Original Article

Clinical and Radiological Outcome in Proximal Tibial Diaphyseal Fracture Managed by Suprapatellar Nailing Technique: A Prospective Cohort Study

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Abstract

Background: There are certain factors that make proximal tibia fractures difficult to align and recover from the fracture site despite being in the setting of high energy trauma. The suprapatellar approach for intramedullary nailing has emerged as a technique that may improve fracture reduction and early rehabilitation outcomes. The objective is to evaluate the clinical and radiological outcomes of proximal tibial diaphyseal fractures managed with suprapatellar intramedullary nailing at 6, 12, and 24 weeks after the treatment of proximal tibial diaphyseal fracture with suprapatellar intramedullary nailing, and to evaluate the functional outcome at same time points using Lysholm knee score, VAS, range of motion and radiological parameters. **Material and Methods:** A prospective cohort study was conducted on 81 patients with extra-articular proximal tibial diaphyseal fractures treated with suprapatellar intramedullary nailing over one year. Clinical and radiological assessments were performed at predefined follow-ups (2, 6, 12, and 24 weeks). Outcome measures included VAS, Lysholm score, knee range of motion, radiological union, and alignment. Statistical analysis was performed using SPSS version 23.0, with $p < 0.05$ considered significant. **Results:** The mean VAS score reduced from 8.25 ± 0.643 at admission to 0.395 ± 0.492 at 24 weeks. Functional outcomes improved significantly, with mean Lysholm scores increasing to 90.346 ± 3.779 at final follow-up. Progressive improvement in knee range of motion was observed, and all patients achieved full weight bearing by 12 weeks. Radiological evaluation demonstrated maintained alignment within acceptable limits and complete cortical bridging in all patients at 24 weeks, indicating successful fracture union. No early postoperative complications were reported. **Conclusion:** Suprapatellar intramedullary nailing is a safe and effective technique for managing proximal tibial diaphyseal fractures, providing reliable alignment, early functional recovery, and excellent radiological union.

Keywords: Proximal tibial fracture, Suprapatellar nailing, Intramedullary nailing, Functional outcome, Radiological union, Lysholm score.

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Introduction

The tibia is the major weight bearing bone of the lower extremity and plays a vital role in the transmission of load and gait. The proximal diaphyseal region is easily vulnerable to injury because it is less well covered by soft tissue and there exists higher biomechanical stress, and this region is challenging in terms of optimal fracture alignment and functional restoration.[1]

They are typically associated with high-energy trauma, including road traffic accidents and falls from heights and usually present with complex fracture pattern which can be standardised using the AO/OTA system, resulting in significant functional impairment and socioeconomic burden in most cases and occurring in the working age group.[2-4]

Clinically, these injuries can be accompanied by a lot of pain, affected weight-bearing status and a lack of mobility in the joints. Inadequate or delayed management may result in complications such as malalignment, delayed union, or persistent anterior knee pain, all of which adversely affect long-term functional outcomes.[5] On a broader scale, tibial fractures constitute a considerable proportion of long-bone injuries worldwide, with an increasing incidence observed in India due to rising vehicular trauma and occupational hazards, particularly in semi-urban and Tier II settings.[6]

Intramedullary nailing has been widely accepted as the standard treatment modality; however, the conventional infrapatellar technique is often limited in proximal fractures due to difficulties in maintaining alignment and higher rates of postoperative anterior knee discomfort.[7] In response to these limitations, the suprapatellar approach has gained attention, allowing nail insertion in a semi-extended position that facilitates improved fracture reduction and alignment control.[8]

Outcome assessment in such cases relies on a combination of radiological evaluation and validated functional scoring systems, including the Lysholm knee score and Visual Analogue Scale, which provide objective and patient-reported measures of

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recovery.[9] Although several studies have demonstrated favorable outcomes with the suprapatellar technique, including reduced pain and improved alignment, variability in results persists across different populations.[10] Notably, there is a relative paucity of region-specific data from India, particularly from Tier II healthcare settings where patient demographics and trauma patterns may differ significantly.[11] Addressing this gap is essential to generate contextually relevant evidence and optimize clinical decision-making.[12] In this context, the present study is designed to evaluate the clinical and radiological outcomes of proximal tibial diaphyseal fractures managed with suprapatellar intramedullary nailing in a tertiary care setting.

