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Original Research Article

Functional Outcome of Distal Tibiofibular Syndesmotic Injuries Associated with Ankle Injuries Treated by Syndesmotic Screw

Harshad Suresh Patil[1], Gopal Yadav[2], Manish Attri[3], Rajeev Anand[4], Dhruvilsinh Mayurdhwasinh Gohil[5], Milind Mahendra Chaudhari[6], Kapil Kathuria[7]

[1]Postgraduate Resident (PG 3rd Year), Department of Orthopaedics, Santosh Medical College & Hospital, Delhi NCR, India

[2]Professor and Head of Department, Department of Orthopaedics, Santosh Medical College & Hospital, Delhi NCR, India

[3]Assistant Professor, Department of Orthopaedics, Santosh Medical College & Hospital, Delhi NCR, India

[4]Professor, Department of Orthopaedics, Santosh Medical College & Hospital, Delhi NCR, India

[5]Postgraduate Resident (PG 3rd Year), Department of Orthopaedics, Santosh Medical College & Hospital, Delhi NCR, India

[6]Postgraduate Resident (PG 3rd Year), Department of Orthopaedics, Santosh Medical College & Hospital, Delhi NCR, India

[7]Postgraduate Resident (PG 3rd Year), Department of Orthopaedics, Santosh Medical College & Hospital, Delhi NCR, India

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Corresponding Author: Dr. Harshad Suresh Patil

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Abstract

Background: Distal tibiofibular syndesmotic injuries associated with ankle fractures threaten mortise stability and, when inadequately treated, predispose to post-traumatic osteoarthritis and functional impairment. Syndesmotic screw fixation is the most widely employed stabilization strategy, yet comparative evidence from prospective Indian cohorts remains limited.

Aim: To assess the functional and radiological outcomes of distal tibiofibular syndesmotic injuries associated with ankle fractures treated with syndesmotic screw fixation versus without syndesmotic fixation.

Methods: A prospective clinical comparative study was conducted at the Department of Orthopaedics, Santosh Medical Hospital, Ghaziabad, enrolling 82 patients (aged 20–60 years) with ankle fractures and confirmed syndesmotic injury. Patients were allocated to a syndesmotic screw group (n=41) or a no-screw group (n=41). Radiological outcomes (tibiofibular clear space, tibiofibular overlap, medial clear space), functional recovery (AOFAS ankle-hindfoot score), pain (VAS), and rehabilitation milestones were assessed at immediate post-operative, 6, 8, 12 weeks, and 6 months.

Results: Both groups were comparable at baseline. The screw group showed significantly better post-operative radiological alignment: tibiofibular clear space (4.93 ± 1.18 vs 6.04 ± 1.05 mm; $p < 0.001$), tibiofibular overlap (6.05 ± 1.02 vs 5.34 ± 0.95 mm; $p = 0.002$), and medial clear space (3.39 ± 0.99 vs 4.24 ± 1.08 mm; $p < 0.001$). Anatomic/near-anatomic reduction was achieved in 66.7% of the screw group versus 24.4% in the no-screw group ($p < 0.001$). Mean 6-month AOFAS scores were 91.5 ± 4.29 (screw) versus 86.5 ± 6.08 (no-screw), with 65.9% achieving excellent outcomes in the screw group compared with 31.7% in the no-screw group ($p = 0.003$). The screw group attained full weight bearing significantly earlier (8.60 ± 1.11 vs 9.24 ± 1.21 weeks; $p = 0.013$). Multivariable regression identified syndesmotic screw fixation as an independent predictor of higher 6-month AOFAS scores (B=5.63, $p < 0.001$).

Conclusion: Syndesmotic screw fixation provides superior mortise restoration and significantly improved functional outcomes without increasing operative burden. Accurate syndesmotic stabilization is essential for patients with ankle fractures associated with syndesmotic injury.

Keywords: Distal Tibiofibular Syndesmosis; Ankle Fractures; Syndesmotic Screw; AOFAS Score; Functional Outcome; Syndesmotic Instability.

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Introduction

Ankle fractures are among the most common orthopaedic injuries, resulting predominantly from rotational forces applied to a weight-bearing joint. Their clinical significance extends beyond bony disruption; fracture patterns frequently compromise the distal tibiofibular syndesmosis, with potentially far-reaching consequences for ankle mortise stability and long-term function. The terms functional outcome, pain, and return to activities—quantified using validated scales—define the clinical end-point against which operative strategies are benchmarked.[1] Rotational ankle fractures are a major substrate for soft-tissue damage, particularly to the syndesmosis, making precise diagnosis and stabilization central to preserving joint mechanics.[2]

The distal tibiofibular syndesmosis is a fibrous articulation between the distal tibia and fibula, stabilized by the anterior inferior tibiofibular ligament (AITFL), posterior inferior tibiofibular ligament (PITFL), interosseous ligament, and interosseous membrane.[4] Disruption of these restraints leads to diastasis that compromises mortise stability. If untreated, pathologic separation alters load transfer across the ankle and predisposes to cartilage degeneration. Anatomic reduction is therefore the therapeutic priority.[5] Syndesmotic injury typically results from external rotation of the talus, often with dorsiflexion, which tensions the AITFL and interosseous complex. Clinical recognition of this mechanism guides intraoperative tests and fixation choices, as subtle diastasis may be missed on routine radiographs without targeted evaluation.[3]

