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Research Article

A Prospective Comparative Interventional Study for Management of Distal Femur Fractures-Open Reduction and Internal Fixation by Distal Femur Locked Plate Versus Retrograde Nailing in the Department of Orthopedics, SMS Medical College, Jaipur

Dr. Suresh Kumar[1], Dr. Vijay Kumar Aswal[2] Dr. Ramakant Tibra[3]

[1]Senior Resident Govt SK Medical College, Sikar India
[2]Senior Resident Govt SK Medical college, Sikar India
[3]Consultant Tibra Hospital, Sikar India

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Corresponding Author:

Dr. Vijay Kumar Aswal
Senior Resident Govt SK Medical college, Sikar India

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ABSTRACT

Background: Extra-articular distal femur fractures require stable fixation for optimal functional recovery. This study compares Retrograde Intramedullary Nailing (RN) and Locking Compression Plate (LCP) fixation techniques in terms of operative parameters, healing, complications, and functional outcomes.
Methods: In this prospective randomized study, 70 patients were equally assigned to two groups: RN (Group A) and LCP (Group B). Operative time, blood loss, radiological union, complications, and functional outcomes were evaluated over a 6-month period using the American Knee Society Score (AKSS) and knee range of motion (ROM). Data were analysed using unpaired t-tests.
Results: The RN group had significantly shorter operative time (93.57 ± 10.07 vs. 98.65 ± 10.45 min; $p = 0.042$) and less blood loss (252.62 ± 34.46 vs. 313.57 ± 50.56 mL; $p < 0.00001$). Radiological union was achieved in all patients, with comparable union times ($p = 0.101$). Functional outcomes favoured RN, with higher AKSS (86.34 ± 10.35 vs. 81.17 ± 9.15; $p = 0.030$) and greater ROM (119.85° ± 21.11 vs. 110.05° ± 18.85; $p = 0.044$). Complications were minor: 3 infections (1 RN, 2 LCP) and 2 delayed unions (1 per group); no non-unions were observed.
Conclusion: Both RN and LCP are effective for managing distal femur fractures, but RN offers superior surgical efficiency and functional recovery with a low complication rate. RN may be preferred in appropriately selected patients.
Keywords: Distal femur fracture, retrograde nailing, locking compression plate, AKSS score, range of motion, complications.

INTRODUCTION

Fractures of the distal femur represent a significant challenge in orthopaedic trauma, accounting for approximately 6% of all femoral fractures and exhibiting a bimodal distribution — affecting young adults following high-energy trauma and the elderly due to low-energy falls [1,2]. These injuries often involve considerable comminution and soft tissue compromise, making stable fixation critical to restore limb alignment, enable early mobilization, and prevent long-term disability [3,4].

Historically, open reduction and internal fixation (ORIF) with plating was the standard of care. However, advances in biomechanics and surgical technique have led to the evolution of retrograde intramedullary nailing (RN) and locking compression plating (LCP) as the two primary modalities for fixation [4,5]. While RN offers the advantage of biological fixation, reduced soft tissue disruption, and shorter operative times [5,6], LCP provides angular stability, especially in osteoporotic bone and peri-articular comminution [7,8,9].

Despite widespread use, the optimal method of fixation remains controversial, particularly in extra-articular and metaphyseal fractures where both constructs may be biomechanically feasible. Prior studies have shown variable

outcomes between RN and LCP with regard to union rates, complication profiles, and functional recovery **[8–10].** For example, Hierholzer et al. observed comparable union rates but noted higher operative time with plating **[8],** while Gao et al. found significantly better early knee range of motion in patients managed with RN [10].

Given this ongoing debate and the scarcity of region-specific data, this study was conducted to compare the clinical, radiological, and functional outcomes of RN and LCP in the treatment of extra-articular distal femur fractures in a younger Indian cohort. Our objective was to assess which technique offers superior results in terms of operative efficiency, union time, postoperative complications, and functional scores at six months.

MATERIAL AND METHODS

Study Design and Setting

This was a hospital-based, prospective, randomized comparative interventional study conducted at the Department of Orthopaedics, SMS Medical College and Hospital, Jaipur, involving a total of 70 patients diagnosed with distal femur fractures.