Materials and Methods

Study Design: This study was conducted as a prospective cohort study.

Study Setting: The study was carried out in the Department of Orthopaedics, Rohilkhand Medical College, Bareilly

Study Duration: The total duration of the study was one year.

Study Population: The study population included patients presenting with proximal tibial diaphyseal fractures fulfilling the predefined inclusion criteria and treated with suprapatellar intramedullary nailing.

Sample Size: The sample size was calculated using the standard formula for cross-sectional studies

$$N = \frac{4pq}{L^2}$$

Where:

- p=5%, q=95%
- L=5% (absolute precision)

The calculated sample size was 81, and a total of 81 patients were included in the study.

Inclusion Criteria:

- Patients with fresh extra-articular proximal tibial diaphyseal fractures (AO/OTA classification: 42A, 42B, 42C and/or 43A)
- Patients willing to provide informed consent

Exclusion Criteria:

- Intra-articular displaced proximal tibial fractures
- Pathological fractures
- Presence of localized skin infection
- Medically unfit patients for surgery

Data Collection: Clinical history and examination was done. Fracture characteristics and healing were evaluated by radiographs (AP and lateral views). ROM, Lysholm score and VAS were used to assess functional outcomes.

Surgical Procedure: The knee was ~15° flexed and the surgical procedure used was Suprapatellar intramedullary nailing under anesthesia. Nails were inserted and fixed (3-4 proximal and 2 distal screws) using fluoroscopy and ensuring the alignment was within <5° of each other.

Postoperative Protocol: Patients were mobilised over the first few days with partial weight bearing and then gradually. This was followed up on, at 2 weeks, 6 weeks, 3 months and 6 months. Callus (union) was considered present if it crossed ≥3 cortices and malalignment was present if >5° angulation was present.

Ethical consideration: Ethical clearance was received from the Institutional Ethics Committee, and informed written consent was obtained from all the participants.

Statistical Analysis: The analysis of the data was done through SPSS v23.0 software. Descriptive statistics were used and if a continuous variable was used, appropriate parametric/non-parametric test was used, and if a categorical variable was used, a chi-square/Fisher exact test was used. P-values <0.05 were considered statistically significant.

Results

[Table 1] demonstrates the baseline demographic and clinical profile of the study population. The majority were males (66.7%), predominantly aged 31–50 years. Road traffic accidents were the leading cause (80.2%). Hypertension and diabetes were common comorbidities. The right limb was more frequently involved (66.7%), reflecting high-energy trauma patterns in this cohort.

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants (N = 81)

Variable	Category	Frequency (n)	Percentage (%)
Age Group (years)	20–30	8	9.9
	31–40	24	29.6
	41–50	27	33.3
	51–60	12	14.8
	61–70	7	8.6
	71–80	3	3.7
Sex	Male	54	66.7
	Female	27	33.3
Comorbidity	Hypertension (HTN)	35	43.2
	Diabetes Mellitus (DM)	27	33.3
	Cardiovascular illness	19	23.5
	Hypothyroidism	3	3.7
	COPD	2	2.5
	Bronchial asthma	2	2.5
	Chronic kidney disease (CKD)	2	2.5
	Anemia	2	2.5
Side Involved	Left	27	33.3
	Right	54	66.7
Mode of Injury	Road Traffic Accident (RTA)	65	80.2
	Fall from Height (FFH)	16	19.8

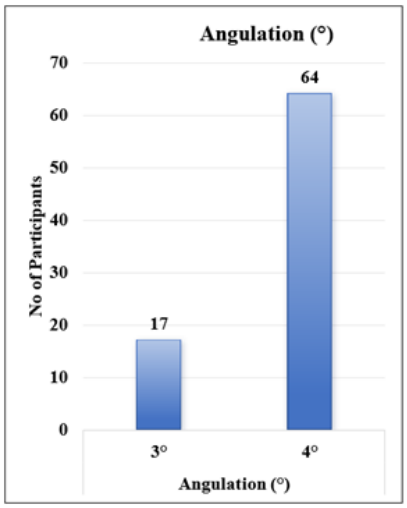
Table 2: Baseline Fracture Characteristics, Operative Details, and Immediate Post-operative Profile (N = 81)