From an epidemiological perspective, ankle fractures are common in the working-age population, with a significant proportion involving the syndesmosis. Juto et al. documented an incidence of 179 ankle fractures per 100,000 person-years in a Swedish county series, with marked age-related variation in fracture patterns.[7] In India, the Shukla et al. study from central India highlighted road traffic accidents (46.85%) as the dominant mechanism and demonstrated seasonal variation in ankle and foot injuries.[10] Giddi et al., reporting from Andhra Pradesh, documented an incidence of approximately 137 ankle fractures per 100,000 individuals per year in the Indian setting.41 These population-level data underscore the magnitude of the clinical problem and the need for standardized, reproducible treatment protocols.

Radiological assessment of the syndesmosis relies on tibiofibular clear space, tibiofibular overlap, and medial clear space measured on anteroposterior, lateral, and mortise radiographs. Standard thresholds have been established, but systematic reviews have highlighted the limited reliability of plain radiographic parameters for detecting subtle malreduction, creating a diagnostic challenge.[12] This uncertainty reinforces the importance of intraoperative stress testing and, in equivocal cases, computed tomography to confirm reduction adequacy.[15,16] A major controversy in the field concerns whether syndesmotic screws should be routinely removed. Desouky et al. conducted a systematic review concluding that current evidence does not support systematic removal, as most studies fail to demonstrate functional benefit from routine extraction.[13]

Contemporary evidence consistently identifies anatomic reduction of the incisura fibularis and fibular position as the strongest modifiable predictor of function after syndesmotic injury.[17,34] Technical variability in clamp position, screw trajectory, and fixation timing can influence malreduction rates; meticulous technique and intraoperative verification are therefore central to outcome quality.[17] Comparative studies between rigid screw fixation and dynamic suture-button constructs have shown broadly similar patient-reported functional scores at short- to mid-term follow-up, but suture-button devices demonstrated lower malreduction rates and fewer hardware-related complications.36 Nevertheless, in resource-constrained settings and high-volume trauma centres, the syndesmotic screw remains the most widely employed fixation method due to familiarity, cost-effectiveness, and reproducibility.[66,42]

Post-traumatic osteoarthritis (PTOA) represents the most feared long-term sequela of inadequate syndesmotic stabilization; malreduction and joint incongruity escalate contact stresses, accelerating cartilage wear.[19,20] Biomechanical studies have demonstrated that even millimetric malalignment of the fibula produces disproportionate pressure changes at the tibiotalar interface.[21,62] Conversely, when the mortise is accurately restored, load distribution normalizes and patients report significantly better pain and function.[5,22]

Classification systems such as the Lauge-Hansen mechanism-based classification and the AO/OTA compendium facilitate communication, guide fixation strategy, and stratify prognosis across institutions.[26,27] Certain fracture patterns—notably Maisonneuve fractures and Weber C injuries—warrant heightened vigilance for syndesmotic disruption, as failure to recognize these patterns risks incomplete stabilization and inferior outcomes.[29] Intraoperative assessment, including the hook test and external rotation stress maneuver under anaesthesia, provides critical information that plain radiographs cannot reliably replicate.[38,39]Despite an expanding literature

from Western and Asian centres, structured prospective Indian data comparing syndesmotic screw fixation with non-fixation strategies using standardized functional outcomes and consistent radiographic markers at fixed follow-up intervals remain limited. This evidence gap, combined with the high burden of ankle fractures in the working-age population of India, motivated the present study. The aim was to assess the functional outcome of distal tibiofibular syndesmotic injuries associated with ankle fractures treated by syndesmotic screw, using the AOFAS ankle-hind foot score and VAS as primary functional measures, and serial radiographic parameters to evaluate mortise restoration.

Material and Methods

Study Design and Setting: This was a prospective clinical comparative study conducted at the Department of Orthopaedics, Santosh Medical Hospital, Ghaziabad, Delhi NCR, India, between 2022 and 2025. Ethical clearance was obtained from the Institutional Ethics Committee of Santosh Deemed to be University. Written informed consent was obtained from all participants prior to enrolment.

Participants: Adults aged 20–60 years presenting to the Emergency Department or Orthopaedic OPD with traumatic ankle fractures and confirmed distal tibiofibular syndesmotic injury were eligible. Inclusion criteria were: ankle fractures with associated syndesmotic injury, Grade I and II open fractures, ankle fractures with or without dislocation, polytrauma patients who were haemodynamically stable, and willingness to provide written informed consent. Exclusion criteria included: age below 20 or above 60 years, Grade III open fractures, local skin disease at the operative site, previous arthrodesis at the target level, pathological or neglected fractures, severe medical comorbidities precluding surgery, and refusal of informed consent.

