

Study of the Functional Outcome of Distal Femur Fractures Operated Using Dual Plating by Neer Score: A Prospective Clinical Study

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ABSTRACT

Background: Medial comminution of distal femur fractures presents a fixing issue. In cases of medial cortical deficit and extensive comminution, conventional lateral plating may not be stable enough. Dual plating provides support to the medial and lateral columns and may improve union rates and functional result. The present study aimed to study the functional and radiological outcomes following medial lateral dual plating in distal femur fractures. **Methods:** Twenty adult patients with AO/OTA 33A-33C distal femur fractures were treated with dual plating using lateral distal femur locking plate augmented with medial buttress/locking plate. The patients were monitored for 12 months. Functional outcomes were measured with the NEER Score. **Results:** Mean age of patient was 44.6 years; 55% had AO 33C fractures. Mean radiological union time was 16.2 weeks. According to the NEER score, 13 patients (65%) had excellent, 3 (15%) good, 2 (10%) fair, and 2 (10%) poor outcomes. average knee flexion was 118.5 degrees. Postoperative complications occurred in 2 patients (10%): one developed superficial surgical-site infection and one developed knee stiffness; both were managed conservatively. **Conclusion:** Dual plating provides a solid construct with predictable union and good functional results, especially in comminuted or osteoporotic distal femur fractures.

Keywords: Distal femur fractures, dual plating, NEER score, functional outcome, and locking compression plate (LCP).

INTRODUCTION

Distal femur fractures are a complex subgroup of lower-limb injuries and account for approximately 4–6% of all femoral fractures¹. These fractures have a bimodal age distribution with high energy trauma in the young and low energy osteoporotic fractures in old age². Maintaining limb alignment, articular congruity and secure fixation is critical for best functional result³.

Historically, distal femur fractures were treated closed with traction and cast immobilization⁴. Charnley developed closed treatment methods, but these led to problems including long immobilization periods, knee stiffness, malunion, and bad functional outcomes⁵. The move to operative treatment started with the development of internal fixation techniques that allowed early mobilization and anatomical restoration⁶. Different implants, such as the angled blade plate, dynamic

condylar screw, condylar buttress plate, and intramedullary nails, have been used with different degrees of success⁷.

The development of locking compression plates (LCPs) was a great advance in the fixation of peri-articular fractures by providing angular stability and improved fixation in osteoporotic bone⁸. Clinical studies have demonstrated good results with LCPs with satisfactory union rates and early mobilization⁹. However, single lateral plating may be inadequate in complex fractures with medial comminution or poor bone quality¹⁰. This can result in problems such as varus collapse, nonunion and implant failure¹¹.

The limits of single plating and the necessity for improved biomechanical stability in such fractures have been highlighted in recent systematic evaluations¹². Therefore, fixation of both the medial and lateral columns (dual plating) has gained increasing attention¹³. Biomechanical studies have demonstrated that dual plating increases construct rigidity and resistance to deforming forces⁷. Clinical evidence supports higher union rates and improved functional outcomes with dual plating in comminuted distal femur fractures¹⁴. Recent literature further highlights its role as an effective strategy in dealing with complex and unstable fracture patterns¹⁵.

Thus, the present study was undertaken to evaluate the functional and radiological outcomes of distal femur fractures treated with medial and lateral dual plating using the NEER scoring system. The study aimed to assess the functional outcomes following dual plate fixation, evaluate radiological outcomes including the time to fracture union, and determine the complications, if any, associated with dual plating. It also sought to assess the effectiveness of dual plating as a reliable fixation strategy for managing complex distal femoral fractures.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective observational clinical study conducted in the Department of Orthopaedics, Sri Aurobindo Medical College & Post Graduate Institute (SAMC & PGI), Indore, Madhya Pradesh, India, over a period of 12 months from July 2024 to June 2025.

Ethical Approval

The study protocol was reviewed and approved by the Institutional Ethics Committee of Sri Aurobindo Medical College & Post Graduate Institute (SAMC & PGI), Indore, Madhya Pradesh, India. The study was conducted in accordance with the ethical principles of

the Declaration of Helsinki. Written informed consent was obtained from all participants before enrolment.