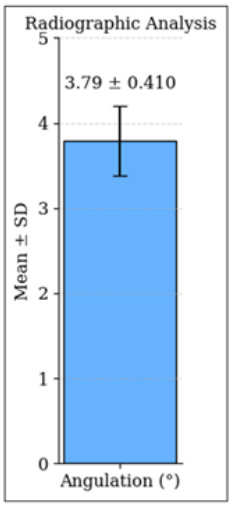
Category	Variable	Subcategory	n (%) / Mean ± SD
Fracture Characteristics	AO/OTA Classification	42A	57 (70.4%)
		42B	12 (14.8%)
		42C	12 (14.8%)
Operative Details	Surgical Approach	Suprapatellar	81 (100.0%)
Clinical Status on Admission	Pain Score (VAS 0–10)	Mean ± SD	8.25 ± 0.643
		Median (Range)	8 (7–9)
		VAS 7	9 (11.1%)
		VAS 8	43 (53.1%)
		VAS 9	29 (35.8%)
	Knee ROM – Flexion (Affected Limb)	0°	74 (91.4%)
		5°–10°	7 (8.6%)
	Knee ROM – Extension Deficit (Affected Limb)	0°	77 (95.1%)
		5°	4 (4.9%)
Immediate Post-operative Status	Weight-Bearing at Discharge	Partial Weight Bearing (PWB)	81 (100.0%)
	Early Post-operative Complications	None	81 (100.0%)

[Table 2] outlines fracture characteristics and initial clinical status. Most fractures were AO/OTA type 42A (70.4%). All patients underwent suprapatellar nailing. Baseline pain was high (VAS 8.25 ± 0.643), with severely restricted knee flexion. All patients were discharged on partial weight bearing, and no immediate postoperative complications were observed.

Table 3: Early Radiographic Assessment at 2 Weeks Post-operatively (N = 81)

Category	Variable	Subcategory	n (%) / Mean ± SD
Radiographic analysis	Angulation (°)	Mean ± SD	3.79 ± 0.410
		3°	17 (21.0%)
		4°	64 (79.0%)
	Bridging callus	1 cortex	52 (64.2%)
		2 cortices	29 (35.8%)
	RUST score	Score 1	81 (100.0%)





[Table 3] presents early radiographic outcomes at 2 weeks. Mean angulation was 3.79° ± 0.410, with most cases within acceptable alignment. Early callus formation was observed, predominantly across one cortex (64.2%). All patients demonstrated a RUST score of 1, indicating initial but definite progression of fracture healing.

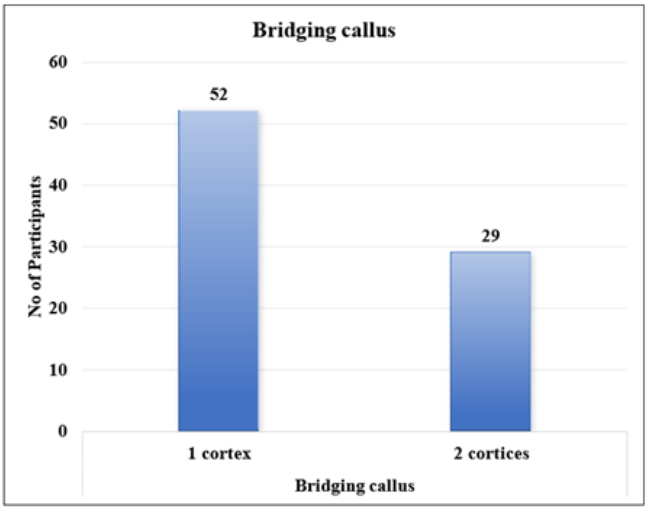


Table 4: Clinical and Radiological Outcomes at 6 Weeks Post-operatively (N = 81)

