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Original Research Article

A COMPARATIVE STUDY OF LOCKING COMPRESSION PLATING VERSUS INTRAMEDULLARY NAILING IN DISTAL FEMUR FRACTURES

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ABSTRACT

Background: Distal femur fractures account for approximately 4–6% of all femoral fractures in adult population. These fractures are becoming increasingly common due to increasing incidence of high-energy trauma in young adults and low-energy falls in the elderly individuals having osteoporotic bones. Locking compression plating (LCP) and retrograde intramedullary nailing (RIMN) are common fixation methods in these cases. Each of these methods are associated with specific advantages and limitations. The purpose of this study was to compare clinical and radiological outcomes of LCP versus RIMN in patient having extra-articular distal femur fractures.

Materials and Methods: A prospective randomized comparative study was conducted over a period of 2 years at a tertiary care teaching hospital. 60 patients (≥18 years) with acute unilateral extra-articular distal femur fractures (AO/OTA type A1-A3) were included in this study. Patients were randomized into two equal groups: Group A (LCP) and Group B (RIMN). Intraoperative parameters (operative time, blood loss), union rates, complications, time to full weight bearing and functional outcomes (as assessed by Neer's score and knee Range of motion) were evaluated. Follow-up was conducted at regular intervals for one year. Statistical analysis was done using SPSS v25. For statistical purposes p value less than 0.05 was considered as statistically significant.

Results: The RIMN group was found to have a significantly shorter mean operative time (75.6 vs. 86.3 min, $p<0.001$) and higher blood loss (275 vs. 220 ml, $p<0.001$). Mean union time was significantly less in the RIMN group (11.7 vs. 17.5 weeks, $p<0.001$). Full weight bearing at 12 weeks was achieved in 93.3% (RIMN) vs 66.7% (LCP). Higher mean Neer's scores (though not statistically significant) and greater knee ROM (118° vs. 112°, $p=0.0007$) were observed in RIMN. LCP had higher rates of infection (16.7% vs. 0%), non-union (13.3% vs. 3.3%), and delayed union (6.7% vs. 0%). Malalignment was seen in 10% of RIMN cases with none in LCP.

Conclusion: RIMN provided superior outcomes in terms of operative efficiency, union time, functional recovery and early weight-bearing. However, LCP offered better alignment control but had higher infection and non-union rates. Therefore, it is important to select implant on the basis of fracture configuration, bone quality and surgeon expertise.

Keywords: Distal femoral fractures, Locking compression plate, Intramedullary nailing, Fracture fixation, Functional outcome.

INTRODUCTION

Distal femur fractures account for approximately 4–6% of all femoral fractures in adult population.[1] These fractures are becoming increasingly common due to increasing incidence of high-energy trauma in young adults and low-energy falls in the elderly individuals having osteoporotic bones.[2] Extra-articular distal femur fractures involve the metaphyseal region without extending into the knee

joint. These fractures pose significant challenges in terms of achieving anatomical alignment and stable fixation because of complex biomechanical environment and poor bone quality seen in this region.[3] With the aging global population and rising incidence of osteoporosis the number of distal femoral fractures is projected to increase substantially particularly in women over the age of 60 years. In this context, effective surgical management of these injuries is critical to minimize complications such as non-union, malunion, limb shortening and joint stiffness. These complications if occur may severely affect the functional outcome and quality of life of the affected individuals.[4]

The principle of management of extra-articular distal femur fractures is to achieve stable fixation. This stable fixation not only allows early mobilization but also helps in preserving adjacent soft tissues.[5] Two commonly surgical techniques used for extra-articular distal femur fractures include locking compression plating (LCP) and retrograde intramedullary nailing (RIMN). Locking compression plates provide excellent angular stability which is crucial in individuals with osteoporotic bones and in situations requiring bridge plating across the comminuted zones.[6] On the other hand, retrograde intramedullary nailing offers biomechanical benefits by virtue of being closer to the weight-bearing axis of the limb. Moreover, RIMN is also associated with smaller incisions, less soft tissue disruption and potentially quicker rehabilitation. However, each of these techniques has its limitations. LCP may be associated with stress shielding and delayed union whereas RIMN may be technically and procedurally challenging in patients with narrow medullary canals or pre-existing knee pathology.[7]

Recent advances in implant design including provision of precontoured locking plates and improved intramedullary nail systems have greatly enhanced effectiveness of both these methods. However, complication rates such as implant failure, delayed union and malalignment still remain concerning.[8] The literature presents conflicting evidence regarding the superiority of one technique over the other in terms of complications such as malunion and non-union. The other variables which need to be considered while choosing method of internal fixation include operative time, functional outcomes and complication profiles.[9] Some studies suggest that RIMN is associated with faster weight bearing and reduced operative duration while others report the superior fixation stability offered by locking plates. This is more so particularly in osteoporotic bone or in cases with metaphyseal comminution.[10]

