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Research Article

Clinical and Radiological Outcome in Closed Unstable Diaphyseal Fracture of Tibia Managed with Dynamic Interlocking Nailing Supplemented with Functional Bracing

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ABSTRACT

Introduction: Unstable tibial diaphyseal fractures from high-energy trauma are challenging due to displacement, comminution, and risk of non-union. This study evaluates dynamic interlocking intramedullary nailing (IMN) with functional bracing to enhance stability, promote union, and allow early mobilization.
Methods: A prospective observational study was conducted at Maharaja Agrasen Medical College, Agroha, from May 2023 to September 2024, involving 40 skeletally mature patients (aged 18–60) with closed, unstable tibial fractures (AO types A1, A2, B1–B3, C1–C3). All underwent infrapatellar dynamic IMN followed by functional bracing post-swelling. Outcomes were assessed at 4, 12, and 24 weeks using modified Ketenjian and Shelton criteria.
Results: Mean age was 36.3 years; 85% were male. Road traffic accidents caused 70% of injuries. Most fractures were mid-shaft (77.5%) and AO 42A1 (45%). Mean surgery time was 86 minutes; union occurred at 19±1 weeks. At 24 weeks, 94.91% showed excellent/good outcomes. Complications included two delayed unions, one non-union, one superficial infection, and one screw migration. No deep infections, malalignment, or implant failures were observed.
Conclusion: Dynamic IMN with functional bracing is a safe, effective approach for unstable tibial fractures, enabling early rehabilitation and high union rates with minimal complications. Further studies are recommended for broader validation.

Keywords: *Tibial shaft fracture, (IMNL) intramedullary nailing, functional bracing, fracture healing, early mobilization.*

INTRODUCTION

The tibia is the second largest bone in the human body and plays a crucial role in weight-bearing and mobility. Fractures of the tibial diaphysis are among the most frequent long bone fractures encountered in orthopedic practice, often occur due to high-energy trauma, such as motor vehicle accidents or falls from significant heights. Management of unstable diaphyseal fractures of the tibia requires a balance between providing adequate stability for bone healing and allowing early mobilization to prevent complications associated with prolonged immobilisation.[1,2] The standard treatment has evolved over the years, with intramedullary nailing emerging as the gold standard for management of diaphyseal fractures.[3] Dynamic interlocking nailing has gained attention for its ability to provide both stability and controlled axial movement at the fracture site, which is essential for promoting callus formation necessary for bone healing, while simultaneously maintaining the proper alignment and rotational stability of the fracture.[4,5] One of the adjuncts to dynamic interlocking

nailing is the use of functional bracing which involves the application of an external brace that allows for controlled movement of the limb while maintaining sufficient stability to protect the healing fracture.[6] The concept is to encourage early mobilization and weight-bearing, which can improve the functional outcomes and reduce the risks associated with prolonged immobilization, such as joint stiffness, muscle atrophy, and deep vein thrombosis.[7] The combination of dynamic interlocking nailing with functional bracing represents a modern approach to managing unstable diaphyseal tibial fractures.

MATERIAL AND METHODS

This hospital-based prospective observational study was conducted in the Orthopedics Department at Maharaja Agrasen Medical College, Agroha, from May 2023 to September 2024, enrolling 40 patients aged 18-60 years with closed unstable tibial diaphyseal fractures, who were ambulatory prior to injury and medically fit. Radiological investigations, in the form of X-rays with standard antero-posterior and lateral views, were done. The fractures were classified according to AO Classification.[8] Open fractures, articular fractures, simple transverse and fractures >2 weeks were excluded from the study. All the patients were operated through infrapatellar approach for fracture tibia.[9] Postoperatively, patients received IV broad-spectrum antibiotics for at least three days, then oral antibiotics until suture removal (day 10–12). Rehabilitation began with non-weight-bearing and non-loading exercises from day one. After swelling reduction, functional bracing allowed for progressive weight-bearing as tolerated. The brace permitted full range of motion at the knee and ankle. Patients were followed at 4, 12, and 24 weeks postoperatively. Functional and clinical outcomes were assessed using the Katenjian and Shelton Criteria (modified by Yokoyama et al.),[10 11] evaluating range of motion, local site condition, fracture site pain, limb shortening, and radiographic evidence of healing (bridging callus in all four cortices).

