

Functional Outcome of Retrograde Femoral Nailing Versus Minimally Invasive Percutaneous Plate Osteosynthesis in Extra-Articular Distal Femur Fractures: A Prospective Quasi-Randomized Comparative Study

Neeraj Singla¹, Anshul Dahuja¹, Lovish Gulbadhar¹, Kapil Bansal¹, Krishmveer Singh¹, Manmohan Singh¹

Learning Point of the Article:

Both retrograde femoral nailing and Minimally Invasive Percutaneous Plate Osteosynthesis provide satisfactory functional outcomes in extra-articular distal femur fractures; however, implant selection should be individualized based on fracture pattern, soft-tissue condition, and surgeon expertise.

Abstract

Introduction: Distal femur fractures represent a challenging injury due to their proximity to the knee joint and the need to restore limb alignment and function. Surgical management has evolved with techniques such as retrograde femoral nailing (RFN) and minimally invasive percutaneous plate osteosynthesis (MIPPO). Both techniques aim to achieve stable fixation while preserving soft tissue and vascularity. We performed an analysis on both groups (30 patients each), and our primary objectives compared were radiological union time, weight-bearing, and functional outcome using NEER's score. Our secondary objectives were complications, surgical time, and fluoroscopy exposure.

Materials and Methods: This prospective comparative study included 60 patients with extra-articular distal femur fractures treated at a tertiary care center. Patients were divided into two groups using an alternate allocation method: (1) Group A: RFN (n = 30). (2) Group B: MIPPO with locking plate (n = 30).

Results: Patients treated with RFN demonstrated earlier initiation of partial and full weight-bearing and earlier fracture union compared with the MIPPO group. Functional outcomes assessed by NEER's score were better in the RFN group at 6 weeks and 3 months, while both groups showed comparable results by 6 months follow-up. Complications observed included superficial infection, knee stiffness, malunion, and non-union.

Conclusion: Both RFN and MIPPO are effective methods for treating extra-articular distal femur fractures. RFN allows earlier mobilization and functional recovery, while MIPPO preserves fracture biology and soft-tissue integrity. The choice of technique should be individualized based on fracture pattern, patient factors, and surgeon experience. Larger multicenter trials with longer follow-up are needed to confirm these findings.

Keywords: Distal femur fracture, retrograde femoral nailing, minimally invasive percutaneous plate osteosynthesis, locking plate, functional outcome, NEER score.

Introduction

The distal femur comprises the femoral condyles and trochlea,

forming a critical component of the knee joint and playing a vital role in stability and motion. Fractures of the distal femur are

Author's Photo Gallery



Dr. Neeraj Singla



Dr. Anshul Dahuja



Dr. Lovish Gulbadhar



Dr. Kapil Bansal



Dr. Krishmveer Singh



Dr. Manmohan Singh

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¹Department of Orthopaedics, Guru Gobind Singh Medical College and Hospital, Faridkot, Punjab, India.

Address of Correspondence:

Dr. Kapil Bansal,
Department of Orthopaedics, Guru Gobind Singh Medical College and Hospital, Faridkot, Punjab, India.
E-mail: singlaneeraj.6897@gmail.com