Furthermore, factors such as age, bone density and presence of comorbidities influence the decision regarding use of LCP versus RIMN. Similarly, fracture-related variables such as fracture pattern and presence of associated soft tissue injury also significantly influence surgical planning and outcomes.[11] Despite several studies examining LCP versus RIMN in patients with distal femur fractures there remains a significant knowledge gap regarding their comparative efficacy particularly in extra-articular distal femur fractures which differ biomechanically and clinically from intra-articular or periprosthetic fractures. The purpose of this study is to compare locking compression plating and retrograde intramedullary nailing in patients presenting with extra-articular distal femur fractures.

MATERIALS AND METHODS

This was a prospective comparative study conducted in the department of orthopaedics of a tertiary care teaching hospital over a period of 2 years. A total of 60 patients diagnosed with distal femur fractures were included in the study based on predefined inclusion and exclusion criteria. Sample size was calculated with a confidence level of 95% and to achieve power of 80%, based on previous studies that indicated a significant difference in union time between patients with distal femoral fractures who underwent locking compression plating (LCP) and retrograde intramedullary nailing (RIMN). With a predicted effect size of 0.75 a minimum of 25 patients per group was required. However, 30 patients were enrolled in each group to account for potential dropouts and loss to follow-up.

The aim of the study was to evaluate and compare intraoperative parameters, post-operative complications, radiological union and functional outcomes. Patients were assessed at the time of admission with a detailed clinical history, mechanism of injury and comorbidity profile. Standard anteroposterior and lateral radiographs of the femur including the knee joint were obtained to classify the fractures according to the AO/OTA classification system (Figure 1). Preoperative stabilization was done with skin traction over a Bohler-Braun splint. The study population was randomized into two groups with the help of a computer-generated random number table.

Group A (LCP group; n = 30): Patients underwent fixation using a distal femur locking compression plate. [Figure 2]

Group B (RIMN group; n = 30): Patients underwent fixation using a retrograde intramedullary nail. [Figure 3]

Figure 1: Figure: Preoperative lateral radiograph of the left distal femur showing a displaced extra-articular supracondylar distal femur fracture (Left). Preoperative anteroposterior (AP) radiograph showing the same fracture with metaphyseal comminution and displacement (Right)

Figure 2: Post-operative AP radiograph after Locking Compression Plate (LCP) fixation, demonstrating a lateral distal femur locking plate with multiple distal locking screws and restoration of alignment

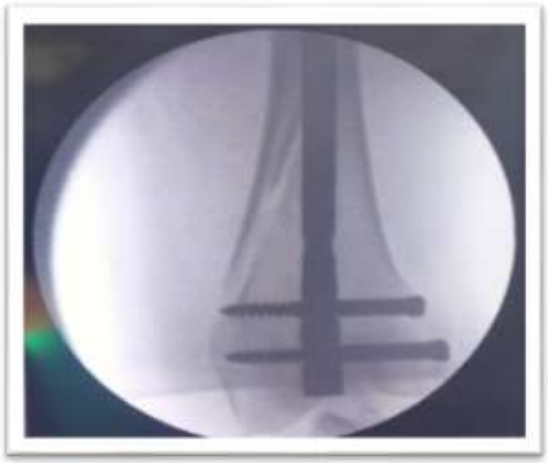

Figure 3: Intraoperative C-arm image after retrograde intramedullary nailing (RIMN) of the distal femur, demonstrating the retrograde femoral nail with distal interlocking screws in situ providing stable fixation

Routine blood investigations and anesthetic fitness were obtained before surgery. All patients were operated upon by surgeons with more than 2 years of post-specialization experience. Group A patients were treated using distal femur LCP via a lateral approach. Open or minimally invasive percutaneous plate osteosynthesis (MIPPO) techniques were employed depending on fracture morphology. Group B patients underwent RIMN insertion through an entry point at the intercondylar notch under fluoroscopic guidance. Closed reduction was preferred however in some cases open reduction was performed when necessary. In both groups, intraoperative parameters such as operative time (skin incision to wound closure) and estimated blood loss were recorded. Post-operatively, all patients received intravenous antibiotics for 72 hours and were shifted to oral antibiotics for one week. Early mobilization was encouraged initially with active-assisted knee range of motion exercises which was started on postoperative day two.

