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Functional Outcome of Surgically Treated Distal Femur Fractures Using Distal Lateral Femoral Locking Plate with Fibular Strut Graft: A Hospital-Based Observational Study

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ABSTRACT

Background: Distal femur fractures are difficult periarticular injuries because metaphyseal comminution, intra-articular extension, open wounds and poor bone stock compromise stable fixation and early knee motion.
Objectives: To evaluate the functional outcome of surgically treated distal femur fractures fixed with a distal lateral femoral locking plate and fibular strut graft.
Methods: This hospital-based observational study included 20 skeletally mature patients with AO type 33A or 33C distal femur fractures treated between October 2022 and July 2024 at a tertiary care orthopaedic unit. Eligible closed fractures and Gustilo-Anderson type I or II open fractures were managed through a lateral approach using a distal femoral locking compression plate with fibular strut augmentation. Patients were followed clinically and radiologically. Fracture union, complications and final functional outcome using the Modified Hospital for Special Surgery knee score were analysed descriptively.
Results: The mean age was 45.1 years, and the age range was 24 to 69 years. Males formed 65.0% of the cohort. Road traffic accidents were the commonest mechanism of injury (85.0%). Closed fractures constituted 60.0%, and AO type A3 was the most frequent pattern (40.0%). Union within six months was recorded in 75.0% of cases. Complications occurred in 30.0%. Final functional grading was excellent in 30.0%, good in 55.0%, fair in 10.0% and poor in 5.0%. Overall, 85.0% achieved good-to-excellent results.
Conclusion: Distal femoral locking plate fixation with fibular strut graft provided a stable construct and favourable functional recovery in most patients with distal femur fractures in this series. The technique was particularly useful for comminuted metaphyseal patterns where medial support is important for maintaining alignment.

Keywords: Distal femur fracture; Fibular strut graft; Locking compression plate; Functional outcome; Modified HSS score; Fracture union.

INTRODUCTION

Distal femur fractures involve the supracondylar and intercondylar regions of the femur and form a clinically demanding subset of adult fractures. Their epidemiology reflects a bimodal pattern, with high-energy trauma in younger adults and low-energy osteoporotic injury in older patients. Adult fracture epidemiology has shown a rising contribution of fragility-related injuries, while reviews of distal femur fractures emphasize the severity of these injuries, the frequent presence of comminution, and the need to restore articular congruity, alignment, length and rotation.[1-3] In India, high-velocity road traffic accidents continue to produce complex fracture patterns in active adults, often with soft-tissue trauma and associated systemic injury.

Management has shifted from prolonged traction and cast immobilisation to operative fixation because conservative care is associated with malunion, knee stiffness, delayed mobilisation and complications of recumbency. Modern fixation aims to preserve biology while providing enough stability for early knee movement. The development of less invasive stabilisation systems and distal femoral locking plates allowed angular stable fixation in metaphyseal comminution and osteoporotic bone, with reduced dependence on plate-bone compression.[4,5] These constructs act as internal fixators and help protect periosteal blood supply when biological fixation principles are respected.

Despite these improvements, locked plating of distal femur fractures remains linked with nonunion, delayed union, implant failure, infection and malalignment. Large clinical series have reported persistent disability after locked plating, and risk-factor studies have identified open fracture, diabetes, smoking, obesity and shorter plate length as contributors to failure or reoperation.[6-8] Intra-articular involvement, medial metaphyseal comminution and varus tendency further increase mechanical demand on a lateral plate. Functional outcome depends not only on union but also on restoration of knee motion, pain control and a structured rehabilitation programme.[9,10]

Fibular strut graft augmentation offers additional structural support in fractures with metaphyseal comminution or medial cortical deficiency. By bridging the defect and improving column support, a strut graft can reduce varus collapse, maintain limb length and assist biological healing when combined with stable locked plating. Recent clinical literature has described the use of intramedullary fibular strut support with lateral locking plates in comminuted distal femur fractures, and current evidence stresses the need for reproducible union assessment and careful monitoring of major complications.[11-14] Therefore, the objective of the present study was to evaluate the functional outcome, fracture union pattern and complications of surgically treated distal femur fractures fixed with a distal lateral femoral locking plate and fibular strut graft.

METHODOLOGY

Study design and setting

This was a hospital-based observational study conducted in the Department of Orthopaedics, Andhra Medical College and King George Hospital, Visakhapatnam, Andhra Pradesh, India. The study period extended from October 2022 to July 2024. All eligible patients admitted through the outpatient clinic or casualty services with distal femur fractures were screened according to predefined criteria.

Study participants

Patients aged 18 years and above with clinical and radiological diagnosis of distal femur fracture were considered. AO/OTA type 33A and 33C fractures, closed fractures, and Gustilo-Anderson type I or II open fractures were included. Patients below 18 years, AO type 33B fractures, Gustilo-Anderson type III injuries, pathological fractures, periprosthetic fractures, pre-existing deformity of the involved limb, body mass index above 35 kg/m2, ipsilateral hemiplegia or hemiparesis, medical unfitness for surgery and refusal of consent were excluded. The final analysed sample included 20 patients.

