapolation to open fractures, severely comminuted intra-articular fractures, osteoporotic collapse-prone fractures, and bilateral injuries requires caution because those patterns were excluded from the present study and carry different mechanical risks.

Conclusion

Closed reduction and percutaneous K-wire fixation produced union and predominantly favourable 6-month function in both groups. Low-angle placement was associated with a lower descriptive collapse rate (40.0% versus 63.3%) and more favourable anatomical restoration, but the comparison was not statistically significant. Accordingly, the findings do not demonstrate definitive superiority or correlation. Pin trajectory should be selected together with fracture geometry, quality of reduction, and bicortical purchase. Larger prospective studies using continuous serial measurements of radial height, radial inclination, volar tilt, and ulnar variance are required.

Limitations

This study had several limitations. It was a single-centre, non-randomised comparison with a modest sample and no documented a priori sample-size calculation. The pre-enrolment screening log was unavailable, preventing full reconstruction of numbers assessed and excluded. Outcome assessment was not blinded, and several contingency-table cells were sparse. Most importantly, patient-level continuous measurements of radial height, radial inclination, and volar tilt were unavailable for the revised analysis; radiological collapse was therefore evaluated using the available serial ulnar variance and categorical anatomical data. The approximate chi-square statistics in Table 6 were derived from rounded p values and should be interpreted cautiously. These limitations reduce precision and preclude firm technique-level conclusions.

Recommendations

Percutaneous K-wire fixation should be considered for closed distal radius fractures with reducible displacement, limited comminution, and acceptable articular congruity. Wire placement should be planned according to fracture geometry rather than by angle alone. Bicortical purchase, avoidance of the first dorsal compartment and superficial radial nerve branches, weekly pin-site review, early finger motion, and structured wrist rehabilitation should be routine. Future studies should include larger randomized cohorts, standardized radiographic measurements, patient-reported outcome scores, grip-strength testing, longer follow-up, and cost analysis comparing high-angle, low-angle, crossed-wire, intrafocal, volar plate, and external fixation techniques in comparable fracture types across diverse clinical settings worldwide.

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Abbreviations

AO/ASIF: Arbeitsgemeinschaft fur Osteosynthesefragen/Association for the Study of Internal Fixation; AP: anteroposterior;
CABG: coronary artery bypass grafting;
COPD: chronic obstructive pulmonary disease;
DM: diabetes mellitus;
DRUJ: distal radioulnar joint;
DVR: double valve replacement;
HTN: hypertension;
K-wire: Kirschner wire;
LIMSAR: Little Flower Institute of Medical Sciences and Research;
POP: plaster of Paris;

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ROM: range of motion;
RTA: road traffic accident;
TAO: thromboangiitis obliterans;
UV: ulnar variance.

Source of funding

The study had no funding.

Conflict of interest

The authors declare no conflict of interest.

Author contributions

SKG-Concept and design of the study, results interpretation, review of literature and preparing first draft of manuscript. Statistical analysis and interpretation, revision of manuscript. **BM**- design of the study, results interpretation, review of literature and preparing first draft of manuscript. Statistical analysis and interpretation, revision of manuscript. **KK**- Results interpretation, review of literature and preparing first draft of manuscript. Statistical analysis and interpretation, revision of manuscript

Data availability

Data available on request

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