Sample Size and Sampling

A total of 20 consecutive adult patients with distal femur fractures were included in the study. The sample size was based on the reported incidence of adult distal femoral fractures (3%) using the formula:

$$Z^2 \times p \times (1 - p) / C^2$$

where **Z** = **1.96** (95% confidence level), **p** = **0.03** (incidence of distal femoral fracture), and **C** = **0.05** (expected error).

Inclusion Criteria

- Patients aged more than 18 years of either gender.
- Patients with distal end femur fractures.

Exclusion Criteria

- Patients with open distal end femur fractures other than Gustilo-Anderson type I fractures.
- Patients with distal femur periprosthetic fractures.
- Polytrauma patients with involvement of multiple organ systems.
- Patients with associated medical and/or surgical comorbidities likely to impair the outcome.
- Patients or their relatives/legal representatives unwilling to provide written informed consent.

Preoperative Evaluation

All patients admitted with distal femur fractures underwent detailed clinical evaluation, including history, general physical examination, systemic examination, and local examination of the injured limb. The evaluation aimed to identify associated injuries, determine the mechanism of trauma, and exclude significant comorbid conditions. Initial resuscitation and emergency management were performed according to the Advanced Trauma Life Support (ATLS) protocol.

Baseline radiological evaluation included anteroposterior and lateral radiographs of the affected femur and knee joint. Additional trauma series radiographs, including pelvis with both hips and cervical or lumbar spine, were obtained whenever indicated to rule out associated injuries. The injured limb was immobilized using an above-knee splint with limb elevation and cold compression to minimize soft tissue swelling.

Routine preoperative investigations, including hematological investigations, chest radiograph, and electrocardiography, were performed to assess fitness for anesthesia. Written informed consent was obtained from all patients before surgery. Intravenous cefuroxime (1.5

g) was administered approximately 30 minutes before skin incision as prophylactic antibiotic coverage.

Surgical Technique

All operations were performed with the patient in the supine position on a radiolucent operating table under fluoroscopic guidance. A bolster was placed beneath the ipsilateral hip whenever required to facilitate surgical exposure.

A standard distal femoral approach was used. Following skin incision and soft tissue dissection, adequate exposure of the distal femur was obtained. Articular fragments, when present, were anatomically reduced using reduction clamps and Kirschner wires and stabilized with interfragmentary screws.

Definitive fixation was performed using a dual plating construct consisting of a lateral distal femur locking compression plate supplemented with a medial buttress or locking plate according to the fracture configuration and medial column integrity. Restoration of limb length, alignment, and rotational profile was carefully ensured. Final reduction and implant position were confirmed under image intensifier guidance. Knee range of motion was assessed intraoperatively to exclude implant impingement before layered wound closure under aseptic precautions.

Postoperative Management

Postoperatively, all patients received appropriate analgesics and intravenous antibiotics (cefuroxime and

amikacin). Deep vein thrombosis prophylaxis was administered according to institutional protocol.

Early rehabilitation was encouraged. Isometric quadriceps and hamstring strengthening exercises were initiated on the first postoperative day, followed by gradual active knee mobilization depending on pain tolerance and fixation stability. Knee flexion was progressively increased during subsequent follow-up. Sutures were removed between the second and third postoperative weeks. Immediate postoperative and follow-up anteroposterior and lateral radiographs were obtained for assessment.

Follow-up and Outcome Assessment

Patients were reviewed at approximately 2 weeks, 6 weeks, 3 months, and subsequently until 12 months postoperatively. Clinical and radiological assessments were performed at every follow-up visit.

Weight-bearing was gradually progressed according to fracture stability and radiographic evidence of healing. Partial weight-bearing was initiated after signs of early fracture healing, while full weight-bearing was permitted after satisfactory fracture union. Clinical union was defined as painless weight-bearing, whereas radiological union was defined by the presence of bridging callus across the fracture cortices.

Functional outcomes were evaluated using the **NEER scoring system**, together with assessment of knee range of motion and overall functional recovery.