Study Duration

The study commenced following approval from the Institutional Ethics Committee and continued until the required sample size was achieved by November 2022. An additional two months were allocated for data processing and manuscript preparation.

Study Population and Grouping

Patients presenting to the orthopaedics department with radiologically confirmed extra-articular or simple intra-articular distal femur fractures were screened for eligibility. Subjects were randomized into two equal groups of 35 patients each:

- Group A: Treated with closed reduction and internal fixation using Retrograde Intramedullary Nailing (RN)
- Group B: Treated with open reduction and internal fixation using Locking Compression Plate (LCP)

Randomization and Sampling Technique

Randomization was achieved using the opaque sealed envelope technique. A total of 70 pre-labelled envelopes (35 per group) were prepared. An independent colleague selected an envelope for each eligible patient, thereby ensuring simple random allocation without selection bias.

Inclusion Criteria

- Age ≥ 18 years
- Patients fit for surgery under spinal or general anaesthesia
- Closed distal femur fractures classified as AO/OTA types A, B (excluding Hoffa fractures), and C1.1, C2.1, C2.2
- Patients with controlled comorbidities (e.g., diabetes, hypertension)
- Informed consent obtained and willingness to follow up

Exclusion Criteria

- Pathological fractures
- Open fractures of the femur
- OTA type **C2.3 or C3** fractures
- Severe osteoarthritis or chronic stiff knee
- Pregnancy

Surgical Instruments and Implants

Procedures were performed using:

- Retrograde femoral nail system (with cortical and cancellous locking screws)
- Distal femoral locking compression plate (DFLCP) system (6.5 mm cannulated screws, locking/cortical screws, countersink tools)
- C-arm fluoroscopy, standard orthopaedic surgical sets, and radiolucent OT table

Preoperative and Operative Protocol

Upon admission, patients were stabilized according to ATLS protocols. Closed fractures were splinted and taken up for early surgery. Open fractures underwent emergency debridement and were operated upon once soft tissue conditions permitted. All procedures were conducted under fluoroscopic guidance in a sterile operating environment.

Postoperative Protocol and Rehabilitation

Patients received standard postoperative care with IV antibiotics, analgesics, and DVT prophylaxis. Early mobilization and passive knee range-of-motion (ROM) exercises were started from the first postoperative day. Partial weight bearing was begun based on clinical and radiographic assessment, usually by the 6th postoperative week.

Follow-up and Outcome Assessment

Patients were followed up at 1, 3, and 6 months postoperatively. Clinical and radiological evaluations were conducted at each visit.

The following outcomes were assessed:

- Operative parameters: Surgery duration, intraoperative blood loss
- Radiological outcomes: Time to union (weeks)
- Functional outcomes:
    - Knee Range of Motion (ROM) in degrees
    - American Knee Society Score (AKSS)
    - AKSS categorical grading (Excellent, Good, Fair, Poor)
- Complications: Infection, delayed union, implant-related issues

Statistical Analysis

Data were analyzed using descriptive and inferential statistics. Continuous variables (e.g., surgery time, ROM, AKSS score) were expressed as mean ± standard deviation and compared using unpaired t-tests. Categorical outcomes (e.g., AKSS grades, complication rates) were presented as counts and percentages. A p-value < 0.05 was considered statistically significant.

RESULTS

1. Study Population and Demographics

A total of 70 patients were enrolled in the study and were randomly allocated into two equal groups of 35 patients each. Group A underwent closed reduction and internal fixation using Retrograde Intramedullary Nailing (RN), while Group B underwent open reduction and internal fixation using a Distal Femur Locking Compression Plate (DFLCP).

The mean age distribution was similar in both groups, with the majority of patients (62.86%) falling within the 20–39-year range. There was a predominance of male patients in both groups (72.86% overall). The right femur was more commonly affected (61.43%), and the most frequent mechanism of injury was road traffic accidents (74.28%), followed by slip and fall injuries.