RESULTS

The average age of patients in our study was 36.3 years. Majority of the patients were male patients comprising 85% of the total. The primary mode of injury was road traffic accidents, accounting for 70% of cases. Assaults and falls each contributed 15%. Most common level of fracture was mid-shaft fractures (77.5%) and AO type 42A1 (45%) being most common. 8 patients had associated fractures at some other site in the body. Some patients had massive swelling, stitched wounds, deep abrasions, and blisters and surgery was delayed with the mean interval from injury to surgery was 8.5 days. The average surgery time was 86 minutes. Majority of patients (56%) achieved full active flexion and no extension lag (72%) of knee at final follow up. Appearance of bridging callus on plain radiographs was considered as union. Mean time for union of fracture was 19±1 weeks. There is delayed union in 2 patients and non-union in 1 patient while 1 patient lost to follow up. None of the patients had significant shortening (>2cm). Alignment was measured on full length AP and lateral tibia films using a goniometer. Malalignment was defined as angulation of >5degrees in any plane. In the present study there was no significant malalignment in any case. Clinical outcomes observed after surgery on final follow up at 24 weeks were based on the Ketenjian and Shelton criteria. Excellent or good outcomes were observed in 94.91% of participants, Fair and poor outcomes in 2.56% patients was observed. One of the patient had superficial surgical site infection which was healed after treatment with i.v antibiotics. Two patients had delayed union while one patient had non union. One patient had migration of proximal dynamic screw laterally. None of the patient had nerve injury, loss of reduction, proximal migration of nail or implant failure.

Table 1: Ketenjian and Shelton criteria

K&S criteria	No. of patients	Percentage
Excellent	33	84.61
Good	4	10.25
Fair	1	2.56
Poor	1	2.56

Fig 1 Nail mounted over zig with 11 degrees Herzog angle

Fig 2 Incision site mark in supine and incision in knee flexion

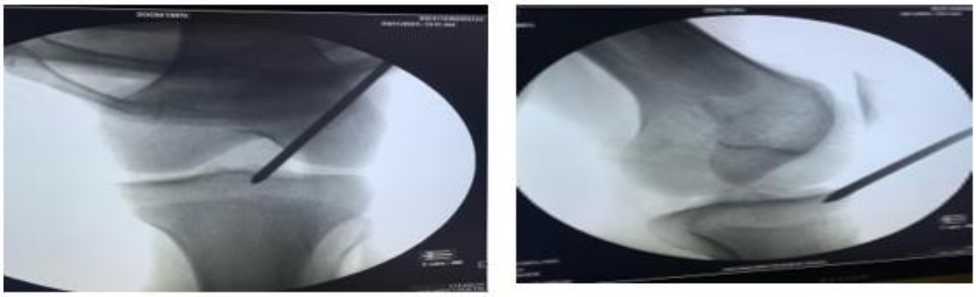

Fig 3 Entry point localized in both AP and Lateral View: 2mm medial to the lateral tibial spine on AP imaging and just distal to the angle between tibial plateau and anterior tibial metaphysis

Fig 4 Ball tip guide wire passed across the fracture into distal fragment from proximal fragment and nail passed in reduced position of fracture in both AP and Lateral views

Fig 5 Distal locking through free hand technique and proximal locking in dynamic hole through Zig

Fig 6 X-rays: Pre op, Immediate Post op and Final follow up

DISCUSSION

Unstable fractures of tibia are characterized by a higher degree of bone displacement, comminution, or both, making them more challenging to manage and more likely to result in complications such as non-union or malunion.[4] Dyamic interlocking nailing supplemented with functional bracing promote early mobilization and micromovement at the fracture site which enhance union.