Pre-operative assessment and surgical technique

Demographic details, mechanism of injury, side involved, fracture type, associated injuries and comorbid illnesses were recorded. Standard pre-operative investigations included hemogram, renal and liver function tests, blood sugar, blood grouping, bleeding and clotting time, chest radiograph, electrocardiogram, two-dimensional echocardiography and additional tests required for anaesthetic fitness. Fractures were classified using radiographs according to the AO/OTA system.[3] Surgery was performed under spinal anaesthesia in the supine position with the knee flexed to approximately 30 degrees. Through a lateral approach, the distal femur was exposed, articular fragments were temporarily held with Kirschner wires where required, and definitive fixation was achieved using a distal femoral locking compression plate. A fibular cortical strut graft harvested from the same side was placed to support the proximal and distal fragments, particularly across metaphyseal comminution.

Post-operative care and rehabilitation

Post-operatively, vital signs, wound condition, pain status and haemoglobin levels were monitored. Blood transfusion was given when clinically indicated. Intravenous antibiotics were administered during the early post-operative period, followed by oral antibiotics until suture removal. Sutures were removed on the fourteenth post-operative day. Static quadriceps exercises, ankle pump exercises and hip mobilisation were encouraged early. Knee range-of-motion exercises were started when fixation stability and soft-tissue condition allowed. Non-weight-bearing walker mobilisation was initiated during the early recovery period. Partial weight bearing was considered after six weeks, and full weight bearing was allowed only after radiological evidence of healing.

Follow-up and outcome assessment

Anteroposterior and lateral radiographs were obtained immediately after surgery and during follow-up at six weeks, ten weeks and then at three-month intervals. Alignment, implant position, loss of reduction, plate lift-off, implant breakage and callus formation were assessed. Union was interpreted clinically by painless full weight bearing and radiologically by bridging callus across cortices, consistent with commonly reported criteria in distal femur fracture studies.[12] Functional assessment included pain, knee range of motion, walking ability, stair climbing and return to activity, and final grading was

done using the Modified Hospital for Special Surgery knee score as excellent, good, fair or poor. Data were summarised as mean, range, frequency and percentage.

Ethical Considerations Institutional Ethics Committee approval was obtained from Andhra Medical College, Visakhapatnam, vide approval number 179/IEC AMC/JULY 2023, before enrolment of participants. Written informed consent was obtained from all participants prior to their inclusion in the study. The study was conducted in accordance with accepted ethical principles for human research, maintaining participant confidentiality and voluntary participation.

RESULTS

A total of 20 patients fulfilling the inclusion criteria were analysed. The mean age was 45.1 years, with an observed range of 24 to 69 years. The largest age group was 41-50 years, accounting for 8 patients (40.0%), followed by 31-40 years with 4 patients (20.0%). Male patients predominated, forming 13 cases (65.0%), while females formed 7 cases (35.0%). Right-sided fractures were more frequent than left-sided injuries. These demographic and injury-side findings are shown in Table 1.

Table 1. Demographic profile and side involvement

Variable	Category	Frequency (n)	Percentage (%)
Age group (years)	20-30	3	15.0
	31-40	4	20.0
	41-50	8	40.0
	51-60	2	10.0
	61-70	3	15.0
Sex	Male	13	65.0
	Female	7	35.0
Side involved	Right	12	60.0
	Left	8	40.0

Road traffic accidents were the leading mechanism of trauma and were documented in 17 patients (85.0%). Self-fall accounted for 3 cases (15.0%). Closed fractures constituted 12 cases (60.0%), while open fractures formed 8 cases (40.0%); these open injuries corresponded to Gustilo-Anderson type I or II wounds. AO type A fractures were more frequent than type C fractures. Type A3 was the commonest fracture pattern, observed in 8 patients (40.0%), followed by A2 in 7 patients (35.0%). The injury mechanism, fracture type and AO distribution are summarised in Table 2.

Table 2. Mechanism of injury, fracture type and AO classification

Variable	Category	Frequency (n)	Percentage (%)
Mode of injury	Road traffic accident	17	85.0
	Self-fall	3	15.0
Type of injury	Closed fracture	12	60.0
	Open fracture	8	40.0
AO classification	A1	1	5.0
	A2	7	35.0
	A3	8	40.0
	C1	2	10.0
	C2	1	5.0
	C3	1	5.0

Associated injuries were recorded in 7 patients (35.0%), whereas 13 patients (65.0%) had no associated injury. Comorbid illness, mainly diabetes mellitus and hypertension, was present in 6 patients (30.0%) and absent in 14 patients (70.0%). The frequency of associated injuries and comorbidities is presented in Table 3.

