EXTRA-ARTICULAR DISTAL FEMUR FRACTURE TREATED WITH DISTAL FEMORAL NAILING-A PROSPECTIVE STUDY

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Abstract:
Background: Extra-articular distal femur fractures are complex injuries commonly resulting from high-energy trauma in younger individuals and low-energy falls in the elderly. Achieving stable fixation with early mobilization remains challenging due to poor bone quality, comminution, and proximity to the knee joint. Distal Femoral Nailing (DFN) has emerged as a preferred fixation method because it offers biological fixation, minimal soft-tissue disruption, and allows early rehabilitation. **Objectives:** To evaluate the clinical, radiological, and functional outcomes of extra-articular distal femur fractures treated with distal femoral nailing and to assess fracture union, complications, and functional recovery over follow-up. **Methods:** This prospective observational study was conducted in the Department of Orthopaedics, Silchar Medical College and Hospital, over a period of one year. Thirty adult patients with closed extra-articular distal femur fractures (AO/OTA 33-A1, A2, A3) were included. All patients underwent fixation with distal femoral nail under spinal or general anesthesia. Patients were followed at 2 weeks, 6 weeks, 12 weeks, and up to 6 months. Clinical evaluation included pain assessment, range of motion, and functional outcome using standardized knee scoring systems. Radiological assessment focused on fracture union and alignment. Data were analyzed using appropriate statistical methods. **Results:** The mean age of patients was 40.9 ± 15.3 years, with male predominance. Road traffic accidents were the most common mode of injury. The mean time to radiological union was 14.4 ± 3.2 weeks, with a union rate of 96.67% at six months. Most patients achieved satisfactory knee range of motion, and excellent to good functional outcomes were observed in 86.67% of cases. Complications were minimal, with knee stiffness being the most common. **Conclusion:** Distal femoral nailing is an effective and reliable treatment for extra-articular distal femur fractures, providing high union rates, good functional outcomes, and a low complication profile when combined with early mobilization and structured rehabilitation.
Keywords: Distal femur fracture; Distal femoral nailing; Extra-articular fracture; Fracture union; Functional outcome
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Introduction:
Fractures involving the distal femur constitute a challenging orthopedic condition due to their complex anatomy, variable fracture morphology, and association with high-energy trauma. The distal femur, forming the lower end of the thigh bone, plays a crucial role in knee stability, weight transmission, and locomotion. Extra-articular fractures of the distal femur, which occur proximal to the femoral condyles without extension into the knee joint, represent a distinct subset of distal femoral fractures. These injuries, while sparing the articular surface, often disrupt the mechanical alignment and stability of the femur, necessitating precise anatomical reduction and stable internal fixation to restore limb function and prevent long-term complications. The management of such fractures has evolved considerably over the years, with intramedullary fixation techniques such as

distal femoral nailing gaining prominence for their biomechanical and clinical advantages.[1,2]

The distal femur is anatomically designed to bear significant load and enable complex movement at the knee joint. It comprises the metaphyseal region, which transitions between the diaphysis and the articular condyles. This area is characterized by a thin cortical shell surrounding cancellous bone, making it susceptible to comminution and angular deformities when fractured. Extra-articular fractures in this region typically occur as a result of high-energy trauma in younger individuals, such as road traffic accidents, or low-energy falls in elderly patients with osteoporotic bone.[2,3]

The advent of intramedullary fixation techniques represented a significant advancement in the management of long bone fractures. The concept of load-sharing internal fixation through an intramedullary device provided both mechanical stability and biological preservation of the fracture environment. The distal femoral nail, a specially designed retrograde intramedullary implant, has emerged as a reliable method for treating extra-articular distal femur fractures. [4,5]

Complications associated with distal femoral fractures include delayed union, nonunion, malalignment, and knee joint stiffness, though their incidence has declined with improved surgical techniques and implant designs. Careful preoperative planning, intraoperative accuracy, and postoperative rehabilitation are key determinants of successful outcomes. In addition, the management of associated injuries, particularly in polytrauma patients, and attention to soft-tissue condition are critical for comprehensive care.[6]

The objectives of this study was to evaluate the clinical, radiological, and functional outcomes of extra-articular distal femur fractures treated with distal femoral nailing and to assess fracture union, complications, and functional recovery over follow-up.

Methods and Methodology:

This prospective observational study was conducted in the Department of Orthopaedics, Silchar Medical College and Hospital, over a period of one year. Thirty adult patients with closed extra-articular distal femur fractures (AO/OTA 33-A1, A2, A3) were included.