Of 84 patients enrolled, 82 completed the full 6-month follow-up protocol and were included in the final analysis. Two patients were excluded after enrolment: one withdrew informed consent prior to surgery, and one was lost to follow-up before the 6-week review. Both exclusions occurred in the no-screw group; their baseline characteristics did not differ meaningfully from those who completed follow-up.

Sample Size Calculation: Sample size was calculated using a two-sided independent samples t-test formula: $n = 2[(Z\alpha/2 + Z\beta)^2 \times \sigma^2] / \delta^2$, assuming a clinically meaningful difference of 5 points in the AOFAS ankle-hindfoot score between groups ($\delta = 5$), a pooled standard deviation of 5.2 points ($\sigma = 5.2$, estimated from pilot data and published literature), 80% statistical power ($\beta = 0.20$), and a two-sided significance level of $\alpha = 0.05$ ($Z\alpha/2 = 1.96$, $Z\beta = 0.84$). Applying these values: $n = 2[(1.96 + 0.84)^2 \times 5.2^2] / 5^2 = 2[7.84 \times 27.04] / 25 \approx 17$ per group. Calculations were verified using G*Power (version 3.1).

The minimum required sample was 17 patients per group. To account for potential dropout and to improve statistical robustness, 41 patients were enrolled in each group, yielding a final analysed sample of 82 patients. The enrolled sample is substantially larger than the minimum required, confirming adequate power for all primary comparisons.

Study Groups: Following admission and routine pre-operative workup (blood investigations, pre-anaesthetic assessment), patients were allocated to one of two treatment groups based on intraoperative assessment of syndesmotic instability (hook test and external rotation stress maneuver under anaesthesia). This allocation method was based on clinical judgment rather than randomization and represents a potential source of selection bias, which is acknowledged as a limitation.

Group A (Screw, n=41) underwent open reduction and internal fixation with placement of a 3.5 mm or 4.5 mm trans-syndesmotic cortical screw in a tricortical or quadricortical configuration. Group B (No Screw, n=41) comprised patients in whom intraoperative assessment indicated no dedicated syndesmotic fixation was required (n=29) or in whom a TightRope/endobutton dynamic suture-button construct was used as an alternative to rigid screw fixation (n=12); these subgroups were analysed together as the non-screw comparator arm. Fracture fixation in both groups followed standard orthopaedic principles: medial malleolar fractures were fixed with malleolar screws, and fibular fractures with one-third tubular or reconstruction plates.

Syndesmotic Screw Technique: With the ankle in neutral dorsiflexion and the syndesmosis manually compressed using a Weber clamp, a guidewire was inserted parallel to the joint line, approximately 2–3 cm proximal to the tibial plafond. A 3.5 mm or 4.5 mm fully threaded cortical screw was inserted in a lateral-to-medial direction at a 30-degree angle from the coronal plane, engaging either three or four cortices depending on bone quality and surgeon preference. Fluoroscopic confirmation of mortise alignment was obtained on anteroposterior and mortise views before wound closure.

Post-Operative Protocol: All patients were immobilized in a below-knee cast or splint and commenced non-weight-bearing mobilization. Partial weight bearing was initiated at a mean of 3–4 weeks, with progression to full weight bearing at 8–10 weeks guided by clinical and radiological

evidence of bony consolidation. In Group A, the syndesmotic screw was removed electively at 8–12 weeks prior to full weight bearing where applicable.

Outcome Measures: Patients were followed at immediate post-operative, 6 weeks, 8 weeks, 12 weeks, and 6 months. Functional recovery was assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot score (maximum 100, higher scores indicate better function) and the Visual Analogue Scale (VAS) for pain (0–10, lower scores indicate less pain). Radiological assessment on anteroposterior, lateral, and mortise views recorded: tibiofibular clear space (TCS, normal ≤6 mm), tibiofibular overlap (TFO, normal ≥6 mm on AP view), and medial clear space (MCS, normal ≤4 mm). Reduction quality was classified as anatomic (TCS ≤4 mm, MCS ≤4 mm, TFO ≥5 mm), near-anatomic, or malreduced. Time to partial and full weight bearing was recorded in weeks. Hospital stay and surgery duration were documented as perioperative parameters.