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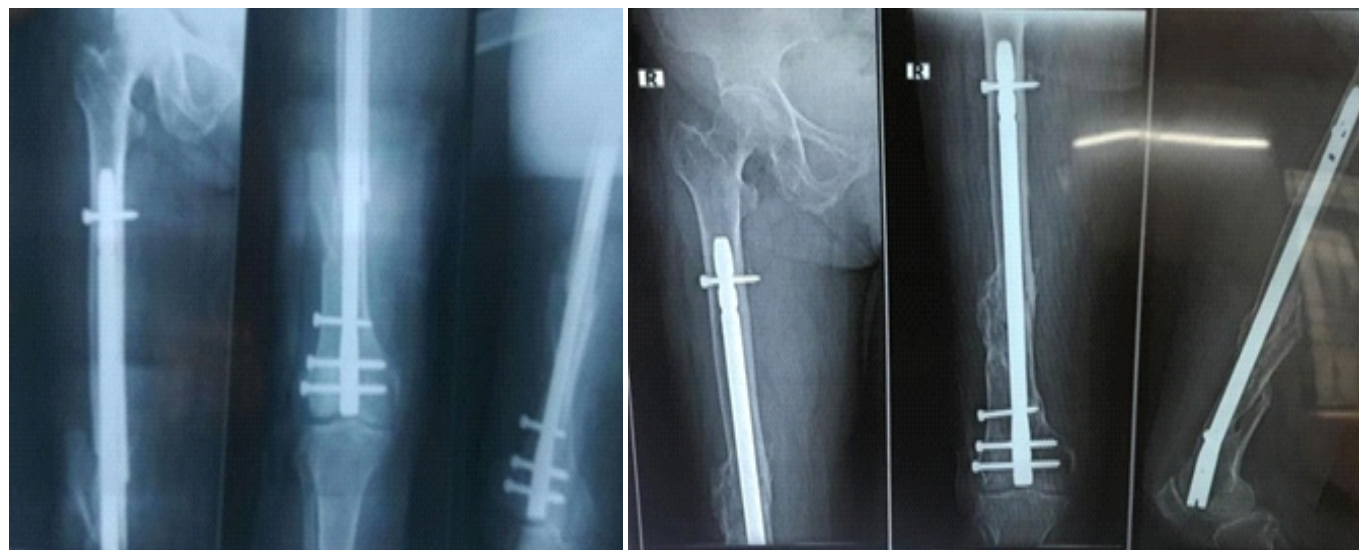


Figure 1: Representative post-operative radiographs showing retrograde femur nailing and 6-month follow-up radiograph.

challenging to manage due to their anatomical complexity and functional significance [1].

These fractures extend from the supracondylar region to the articular surface and commonly result from low-energy trauma in osteoporotic elderly patients and high-energy injuries in younger individuals. They are broadly classified as intra-articular or extra-articular, with the latter involving the metaphyseal region without joint surface disruption. Extra-articular fractures may be transverse, oblique, spiral, or comminuted, and their classification is essential for guiding treatment strategies [1, 2].

Distal femur fractures account for approximately 1% of all fractures and 6–7% of femoral fractures, with an incidence of around 37/100,000 population. Due to their complexity, most cases require surgical intervention [3].

The primary goals of management include restoration of alignment, stable fixation, preservation of vascularity, and early mobilization to optimize functional outcomes. Surgical options include ORIF, Minimally Invasive Percutaneous Plate Osteosynthesis (MIPPO), and Retrograde Intramedullary Nailing (RIMN) [4, 5].

RIMN provides stable fixation along the mechanical axis with minimal soft-tissue disruption and is associated with shorter operative time, reduced infection rates, and early mobilization. However, it has limitations such as intra-articular entry complications, difficulty in distal fragment control, and potential malalignment [6, 7].

Conventional open plating techniques, although effective, are associated with extensive soft-tissue dissection and periosteal stripping, increasing the risk of infection and delayed union. To address these concerns, minimally invasive plating techniques such as MIPPO have been developed, focusing on biological fixation and preservation of blood supply [8].

MIPPO allows indirect fracture reduction and promotes callus formation through controlled micromotion, leading to improved healing and reduced complications. It is particularly advantageous in osteoporotic bone; however, it carries risks of malalignment, technical difficulty, and a steep learning curve [9, 10].

While both RIMN and MIPPO are widely used for extra-articular distal femur fractures, the optimal method of fixation remains controversial, with each technique offering distinct advantages and limitations [11, 12].



Figure 2: Representative post-operative radiographs showing minimally invasive percutaneous plate osteosynthesis and 6-month follow-up radiograph.