The sample size for the study was calculated using Daniel's formula for sample size estimation in a finite population. The formula used was:

$$n = \frac{Z^2 P(1-P)}{d^2}$$

Where;
n = Required Sample size
Z = Z-Score for the desired confidence level (set at 95% hence Z= 1.96)
P = Expected prevalence or proportion (Conservatively set at 0.01 or 1% due to the relatively low incidence of these specific fractures)
d = Margin of error or precision (Set at 5%, hence d = 0.05)

Plugging in the values:

$$n = \frac{(1.96)^2 \text{ X } 0.01 \text{ X } (1-0.01)}{(0.05)^2} = \frac{3.8416 \text{ X } 0.0099}{0.0025} = \frac{0.03803184}{0.0025} = 15.21$$

The initial calculation yielded a sample size of 15.21, which was rounded up to 16. However, to enhance the power of the study, account for potential dropouts, and obtain more robust data for statistical analysis, a minimum sample size of 30 participants was deemed necessary and was therefore targeted for enrolment.

Inclusion Criteria

Adults (≥18 years), either sex.
Written informed consent obtained.
Closed extra-articular distal femur fractures (AO/OTA 33-A1, A2, A3) confirmed radiologically.
Medically fit for surgery after pre-anaesthetic evaluation.
Conservative treatment failed or was unsuitable due to fracture pattern/displacement.

Exclusion Criteria

Intra-articular distal femur fractures (AO/OTA 33-B, 33-C).
Open distal femur fractures.
Inability or unwillingness to comply with rehabilitation or follow-up.
Contraindications to surgery (e.g., active malignancy, decompensated liver disease, end-stage renal disease, uncompensated heart failure).
Fractures with established clinical or radiological union at presentation.

- **SURGICAL TECHNIQUE**
- Distal Femoral Nailing (DFN) was performed under C-arm fluoroscopic guidance using standard surgical instruments.

- Under spinal/general anaesthesia, fracture alignment was assessed with fluoroscopy.
- The patient was positioned supine on a radiolucent table with the affected knee flexed 30–45° using a radiolucent bolster.
- The limb was prepared and draped aseptically.
- A 4–6 cm midline incision was made from the inferior pole of the patella.
- The patellar tendon was split or retracted (parapatellar approach) to access the intercondylar notch.
- The entry point was created in the centre of the intercondylar notch, just anterior to the PCL insertion and above Blumensaat's line.
- A guidewire was advanced across the fracture into the proximal fragment under fluoroscopy.
- Fracture reduction was achieved by traction and percutaneous techniques as required.
- Sequential reaming was performed in 0.5 mm increments until cortical chatter was felt, avoiding excessive comminution.
- A suitably sized DFN was assembled with the targeting guide and inserted over the guidewire.
- The nail was seated flush or slightly countersunk, and fluoroscopy confirmed alignment before guidewire removal.
- Distal locking screws were inserted using the targeting guide through stab incisions.
- Proximal locking was performed free-hand under fluoroscopy (perfect circles technique), with screw placement confirmed radiographicaly
- The wound was irrigated, haemostasis achieved, and closed in layers with or without a suction drain.
- Sterile dressings were applied.
- FOLLOW-UP

All patients underwent fixation with distal femoral nail under spinal or general anesthesia. Patients were followed at 2 weeks, 6 weeks, 12 weeks, and up to 6 months. Clinical evaluation included pain assessment, range of motion, and functional outcome using standardized knee scoring systems. Radiological assessment focused on fracture union and alingment

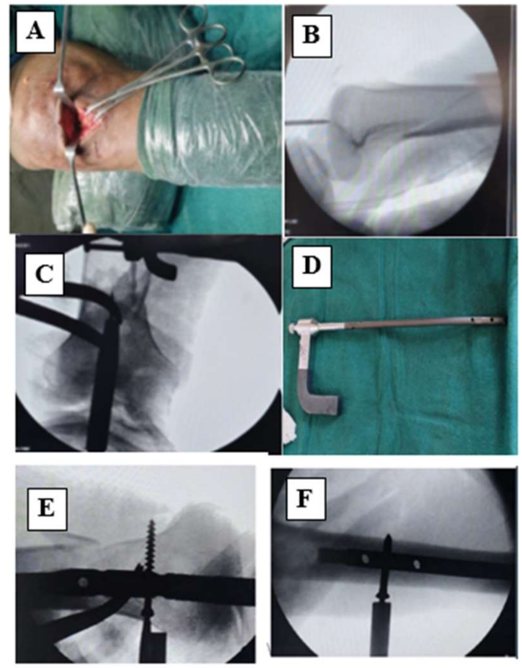

Figure 1: Showing Operative clips (A) Patient placement, Skin incision and patellar tendon splitting, (B) Entry point on lateral, (C) Canal preparation, (D) Nail assembly, (E) Distal locking, (F) Proximal locking.

