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Original Article

Dynamic Interlocking Nailing supplemented with Functional Bracing in management of Unstable Femoral Shaft Fractures: A Prospective Study of Clinico-Radiological

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ABSTRACT

Background: Intramedullary interlocking nailing is the standard of care for femoral shaft fractures. However, optimal mechanical modulation, particularly the role of primary dynamization combined with functional bracing remains inadequately defined in unstable fracture patterns.
Purpose: To evaluate the clinical and radiological outcomes of unstable femoral shaft fractures treated with primary dynamic interlocking nailing supplemented by functional bracing.
Materials and Methods: A prospective observational study was conducted on 40 adult patients with closed unstable diaphyseal femoral fractures. All patients underwent dynamic interlocking intramedullary nailing, followed by early functional bracing and subsequent full weight bearing. Patients were followed at 4, 12 and 24 weeks. Outcomes included time to union, functional outcome (Thoresen criteria4), range of motion, alignment and complications.
Results: The mean union time was 19.2 ± 2.7 weeks, with union achieved in 92.5% of patients. Delayed union occurred in 5% and non-union in 2.5%. Excellent functional outcomes were observed in 82.5% of cases. There were no cases of implant failure or clinically significant malalignment.
Conclusion: Primary dynamic interlocking nailing combined with functional bracing provides a biomechanically favourable environment for fracture healing, enabling early mobilization with excellent functional outcomes in unstable femoral shaft fractures.

Keywords*: Dynamic interlocking nail, Thoresen clinical criteria, functional bracing.*

INTRODUCTION

Closed intramedullary interlocking nailing is currently regarded as the gold standard for the treatment of femoral shaft fractures because it provides stable fixation, preserves fracture biology, allows early mobilization and facilitates early weight bearing[1–4]. Advances in implant design and surgical techniques have significantly improved union rates and functional outcomes in these fractures. Intramedullary fixation promotes secondary bone healing through bridging callus formation. Also, it has advantages such as reduced rates of malunion, limb shortening, shorter hospital stays and early return to daily activities[1,5,6]. nterlocking nails can be used in either static or dynamic mode. In static locking, the implant acts as a load-bearing device with minimal compression at the fracture site, whereas dynamic locking permits controlled axial compression and interfragmentary movement during weight bearing. Controlled interfragmentary movement is known to stimulate periosteal callus formation and enhance fracture healing.[5,6,7] Dynamization, achieved by removal of one or

more locking screws, is commonly used in cases of delayed union and nonunion because it is a simple, minimally invasive and cost-effective method to promote union.[2,3,8] A similar study had been done in unstable shaft of tibia fractures by Yogesh et al and they concluded that dynamic IMN in unstable tibial fractures managed with dynamic nailing and supplemented with functional bracing is a safe and effective approach. It enabled early rehabilitation of patients with minimal complications and high union rates.[9]However, the optimal timing and role of primary dynamic nailing in unstable femoral shaft fractures remain controversial.[3,10]

Functional bracing based on Sarmiento principles provides additional fracture stabilization by reducing angular and rotational stresses while allowing controlled motion at the fracture site.[11,12] When combined with intramedullary nailing, functional bracing may enhance fracture healing and permit early rehabilitation. Despite the established role of dynamization in stable fractures, there is limited literature regarding the use of primary dynamic interlocking nailing supplemented with functional bracing in unstable femoral shaft fractures.

Therefore, the present study aims to evaluate the clinical and radiological outcomes of this treatment modality.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Orthopaedics at Maharaja Agrasen Medical College, Agroha (Hisar), from March 2024 to September 2025.

The study was initiated after approval from the Institutional Ethical Committee (IEC). A total of 40 patients were included in this study based on following inclusion and exclusion criteria;

Inclusion Criteria

a) All skeletally mature patients (>18 years) with closed unstable diaphyseal fractures of femur confirmed with appropriate radiograph.
b) Fractures <2 weeks duration.
c) All Association of Osteosynthesis (AO) Muller classification 32(A, B, C) for diaphyseal fracture of femur 32(A1, A2, B1, B2, B3, C1, C2, C3 except A3).[13] as per annexure II.
d) Patients who is ambulatory and medically fit for surgery.
e) Patients willing to provide voluntary informed and written consent for participation in the study.

Exclusion Criteria

a) Open fracture
b) Fractures with intra articular extension
c) Pathological fractures
d) Fractures >2week duration
e) Any preexisting disease in lower limb which prevent full weight bearing in post operative period
f) Medically unfit for surgery or with associated injuries of the limbs, pre-existing injury, systemic injury preventing full weight bearing in post operative period.

The sample size was calculated on basis of previous study by khalid et al[4] with proportion excellent score 66.7% after dynamization of antegrade introducing nailing in femoral shaft fractures, yielding a minimum of 34 cases although 40 patients were taken for better reliability.

