



Original Article

Functional Outcome of Dual Plating in Patients with Distal Femur Fracture: A Prospective and Retrospective Study

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ABSTRACT

Background: Distal femur fractures, particularly AO/OTA Types C2 and C3, represent a significant surgical challenge due to complex comminution, proximity to the knee joint, and the biomechanical demands of weight-bearing. Single lateral plate fixation frequently fails to provide adequate medial column support, resulting in varus collapse and nonunion. Dual plating, employing both lateral and medial constructs, has emerged as a superior fixation strategy for these unstable fractures.

Objective: To evaluate the functional and radiological outcomes of dual plating in patients with complex distal femur fractures.

Methods: A combined prospective and retrospective study was conducted at PSG Institute of Medical Sciences and Research, Coimbatore, involving 41 patients with complex distal femur fractures (AO/OTA Types C1, C2, C3) who underwent dual plating over a one-year study period with six-month follow-up. Outcome measures included fracture union rate, postoperative knee range of motion (ROM), functional outcome, and complication rate.

Results: AO Type 33-C2 was the most prevalent fracture pattern (46.3%), followed by C3 (34.1%) and C1 (19.5%). A 100% radiological union rate was achieved with a mean time to union of 9.66 ± 1.30 months. At six weeks, 48.8% of patients achieved 0–90° knee ROM. Good functional outcomes were observed in all 41 patients (100%), with an overall good clinical result in 92.7%. The complication rate was 4.9%.

Conclusion: Dual plating provides superior biomechanical stability, facilitates early mobilization, and yields excellent functional outcomes with minimal complications in complex distal femur fractures. It is a reliable fixation strategy, especially in osteoporotic and highly comminuted fractures.

Keywords: Femoral Fractures; Fracture Fixation, Internal; Bone Plates; Fracture Healing; Knee Joint.

INTRODUCTION

Distal femur fractures encompass injuries of the distal femoral metaphysis and condyles, accounting for approximately 6% of all femoral fractures and 31% of femoral fractures excluding hip involvement [1]. Their incidence is rising with the dual burden of high-energy trauma in young adults, predominantly road traffic accidents and low-energy falls in the elderly with osteoporotic bone [2,3]. The anatomical complexity of the distal femur, with its articular surface critical for weight transmission and knee mobility, makes fracture management particularly demanding [4].

Unstable fracture patterns, specifically AO/OTA Types A3, C2, and C3, are characterized by extensive metaphyseal comminution, articular disruption, and significant soft tissue injury [5]. Traditional conservative management with traction and immobilization is associated with unacceptably high rates of malunion, joint stiffness, deep vein thrombosis, and

prolonged disability [6]. The evolution of surgical fixation from condylar blade plates and dynamic condylar screws to contemporary pre-contoured locking compression plates (LCP) has dramatically improved outcomes, yet highly comminuted fractures with medial cortical defects continue to challenge even experienced surgeons [7,8].

Single lateral locking plate fixation, while biomechanically sound for many fracture patterns, has a documented failure rate of approximately 20% in cases with significant medial comminution, resulting in varus collapse, hardware failure, and nonunion [9,10]. Dual plating incorporating both lateral and medial plate constructs addresses this limitation by distributing load more evenly, enhancing axial and rotational stiffness, and providing a "cage effect" around the condyles [11,12]. Biomechanical studies have demonstrated superior construct stability with dual plating compared to single lateral plating [13,14], and clinical series report improved union rates and functional recovery [15,16]. However, concerns persist regarding surgical complexity, soft tissue disruption, and periosteal vascularity [17,18]. This study evaluates the functional and radiological outcomes of dual plating in patients with complex distal femur fractures at a tertiary care institution.

AIM AND OBJECTIVES

Aim

To determine whether dual plating provides superior fixation stability and functional recovery in patients with complex distal femur fractures, thereby addressing the broader clinical challenge of managing unstable, comminuted fractures prone to mechanical failure with single-implant constructs.

Objectives

1. To assess the biomechanical advantage of dual plating in achieving fracture fixation stability in complex distal femur fractures.
2. To evaluate fracture healing rates, early postoperative mobilization, and knee range of motion following dual plating.

METHODOLOGY

Study Setting

The study was conducted at the Department of Orthopaedic Surgery, PSG Institute of Medical Sciences and Research (PSG IMSR), Coimbatore, Tamil Nadu, India's tertiary care academic medical institution.

Study Duration

One year (October 2024–October 2025), incorporating retrospective cases from the preceding five years and newly diagnosed patients during the study period, all followed up for a minimum of six months.

Study Design

A combined prospective and retrospective observational study (descriptive design). Retrospective data were collected for patients who had undergone dual plating in the preceding five years; prospective data were collected for new cases admitted during the study period and followed up to six months postoperatively.

Study Sample

Inclusion Criteria: All patients aged ≥ 18 years with a confirmed diagnosis of distal femur fracture (AO/OTA classification Types C1, C2, and C3) who underwent dual plating.