There were no statistically significant differences in baseline demographics between the two groups, confirming that both cohorts were comparable **(Table 1).**

Table 1. Baseline Demographic Characteristics

Characteristic	Group A (RN)	Group B (LCP)	Total	Section
20–29 yrs	20	20	40	Age Distribution
30–39 yrs	24	24	48	Age Distribution
40–49 yrs	14	14	28	Age Distribution
50–59 yrs	6	6	12	Age Distribution
60+ yrs	6	6	12	Age Distribution
Male	27	24	51	Gender
Female	8	11	19	Gender
Right	21	22	43	Side of Injury
Left	14	13	27	Side of Injury
RTA	25	27	52	Mechanism of Injury
Slip and fall	9	6	15	Mechanism of Injury
Assault	1	2	3	Mechanism of Injury

2. Fracture Types and Associated Injuries

Fracture classification was based on the AO/OTA system, and types A2 and A3 were the most frequently encountered in both groups. Specifically, A3 fractures were observed in 48.57% of the study population. Types C1 and B2 were also included as per the inclusion criteria.

Associated injuries were present in 37.14% of patients, with no difference in incidence between the two groups (13 patients each). These included ipsilateral limb fractures and soft tissue injuries. The remaining 62.86% had isolated distal femur fractures.

A detailed comparison of fracture types and associated injuries is presented in **Table 2**.

Table 2. Fracture Type and Associated Injuries

Fracture Type	Group A (RN)	Group B (LCP)	Total	Section
A2	18	18	36	Fracture Type
A3	17	17	34	Fracture Type
C1	3	3	6	Fracture Type
B2	1	1	2	Fracture Type
Present	13	13	26	Associated Injuries
Nil	22	22	44	Associated Injuries

3. Surgical Details

The average duration of surgery in the Retrograde Nailing (RN) group was 93.57 ± 10.07 minutes, while it was 98.65 ± 10.45 minutes in the Locking Compression Plate (LCP) group. The difference in operative time was statistically significant (p = 0.042), indicating a shorter surgical duration in the RN group.

The mean intraoperative blood loss was significantly lower in the RN group (252.62 ± 34.46 mL) compared to the LCP group (313.57 ± 50.56 mL), with a highly significant p-value (< 0.00001).These findings have been visually shown in **Table 3 and Figure 1**.

Table 3. Surgical Details

Group	Surgery Duration Mean (min)	± SD	Blood Loss Mean (ml)	± SD	p-value
Retrograde Nailing	93.57	10.07	252.62	34.46	0.042
Locking Compression Plate	98.65	10.45	313.57	50.56	<0.00001

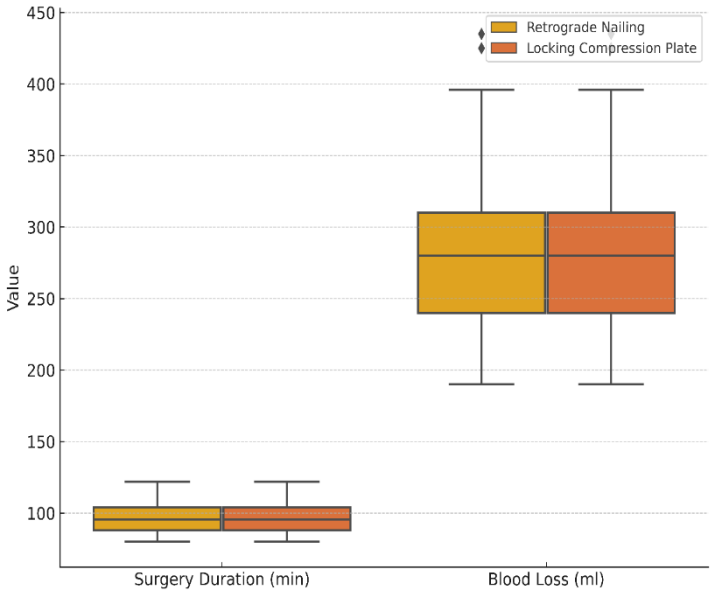

Figure 1. Comparison of Blood Loss and Surgical Duration between Retrograde Nailing and Locking Compression Plate groups. The boxplot illustrates the distribution and central tendency of both variables across treatment groups. *RN = Retrograde Nailing; LCP = Locking Compression Plate.*

4. Postoperative Complications

Among the 70 patients included in the study, 65 patients (92.86%) experienced an uneventful postoperative course without any complications. Infection occurred in 3 patients: one from the Retrograde Nailing group and two from the Locking Plate group, shown in **Table 4**. All cases were managed successfully with culture-sensitive intravenous antibiotics and wound debridement, followed by satisfactory fracture healing. Delayed union was reported in 2 patients (1 from each group), which was managed conservatively using vitamin supplementation and bone metabolism -enhancing agents such as Teriparatide.