Postoperative follow-up was done at 4-week intervals for the first 6 months and then every 3 months up to one year. At each visit, clinical assessment included wound evaluation, pain assessment using the Visual Analogue Scale (VAS) and evaluation of knee range of motion (ROM). Radiological union (defined as the presence of bridging callus in at least three cortices and obliteration of the fracture line) was assessed with serial AP and lateral X-rays, Full weight-bearing was started on the basis of clinical and radiological healing typically between 8 and 16 weeks. Malalignment was assessed by full-length lower limb scanograms. Angulation >10° from the anatomical axis was considered significant and suggestive of malalignment. Delayed union was defined as lack of healing progression at 6 months and non-union was defined as absence of radiological union at 9 months without signs of callus formation. Functional outcome at final follow-up was assessed using the Neer's Score.[12]

Data was compiled and analyzed using IBM SPSS software version 25.0. Descriptive statistics were used for demographic variables. Comparison of continuous variables was done by using the Student's t-test and categorical variables were analyzed using Chi-square test or Fisher's exact test. A p-value less than 0.05 was considered statistically significant.

Inclusion Criteria

- Acute unilateral distal femur fracture (AO/OTA Type A1, A2, A3)
- Age ≥ 18 years
- Closed fractures and Gustilo-Anderson Type I open fractures
- Patients providing informed consent

Exclusion Criteria

- Open fractures classified as Gustilo-Anderson Type II and III
- Pathological fractures (e.g., due to metastasis)
- Pre-existing femoral deformities
- Polytrauma patients requiring ICU care

- Fractures older than 3 weeks
- Periprosthetic distal femur fractures
- Associated neurovascular injury

RESULTS

The analysis of the gender distribution in studied cases showed that males constituted the majority in both groups, with 20 (66.7%) in the LCP group and 22 (73.3%) in the RIMN group. Females accounted for 10 (33.3%) in the LCP group and 8 (26.7%) in the RIMN group. The difference in gender distribution between the LCP and RIMN groups was not statistically significant (p = 0.7787).

Table 1: Gender Distribution in studied cases

Gender	LCP Group (n=30)	RIMN Group (n=30)	P Value
Male	20	22	0.7787 (Not Significant)
Female	10	8	
Total	30	30	

The analysis of the age distribution of the studied cases showed that the most commonly affected age group in both the LCP and RIMN groups was 51–60 years (33.3% versus 30%)cases respectively. It was followed by the >60 years group 9 (30%) LCP and 7 (23.3%) in RIMN. The 41–50 years age group included 6 (20%) cases in LCP and 7 (23.3%) in RIMN. younger age groups like 31–40 years had 3 (10%) in LCP and 4 (13.3%) in RIMN, and 18–30 years had the fewest cases with 2 (6.7%) in LCP and 3 (10%) in RIMN. The difference in mean age of cases in both the groups was not statistically significant (p = 0.3070).

Table 2: Age distribution (years) in both study groups (n = 60)

Age group (years)	LCP Group (n=30)	RIMN Group (n=30)	P value
18–30	2	3	P = 0.3070 (Not significant)
31–40	3	4	
41–50	6	7	
51–60	10	9	
>60	9	7	
Total	30	30	
Mean Age (Years)	53.4 ± 14.2	49.7 ± 13.6	

According to AO classification, the most common fracture type was A1, observed in 12 (40%) cases in the LCP group and 13 (43.3%) in the RIMN group, followed by A2 in 10 (33.3%) and 9 (30%) cases respectively, while A3 type was seen equally in both groups with 8 (26.7%) cases. Regarding the side of injury, left-sided fractures were reported in 14 (46.7%) cases in the LCP group and 12 (40%) in the RIMN group while right-sided involvement was slightly more common with 16 (53.3%) in LCP and 18 (60%) in RIMN. The most frequent mechanism of injury was fall, seen in 22 (73.3%) cases in the LCP group and 21 (70%) in the RIMN group. Road traffic accidents (RTA) was the etiological cause in 7 (23.3%) and 8 (26.7%) cases respectively. Physical assault was the least common cause in both groups with 1 (3.3%) case each. All observed differences in AO classification, side of injury, and mechanism of injury between the two groups were statistically not significant (P>0.05).