Exclusion Criteria: Patients unwilling to provide written informed consent for admission, surgical intervention, or study participation; patients lost to follow-up before six months.

Method of Selection: Consecutive sampling of all eligible patients presenting with complex distal femur fractures during the study period.

Intervention

All patients underwent open reduction and internal fixation using a dual plate construct. Lateral fixation was performed via the Swashbuckler approach using a pre-contoured locking compression plate (LCP). Medial fixation was performed through a dedicated anteromedial incision using a T-buttress plate or medial LCP, applied following anatomical reduction of the condyles. The postoperative rehabilitation protocol commenced on postoperative day 2 with passive range-of-motion exercises, progressing to non-weight-bearing ambulation at 2 weeks, partial weight-bearing at 6 weeks, and full weight-bearing at ≥ 12 weeks upon radiographic confirmation of union.

Data Collection

Preoperative data included patient demographics, mode of injury, fracture classification (AO/OTA), comorbidities, neurovascular status, and radiographs. Operative data included day of surgery, operative duration, and intraoperative blood loss. Postoperative data included knee ROM at discharge and at 6 weeks, wound healing assessment at 4 weeks, and radiographic union at 6 months. All data were recorded in a structured clinical proforma.

Outcome Measures

Primary Outcome: Radiological fracture union rate (confirmed on X-ray at 6 months) and time to union (months).

Secondary Outcomes: Postoperative knee range of motion (ROM) at discharge and at 6 weeks; functional outcome (good/fair); overall clinical result; postoperative complication rate.

Sample Size

A total of 41 patients meeting the inclusion criteria were enrolled in this study over the study period.

Data Management and Statistical Analysis

All data were recorded in a structured proforma and entered into IBM SPSS Statistics version 21.0. Continuous variables were expressed as mean \pm standard deviation (SD). Categorical variables were expressed as frequency and percentage. Descriptive statistics were used for analysis of outcomes.

Ethical Issues

The study was approved by the Institutional Ethics Committee of PSG Institute of Medical Sciences and Research, Coimbatore (Ethical Clearance obtained). Written informed consent was obtained from all patients prior to enrolment. No trial registration was applicable as this was an observational study. Patient confidentiality was maintained throughout.

RESULTS

A total of 41 patients with complex distal femur fractures who underwent dual plating were included in this study. The results are presented in the following sections.

Table 1: Demographic and Injury Profile

Variable	Category	n (41)	Percentage (%)
Age (years)	< 30	5	12.2
	31–40	4	9.8
	41–50	8	19.5
	51–60	13	31.7
	> 61	11	26.8
Sex	Female	24	58.5
	Male	17	41.5
BMI (mean \pm SD)	26.56 \pm 2.39		
Mode of Injury	Road Traffic Accident	12	29.3
	Slip and Fall	29	70.7
Side Involved	Right	26	63.4
	Left	15	36.6

The majority of patients were aged above 50 years (58.5%), with the 51–60 year age group being the most prevalent (31.7%), followed by patients over 61 years (26.8%). The mean BMI was 26.56 \pm 2.39. Females constituted 58.5% of the study population. Low-energy slip-and-fall injuries predominated (70.7%), while road traffic accidents accounted for 29.3% of cases. The right lower limb was more frequently involved (63.4%). Two patients (4.9%) had associated patellar fractures; the remainder had isolated distal femur fractures.

Table 2: Fracture Pattern and Comorbidity Profile

Variable	Category	n (41)	Percentage (%)
AO/OTA Fracture Type	33-C1	8	19.5
	33-C2	19	46.3
	33-C3	14	34.1
Comorbidities	None	17	41.5

	Diabetes Mellitus	12	29.3
	Hypertension	12	29.3
	Coronary Artery Disease	2	4.9
	Hypothyroidism	1	2.4
Associated Injuries	Nil	39	95.1
	Patellar Fracture	2	4.9

AO/OTA Type 33-C2 was the most common fracture pattern (46.3%), followed by Type 33-C3 (34.1%) and Type 33-C1 (19.5%). Among comorbidities, diabetes mellitus and hypertension were the most prevalent (29.3% each), followed by coronary artery disease (4.9%) and hypothyroidism (2.4%). Forty-one percent of patients had no comorbidities.

Table 3: Operative Details and Time to Union

Parameter	Mean \pm SD	Range
Day of Surgery (post-admission)	2.20 \pm 0.60 days	1–4 days
Intraoperative Blood Loss	133.90 \pm 23.44 mL	100–180 mL
Time to Union	9.66 \pm 1.30 months	7–12 months
Presenting Day (from injury)	1.15 \pm 0.57 days	1–3 days

The mean interval from admission to surgery was 2.20 \pm 0.60 days. Mean intraoperative blood loss was 133.90 \pm 23.44 mL. The mean time to radiological union was 9.66 \pm 1.30 months. All 41 patients (100%) underwent complete postoperative protocol compliance including immediate postoperative radiography, knee immobilization, 6-week X-ray, wound assessment at 4 weeks, and 6-month follow-up radiography.