Statistical Analysis: Data were entered in Microsoft Excel and analysed using STATA MP-17. A two-sided p-value < 0.05 was considered statistically significant throughout. Normality was assessed by Kolmogorov-Smirnov and Shapiro-Wilk tests. Quantitative data are expressed as mean ± standard deviation. Between-group differences were tested using independent-samples t-test or Mann-Whitney U test; within-group pre- to post-operative changes were assessed with paired t-test or Wilcoxon signed-rank test. Categorical variables are presented as frequencies and percentages and compared by chi-square or Fisher's exact test. Serial AOFAS and VAS data were analysed by repeated-measures analysis of variance (RM-ANOVA) with time as the within-subjects factor and treatment group as the between-subjects factor; sphericity was assessed using Mauchly's test, and Greenhouse–Geisser correction was applied where the assumption was violated. Correlation between radiological parameters and outcome scores was assessed by Pearson's r or Spearman's ρ as appropriate. Multivariable linear regression was performed to identify independent predictors of 6-month AOFAS score; multicollinearity was assessed using variance inflation factor (VIF), and model residuals were examined for normality and homoscedasticity. Variables entered into the regression model were selected a priori based on clinical relevance and included: treatment group (screw vs no-screw), age, sex, fracture type, mechanism of injury, reduction quality category, surgery duration, hospital stay, and time to full weight bearing. The Enter method was used to include all pre-specified variables simultaneously. Results of regression analyses are presented with unstandardised coefficients (B), standardised coefficients (β), and 95% confidence intervals. Effect sizes were reported as Cohen's d for continuous comparisons and partial eta-squared (η^2) for ANOVA.

Results

Baseline Characteristics: Eighty-two patients were included in the final analysis (41 per group). The cohort was predominantly male (74.4%) with a mean age of 39.8 ± 8.8 years. Most patients were in the 30–49 year age bracket (71.9% combined), reflecting the economically active working population.

Road traffic accidents were the predominant mechanism of injury (59.8%), followed by falls (32.9%). Weber B bimalleolar fractures were the most common fracture pattern (37.8%), followed by trimalleolar (29.3%) and Weber C bimalleolar fractures (25.6%). Both treatment groups were comparable across all baseline demographic, occupational, socioeconomic, and fracture pattern variables, with no statistically significant intergroup differences (Table 1).

Table 1: Baseline Demographic and Clinical Characteristics by Treatment Group (N = 82)

Variable / Category	No Screw (n=41) n (%)	Screw (n=41) n (%)	Total (N=82) n (%)	p-value
Age: 18–29 yrs	4 (9.8%)	8 (19.5%)	12 (14.6%)	
Age: 30–39 yrs	15 (36.6%)	16 (39.0%)	31 (37.8%)	
Age: 40–49 yrs	14 (34.1%)	14 (34.1%)	28 (34.1%)	
Age: 50–60 yrs	8 (19.5%)	3 (7.3%)	11 (13.4%)	0.349
Male Gender	31 (75.6%)	30 (73.2%)	61 (74.4%)	0.620
RTA (Mechanism)	27 (65.9%)	22 (53.7%)	49 (59.8%)	
Fall (Mechanism)	10 (24.4%)	17 (41.5%)	27 (32.9%)	0.456
Weber B Bimalleolar	14 (34.1%)	17 (41.5%)	31 (37.8%)	
Weber C Bimalleolar	12 (29.3%)	9 (22.0%)	21 (25.6%)	
Trimalleolar	12 (29.3%)	12 (29.3%)	24 (29.3%)	0.869
Mean Age ± SD (years)	41.3 ± 8.99	38.3 ± 8.52	39.8 ± 8.8	0.349

RTA = Road Traffic Accident; SD = Standard Deviation. Chi-square test for categorical variables; independent-samples t-test for continuous variables.

Radiological Outcomes: Baseline pre-operative radiological parameters were similar between groups (Table 2). The mean tibiofibular clear space was 8.23 ± 1.07 mm in the no-screw group and 7.97 ± 1.19 mm in the screw group (mean difference −0.26 mm, 95% CI −0.76 to 0.24; p = 0.284); tibiofibular overlap was 4.18 ± 0.91 mm versus 3.42 ± 0.97 mm (mean difference −0.76 mm, 95% CI −1.17 to −0.35; p = 0.106); and medial clear space was 5.57 ± 1.03 mm versus 5.39 ± 0.92 mm (mean difference −0.18 mm, 95% CI −0.61 to 0.25; p = 0.409). Post-operatively, the screw group demonstrated significantly better alignment on all parameters: tibiofibular clear space 4.93 ± 1.18 versus 6.04 ± 1.05 mm (mean difference −1.11 mm, 95% CI −1.60 to −0.62; p < 0.001, Cohen's d=0.995); tibiofibular overlap 6.05 ± 1.02 versus 5.34 ± 0.95 mm (mean difference 0.71 mm, 95% CI 0.28 to 1.14; p = 0.002, d=0.717); and medial clear space 3.39 ± 0.99 versus 4.24 ± 1.08 mm (mean difference −0.85 mm, 95% CI −1.31 to −0.39; p < 0.001, d=0.813).

Within-group paired analysis confirmed highly significant pre-to-post improvements in all radiological parameters in both the screw group (p < 0.001, Cohen's d 4.19–6.79, calculated using paired effect size formula) and the no-screw group (p < 0.001, d 2.51–3.98), with substantially larger effect sizes in the screw group; these exceptionally large within-group values reflect the marked baseline syndesmotic widening relative to the narrow post-operative SD, which is characteristic of paired pre-post analyses in this clinical context.

Reduction quality differed significantly between groups (χ^2=17.7, p < 0.001): anatomic reduction was achieved in 34.1% and near-anatomic in 34.1% of the screw group, compared with 4.9% and 19.5% respectively in the no-screw group, where malreduction predominated (75.6%).