Table 1. Components of Neer's Scoring System

Parameter	Assessment
Pain	Degree of pain experienced during daily activities
Functional Ability	Ability to perform routine activities and walking capacity
Range of Motion	Knee flexion and extension achieved postoperatively
Work Capacity	Ability to return to previous occupation or daily work
Gross Anatomy	Limb alignment, shortening, and deformity
Radiographic Assessment	Fracture union, alignment, and implant position
Total Score	100 points

According to Neer's scoring system, a total score of more than 85 points was considered excellent, 70–85 points as good, 55–69 points as fair, and less than 55 points as poor functional outcome.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using **IBM SPSS Statistics (Version 2022)**. Descriptive statistics were used to summarize demographic, clinical, radiological, and functional outcome variables. Continuous variables were expressed as mean $\pm$ standard deviation, while categorical variables were presented as frequencies and percentages.

RESULTS

A total of **20 patients** with distal femur fractures treated with dual plating were included in this prospective study. All patients completed a minimum follow-up of **12 months**. The study population comprised 14 males (70%) and 6 females (30%), with a mean age of 44.6 ± 12.3 years (range: 22–68 years). The majority of patients belonged to the 31–50 years age group, followed by 18–30 years and 51–69 years. Road traffic accidents were the most common mechanism of injury, followed by

falls from height and low-energy falls. Younger patients predominantly sustained injuries following high-energy trauma, whereas low-energy injuries were observed in the elderly. [Table 2, Figure 1]

Table 2. Baseline demographic characteristics and mechanism of injury of the study population (N = 20)

Variable	Category	n	%
Age group (years)	18–30	6	30.0
	31–50	11	55.0
	51–69	3	15.0
Sex	Male	14	70.0
	Female	6	30.0
Mechanism of injury	Road traffic accident	16	80.0
	Fall from height	3	15.0
	Low-energy fall	1	5.0

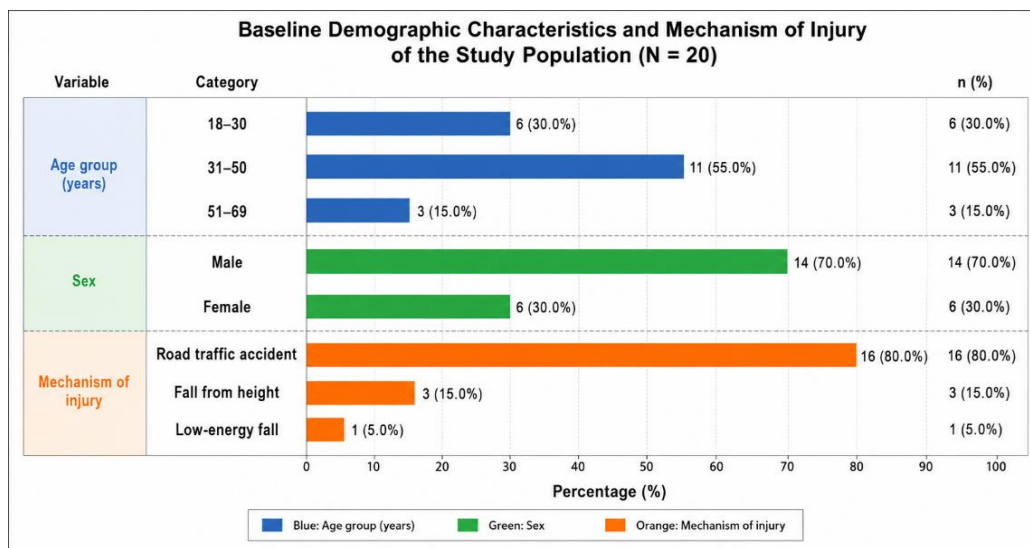


Figure 1: Baseline demographic characteristics and mechanism of injury of the study population (N = 20)

According to the AO/OTA classification, Type 33-C fractures were the most common, occurring in 11 patients (55%), followed by Type 33-A fractures in 6 patients (30%) and Type 33-B fractures in 3 patients (15%) [Table 3].