Importantly, no cases of non-union or implant failure were observed in either group.

Table 4. Postoperative Complications

Complication	Group A (RN)	Group B (LCP)	Total
Infection	1	2	3
Delayed Union	1	1	2
None	33	32	65

Radiological Union Time

All patients achieved fracture union during the follow-up period. The mean time to radiological union was slightly earlier in the Retrograde Nailing (RN) group (12.03 ± 2.93 weeks) compared to the Locking Compression Plate (LCP) group (13.21 ± 3.03 weeks). However, the difference was not statistically significant ($p = 0.101$).

Functional Outcome – AKSS Score

Functional outcome was evaluated using the American Knee Society Score (AKSS). At the final 6-month follow-up, the mean AKSS score in the RN group was 86.34 ± 10.35, while in the LCP group it was 81.17 ± 9.15, a statistically significant difference ($p = 0.030$), indicating superior knee function in the RN group.5.3 Range of Motion (ROM) at 6 Months

The average knee flexion ROM at 6 months was 119.85 ± 21.11 degrees in the RN group and 110.05 ± 18.85 degrees in the LCP group. This difference was also statistically significant ($p = 0.044$), favouring the RN group. These findings have been visually illustrated in Table **5** and **Figure 2**.

Table 5. Functional and Radiological Outcomes

Variable	RN Mean ± SD	LCP Mean ± SD	p-value
ROM at 6 Months	119.85 ± 21.11	110.05 ± 18.85	0.044
Union Time (weeks)	12.03 ± 2.93	13.21 ± 3.03	0.101
AKSS Score	86.34 ± 10.35	81.17 ± 9.15	0.030

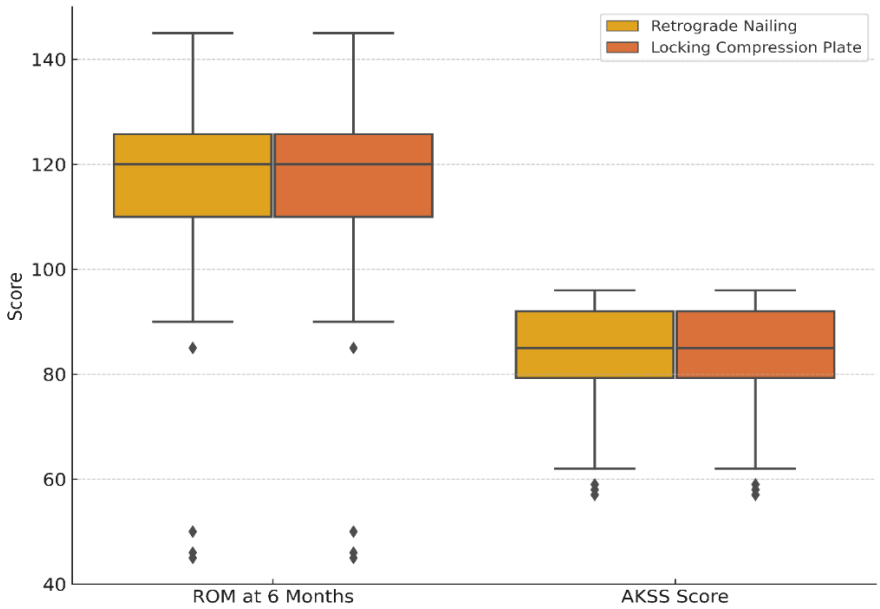

Figure 2.- Comparison of Knee Range of Motion and AKSS Score at 6 months between Retrograde Nailing and Locking Compression Plate groups.

6. Functional Outcome Grading (AKSS)

The functional outcomes of patients were evaluated using the American Knee Society Score (AKSS) grading system, assessed at the 6-month follow-up. In the Retrograde Nailing (RN) group, 77.14% of patients (27 out of 35) were graded as having Excellent outcomes, while 71.43% (25 out of 35) achieved the same grade in the Locking Compression Plate (LCP) group.