Table 3. Associated injuries and comorbidities

Variable	Category	Frequency (n)	Percentage (%)
Associated injuries	Present	7	35.0
	Absent	13	65.0
Comorbidities	Present	6	30.0
	Absent	14	70.0

Radiological and clinical union occurred within three months in 6 patients (30.0%). Union between three and six months was observed in 9 patients (45.0%), giving an overall union within six months in 15 patients (75.0%). Five patients (25.0%) required more than six months for union or prolonged healing observation. Complications were present in 6 patients (30.0%) and absent in 14 patients (70.0%). Documented complications included restriction of knee movement, thigh pain, superficial infection, malalignment and delayed/nonunion patterns. These findings are given in Table 4.

Table 4. Time to union and complications

Outcome variable	Category	Frequency (n)	Percentage (%)
Time to union	Less than 3 months	6	30.0
	3-6 months	9	45.0
	More than 6 months	5	25.0
Complications	Present	6	30.0
	Absent	14	70.0

Table 5. Functional outcome according to Modified Hospital for Special Surgery knee score

Functional outcome grade	Frequency (n)	Percentage (%)
Excellent	6	30.0
Good	11	55.0
Fair	2	10.0
Poor	1	5.0
Good-to-excellent overall	17	85.0

Final functional assessment using the Modified Hospital for Special Surgery knee score showed excellent outcome in 6 patients (30.0%), good outcome in 11 patients (55.0%), fair outcome in 2 patients (10.0%) and poor outcome in 1 patient (5.0%). Therefore, good-to-excellent functional recovery was achieved in 17 patients (85.0%), as shown in Table 5.

DISCUSSION

The present observational study assessed 20 patients with distal femur fractures treated using a distal lateral femoral locking plate combined with fibular strut graft. The cohort had a mean age of 45.1 years and a male predominance, reflecting the trauma burden in a working-age population. Road traffic accident was the dominant injury mechanism. This pattern is consistent with the known bimodal epidemiology of distal femur fractures, where high-energy injuries are common in younger adults while low-energy osteoporotic fractures are more frequent in older patients.[1,2] The high proportion of AO type A2 and A3 fractures in this series indicates substantial metaphyseal involvement, making stable fixation and maintenance of alignment essential.

The rationale for using a locking plate in this setting is its angular stability and ability to function as an internal fixator. Less invasive stabilisation concepts and locked plating have improved fixation in short distal fragments and comminuted metaphyseal zones.[4,5] However, lateral locked plating alone is not free from failure. Clinical outcome studies have shown

nonunion, persistent disability and implant failure after distal femur locked plating, especially in open injuries and high-risk host conditions.[6-8] In the present series, complications were seen in 30.0% of patients, but most were manageable and did not prevent an overall good-to-excellent functional result in 85.0% of cases.

Union within six months was documented in 75.0% of patients. This is clinically relevant because contemporary reviews show wide variation in the definition and timing of radiographic union after distal femur fixation.[12] The use of clinical pain-free weight bearing along with radiographic bridging callus provided a practical endpoint for follow-up in this study. Current systematic evidence also indicates that locked plating continues to have a meaningful risk of nonunion and major complications, with nonunion being a leading reason for reoperation.[10,11] Therefore, additional strategies that improve medial column support are important in selected comminuted patterns.

Fibular strut graft augmentation was used in this study to increase structural support across the metaphyseal region. This approach is biologically and mechanically attractive because the graft acts as an intramedullary scaffold, helps preserve limb length and resists varus collapse. Recent reports of intramedullary fibular strut support with lateral locking plates have described improved early knee function and potential benefits in comminuted distal femur fractures.[13,14] The present results support this concept, as most patients achieved union and favourable Modified HSS grades. Nevertheless, larger comparative studies with longer follow-up are required before concluding that fibular strut augmentation is superior to locked plating alone or alternative constructs such as retrograde nailing, dual plating or nail-plate combinations.[9-11]

Limitations

This study was limited by its single-centre observational design, small sample size and absence of a comparison group treated without fibular strut graft. Functional outcome was assessed mainly with the Modified HSS score, and detailed patient-reported KOOS subscale analysis was not available for all cases. Follow-up duration varied, restricting assessment of late arthritis, implant-related symptoms and long-term return to work.

CONCLUSION

Distal femur fractures treated with a distal lateral femoral locking plate and fibular strut graft showed favourable functional recovery in this observational series. Most patients were young or middle-aged males injured in road traffic accidents. AO type A3 and A2 patterns were common. Union within six months was achieved in three-fourths of cases, and good-to-excellent Modified HSS outcomes were recorded in 85% of patients. Fibular strut augmentation appeared useful for maintaining metaphyseal support in comminuted fractures. Careful patient selection, stable fixation, respect for soft tissues and structured rehabilitation remain central to outcome. Larger comparative studies are needed to confirm these findings with stronger overall evidence in routine orthopaedic trauma practice.

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