Table 3. AO/OTA fracture classification

Fracture type	n	%
33-A	6	30.0
33-B	3	15.0
33-C	11	55.0

At the final follow-up, the **mean knee flexion was $118.5^\circ \pm 10.2^\circ$** . Nine patients (45%) achieved knee flexion of $\geq 120^\circ$, eight patients (40%) had flexion between 100° and 120° , and three patients (15%) had flexion of $<100^\circ$ (Table 4). All patients regained full knee extension except one patient, who had a residual flexion contracture of 5° . [Table 4]

Table 4. Knee range of motion at final follow-up

Knee flexion	n	%
$<100^\circ$	3	15.0
$100-120^\circ$	8	40.0
$\geq 120^\circ$	9	45.0

Functional outcome was assessed using the **NEER scoring system** at 12 months. Excellent results were observed in **13 patients (65%)**, good in **3 patients (15%)**, fair in **2 patients (10%)**, and poor in **2 patients (10%)**. Overall, **80% of patients achieved excellent or good functional outcomes**. [Table 5, Figure 2]

Table 5. Functional outcome according to NEER score

NEER outcome	n	%
Excellent	13	65.0
Good	3	15.0
Fair	2	10.0
Poor	2	10.0

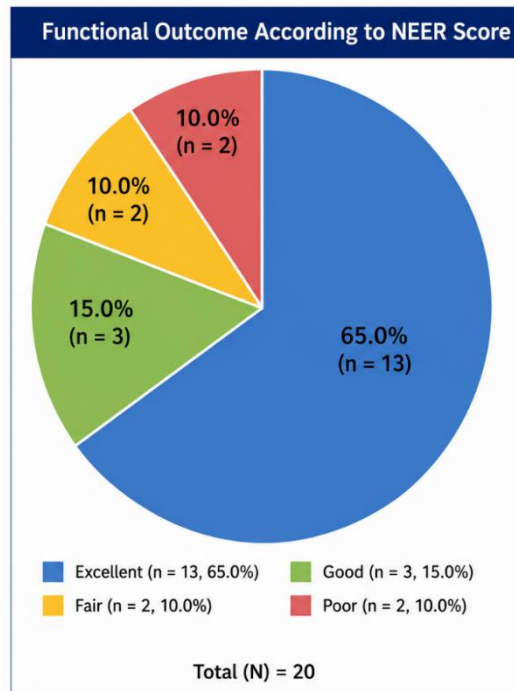


Figure 2: Functional outcome according to NEER score

The mean radiological union time was 16.2 ± 2.8 weeks (range: 12-22 weeks). Three patients (15%) achieved union within 12-16 weeks, fifteen patients (75%) demonstrated union between 16 and 20 weeks, while two patients (10%) experienced delayed union beyond 20 weeks [Table 6]. No cases of nonunion were observed. [Table 6]

Table 6. Radiological union time

Union time (weeks)	n	%
12-16	3	15.0
16-20	15	75.0
>20	2	10.0

Postoperative complications occurred in 2 patients (10%), while 18 patients (90%) had an uncomplicated recovery. One patient (5%) developed a superficial surgical site infection that resolved with conservative treatment and antibiotics, and one patient (5%) experienced knee stiffness requiring physiotherapy [Table 7, Figure 3]. No cases of implant failure, loss of reduction, or nonunion were encountered.