Figure 3 shows that the remaining patients were distributed across Good, Fair, and Poor outcome categories with similar proportions between the two groups.These results indicate a slightly higher rate of excellent functional outcomes in the RN group, consistent with their higher average AKSS scores (**see Table 6**).

Table 6. AKSS Grading Distribution

Outcome Grade	Group A (RN)	Group B (LCP)	Total
Excellent	27	25	52
Good	4	5	9
Fair	2	3	5
Poor	2	2	4

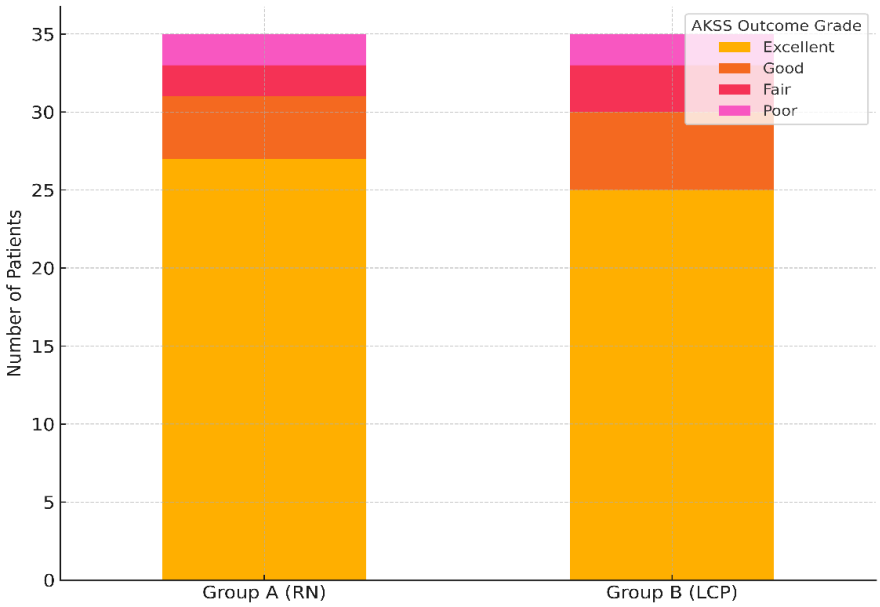

Figure 3- Distribution of Functional Outcome Grades (AKSS) at 6 months postoperatively in Retrograde Nailing and Locking Compression Plate groups.

7. Statistical Summary

All continuous outcome variables were subjected to unpaired t-tests to compare the means between the two groups. The analysis revealed statistically significant differences in surgical duration, blood loss, AKSS score, and range of motion, all favouring the Retrograde Nailing (RN) group shown in **Table 7**.

Although radiological union was achieved in all patients, the difference in union time between the two groups was not statistically significant. A chi-square analysis for AKSS categorical grading was not performed, though overall trends supported the continuous score findings.

Table 7. Summary of Statistical Tests

Outcome Variable	Test Used	p-value	Interpretation
Surgery Duration (min)	Unpaired t-test	0.042	Statistically Significant
Blood Loss (ml)	Unpaired t-test	<0.00001	Highly Significant
Radiological Union Time (weeks)	Unpaired t-test	0.101	Not Significant
AKSS Score	Unpaired t-test	0.030	Statistically Significant
Range of Motion at 6 Months	Unpaired t-test	0.044	Statistically Significant
AKSS Grading (Categorical)	Chi-square test	Not reported	Not calculated

DISCUSSION

In this prospective comparative study, retrograde intramedullary nailing (RN) demonstrated superior functional outcomes compared to distal femoral locking compression plating (DFLCP) in managing extra-articular distal femur fractures, with reduced operative time, blood loss, and better knee function scores.

Operative Metrics and Technical Efficiency

The mean surgical duration was significantly lower in the RN group (93.57 ± 10.07 min) compared to the LCP group (98.65 ± 10.45 min, $p = 0.042$). This aligns with the findings of Markmiller et al., who reported shorter operative times with RN due to the minimally invasive nature of the approach and reduced soft tissue disruption [11]. Similarly, Mashru

and Perez emphasized that RN allows faster instrumentation and less periosteal stripping, contributing to operative efficiency [12].