Table 3: Baseline Demographic and Clinical Characteristics

Parameter	LCP Group (n=30)	RIMN Group (n=30)	*p*-value
AO Classification	A1: 12 (40%) A2: 10 (33.3%) A3: 8 (26.7%)	A1: 13 (43.3%) A2: 9 (30%) A3: 8 (26.7%)	0.94
Side of Injury (Lt/Rt)	14 / 16	12 / 18	0.79
Mechanism of Injury	Fall: 22 (73.3%) RTA: 7 (23.3%) Assault: 1 (3.3%)	Fall: 21 (70%) RTA: 8 (26.7%) Assault: 1 (3.3%)	0.92

The mean operative time was significantly longer in the LCP group at 86.3 ± 7.1 minutes compared to 75.6 ± 6.4 minutes in the RIMN group. Conversely, the mean blood loss was higher in the RIMN group, measuring 275 ± 20 ml, while the LCP group had a lower average blood loss of 220 ± 15 ml. Both differences in operative time and blood loss between the two groups were statistically significant, with p-values of <0.001.

Table 4: Intraoperative Parameters

Parameter	LCP Group (n=30)	RIMN Group (n=30)	*p*-value
Mean Operative Time (min)	86.3 ± 7.1	75.6 ± 6.4	<0.001
Mean Blood Loss (ml)	220 ± 15	275 ± 20	<0.001

The mean time to union was significantly longer in the LCP group at 17.5 ± 6.8 weeks compared to 11.7 ± 4.1 weeks in the RIMN group. Non-union was observed in 4 (13.3%) cases in the LCP group and 1 (3.3%) in the RIMN group, while delayed union occurred in 2 (6.7%) cases in the LCP group and none in the RIMN group. Infection was reported exclusively in the LCP group, affecting 5 (16.7%) patients, while no infections were noted in the RIMN group. Malalignment greater than 10° was absent in the LCP group but occurred in 3 (10%) cases in the RIMN group. Among these parameters, the differences in mean time to union and infection rates were statistically significant ($p < 0.001$), while differences in non-union ($p = 0.353$), delayed union ($p = 0.491$), and malalignment ($p = 0.237$) were not statistically significant.

Table 5: Postoperative Complications and Union Status

Parameter	LCP Group (n=30)	RIMN Group (n=30)	*p*-value
Mean Time to Union (weeks)	17.5 ± 6.8	11.7 ± 4.1	<0.001
Non-union	4 (13.3%)	1 (3.3%)	0.353
Delayed Union	2 (6.7%)	0 (0%)	0.491
Infection (any)	5 (16.7%)	0 (0%)	<0.001
Malalignment (>10°)	0 (0%)	3 (10%)	0.237

The analysis of the functional outcomes of the studied cases showed that the majority of patients in both groups achieved either excellent or good results, with excellent outcomes in 10 (33.3%) cases in the LCP group and 12 (40%) in the RIMN group, and good outcomes in 12 (40%) and 13 (43.3%) cases respectively. Fair results were observed in 6 (20%) cases in the LCP group and 5 (16.7%) in the RIMN group. Poor outcome was reported only in the LCP group with 2 (6.7%) cases. The difference in overall functional outcome between the two groups was not statistically significant ($p > 0.05$).

Table 6: Functional Outcome Based on Neer's Score at 1 Year

Outcome Grade	LCP Group (n=30)	RIMN Group (n=30)	*p*-value
Excellent	10 (33.3%)	12 (40%)	> 0.05 Not Significant
Good	12 (40%)	13 (43.3%)	
Fair	6 (20%)	5 (16.7%)	
Poor	2 (6.7%)	0 (0%)	
Mean Score	83.7 ± 8.4	87.2 ± 7.6	

The analysis of postoperative functional recovery parameters showed that full weight bearing at 12 weeks was achieved in 20 (66.7%) cases in the LCP group compared to 28 (93.3%) in the RIMN group, indicating a statistically significant difference ($p = 0.021$). The mean knee range of motion at 1 year was better in the RIMN group (118 ± 7 degrees) as compared to LCP group (112 ± 6 degrees). The difference was statistically significant ($p = 0.0007$). Knee pain at 6 months was not statistically significant in RIMN versus LCP group ($p = 0.360$). Thus, both full weight bearing at 12 weeks and knee ROM at 1 year showed statistically significant differences favouring the IMN group while the difference in knee pain was not significant.