Table 7. Postoperative complications

Complication	n	%
None	18	90.0
Knee stiffness	1	5.0
Superficial infection	1	5.0

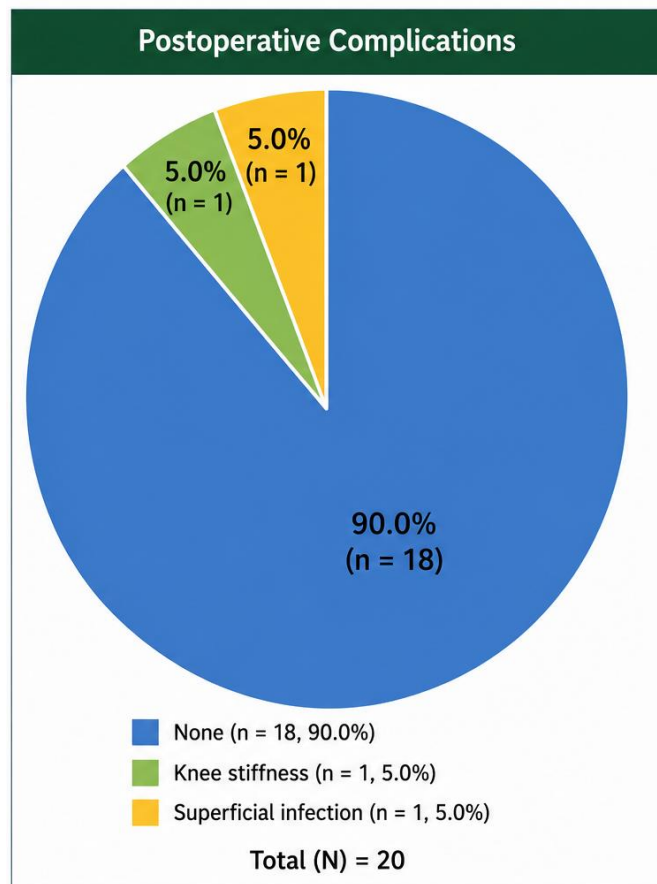


Figure 3: Postoperative complications



Figure 4. Preoperative anteroposterior and lateral radiographs demonstrating a left distal femur fracture



Figure 5. Immediate postoperative anteroposterior and lateral radiographs demonstrating fixation of the distal femur fracture using medial and lateral dual plating.



Figure 6. Three-month follow-up radiographs showing early fracture union with callus formation and maintained implant position.

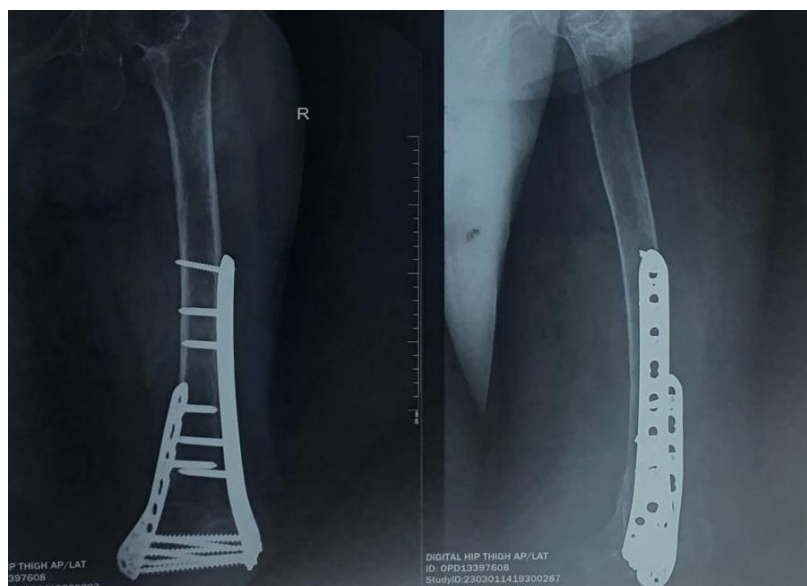


Figure 7. Six-month follow-up radiographs demonstrating progressive fracture union with maintained alignment and stable implant fixation.