Table 2: Pre-Operative and Post-Operative Radiological Parameters and Reduction Quality by Treatment Group (N = 82)

Radiological Parameter	No Screw (n=41) Mean ± SD	Screw (n=41) Mean ± SD	t-statistic	p-value	Cohen's d
Pre-Operative					
TF Clear Space (mm)	8.23 ± 1.07	7.97 ± 1.19	1.078	0.284	0.235
TF Overlap (mm)	4.18 ± 0.91	3.42 ± 0.97	1.633	0.106	0.356
Medial Clear Space (mm)	5.57 ± 1.03	5.39 ± 0.92	0.830	0.409	0.181
Post-Operative					
TF Clear Space (mm)	6.04 ± 1.05	4.93 ± 1.18	4.56	p < 0.001	0.995
TF Overlap (mm)	5.34 ± 0.95	6.05 ± 1.02	-3.28	p = 0.002	0.717
Medial Clear Space (mm)	4.24 ± 1.08	3.39 ± 0.99	3.73	p < 0.001	0.813
Reduction Quality					
Anatomic	2 (4.9%)	14 (34.1%)	χ^2=17.7	p < 0.001	—
Near-anatomic	8 (19.5%)	14 (34.1%)	—	—	—
Malreduced	31 (75.6%)	13 (31.7%)	—	—	—

TF = Tibiofibular; SD = Standard Deviation. *p < 0.05 statistically significant. Independent-samples t-test for continuous variables; chi-square test for reduction quality categories.

Functional Outcomes: AOFAS Scores: AOFAS scores improved progressively over the entire follow-up period in both groups (Table 3). In the screw group, mean AOFAS improved from 59.2 ± 6.37 at immediate post-operative to 91.5 ± 4.29 at 6 months.

In the no-screw group, corresponding values were 55.9 ± 7.35 and 86.5 ± 6.08. The between-group difference at 6 months was 5.0 points (95% CI 2.68 to 7.32) in favour of the screw group. The screw group consistently achieved higher scores at every time point. Repeated-measures ANOVA demonstrated a highly significant main effect of time (F=315.1, df=4, p < 0.001) reflecting progressive recovery, and a significant between-subjects effect of treatment group (F=51.6, df=1, p < 0.001) confirming a consistent overall functional advantage of screw fixation. The time-by-group interaction was not significant (F=0.27, p = 0.895), indicating that both groups recovered at a parallel rate, but the screw group maintained a higher functional baseline throughout (Figure 1A).

Functional Outcomes: VAS Pain Scores: VAS pain scores declined steadily in both groups (Table 3, Figure 1B). Mean VAS decreased from 6.09 ± 1.11 to 1.36 ± 0.60 in the screw group and from 6.34 ± 1.01 to 1.43 ± 0.49 in the no-screw group over 6 months. RM-ANOVA confirmed a dominant time effect (F=393.98, p < 0.001) and a significant between-subjects group effect (F=8.42, p = 0.005), while the time-by-group interaction was not significant (p = 0.387), indicating parallel pain reduction trajectories with overall lower pain levels in the screw group.

Table 3: Serial AOFAS Scores, VAS Scores, Weight-Bearing Milestones, and 6-Month Outcome Categories by Treatment Group (N = 82)

Outcome Measure / Time Point	No Screw (n=41) Mean ± SD	Screw (n=41) Mean ± SD	Statistic	p-value
Aofas Ankle-Hindfoot Score				
Immediate Post-Op	55.9 ± 7.35	59.2 ± 6.37	—	—
6 Weeks	67.7 ± 6.67	71.3 ± 7.34	—	—
8 Weeks	73.6 ± 5.39	77.3 ± 6.40	—	—
12 Weeks	80.6 ± 4.97	85.2 ± 5.74	—	—
6 Months	86.5 ± 6.08	91.5 ± 4.29	—	—
Group Effect (RM-ANOVA)	—	—	F=51.6	p < 0.001
Vas Pain Score (0–10)				
Immediate Post-Op	6.34 ± 1.01	6.09 ± 1.11	—	—
6 Weeks	4.44 ± 1.00	4.50 ± 0.93	—	—
8 Weeks	3.65 ± 0.78	3.50 ± 0.75	—	—
12 Weeks	2.58 ± 0.71	2.22 ± 0.67	—	—
6 Months	1.43 ± 0.49	1.36 ± 0.60	—	—
Group Effect (RM-ANOVA)	—	—	F=8.42	p = 0.005
Weight-Bearing Milestones				
Time to Partial WB (weeks)	3.40 ± 0.73	3.14 ± 0.68	t=1.69	0.094
Time to Full WB (weeks)	9.24 ± 1.21	8.60 ± 1.11	t=2.55	p = 0.013
6-Month AOFAS Categories				
Excellent (≥90)	13 (31.7%)	27 (65.9%)	χ^2=12.0	p = 0.003
Good (80–89)	23 (56.1%)	14 (34.1%)	—	—
Fair (70–79)	5 (12.2%)	0 (0.0%)	—	—

WB = Weight Bearing; RM-ANOVA = Repeated-Measures ANOVA; *p < 0.05.