Category	Variable	Subcategory	n (%) / Mean ± SD
Pain assessment	VAS score (0–10)	Mean ± SD	3.04 ± 0.749
		Score 2	21 (25.9%)
		Score 3	36 (44.4%)
		Score 4	24 (29.6%)
Functional outcome	Lysholm knee score	Mean ± SD	64.38 ± 3.983
		Score 60	31 (38.3%)
		Score 65	29 (35.8%)
		Score 70	21 (25.9%)

Knee ROM – affected limb	Flexion (°)	0–70°	23 (28.4%)
		0–80°	26 (32.1%)
		0–90°	32 (39.5%)
	Extension deficit (°)	0–3°	32 (39.5%)
		0–4°	24 (29.6%)
		0–5°	25 (30.9%)
Knee ROM – unaffected limb	Flexion (°)	0–105°	15 (18.5%)
		0–110°	16 (19.8%)
		0–115°	26 (32.1%)
		0–120°	24 (29.6%)
	Extension (°)	0–10° (within normal limits)	81 (100.0%)
Weight-bearing status		Partial weight bearing (PWB)	81 (100.0%)
Radiographic analysis	Angulation (°)	Mean ± SD	3.54 ± 0.501
		3°	37 (45.7%)
		4°	44 (54.3%)
	Bridging callus	2 cortices	47 (58.0%)
		3 cortices	34 (42.0%)
	RUST score	Score 2	81 (100.0%)

[Table 4] shows significant clinical and radiological improvement at 6 weeks. Mean VAS decreased to 3.04 ± 0.749, with fair functional recovery (Lysholm 64.38 ± 3.983). Knee flexion improved up to 90°, while alignment remained acceptable. Progressive callus formation (≥2 cortices) and RUST score 2 in all patients indicated satisfactory early fracture healing.

Table 5: Clinical and Radiological Outcomes at 12 Weeks (3 Months) Post-operatively (N = 81)

Category	Variable	Subcategory	n (%) / Mean ± SD
Pain assessment	VAS score (0–10)	Mean ± SD	1.46 ± 0.501
		Score 1	44 (54.3%)
		Score 2	37 (45.7%)
Functional outcome	Lysholm knee score	Mean ± SD	77.84 ± 2.492
		Score 75	35 (43.2%)
		Score 80	46 (56.8%)
Knee ROM – affected limb	Flexion (°)	0–100°	1 (1.2%)
		0–105°	36 (44.4%)
		0–110°	29 (35.8%)
		0–115°	15 (18.5%)
	Extension deficit (°)	0–6°	18 (22.2%)
		0–8°	39 (48.1%)
		0–10°	24 (29.6%)
Knee ROM – unaffected limb	Flexion (°)	0–105°	15 (18.5%)
		0–110°	16 (19.8%)
		0–115°	26 (32.1%)
		0–120°	24 (29.6%)
	Extension (°)	0–10° (within normal limits)	81 (100.0%)
Weight-bearing status		Full weight bearing (FWB)	81 (100.0%)
Radiographic analysis	Angulation (°)	Mean ± SD	2.38 ± 0.489
		2°	50 (61.7%)
		3°	31 (38.3%)
	Bridging callus	3 cortices	31 (38.3%)
		All cortices	50 (61.7%)
	RUST score	Score 2	81 (100.0%)

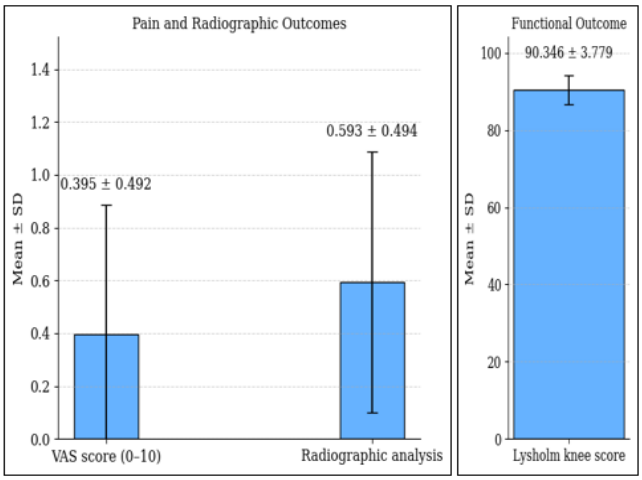
[Table 5] demonstrates marked clinical and radiological recovery at 12 weeks. Mean VAS further decreased to 1.46 ± 0.501, with improved functional outcome (Lysholm 77.84 ± 2.492). Most patients achieved near-normal knee flexion and full weight bearing. Radiologically, progressive union with bridging across ≥3 cortices and improved alignment was observed.