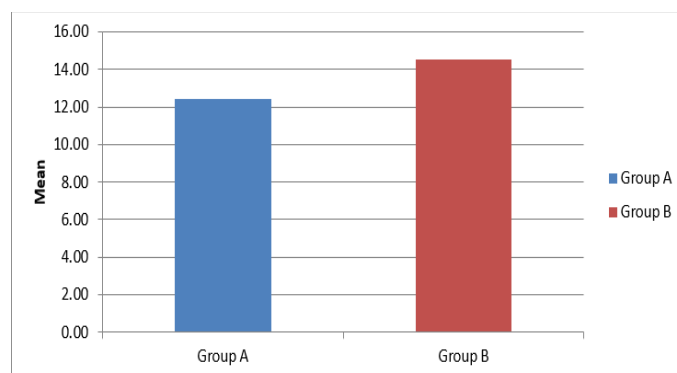


Figure 3: Radiological union time (weeks).

Therefore, this study was conducted to compare preoperative, intraoperative, and post-operative outcomes – including blood loss, duration of surgery, and functional outcome (NEER score) – between retrograde femoral nailing (RFN) and minimally invasive plate osteosynthesis in the management of extra-articular distal femur fractures.

Materials and Methods

Study design

This prospective comparative study was conducted at the Department of Orthopaedics, Guru Gobind Singh Medical College and Hospital, Faridkot, Punjab, from May 2023 to June 2025. A single-center study design was utilized, enrolling 60 consecutive eligible patients with AO type 33A2 and 33A3 fractures.

Group allocation

The study was conducted after obtaining approval from the Institutional Ethics Committee (BFUHS/2K24p-Th-2223). Patients were allocated using an alternate allocation method (quasi-randomization). Neither the patients, operating surgeons, nor outcome assessors were blinded to the surgical procedure. Introducing potential performance and observation bias:

- Group A: RFN (n = 30)
- Group B: MIPPO with distal femur locking plate (n = 30).

Inclusion criteria

- Age >18 years
- Extra-articular distal femur fractures (AO type A2–A3).

Exclusion criteria

- Intra-articular distal femur fractures

- Pathological fractures
- Open fractures
- Polytrauma requiring other priority surgeries
- Patients unfit for surgery.

Surgical technique

RFN

The procedure was performed with the patient in the supine position. Entry was made through the intercondylar notch. Closed reduction was attempted, and the nail was inserted retrograde into the femoral canal. Proximal and distal locking screws were inserted for stable fixation (Fig. 1).

MIPPO technique

In the MIPPO group, a distal femoral locking compression plate was inserted through small incisions with minimal soft-tissue dissection. The plate was slid submuscularly and fixed with locking screws proximally and distally under fluoroscopic guidance (Fig. 2).

All surgeries were performed by experienced orthopedic trauma surgeons; however, surgeon experience was not strictly standardized or stratified between groups.

Post-operative protocol

- Early quadriceps exercises
- Knee range of motion exercises
- Gradual progression to partial and full weight-bearing depending on fracture stability and radiological signs of union.

Outcome measures

Patients were assessed based on:

1. Radiological union time

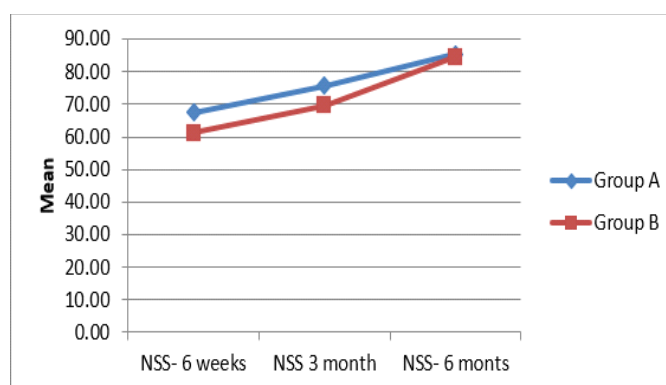


Figure 4: NEER rate score at different time intervals.