Statistical Analysis:
Data were entered into Microsoft Excel and analyzed using SPSS version 30. Quantitative variables were expressed as mean ± SD, while qualitative variables were presented as frequencies and percentages. The Chi-square test was used for categorical variables, and Pearson correlation assessed functional outcomes at different follow-up intervals. A p-value <0.05 was considered statistically significant

Results:
Table 1: Age Distribution of Study Participants, Gender distribution, Distribution of Mode of Injury, Laterality of Distal Femur Fractures and AO/OTA Classification of Fractures

Age Group (years)	**Frequency (n)**	**Percentage (%)**
18–30	8	26.67
31–40	7	23.33
41–50	6	20.00
51–60	5	16.67
>60	4	13.33
Total	**30**	**100.00**
Mean ± SD	**40.9 ± 15.3 years**	**Range: 18–68**
Gender	**Frequency (n)**	**Percentage**

		(%)
Male	19	63.33
Female	11	36.67
Total	**30**	**100.00**
Male : Female Ratio	**1.73 : 1**	
Mode of Injury	**Frequency (n)**	**Percentage (%)**
Road Traffic Accident	17	56.67
Fall from Height	8	26.67
Assault	3	10.00
Fall on Ground	2	6.67
Total	**30**	**100.00**
Side	**Frequency (n)**	**Percentage (%)**
Right	16	53.33
Left	14	46.67
Total	**30**	**100.00**
AO/OTA Type	**Frequency (n)**	**Percentage (%)**
33-A1 (Simple)	9	30.00
33-A2 (Wedge)	13	43.33
33-A3 (Complex)	8	26.67
Total	**30**	**100.00**

Table 1 summarizes the demographic and fracture characteristics of the 30 patients. The mean age was 40.9 ± 15.3 years (range: 18–68 years), with 50% aged ≤40 years. Males predominated (63.33%) with a male-to-female ratio of 1.73:1. Road traffic accidents were the commonest mode of injury (56.67%), followed by falls from height (26.67%). Right-sided fractures (53.33%) were slightly more frequent than left-sided fractures (46.67%). AO/OTA 33-A2 was the most common fracture type (43.33%), followed by 33-A1 (30.00%) and 33-A3 (26.67%).

Table 2: Duration between Injury and Surgery, Duration of Surgery, Duration of Surgery by AO/OTA Fracture Type

Duration (days)	**Frequency (n)**		**Percentage (%)**
0–3	12		40.00
4–7	11		36.67
8–14	5		16.67
>14	2		6.67
Total	**30**		**100.00**
Duration (minutes)	**Frequency (n)**		**Percentage (%)**
50–60	10		33.33
61–75	12		40.00
76–90	6		20.00
>90	2		6.67
Total	**30**		**100.00**
Mean ± SD	**69.2 ± 13.5 min**		**Range: 50–95**
AO/OTA Type	**n**	**Mean (min)**	**SD**
33-A1 (Simple)	9	54.8	3.1
33-A2 (Wedge)	13	67.6	4.9
33-A3 (Complex)	8	88.1	4.1

Table 2 illustrates the time interval between injury and surgical intervention, Duration of Surgery, Duration of Surgery by AO/OTA Fracture Type. The majority of patients (76.67%) underwent surgery within 7 days of injury, with 40.00% operated within the first 3 days. Only 23.33% experienced delayed surgery beyond one week. The mean surgical duration was 69.2±13.5 minutes (range 50 95 minutes), with 73.33% of surgeries completed within 75 minutes. The 61 75 minutes category was the most frequent (40.00%).