Table 6: Clinical and Radiological Outcomes at 24 Weeks (6 Months) Post-operatively (N = 81)

Category	Variable	Subcategory	n (%) / Mean ± SD
Pain assessment	VAS score (0–10)	Mean ± SD	0.395 ± 0.492
		Score 0	49 (60.5%)
		Score 1	32 (39.5%)
Functional outcome	Lysholm knee score	Mean ± SD	90.346 ± 3.779
		Score 85	19 (23.5%)
		Score 90	39 (48.1%)
		Score 94	7 (8.6%)
		Score 95	1 (1.2%)

		Score 96	15 (18.5%)
Knee ROM – affected limb	Flexion (°)	0–102°	1 (1.2%)
		0–105°	34 (42.0%)
		0–110°	25 (30.9%)
		0–115°	21 (25.9%)
	Extension deficit (°)	0–4°	23 (28.4%)
		0–6°	32 (39.5%)
		0–8°	18 (22.2%)
		0–10°	8 (9.9%)
Knee ROM – unaffected limb	Flexion (°)	0–105°	15 (18.5%)
		0–110°	16 (19.8%)
		0–115°	26 (32.1%)
		0–120°	24 (29.6%)
	Extension (°)	0–10° (within normal limits)	81 (100.0%)
Weight-bearing status		Full weight bearing (FWB)	81 (100.0%)
Radiographic analysis	Angulation (°)	Mean ± SD	0.593 ± 0.494
		0°	33 (40.7%)
		1°	48 (59.3%)
	Bridging callus	All cortices	81 (100.0%)
	RUST score	Score 2	61 (75.3%)
		Score 3	20 (24.7%)

[Table 6] demonstrates excellent clinical and radiological outcomes at 24 weeks. Mean VAS reduced to 0.395 ± 0.492, with most patients pain-free. Functional recovery was high (Lysholm 90.346 ± 3.779), with near-normal knee ROM. All patients achieved full weight bearing, and complete radiological union with maintained alignment was observed.



Discussion

Table 1 demonstrates that the majority of patients were within the 31–50 year age group (62.9%) with a clear male predominance (66.7%), which aligns with the demographic profile reported by Chaubey et al. (2025),[1] where most patients were young males aged 18–45 years. Similar findings were observed by Mohan et al,[3] (2025) and Sahni et al. (2023),[9] both reporting male predominance and concentration in the active working population. Kulkarni et al,[12] (2020) also reported a comparable mean age of 38.4 years. The predominance of road traffic accidents (80.2%) is consistent with Panda et al,[6] (2024) and Singh et al. (2020).[11] In contrast, Teixidor-Serra et al,[5] (2024) included an older cohort (mean 47.7 years), and Yoon et al,[2] (2025) showed balanced demographics due to matched sampling.

[Table 2] shows that AO/OTA type 42A fractures were most common (70.4%), consistent with Mohan et al,[3] (2025) and Panda et al,[6] (2024) where simple fracture patterns predominated. The uniformly high baseline pain score (VAS 8.25 ± 0.643) parallels findings by Sahni et al,[9] (2023) and Wang et al (2024),[7] indicating severe initial pain in tibial fractures. Markedly restricted knee flexion (91.4% with 0°) is comparable to observations by Singh et al,[11] (2020) and Kulkarni et al. (2020).[12] The absence of early postoperative complications and universal partial weight bearing align with Cepni et al,[8] (2023) and Teixidor-Serra et al (2024).[5] However, Makaram et al,[4] (2024) reported a small proportion of malalignment, indicating slight variability in early outcomes.