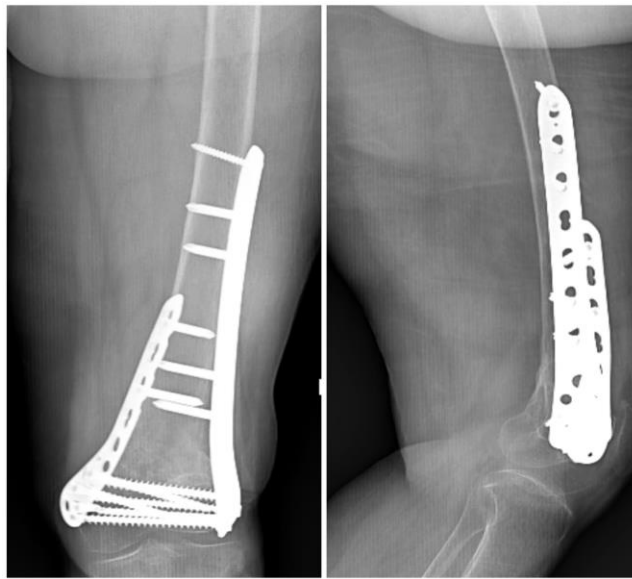


Figure 8. Twelve-month follow-up radiographs demonstrating complete fracture union with satisfactory remodeling and maintained implant stability.



Figure 9. Clinical photographs at one-year follow-up demonstrating functional outcome after dual plating: (A) Full knee extension, (B) Knee flexion, (C) Further knee flexion demonstrating Straight leg raise with maintained quadriceps control.

DISCUSSION

Distal femur fractures continue to be one of the difficult injuries in orthopedic practice due to their complex anatomy, frequent intra-articular involvement and correlation with high energy trauma. Restoration of articular congruity, maintenance of limb alignment, stable fixation and early mobilization to obtain optimal functional results are the key goals of therapy. The dual plating has recently been described as a viable fixing method, especially in fractures with medial comminution and instability.

The present study showed a significant male predominance (70%) with mean age of 44.6 years, most frequently affecting individuals in the 31–50 year age group. These results are comparable with the results of Martinet et al. who showed a higher incidence of distal femur fractures in middle-aged males, mostly in the 30–50-year-old population, often associated with high-energy trauma¹. Similarly, Pai Manjeswar et al., showed the same demographic distribution with male preponderance and majority of patients in the age category of 31–50¹⁴ corroborating the fact that this injury is common in active working population.

In the present study, road traffic accidents were responsible for 80% of the cases, making them the main cause of injury. This observation agrees with Gwathmey et al. who said that high energy trauma, especially road traffic accidents, continues to be the most frequent mechanism of damage in distal femur fractures². The higher incidence of complicated fracture patterns in the present study can also be attributed to the prevalence of such processes.

As for the fracture morphology, AO/OTA type 33-C fractures were observed in 55% of the cases in the present study. Intra-articular fractures (type C) constitute a significant percentage of distal femur fractures, particularly in the setting of high-energy trauma³, as documented by Ehlinger et al. Tripathy et al., in their systematic study, similarly reported a prevalence of type C fractures, emphasizing the frequent occurrence of complicated articular patterns¹². Schatzker et al. also reported a high incidence of supracondylar fractures with intra-articular extension¹⁵ which lends further support to the prevalence of type C fractures seen in the present study.

Functional results were good with a mean knee flexion of 118.5° and 85% of patients had flexion >100°. These results are similar to Bologna et al., who reported postoperative knee flexion between 110° and 125 degree⁹. DeMelo et al. found a mean knee flexion of around 115–120° in patients treated with dual plating¹¹. Zlowodzki et al. reported outcomes of knee flexion of

between 105° and 120degree⁷. These consistent results show that dual plating offers sufficient stability to support early mobilization and acceptable knee function. Functional assessment by NEER scoring system showed excellent to good results in 80% of patients in present study. This is close to the findings of Pai Manjeswar et al who reported excellent to good results in roughly 80–85% of cases¹⁴. In addition, NEER in his original series reported favorable functional outcomes in most of the patients after treatment of supracondylar femur fractures, which supports the reliability of obtaining good functional recovery with secure fixation⁵.

In the present study, radiological union was obtained at a mean duration of 16.2 weeks. This result is in accordance with Bologna et al. who found union times between 14 and 18 weeks⁹. DeKeyser et al. found union periods of roughly 15–17 weeks¹⁰ while Ricci et al. noted fracture union within 16–20 weeks in most cases⁸. The similar union time suggests dual plating provides an ideal mechanical and biological environment for fracture healing.