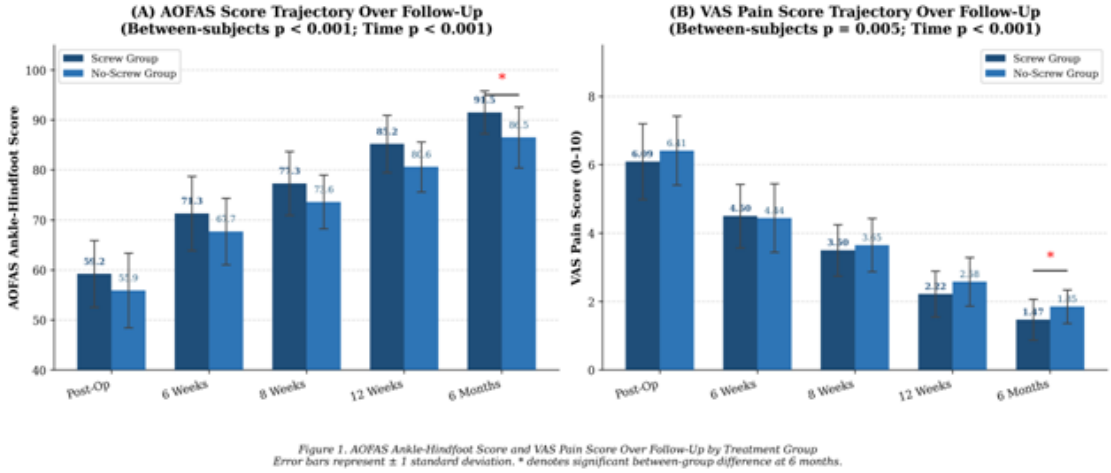


Figure 1: AOFAS Ankle-Hindfoot Score (A) and VAS Pain Score (B) Over Follow-Up by Treatment Group. Error bars represent ± 1 SD. *Significant between-group difference. Group effect p < 0.001 (AOFAS) and p = 0.005 (VAS)

Weight-Bearing Milestones and Perioperative Parameters: Time to partial weight bearing was similar between groups (3.14 ± 0.68 vs 3.40 ± 0.73 weeks; mean difference −0.26 weeks, 95% CI −0.57 to 0.05; p = 0.094). The screw group achieved full weight bearing significantly earlier (8.60 ± 1.11 vs 9.24 ± 1.21 weeks; mean difference −0.64 weeks, 95% CI −1.14 to −0.14; p = 0.013; Cohen's d=0.556).

Hospital stay (3.83 ± 0.94 vs 3.46 ± 0.74 days; mean difference 0.37 days, 95% CI −0.10 to 0.84; p = 0.796) and surgery duration (72.26 ± 8.57 vs 69.24 ± 8.40 minutes; mean difference 3.02 minutes, 95% CI −0.72 to 6.76; p = 0.115) did not differ significantly between groups, indicating comparable perioperative resource utilization.

Correlation and Regression Analyses: Residual tibiofibular clear space correlated negatively with 6-month AOFAS score (r=−0.286, p = 0.008), and medial clear space also showed a negative correlation with AOFAS (r=−0.254, p = 0.020). Medial clear space correlated positively with 6-month VAS (r=0.248, p = 0.023), while tibiofibular overlap showed a negative correlation with VAS

(r=−0.270, p = 0.013). Time to full weight bearing was not significantly correlated with 6-month AOFAS (ρ=−0.124, p = 0.263) or VAS (ρ=−0.010, p = 0.927). Multivariable linear regression (R^2=0.324) confirmed syndesmotic screw fixation (B=5.63, 95% CI 3.87–7.39, p < 0.001, β=0.45) and age (B=0.16, 95% CI 0.01–0.31, p = 0.039, β=0.25) as independent predictors of higher 6-month AOFAS scores; fracture type, mechanism of injury, gender, and perioperative factors did not independently influence outcome.

Reduction quality was included in the model as a clinically important a priori variable despite its association with treatment group allocation; although screw fixation and reduction quality are conceptually related, VIF values were all below 2.0, confirming no statistically significant multicollinearity, and both variables were retained to separate the direct effect of fixation from the mediated effect through reduction adequacy.