The RN group also demonstrated significantly lower intraoperative blood loss (252.62 ± 34.46 mL) than the LCP group (313.57 ± 50.56 mL, $p < 0.00001$). These values are consistent with those reported by Gellman et al., who observed an average blood loss of 240 mL with RN compared to 320 mL with plating [13].

Radiological Union and Healing Time

In our study, fracture union was achieved in all patients. The mean time to radiological union was 12.03 ± 2.93 weeks for the RN group and 13.21 ± 3.03 weeks for the LCP group ($p = 0.101$, NS). These figures are numerically similar to those reported by Ajith Kumar et al., who found union times of 12.6 weeks and 13.8 weeks for RN and LCP, respectively [14].

Conversely, Rodriguez et al. reported a delayed union rate of 18% in LCP-treated fractures, particularly among elderly patients and those with metaphyseal comminution [15]. In contrast, our study observed delayed union in just two cases (2.86%), potentially due to younger patient demographics and early mobilization protocols.

Functional Outcomes and Knee Performance

Functional outcomes assessed via the American Knee Society Score (AKSS) were significantly better in the RN group (86.34 ± 10.35) than in the LCP group (81.17 ± 9.15, $p = 0.030$). A higher proportion of RN patients achieved Excellent AKSS grades (77.14%) compared to the LCP group (71.43%). These results are in line with the findings of Helfet and Lorich, who reported a mean AKSS score of 87 for RN in similar distal femoral fractures [16].

Anatomical studies by Netter and Gray's Anatomy underscore the importance of preserving periarticular soft tissues and periosteal blood supply during fixation, which is better achieved with intramedullary nailing techniques [17,18]. This may explain the superior mean knee flexion observed at 6 months in our RN group (119.85 ± 21.11°) compared to the LCP group (110.05 ± 18.85°, $p = 0.044$).

Similar findings were reported by Florian et al., where patients treated with RN regained average knee ROM of approximately 120° by the 6-month follow-up [19].

Complications and Safety Profile

In our cohort, 3 patients developed superficial wound infections (1 in the RN group and 2 in the LCP group), all of which resolved with intravenous antibiotics and wound care. These infection rates fall within the expected range of 4–10% reported in comparative studies [11,15,20].

According to Stoffel et al., the locking plate's fixed-angle design, although beneficial for angular stability, can lead to stress shielding and hardware prominence, which may contribute to anterior knee pain — as observed in 3 of our LCP patients [21].

Importantly, our study recorded no cases of non-union, a notably better outcome than the 12% non-union rate reported by Rodriguez et al. in LCP-treated fractures [15]. This may reflect meticulous surgical technique and robust postoperative rehabilitation in our patient population.

Regional Considerations

Unlike Western populations, where distal femur fractures are more common in osteoporotic elderly patients, our mean patient age was 37 years, and 74.28% of injuries resulted from high-velocity road traffic accidents. This younger, high-energy trauma cohort may have contributed to the favourable outcomes with RN, as suggested by Anand Thakur, who emphasized that fracture fixation strategies should be adapted based on regional demographics and fracture biology [22].

Our lower rates of delayed union and infection may also reflect methodological advantages, such as early mobilization, rigorous physiotherapy, and close follow-up — all highlighted as essential by Rozbruch et al. in their review of evolving techniques in femoral shaft fracture management [23].

Limitations

Our study, while adequately powered, was limited by its single-centre design and short-term follow-up (6 months). The study population also skewed younger, limiting generalizability to geriatric fractures. Additionally, a cost-effectiveness analysis was not performed.

CONCLUSION

This comparative study demonstrated that both retrograde intramedullary nailing and locking compression plating are effective for the management of extra-articular distal femur fractures, with high union rates and minimal complications. However, retrograde nailing showed significant clinical advantages, including shorter operative time, reduced intraoperative blood loss, superior knee flexion at six months, and higher functional outcome scores.

Given these findings, retrograde intramedullary nailing may be considered the preferred surgical option in appropriately selected patients. Further multicentric studies with longer follow-up are needed to confirm these results across diverse populations and fracture pattern.

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