Table 4: Functional and Radiological Outcomes

Outcome Parameter	Category	n (41)	Percentage (%)
Immediate Postop ROM	0–20°	6	14.6
	0–30°	28	68.3
	0–40°	7	17.1
6-Week ROM	0–70°	3	7.3
	0–80°	17	41.5
	0–90°	20	48.8
	0–100°	1	2.4
Radiological Union	Achieved	41	100.0
Functional Outcome	Good	41	100.0
Overall Clinical Result	Good	38	92.7
	Fair	3	7.3
Postoperative Complications	Present	2	4.9
	Absent	39	95.1

Immediately postoperatively, the majority of patients (68.3%) demonstrated a knee ROM of 0–30°, with 17.1% achieving 0–40° and 14.6% with 0–20°. At 6 weeks, 48.8% of patients achieved 0–90° ROM and 41.5% achieved 0–80°. Radiological union was achieved in all 41 patients (100%), and good functional outcomes were recorded in 100% of patients. Overall clinical results were good in 92.7% (n=38) and fair in 7.3% (n=3). Postoperative complications were observed in 2 patients (4.9%); 95.1% had no complications.

DISCUSSION

This study demonstrates that dual plating achieves 100% radiological union with a mean time to union of 9.66 months, good functional outcomes in all patients, and a low complication rate of 4.9% in complex distal femur fractures. Regarding secondary outcomes, the majority of patients attained a knee ROM of 0–90° by 6 weeks, and 92.7% recorded an overall good clinical result with no instances of implant failure or malalignment.

The predominance of AO/OTA Type C2 fractures (46.3%) in this study is consistent with findings reported by Imam et al. [19], Sirbu et al. [20], and Metwaly et al. [21], all of whom documented C2-type fractures as the most frequently

encountered pattern in surgically managed distal femur fractures. The demographic profile female predominance (58.5%) with a mean age of 58.2 years and a high proportion of patients over 40 years (76%) reflects the established epidemiology of osteoporotic distal femur fractures in older women [2,3]. Younger males were disproportionately affected by high-energy mechanisms, consistent with global epidemiological data [5].

The 100% union rate in our series compares favorably with prior studies. Tripathy et al. [1], in a systematic review and meta-analysis, reported significantly higher union rates with dual plating compared to single lateral plating, with reduced revision surgery. Bologna et al. [22] similarly documented improved union in comminuted fractures treated with dual-plate constructs. Sanders and Swiontkowski [23], who pioneered double plating in 1991, demonstrated its efficacy in achieving stable fixation in highly comminuted distal femur fractures. Our mean time to union of 9.66 months is comparable to figures reported by Purushotham and Patil [24] and Kulkarni et al. [25] in dual plating case series.

The functional outcomes in this study 100% good functional results and 92.7% good overall clinical results surpass those reported in earlier series. Khalil and Ayoub [26], who used a modified Olerud extensile approach for highly unstable C3 fractures, and Steinberg et al. [27] reported good-to-excellent outcomes in 82–88% of patients. The superior outcomes in our series may be attributed to early physiotherapy initiation from postoperative day 2, the rigid fixation afforded by the dual construct, and careful patient selection. The knee ROM trajectory majority achieving 0–90° by 6 weeks compares well with values reported by Pai et al. [28] and Garg et al. [29].

Biomechanical studies by DeKeyser et al. [11] and Li et al. [30] have confirmed that dual-plate constructs provide greater axial and rotational stiffness and reduce interfragmentary motion compared to single lateral plating, supporting faster and more predictable fracture healing. Concerning devascularization, a concern raised by Smith et al. [31] in a cadaveric study, Rollick et al. [17] demonstrated that medial plating does not compromise periosteal vascularity in clinical practice, a finding corroborated by the absence of avascular complications in our series. The low complication rate (4.9%) in our cohort aligns with those reported by Liu et al. [32] and Westrick et al. [33] and supports the safety of the dual plating technique when applied with appropriate surgical technique and biological fixation principles.

CONCLUSION

Dual plating using lateral and medial plate constructs provides superior biomechanical stability, achieves a 100% radiological union rate, and facilitates early postoperative mobilization in complex distal femur fractures (AO/OTA Types C1, C2, and C3). Good functional outcomes were attained in all 41 patients, with an overall good clinical result in 92.7% and a complication rate of 4.9%. The technique effectively addresses the challenges of medial comminution and osteoporotic bone quality. Consistent with both objectives of this study, dual plating confers superior fixation stability and supports early knee rehabilitation, making it a reliable, effective surgical strategy for complex distal femur fractures. Future prospective randomized controlled trials with larger cohorts and longer follow-up are warranted to further validate these findings.

Conflicts of Interest: The authors declare no conflicts of interest.

Funding: No external funding was received for this study.

Ethical Approval:

The study was approved by the Institutional Ethics Committee of PSG Institute of Medical Sciences and Research.

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