[Table 3] demonstrates satisfactory early radiological alignment with a mean angulation of 3.79° ± 0.410, consistent with Teixidor-Serra et al (2024),[5] where alignment ≤5° was achieved in 92.8% of cases. Similar alignment control was reported by Makaram et al. (2024),[4] with reduced malalignment (3%) in the suprapatellar group. Early callus formation across one cortex (64.2%) and two cortices (35.8%) reflects progressive healing comparable to Kulkarni et al,[12] (2020) and findings summarized by Wang et al. (2024).[7] Uniform RUST score of 1 indicates consistent early healing, similar to early observations in Sepehri et al. (2022).[10] In contrast, Yoon et al,[2] (2025) focused on long-term alignment and did not report early radiological healing parameters.

[Table 4] demonstrates notable early improvement at 6 weeks, with mean VAS decreasing to 3.04 ± 0.749 and Lysholm score reaching 64.38 ± 3.983, indicating fair functional recovery. These findings are comparable to Mohan et al. (2025),[3] who reported superior early functional outcomes with suprapatellar nailing, and Sahni et al. (2023),[9] who observed reduced pain and improved early mobility. Panda et al,[6] (2024) also noted improved early functional scores and alignment. Radiological findings showing angulation of 3.54° ± 0.501 and bridging callus in ≥2 cortices align with Teixidor-Serra et al,[5] (2024) and Wang et al. (2024).[7] In contrast, Makaram et al,[4] (2024) reported no significant early functional advantage despite better radiological alignment.

[Table 5] shows continued improvement at 12 weeks, with mean VAS further reduced to 1.46 ± 0.501 and Lysholm score

improving to 77.84 ± 2.492, reflecting good functional recovery. These findings are consistent with Mohan et al,[3] (2025) and Panda et al (2024),[6] both demonstrating improved early functional outcomes at intermediate follow-up. Sahni et al,[9] (2023) also reported reduced pain and better functional scores at later follow-up. Radiological improvement with angulation reduced to 2.38° ± 0.489 and bridging callus across all cortices in 61.7% is comparable to Teixidor-Serra et al,[5] (2024) and Kulkarni et al (2020).[12] In contrast, Cepni et al,[8] (2023) and Makaram et al,[4] (2024) reported similar functional outcomes without significant early differences between techniques.

[Table 6] demonstrates excellent outcomes at 24 weeks, with minimal pain (VAS 0.395 ± 0.492) and high functional scores (Lysholm 90.346 ± 3.779), indicating near-complete recovery. These findings are consistent with Singh et al. (2020),[11] who reported sustained superior functional outcomes, and Kulkarni et al (2020),[12] who observed high functional scores and complete union. Teixidor-Serra et al,[5] (2024) reported a healing rate of 97.6%, while Wang et al,[7] (2024) and Sepehri et al,[10] (2022) also demonstrated improved functional and radiological outcomes. Complete bridging callus in 100% and minimal angulation (0.593° ± 0.494) reflect excellent healing. In contrast, Chaubey et al,[1] (2025) and Cepni et al,[8] (2023) reported comparable long-term outcomes between techniques without significant differences.

Conclusion

The findings demonstrate that suprapatellar intramedullary nailing provides consistent and progressive improvement in both clinical and radiological outcomes in proximal tibial diaphyseal fractures. There was a marked reduction in pain from a mean VAS of 8.25 at admission to 0.395 at 24 weeks, accompanied by significant functional recovery as reflected by improvement in Lysholm scores from early fair to good–excellent outcomes (90.346 ± 3.779). Range of motion of the affected knee improved steadily, approaching near-normal values by final follow-up, while full weight bearing was achieved in all patients by 12 weeks. Radiologically, satisfactory alignment was maintained within acceptable limits, with gradual progression of callus formation culminating in complete cortical bridging in all cases. The absence of early complications and uniform fracture union further supports the reliability of this technique. Overall, the results indicate that the suprapatellar approach is an effective and safe modality for managing proximal tibial diaphyseal fractures with favorable functional and radiological outcomes.

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Conflicts of interest

There are no conflicts of interest.

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