Table 3: Intraoperative Blood Loss, Blood Loss by AO/OTA Fracture Type

Blood Loss (ml)	**Frequency (n)**		**Percentage (%)**
100–150	9		30.00
151–200	10		33.33
201–250	6		20.00
>250	5		16.67
Total	**30**		**100.00**
Mean ± SD	**191.0 ± 48.7 ml**		**Range: 120–280**
AO/OTA Type	**n**	**Mean (ml)**	**SD**
33-A1 (Simple)	9	136.8	10.3
33-A2 (Wedge)	13	187.2	18.0
33-A3 (Complex)	8	258.1	13.3

Table 3 depicts the intraoperative blood loss during distal femoral nailing and Blood Loss by AO/OTA Fracture Type. The mean blood loss was 191.0±48.7 ml (range 120 280 ml). The majority of patients (63.33%) had blood loss of 200 ml or less, and no patient required intraoperative blood transfusion.

Table 4: Pattern of Associated Injuries

Associated Injury	**Present n (%)**	**Absent n (%)**
Ipsilateral Tibia Fracture	4 (13.33)	26 (86.67)
Contralateral LL Fracture	2 (6.67)	28 (93.33)
Upper Limb	3 (10.00)	27 (90.00)

Fracture		
Head Injury	2 (6.67)	28 (93.33)
Chest Injury	3 (10.00)	27 (90.00)
Abdominal Injury	1 (3.33)	29 (96.67)
At least one injury	**11 (36.67)**	**19 (63.33)**

Table 4 describes the pattern of associated injuries among study participants. Eleven patients (36.67%) sustained at least one associated injury. Ipsilateral tibia fracture was the most common skeletal injury (13.33%), while chest injury (10.00%) and upper limb fracture (10.00%) were equally frequent.

Table 5: Statistical Findings

SN	Analysis	Test	Statistic	p-value	Inference
1	Age vs Outcome	Chi-square	$\chi^2=4.615$	0.032	Significant*
2	Fracture vs Union	ANOVA	F=7.457	0.003	Highly Sig**
3	MOI vs Comp.	Fisher's	–	0.183	Not Significant
4	Timing vs Infection	Fisher's	–	1.000	Not Significant
5	Assoc. Inj vs Stay	t-test	t=−4.46	<0.001	Highly Sig***
6	Gender vs Outcome	Fisher's	–	1.000	Not Significant
7	Union Time vs ROM	Pearson	r=−0.432	0.017	Significant*
8	Comp vs Outcome	Fisher's	–	<0.001	Highly Sig**

Table 5 presents all eight inferential statistical analyses conducted in this study. Five analyses yielded statistically significant results: age versus functional outcome (p=0.032), fracture type versus union time (p=0.003), associated injuries versus hospital stay (p<0.001), union time versus ROM (p=0.017), and complications versus functional outcome (p<0.001).

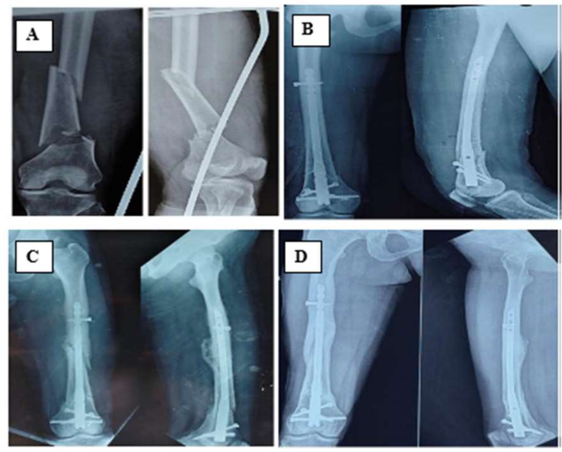

Figure 2: (A) PRE-OPERATIVE XRAY, (B) POST OP XRAY, (C) POST OP XRAY AT 3 MONTHS, (D) POST OP XRAY AT 6 MONTHS

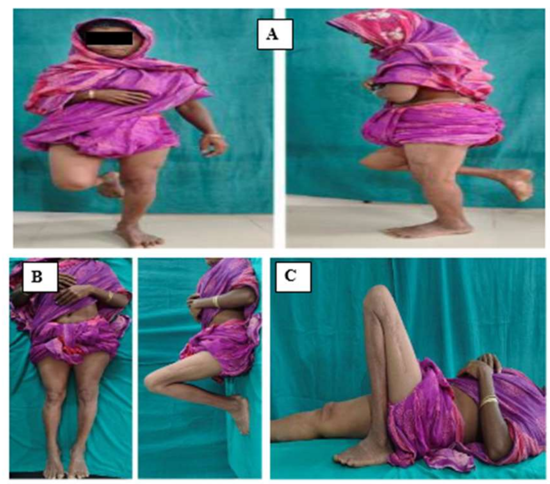

Figure 3: FUNCTIONAL OUTCOME: (A) WEIGHT BEARING, (B) NO LIMB LENGTH DISCREPENCY, (C) KNEE FLEXION

Discussion:

Thirty patients with a mean age of 40.9 ± 15.3 years were included, with 50% aged ≤40 years, indicating predominance of young and middle aged adults. This contrasts with geriatric cohorts such as Kim et al. (2009), who reported a mean age of 67.2 years [7]. Despite older age, Kim et al. achieved high union rates, though non-unions occurred in AO A3 fractures. In osteoporotic fractures, Kim et al. (2012) reported reliable union with augmentation [8]. Males constituted 63.33% of patients, reflecting higher exposure to high energy trauma. Literature suggests outcomes are influenced more by fracture comminution and reduction difficulty than by sex. Kim et al. (2009) linked poor outcomes to highly comminuted fractures rather than demographic factors [7], while Singh et al. (2024) emphasized individualized management [9].

Road traffic accidents were the most common cause (56.67%), followed by falls from height. High energy mechanisms are associated with increased comminution and operative demands. Kim et al. (2009) reported complications predominantly in AO A3 fractures [7]. Although Nino et al. (2022) achieved union in complex fractures, complication rates were high [10]. Aggarwal et al. (2022) found comparable outcomes between retrograde nailing and plating, with lower nonunion and infection rates for nailing [11]. Thus, fracture severity rather than mechanism alone determines outcome. Outcomes depend mainly on fracture morphology, reduction quality, and alignment control, as supported by Seyhan et al. (2013) using blocking screws to improve stability [12]. AO/OTA 33 A2 fractures (43.33%) were most common, followed by A1 (30%) and A3 (26.67%). Union time increased significantly with fracture complexity ($p = 0.003$). Kim et al. (2009) reported nonunions exclusively in AO A3 fractures [7], while Seyhan et al. (2013) demonstrated improved outcomes with alignment aids [12]. Most patients (76.67%) underwent surgery within 7 days. Early fixation facilitated rehabilitation and was associated with a low infection rate (3.33%), with no significant association between delay and infection, Aggarwal et al. (2022) and Kishore et al. (2025) similarly reported low infection rates with retrograde nailing [11, 13], supporting its safety when standard protocols are followed. Mean operative time was 69.2 ± 13.5 minutes, increasing with fracture complexity (A1 < A2 < A3). This trend aligns with Kim et al. (2009) and Kishore et al. (2025), who reported longer durations in comminuted fractures [7, 13]. Mean blood loss was 191.0 ± 48.7 ml, increasing with AO/OTA complexity. No patient required transfusion. This mirrors reports by Kishore et al. (2025) highlighting lower blood loss with minimally invasive nailing [13]. In selected frail patients, construct augmentation may allow early weight bearing, as shown by Linker et al. (2025) [14]. Overall, the findings highlight the importance of multidisciplinary trauma care and realistic counseling in polytrauma patients.

Limitations:

The study is limited by a relatively small sample size, which restricts statistical power for detecting associations in low frequency outcomes such as infection or nonunion. Its single center design may limit generalized ability, as outcomes can vary with surgical expertise, trauma systems, and rehabilitation resources. The absence of a comparative fixation group prevents direct evaluation against alternative methods such as locking plates. Additionally, the follow up duration focused on early recovery, and patient reported quality of life measures and long-term complications were not assessed, limiting broader functional interpretation.

Conclusion:

In summary, distal femoral nailing for extra articular distal femur fractures in this cohort resulted in high union reliability (96.67% by 6 months), timely mean union (14.4 weeks), satisfactory early ROM (111.2° at 12 weeks), substantial pain resolution (63.33% pain free at 12 weeks), and predominantly excellent to good functional outcomes (86.67%), while demonstrating that fracture complexity, patient age, delayed union, and complications are key determinants of recovery and should guide perioperative planning, patient counseling, rehabilitation intensity, and follow up prioritization.

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Conflict of interest: None declared

Ethical approval: The study was conducted in strict adherence to the ethical principles for medical research involving human subjects as outlined in the Declaration of Helsinki. Prior to commencement, the complete study protocol was submitted for review and approval to the Institutional Ethical Committee (IEC) of Silchar Medical College and Hospital, Silchar. Formal written approval was obtained from the IEC before any patient was enrolled.

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