After pre-anesthetic clearance, all patients underwent surgery under spinal or epidural anesthesia with prophylactic intravenous antibiotics administered 30 minutes prior to incision. Standard technique for antegrade femur nailing was used and proximal locking was performed in dynamic mode using the oblong hole in all cases.

Postoperatively, all patients were started on non-weight-bearing mobilization and range-of- motion exercises from the first postoperative day. Functional thigh braces were applied after subsidence of swelling while keeping the hip and knee joints free. Full weight bearing as tolerated was permitted only with the brace support. Sutures were removed on the 10th 12th postoperative day and patients were subsequently discharged with the brace. Follow-up evaluations were performed at 4, 12 and 24 weeks. It included clinical assessment for pain, swelling, range of motion, extension lag and limb shortening (using Thoresen clinical criteria[4]), along with radiological assessment of fracture union based on bridging callus formation.


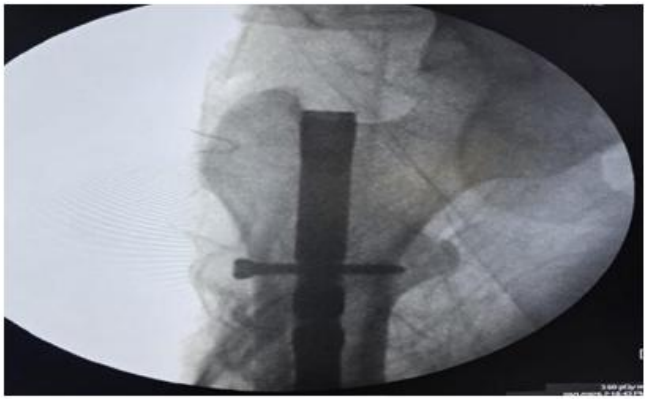

Fig-1 Fig-2 Intraop C arm image showing femur nail in dynamic mode

Fig-3 Patient with functional thigh brace

RESULTS

Total 40 patients were included in the study with no loss to follow up. The age of the patients in the present study was in the range of 18-60 years with a mean value of 36.3±4.5 years. The majority of participants were male, making up 85% of the sample, while females constituted 15%. The primary mode of injury was road traffic accidents, accounting for 90% of cases. Fall contributed 7.5% and assault contributed 2.5%. Mid shaft femur fractures were the most common (75 %) followed by distal and proximal among the study participants. Most fractures were classified as 32A1 (37.5%) or 32A2 (22.5%). Other types, such as 32B1, 32B2,32B3, 32C1, 32C2, and 32C3, were less frequent.

Table 1: AO – Classification of fractures[13]

AO classification	Frequency	Percentage
32A1	15	37.5
32A2	9	22.5
32B1	4	10
32B2	1	2.5
32B3	3	7.5
32C1	5	12.5
32C2	2	5
32C3	1	2.5

Thigh brace was given to all the patients when swelling subsided with hip and knee joints kept free. In 18 patients brace was given on day 10, in 12 patients on day 9, in 5 patients on day 8 and day 11 and all patients were allowed to bear full weight immediately after application of brace as per tolerance and cooperation of patient. 1 patient had superficial surgical site infection which healed with intravenous antibiotics. One patient had minor proximal dynamic screw migration but it was managed conservatively as the patient was asymptomatic and union was achieved at final follow up.

Patients were followed at 4, 12 and 24 weeks in OPD. X-rays and clinical examination was done to determine fracture union and functional outcome (using Thoresen clinical criteria[4]). Range of motion at knee (> 110 degrees) and hip (> 100 degrees) achieved in all the patients at final follow up. In this study on final follow up (24 weeks), there was up to 5 degrees

of extension lag in 8 patients while 1 patient had extension lag more than 5 degrees while 31 patients had no extension lag which was improved with physiotherapy. No significant shortening (> 2 cm) and malalignment was noted in any patients. Mean time for union of fracture was 19.2 ± 2.7 weeks. Delayed union was observed in 2 patients, however union was ultimately achieved at 28 and 30 weeks. 1 patient suffered from nonunion who was managed with percutaneous bone marrow grafting.

Table 2: Union time (weeks)

Union (in weeks)	No. of patients	Percentage
Up to 16 Weeks	8	20
16-18 Weeks	10	25
18-24 Weeks	19	47.5
24-28 Weeks	2	5
Non- union	1	2.5

Clinical outcomes were evaluated using Thoresen clinical criteria[4]. Excellent outcomes were observed in 82.50 % of participants, Good in 12.50 % and Fair in 5 % patients at final follow up(24 weeks).