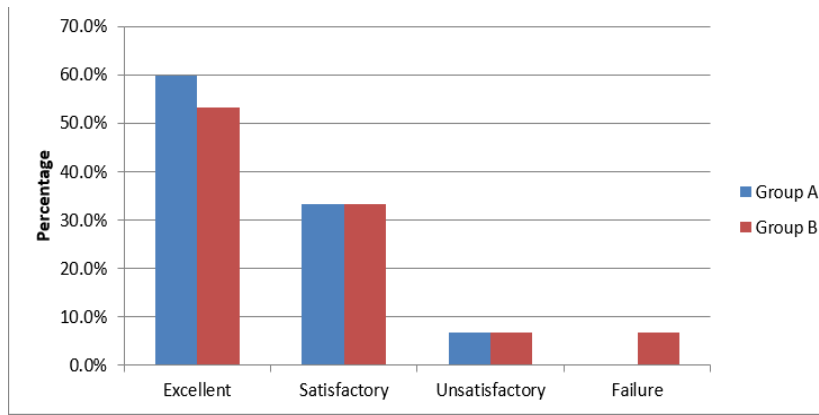


Figure 5: Functional outcome.

2. Time to partial weight-bearing
3. Time to full weight-bearing
4. Functional outcome using NEER's scoring system
5. Complications
6. Surgical time
7. Fluoroscopy exposure.

Follow-ups were conducted at:

1. 6 weeks
2. 3 months
3. 6 months.

Statistical analysis

Data were entered and compiled using Microsoft Excel. Statistical analysis was performed using IBM Statistical Package for the Social Sciences Statistics version 22. Continuous variables were expressed as mean and standard deviation, while categorical variables were expressed as frequencies and percentages. Comparison between the two groups for continuous variables was carried out using the Student's t-test. Categorical variables were analysed using the Pearson Chi-square test. $P < 0.05$ was considered statistically significant.

Results

Demographic profile

The mean age was 49.67 ± 10.54 years, with 35 males and 25 females. Road traffic accidents accounted for 71.6% of injuries, followed by falls (25%) and assault (3.33%) (Table 1).

Radiological union time (weeks)

Patients in the RFN group had a mean fracture union time of 12.42 weeks, which was significantly less than that of patients in the MIPPO group (14.50 weeks) (Fig.

3).

Time to partial weight-bearing (weeks)

The current study discovered that the mean partial weight-bearing period was 5.97 weeks for the RFN group and 7.30 weeks for the MIPPO group. The $P < 0.05$ indicates a statistically significant difference between the groups' mean times for partial weight-bearing (Table 2).

Timing of full weight-bearing (in weeks) (Table 3)

In the RFN group, the mean time of full weight-bearing was 13.03 weeks, with a standard deviation of 2.39, while in the MIPPO group; it was 15.73 weeks, with a standard deviation of 2.75. Results are statistically significant on comparison.

NEER score

At 6 weeks, the mean NEER score for participants in the RFN group was 67.43, compared to 61.13 for patients who had MIPPO. At 3 months, participants in the RFN group's mean NEER score was 75.57, compared to 69.57 for patients who had MIPPO. Mean NEER score was 85.40 in the RFN group and 84.50 in MIPPO group at 6 months.

At 6 weeks and 3rd months after surgery, the RFN group's mean NEER score was found to be significantly higher, but at 6 months, both groups were statistically insignificant (Fig. 4).

Functional outcome

In the patients of RFN group, excellent, satisfactory, unsatisfactory, and failure results were seen in 60%, 33.3%, 6.7%, and 0% of the patients, respectively. Among patients in MIPPO group, excellent, satisfactory, unsatisfactory, and failure

Table 1: Demographic profile of participants

Parameter	RFN group	MIPPO group	Total (n=60)
Mean age (years)	48.67±10.32	50.67±10.76	49.67±10.54
Gender (Male:Female)	1.7:1	1.1:1	1.4:1
Mechanism (RTA/fall/assault)	22-07-2001	21-08-2001	43/15/2
RTA: Road-traffic accidents, RFN: Retrograde femoral nailing, MIPPO: Minimally invasive percutaneous plate osteosynthesis			

Table 2: Time to partial weight-bearing (weeks)

Time to partial weight-bearing (weeks)	Group A	Group B
Mean	5.97	7.3
Standard deviation	1.47	1.73
<i>P</i> -value	0.001 (Significant)	

results were observed in 53.3%, 33.3%, 6.7%, and 6.7% of the patients, respectively. Non-significant results were found when evaluating and contrasting the functional outcomes between the two study groups (Fig. 5).