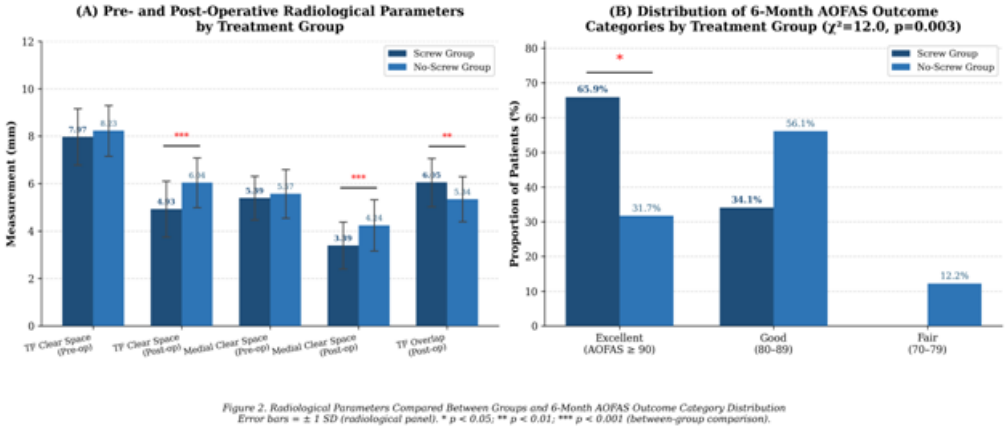


*Figure 2. Radiological Parameters Compared Between Groups and 6-Month AOFAS Outcome Category Distribution Error bars = ± 1 SD (radiological panel). * p < 0.05; ** p < 0.01; *** p < 0.001 (between-group comparison).*

Figure 2: Post-Operative Radiological Parameters (A) and 6-Month AOFAS Outcome Category Distribution (B) by Treatment Group. Error bars = ± 1 SD. *p < 0.05; **p < 0.01; ***p < 0.001

Discussion

This prospective comparative study systematically evaluated functional and radiological outcomes following operative management of ankle fractures with distal tibiofibular syndesmotic injury, providing structured evidence from a tertiary care centre in Delhi NCR, India. The principal finding is that syndesmotic screw fixation confers a measurable advantage in restoring mortise congruity and optimizing mid-term functional recovery, while not increasing operative burden—a clinically important observation for practice in high-volume trauma settings.

The baseline demographic profile—predominantly male patients (74.4%) in the 30–49 year age bracket (71.9%), with road traffic accidents as the leading mechanism (59.8%)—mirrors epidemiological patterns documented by Juto et al.[7] and Shukla et al.[10], who reported male predominance and high proportions of transport-related ankle fractures in economically active adults. The mean age in the present cohort (39.8 years) is closely aligned with the 40.67 years reported by Prajapati et al.[40] and falls within the range of 43.7 ± 5.6 years in the systematic review by Levy et al.[42] The balanced distribution of fracture patterns between groups confirms methodological validity and minimizes confounding.Post-operative radiological improvement in both groups is consistent with the principle that fracture fixation itself partially restores syndesmotic alignment, as noted by Schepers et al.[46] However, the magnitude of correction was significantly greater in the screw group, with large-to-very-large effect sizes across all three radiological parameters, aligning with reports from Giddi et al.[41] and Pogliacomi et al.[34] who demonstrated that direct syndesmotic stabilization achieves more reliable radiographic normalization. The markedly higher rate of malreduction in the no-screw group (75.6% vs 31.7%) parallels the concerns raised by Li et al.[25], who documented a malreduction incidence of up to 69.2% at immediate post-operative CT in screw-fixed ankles, and underscores the risk of residual instability when the syndesmosis is not directly addressed. Hadley Jr et al.[39] similarly observed lower malreduction rates with more stable fixation constructs. The functional recovery trajectories in both groups are comparable to those reported in the broader literature. The 6-month AOFAS of 91.5 ± 4.29 in the screw group resembles the mean score of 88.7 ± 4.1 from Levy et al.[42] and the long-term values exceeding 90 reported by Steinmetz et al.[43] following screw fixation with ligament repair. Prajapati et al.[40] documented an AOFAS improvement from 59.8 to 88.7 at 12 weeks using a posterolateral approach for posterior malleolus fixation in syndesmotic injuries—a similar magnitude of recovery to that observed in the present study. The consistently

higher AOFAS scores in the screw group at all time points, supported by a significant between-subjects effect of treatment group ($F=51.6$, $p < 0.001$), affirms the functional benefit of definitive syndesmotic stabilization highlighted by Giddi et al.[41] in their prospective Indian study reporting excellent or good outcomes in 90% of screw-fixed patients.

The significant between-subjects VAS effect ($F=8.42$, $p = 0.005$) demonstrating lower overall pain in the screw group complements mechanistic insights from Romero et al.[14] and Pogliacomi et al.[34] that improved syndesmotic stability reduces pathologic micromotion and secondary pain. The correlations between residual clear space widening and inferior AOFAS ($r=-0.286$, $p = 0.008$) and between overlap and lower VAS ($r=-0.270$, $p = 0.013$) provide radiographic-functional linkage consistent with the malreduction-outcome relationship described by Li et al.[25] and Hadley Jr et al.[39], while further supporting the principle articulated by Krähenbühl et al.[12] that persistent syndesmotic gap adversely affects function. These findings together reinforce the clinical imperative to achieve and maintain anatomic reduction.