Table 3: Thoresen Clinical criteria[4]

Thoresen criteria	No. of patients	Percentage
Excellent	33	82.50
Good	5	12.50
Fair	2	5
Poor	0	0

Delayed union was observed in 2 patients, however on further follow up union was ultimately achieved at 28 and 30 weeks. One patient suffered from nonunion at final follow up who was managed with 2 injections of percutaneous bone marrow grafting one month apart and fracture ultimately united. One patient had knee stiffness which was managed with active and passive physiotherapy.

Case no. 4

Figure-4 Pre op x-ray

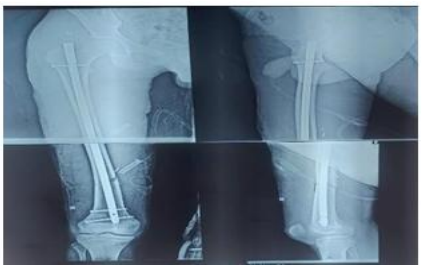

Figure- 5 Post op x-ray

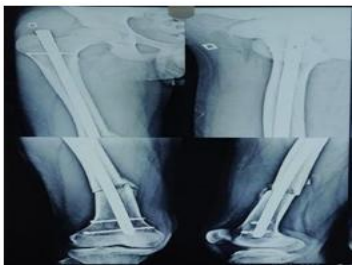

Fig-6 Final follow up xray

Fig-6

Fig-7

Fig-8

DISCUSSION

The present prospective observational study evaluated the clinical and radiological outcomes of closed unstable diaphyseal femoral fractures managed with dynamic interlocking intramedullary nailing supplemented by functional bracing. The demographic profile and fracture characteristics observed in the present study were comparable with previously published literature. Most patients belonged to the young and middle-aged population, with a marked male predominance and road traffic accidents being the leading mode of injury, reflecting the high-energy mechanism commonly associated with femoral shaft fractures.[14-16] The middle third of the femoral shaft was the most frequently involved segment, and unstable fracture patterns including wedge and comminuted fractures constituted a substantial proportion of cases. The mean time to radiological union in the present study was 19.2 ± 2.3 weeks, which was comparable to findings reported by Patel et al., Perumal et al. and Kabir et al.[3,14,15] Controlled dynamization achieved through proximal dynamic locking likely promoted axial micromotion and compression at the fracture site, thereby creating a favourable biomechanical environment for secondary bone healing and callus formation.[5,17]

Functional outcomes in the present study were satisfactory, with excellent to good outcomes achieved in the majority of patients according to Thoresen criteria[4]. Early mobilization, controlled weight bearing, and aggressive physiotherapy contributed to restoration of near- normal hip and knee range of motion in most patients. Similar functional outcomes have been reported in studies evaluating interlocking nailing in femoral shaft fractures.[14,15] No clinically significant malalignment or limb shortening was observed, indicating that dynamic interlocking nailing effectively maintained fracture alignment and limb length even in unstable fracture patterns. These findings are consistent with reports by Ricci et al.[18] and Healy et al.[19], who emphasized the importance of adequate reduction and stable fixation in preventing postoperative deformity.[19,20] Functional bracing served as an important adjunct by reducing bending and rotational stresses while permitting controlled axial loading, thereby enhancing fracture stability during rehabilitation.[12,13,14]

The complication rate in the present study was low and comparable to previously published literature. One patient developed superficial surgical site infection that resolved with antibiotic therapy, while delayed union and nonunion were observed in a small number of cases. No implant failure, loss of reduction, or neurovascular complications were encountered. The favourable outcomes observed in this study support the concept that controlled mechanical stimulation enhances fracture healing [5,8,21]. Although literature regarding the combined use of dynamic femoral interlocking nailing and functional bracing remains limited, the present study demonstrates that this technique is safe and effective in the management of unstable femoral shaft fractures. Similar principles have been successfully applied in unstable tibial fractures managed with dynamic nailing supplemented with functional bracing[9]. Further multicentric comparative studies with larger sample sizes and longer follow-up are recommended to validate these findings and establish standardized treatment protocols.

CONCLUSION

The present study demonstrates that dynamic interlocking intramedullary nailing supplemented with functional bracing is a safe, effective and biologically favourable treatment modality for closed unstable diaphyseal fractures of the femur. This combined approach achieved satisfactory fracture union, excellent functional outcomes, maintenance of alignment and limb length with low complication rates. Functional bracing served as an effective adjunct by permitting early controlled weight bearing, reducing implant-related bending stresses and facilitating controlled axial micromotion at the fracture site, thereby enhancing callus formation and secondary bone healing. Early mobilization further contributed to preservation of hip and knee joint mobility, prevention of stiffness and immobilization-related complications and accelerated return to routine activities. The findings of the present study support the concept that optimal fracture healing is achieved through a balanced integration of mechanical stability and biological stimulation. Although larger randomized comparative studies with longer follow-up are required for further validation, the present study of dynamic interlocking femoral nailing combined with functional bracing has proved to be a reliable and promising strategy for the management of unstable femoral shaft fractures.

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