The overall rate of complications in the present investigation was 10%, which is in the acceptable range stated in the literature. O'Neill et al. reported complication rates between 8% and 15% in studies evaluating dual plating¹³. Similarly, Ricci et al reported complication and failure rates of 10% to 20% in distal femur fracture fixation⁸. The comparatively low risk of complications in this study may be due to better biomechanical stability with dual plating, especially in fractures with medial comminution.

Overall, the present study results are in agreement with the previous literature, suggesting that dual plating is a successful and dependable fixing approach for complicated distal femur fractures. It gives better biomechanical stability, early mobilization and satisfactory functional and radiological results with an acceptable complication profile

Limitations

This study has several limitations. First, the sample size was small, with only 20 patients, which limits the statistical power and generalizability of the findings. Second, the study was conducted at a single institution, which may limit external validity. Third, there was no comparison group treated with single lateral plating or another fixation method; therefore, the observed outcomes cannot be attributed to dual plating with certainty relative to alternative treatment strategies. Fourth, the follow-up period was limited to 12 months, and longer-term functional outcomes and late implant-related complications could not be assessed. Finally, the

study was observational in design and may therefore be subject to selection and measurement bias.

Strengths of the Study

The present study has several strengths. First, the prospective study design allowed systematic clinical and radiological assessment of patients from the time of surgical treatment through 12 months of follow-up. Second, all patients were treated using a standardized medial–lateral dual-plating construct, allowing consistent evaluation of this fixation strategy in distal femur fractures. Third, the study included different AO/OTA fracture patterns, including complex intra-articular fractures, thereby providing clinically relevant information regarding the use of dual plating in challenging fracture configurations. Fourth, functional outcomes were assessed using the NEER scoring system in combination with knee range of motion, radiological fracture union, and postoperative complications, providing a multidimensional assessment of treatment outcomes. Finally, the availability of serial radiographic and clinical follow-up for 12 months allowed assessment of fracture healing, maintenance of alignment and implant stability, and late postoperative functional recovery.

Future Directions

Future studies should include larger, multicenter prospective cohorts to improve the statistical power and generalizability of the findings. Comparative studies evaluating medial–lateral dual plating against single lateral plating and other fixation techniques would help determine whether dual plating provides superior functional and radiological outcomes. Longer follow-up is also required to assess the durability of fixation, late complications, post-traumatic knee osteoarthritis, and long-term functional recovery. Future research should additionally evaluate the influence of fracture morphology, bone quality, medial column comminution, and intra-articular involvement on treatment outcomes. Standardized rehabilitation protocols and patient-reported outcome measures may further improve the assessment of functional recovery following dual plating of distal femur fractures.

Clinical Implications

The findings suggest that medial and lateral dual plating may be considered in selected distal femur fractures with medial column comminution, intra-articular extension, or compromised lateral-column fixation. However, treatment selection should be individualized according to fracture morphology, bone quality, soft-tissue status, and surgeon experience.

CONCLUSION

Dual plating is a reliable and effective fixation method for the management of complex distal femur fractures, particularly those with medial comminution and intra-articular extension. It provides excellent biomechanical stability, promotes satisfactory fracture healing, and facilitates early rehabilitation. Patients achieved favorable functional recovery with good knee range of motion and acceptable radiological outcomes. The procedure was associated with a low complication profile, with postoperative complications being manageable through appropriate treatment. Overall, dual plating represents a dependable surgical option for restoring limb alignment, maintaining stable fixation, and improving functional outcomes in patients with complex distal femur fractures.

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Conflict of Interest

The authors declare that they have no conflicts of interest related to this study.

Consent for Publication

Written informed consent was obtained from the patient(s) for publication of the clinical photographs and accompanying radiological images included in this manuscript.

Author Contributions

All authors contributed to the conception and design of the study, data collection, analysis and interpretation of the findings, and preparation and critical revision of the manuscript. All authors approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

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Data Availability Statement

The datasets generated and/or analyzed during the current study are not publicly available because of institutional and participant confidentiality requirements but may be made available from the corresponding

author on reasonable request, subject to applicable institutional policies.

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