The earlier attainment of full weight bearing in the screw group (8.60 ± 1.11 vs 9.24 ± 1.21 weeks; $p = 0.013$) reflects the biomechanical rationale that a stable, well-reduced syndesmosis permits more confident rehabilitation advancement. Pogliacomi et al.[34] and Romero et al.[14] both emphasized that syndesmotic stability is a prerequisite for safe loading of the reconstructed ankle. Notably, earlier weight bearing did not independently predict 6-month functional or pain outcomes in the multivariable model, consistent with observations by Schepers et al.[46] who found that rehabilitation timelines have less impact on outcomes than fixation quality. Klepacki et al.[35] also reported no overall functional differences based on timing of screw removal, though they recommended removal at 8–15 weeks to facilitate rehabilitation.

The multivariable regression identified syndesmotic screw fixation and age as the only independent predictors of 6-month AOFAS score, with treatment group explaining the largest standardised effect ($\beta=0.45$). Fracture type, mechanism, gender, reduction quality category, hospital stay, surgery duration, and time to weight bearing were not independent predictors after adjustment. This finding aligns with Schepers et al.[46] who demonstrated that patient and fracture characteristics drive outcomes more than hardware details, but contrasts with the emphasis on reduction quality as a predictor in studies using CT-based assessment.[25] The model R^2 of 0.324 indicates that additional variables—including cartilage status, physiotherapy compliance, and implant specifics—account for a substantial proportion of the variance, underscoring the multifactorial nature of ankle fracture recovery.

Comparisons with dynamic fixation alternatives are informative. Zhang et al.[36] demonstrated in a systematic review that suture-button devices achieve similar pooled AOFAS scores (91.06 vs 87.78) to screws at short-to-mid-term follow-up, but with significantly lower malreduction rates (1.0% vs 12.6%) and near-zero hardware failure. Kortekangas et al.[44] found comparable malreduction rates between TightRope and screw fixation on CT, while Seyhan et al.[45] showed equivalent AOFAS scores but superior range of motion with elastic fixation at 12 months. The present study demonstrates that when screw fixation is contrasted with absence of dedicated syndesmotic fixation rather than with a dynamic alternative, the functional advantage is substantial and statistically unambiguous. These data support the continued use of syndesmotic screws in resource-limited and high-volume settings where cost and familiarity remain relevant considerations, provided that meticulous reduction is achieved and verified intraoperatively.

The systematic review by Desouky et al.[13] concluded that routine screw removal does not confer clear functional benefit, a finding that contextualizes the present results: the advantages of syndesmotic screw fixation observed here are primarily attributable to restoration of alignment rather than subsequent hardware management. Liu et al.[38] highlighted advances in minimally invasive and dynamic stabilization options for combined deltoid-syndesmotic injuries, while acknowledging the need for further evidence before these techniques can displace established methods in routine practice. Indian-specific data from Sharma et al.[37] and Giddi et al.[41] reinforce that delayed treatment and inadequate fixation correlate with poorer outcomes in this setting, strengthening the argument for timely, definitive syndesmotic stabilization.

Several limitations are acknowledged. First, the single-centre design and relatively modest sample size limit statistical power for subgroup analyses and restrict generalizability. Second, allocation was based on intraoperative judgment rather than true randomization, introducing potential selection bias; a randomized controlled design would be required to eliminate this bias. Third, outcome assessors were not blinded to treatment allocation, introducing the potential for observer bias in functional scoring. Fourth, the no-screw group was heterogeneous, comprising patients managed without syndesmotic fixation and those treated with a dynamic suture-button construct, which may have diluted or altered the observed between-group differences. Fifth, radiological assessment relied on plain radiographs without routine post-operative

CT, which may have underestimated subtle rotational malreduction. Sixth, functional assessment was limited to AOFAS and VAS; inclusion of additional patient-reported measures such as OMAS or PROMIS would have enriched the multidimensional evaluation. Seventh, the 6-month follow-up is insufficient to capture long-term sequelae including post-traumatic osteoarthritis and late hardware complications. Future multicentre randomized trials with longer follow-up, CT-based reduction assessment, blinded outcome assessment, and contemporary dynamic fixation arms are needed to further refine treatment algorithms.

Conclusion

This prospective comparative study demonstrates that syndesmotic screw fixation in ankle fractures with distal tibiofibular syndesmotic injury provides superior restoration of ankle mortise congruity and significantly improved mid-term functional outcomes compared with management without syndesmotic fixation.

The screw group achieved better post-operative radiological alignment, a substantially higher proportion of anatomic and near-anatomic reductions, consistently higher AOFAS scores across all follow-up intervals, lower VAS pain scores, and earlier attainment of full weight bearing.

Multivariable analysis confirmed syndesmotic screw fixation as an independent predictor of superior 6-month functional outcome, while perioperative parameters were comparable between groups. Residual syndesmotic widening adversely affected both function and pain, underscoring the clinical importance of precise mortise restoration.

These findings support the routine intraoperative assessment of syndesmotic instability and its definitive fixation when identified, as omission is associated with higher rates of malreduction and inferior functional categories at mid-term follow-up.

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