Complications

Among patients in the RFN group, 3.3%, 6.7%, 0%, 6.7%, and 10% of patients, respectively, experienced superficial infection, knee stiffness, non-union, knee pain, and malunion. Out of the patients in the MIPPO group, 6.7% experienced superficial infection, 3.3% experienced knee stiffness, 10% experienced non-union, 0% experienced knee discomfort, and 3.3% experienced malunion. Patients in the RFN group experienced greater rates of knee discomfort and malunion, whereas those in the MIPPO group saw higher rates of non-union.

Duration of surgery (minutes)

In the RFN group, the mean surgery time was 89.17 min, with a standard deviation of 25.70; in the group receiving MIPPO, the mean surgery time was 109.50 min, with a standard deviation of 12.06. Results are statistically significant on comparison.

Fluoroscopy exposure (cGy)

Patients in the MIPPO group had an average fluoroscopy exposure of 16.67 cGy, while those in the RFN group had an average of 21.17 cGy. In terms of statistical comparison, patients in the RFN group had a considerably higher mean fluoroscopy exposure than those in the MIPPO group.

Discussion

Management of extra-articular distal femur fractures remains a challenging aspect of orthopedic trauma due to the complex anatomy, biomechanical forces, and frequent association with osteoporotic bone. The present study compares functional and radiological outcomes between RFN and MIPPO, two widely accepted modalities that aim to balance mechanical stability with

biological preservation.

Distal femur fractures account for approximately 6–7% of all femoral fractures and demonstrate a bimodal distribution, affecting elderly osteoporotic individuals following low-energy trauma and younger patients after high-energy injuries. This dual pattern necessitates individualized treatment strategies based on fracture configuration, bone quality, and patient factors.

The current study observed comparable functional outcomes between RFN and MIPPO, which aligns with several previous studies. Markmiller et al. reported no significant difference in knee range of motion or complication rates between less invasive stabilization system plating and retrograde nailing, suggesting both techniques are equally effective in managing distal femur fractures [13]. Similarly, Jankowski et al., in a systematic review, found no statistically significant differences in union rates, functional outcomes, or complication profiles between intramedullary nailing and locked plating [14]. These findings support the hypothesis that both implants can achieve satisfactory results when applied appropriately.

RFN offers the advantage of a load-sharing construct, which facilitates earlier weight-bearing and promotes faster union. In the present study, patients treated with RFN demonstrated relatively shorter operative times and earlier mobilization, which is consistent with findings by Jillala et al., who reported reduced surgical duration and earlier fracture union in the nailing group [15]. In addition, Singh et al. highlighted earlier weight-bearing and improved knee flexion with retrograde nailing, although it was associated with a higher incidence of anterior knee pain [16]. The intra-articular entry point of the nail remains a concern, as it may contribute to post-operative knee discomfort and stiffness.

On the other hand, MIPPO with locking compression plates emphasizes biological fixation by preserving periosteal blood supply and minimizing soft-tissue disruption. The current study demonstrated slightly better alignment and fewer malalignment-related complications in the plating group. This observation is supported by Haider et al., who reported improved fracture alignment and earlier union with MIPPO due to better preservation of fracture biology [17]. Similarly, Krettek et al.

Table 3: Timing of full weight-bearing (in weeks)

Time to full weight-bearing (weeks)	Group A	Group B
Mean	13.03	15.73
Standard deviation	2.39	2.75
<i>P</i> -value	0.001 (Significant)	

emphasized that MIPPO techniques reduce soft-tissue trauma and enhance fracture healing through indirect reduction and callus formation [7].

Despite these advantages, MIPPO is technically demanding and associated with a learning curve. Malalignment, particularly varus deformity, remains a recognized complication due to indirect reduction techniques. Henderson et al. reported non-union and hardware failure associated with inadequate mechanical stability in locked plating [18], underscoring the importance of surgical expertise and appropriate implant selection.