Table 2: Comparison of time for union

Study	Year	Total no. of patients	Treatment Method	Fracture pattern	Union (weeks)
Gadegone et al[6]	2015	40	Dynamic Intramedullary Interlocking Nail	Stable and unstable diaphyseal fractures	18
Rathwa et al[12]	2017	50	Intramedullary Interlocking Nail in static mode	Stable and unstable diaphyseal fractures	19

Badami et al[13]	2018	50	Dynamically Locked Intramedullary Interlocking Nail	Stable Diaphyseal fractures	17
Present study	2024	40	Intramedullary interlocking nail in dynamic mode supplemented with functional bracing	Unstable daiphyseal fractures	19

In present study the mean time to union was 19.1 weeks. The maximum numbers of fracture united between 18 -24 weeks. There were 2 cases of delayed union which united at 26 weeks and 27 weeks respectively aligning closely with the findings of Gadegon et al, Badami et al and Rathwa et al reported an average union time of 18 weeks, 19 weeks and 17 weeks respectively.

Table 3: Comparison of Functional outcomes

Studies	Year	Study population	treatment method	Fracture pattern	Functional Outcomes
Vinod et al[14]	2016	30	functional cast bracing (Conservative method)	Tibia diaphyseal stable fractures	73.3% (good)
		30	intramedullary interlocking nail (Static mode)	Tibia diaphyseal stable fractures	80% (excellent or good)
Rathwa et al[12]	2017	50	intramedullary interlocking nail (Static mode)	Tibia diaphyseal stable and unstable fractures	80% (Excellent)
Present study	2024	40	Intramedullary interlocking (dynamic mode) nail with functional bracing	Tibia diaphyseal unstable fractures	94.90 (Excellent or good)

The functional outcomes in this study, was evaluated using the Ketenjian and Shelton criteria, were excellent or good in 94.91% of participants. These results are in concordance with Rathwa et al. (2017), who reported excellent outcomes in 80% of patients treated with intramedullary interlocking tibial nails.[12] Furthermore, Vinod et al. (2016) demonstrated superior functional outcomes in the surgically managed group, particularly regarding weight-bearing ability and mobility, supporting the findings of the present study.[14]

Early mobilization through functional bracing significantly aided recovery, with 97.5% of patients weight-bearing by postoperative day 12. This aligns with Beebee et al. (2019), who found immediate weight-bearing safe after intramedullary fixation.[15] Although 35% of participants were smokers, the specific impact on healing wasn't assessed, though smoking is known to delay union Agarwal et al. (2022).[16] Callus formation was observed in 92.2% by week 18, supported by literature Ziran et al. (2022) endorsing dynamic nailing's biological benefits.[17] Complications were minimal—only one superficial infection, one screw migration, two delayed unions, and one non-union—echoing findings from Srinivas et al. (2017).[18] A male predominance (85%) was noted, consistent with previous reports attributing this to occupational risk factors. Compared to conservative treatment (Vinod et al., 2016), the combination of dynamic interlocking nailing and functional bracing proved superior in promoting favorable clinical and radiological outcomes.[14]

Intra- operative observation

In 7 cases of AO type 42B fractures, difficulty was encountered in guiding the wire into the distal fragment due to its exit through the fracture site. Control of the butterfly fragment was challenging, resulting in a fracture gap. This was successfully managed using a percutaneous clamp and bimanual compression.

In 6 cases of AO type 42C comminuted fractures, maintaining length, alignment, and reduction was difficult. These challenges were addressed with percutaneous clamps, tongs, bimanual compression, and careful centering of the guide wire in each fragment prior to reaming and nailing.

Limitation

This study's limitations include a small sample size, exclusion of complex fractures, short follow-up duration, limited analysis of patient-related factors, and single-center design, restricting generalizability. Future multi-center studies with larger, diverse cohorts and long-term follow-up are needed.

CONCLUSION

Dynamic interlocking nailing with functional bracing is a safe, effective method for treating unstable tibial diaphyseal fractures. It ensures timely union, excellent recovery, and minimal complications. Early mobilization through bracing enhances outcomes, aligning with minimally invasive principles. Supported by existing literature, this approach shows clear advantages, highlighting its role as a key evidence-based strategy in fracture management.

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