Table 7: Weight Bearing and Knee Range of Motion (ROM)

Parameter	LCP Group (n=30)	RIMN Group (n=30)	*p*-value
Full Weight Bearing at 12 Weeks	20 (66.7%)	28 (93.3%)	0.021
Knee ROM at 1 Year (degrees)	112 ± 6	118 ± 7	0.0007
Knee Pain at 6 Months (VAS >3)	5 (16.7%)	9 (30%)	0.360

DISCUSSION

This prospective comparative study aimed to evaluate the clinical and radiological outcomes of locking compression plating (LCP) versus retrograde intramedullary nailing (RIMN) in the treatment of extra-articular distal femur fractures. Our intraoperative findings showed that RIMN significantly reduced operative time, whereas LCP resulted in significantly lower blood loss ($p<0.001$ for both). Handolin L et al conducted a retrospective study to evaluate outcomes of retrograde intramedullary nailing in distal femoral fractures.[13] For this purpose the authors undertook a study comprising of 44 patients with 46 distal femoral fractures treated by retrograde intramedullary nail; operative records, complications, and healing outcomes were evaluated retrospectively after patients were followed up for an average of 9 months. The study found that the final bone union rate was 95% with a mean union time of 17.5 weeks (range 8–68 weeks). Restoration of limb alignment and length

was inadequate in two cases, three patients had a loss of reduction and one non-union occurred; two distal locking screw breakages and one iatrogenic arterial branch injury were observed, and three superficial infections were recorded but no deep infections. On the basis of these findings the authors concluded that retrograde intramedullary nailing using the Distal Femoral Nail was a reliable alternative for treating distal femoral fractures yielding a high union rate and a relatively low complication rate. Similar findings were also reported by the authors such as Kubiak EN et al,[14] and Kishore R et al. [15]

Our study revealed a statistically significant earlier union in the RIMN group (mean 11.7 ± 4.1 weeks) as compared to the LCP group (mean 17.5 ± 6.8 weeks). K Chandra Vemulapalli et al conducted a retrospective comparative study to assess whether retrograde intramedullary nailing (RIMN) is superior to lateral locked plating (LLP) for treating complete articular distal femur fractures.[16] For this purpose the authors undertook a study comprising of 106 patients with distal femur fractures, of whom 50 underwent RIMN and 56 underwent lateral locked plating, and reviewed radiographic alignment, time to union, non-union rates, and secondary operations retrospectively using clinical records from the study period. The study found that average time to union was 6 months in the RIMN group and 6.6 months in the LLP group (p = .52); non-union occurred in 11.8 % of the RIMN group and 27.5 % of the LLP group (p = .008). Coronal plane malalignment was greater in the LLP group, with average anatomic lateral distal femoral angle (aLDFA) of 87.9° versus 83.7° in the RIMN group (p = .005). Eight secondary procedures for non-union were performed after RIMN and 18 after LLP (p = .43). On the basis of these findings the authors concluded that RIMN demonstrated lower non-union rates and less coronal plane malalignment compared to lateral locked plating, suggesting that RIMN may be an appropriate fixation method for complete articular distal femur fractures, though prospective data were needed to confirm this. Similar findings were also reported by the authors such as Guzel I et al,[17] and Neradi D et al.[18]

In terms of functional outcomes, our study demonstrated superior Neer's scores (though statistically not significant) and knee range of motion at one year in the RIMN group. In our study 83.3% of patients achieved excellent to good results as compared to 73.3% in the LCP group. However the difference was not statistically significant. Nathan L Hartin et al conducted a randomized controlled study to compare retrograde intramedullary nailing versus fixed-angle blade plating for supracondylar femoral fractures.[19] For this purpose the authors undertook a study comprising of 22 patients with 23 supracondylar femur fractures, assigned to either retrograde intramedullary nailing (IM group, 12 fractures) or fixed angle blade plating (BP group, 11 fractures), and followed up for 12–36 months, with primary outcome measures of revision surgery and general health (e.g., pain and SF 36 scores). The study found that 3 patients in the retrograde IM group required revision surgery for implant component removal, whereas no reoperations occurred in the blade plate group; there was a trend toward greater pain in the IM group, but no statistically significant differences in SF 36 general health domain scores between the groups. On the basis of these findings the authors concluded that both distal femoral nailing and fixed angle blade plating provided good outcomes for supracondylar femoral fractures, though there was a trend for increased pain and need for implant removal in patients undergoing retrograde nailing. Similarly, Markmiller et al also reported improved functional outcomes and quicker rehabilitation in patients treated with RIMN for distal femur fractures attributing this to early mobilization and weight-bearing.[20]

CONCLUSION

In this prospective comparative study of extra-articular distal femur fractures, retrograde intramedullary nailing demonstrated significantly shorter operative time, earlier radiological union, faster progression to full weight bearing and better knee range of motion at one year compared to locking compression plating. However, RIMN showed a higher trend toward malalignment while LCP had a significantly higher infection rate and more non-union/delayed union. Therefore, it is important to individualized choice of implants based on fracture morphology, bone quality and surgical expertise.

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