Union rates in both groups in the present study were comparable, consistent with previous literature. Studies by Gellman et al. and Handolin et al. demonstrated high union rates with retrograde nailing, often exceeding 90% [19, 20]. Similarly, studies evaluating MIPPO techniques have reported excellent union rates and functional outcomes, particularly in osteoporotic bone [21, 22]. Aggarwal et al., in a meta-analysis, concluded that both plating and nailing provide similar union rates, with minor differences in complication profiles [23].

One of the important findings of this study is that implant selection should be guided by fracture morphology and patient-specific factors rather than a one-size-fits-all approach. Retrograde nailing may be more suitable for simple extra-articular fractures with good canal anatomy, whereas MIPPO is preferable in comminuted fractures, osteoporotic bone, or where preservation of soft-tissue envelope is critical.

The strengths of this study include its comparative design and focus on functional outcomes using standardized scoring systems. However, certain limitations must be acknowledged. The sample size is relatively small, and the follow-up period may not be sufficient to assess long-term complications such as post-traumatic osteoarthritis. In addition, surgeon experience and technical variability may influence outcomes.

To establish clearer evidence-based guidelines for implant selection, a prospective, larger multicenter randomized controlled trial with extended follow-up is necessary.

Limitations

This study has several limitations that should be considered when interpreting the results:

1. **Sample Size and Generalizability:** The sample size of 60 patients (30/group) was determined based on eligible consecutive admissions during the study timeframe
2. **Single-Center Design:** Conducting the study at a single tertiary care facility reduces external validity and applicability across different healthcare settings

3. **Follow-Up Duration:** The 6-month follow-up period was chosen to evaluate short-term fracture union and early functional recovery; however, it is insufficient to evaluate late outcomes such as post-traumatic osteoarthritis, implant fatigue/failure, or functional decline

4. **Cohort Selection:** Inclusion was restricted to closed AO type 33A2 and 33A3 fractures, limiting applicability to intra-articular (types B/C), open, periprosthetic, or highly comminuted fractures

5. **Allocation Method and Selection Bias:** Patients were allocated using an alternate allocation technique (quasi-randomization) rather than strict computer randomization, introducing potential selection bias

6. **Blinding:** Neither patients nor outcome assessors were blinded to the intervention, increasing the risk of observer and performance bias.

7. **Surgical and Bone Variations:** Surgeon experience and technical expertise were not standardized or analyzed, which may influence surgical duration and reduction quality. In addition, bone mineral density (DEXA) was not routinely measured despite its impact on construct stability

8. **Rehabilitation Tracking:** Post-operative rehabilitation protocols were standardized on paper, but patient compliance was not objectively monitored

9. **Outcome Assessments:** Functional evaluation relied primarily on the NEER score and range-of-motion measurements without validated patient-reported outcome measures (PROMs) such as KOOS, Oxford Knee Score, SF-36, or EQ-5D, or objective assessments like gait analysis and muscle strength testing

10. **Knee range of motion (flexion degrees)** was measured and reported at 6 weeks, 3 months, and 6 months. However, objective gait analysis, formal dynamometric muscle strength testing, and detailed return-to-work metrics were not performed

11. **Radiographic and Economic Scope:** Radiographic analysis was focused on gross union and clinical alignment rather than standardized 3D coronal/sagittal/rotational metrics or limb length discrepancy. Furthermore, economic variables (hospital cost, implant pricing, cost-effectiveness) were not evaluated

12. **While fluoroscopy exposure (cGy)** was measured, sub-analyses controlling for specific fracture subtypes and cumulative dose parameters were not performed.

Conclusion

Both RFN and minimally invasive plate osteosynthesis are effective treatment modalities for extra-articular distal femur

fractures, with comparable functional and radiological outcomes. RFN offers advantages of shorter operative time and earlier mobilization, whereas MIPPO provides superior biological fixation and better alignment in selected cases. Therefore, treatment should be individualized based on fracture characteristics, bone quality, and surgeon expertise. Future multicenter randomized controlled trials with extended

follow-up are recommended to validate these findings and establish definitive clinical guidelines.

Clinical Message

Retrograde nailing and MIPPO yield similar outcomes in extra-articular distal femur fractures; treatment should be tailored to fracture morphology and patient factors.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

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