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STATIC VERSUS DYNAMIC INTERLOCKING INTRAMEDULLARY NAILING IN TRANSVERSE / OBLIQUE FEMORAL FRACTURES OF MIDDLE AND DISTAL THIRD

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Abstract

OBJECTIVE: *To compare the outcomes of static and dynamic interlocking intramedullary nailing in patients with transverse/oblique femoral fracture of the middle of the distal third.*

METHODOLOGY: *This randomized controlled trial was conducted at Chandka Medical College to compared static and dynamic interlocking intramedullary nailing among the sample of 136 patients with transverse or oblique femoral shaft fractures. Patients were randomized after providing informed consent by using sealed opaque envelopes: Group A underwent reamed antegrade nailing with dynamic interlocking, and Group B underwent static interlocking fixation. Final outcomes assessed at 24 weeks which included non-union, delayed union, surgical site infection, and functional recovery using Thorensen's criteria. Data were analyzed with SPSS, using $p \leq 0.05$ for significance.*

RESULTS: *In a study encompassing a sample of 136 participants (mean age 36.7 years; 72.8% male) diagnosed with mid-to-distal transverse or oblique femoral fractures, the utilization of dynamic interlocking nailing resulted in significantly lower rates of delayed union (5.9% as opposed to 27.9%, p=0.001), non-union (2.9% in contrast to 17.6%, p=0.004), and surgical site infection (4.4% relative to 20.6%, p=0.004), concurrently exhibiting enhanced functional outcomes (p=0.0001).*

CONCLUSION: *It can be inferred that dynamic interlocking intramedullary nailing employed in mid-to-distal transverse and oblique femoral fractures exhibited markedly reduced incidences of delayed union, non-union, and surgical site infection, alongside enhanced functional outcomes when contrasted with static nailing. These results support that dynamic fixation is a better method for helping fractures heal and recover in the right patients.*

INTRODUCTION

The femur is one of the most common and load-bearing bones of the body that is broken and in need of surgery, such as fixation. Femoral shaft fractures (FSF) are some of the most frequent injuries seen by orthopaedic surgeons [1]. They are typically caused by high-energy traumas in young adults and low-energy traumas in older patients, and traffic accidents including MVC are one of the most common mechanisms in which these types of injuries occur. Fractures of the femoral shaft are injuries that may be managed non-operatively or operatively depending on numerous factors, such as the age of the patient, open versus closed fracture, the degree of comminution, and other free injuries.

The treatment goal of these fractures is to obtain rapid healing of fractures with a possibility of early weight bearing and return to work [2,3]. The current gold standard treatment of femoral shaft fractures is intramedullary nail stabilization, with union rates for femurs as high as 97% in the literature [4]. Compared with external fixation, intramedullary nail fixation is a kind of minimally invasive surgery which is associated with the advantages of less damage of the perfusion at the fracture end, less complications, and more stable fixation [5].

In orthopaedic surgery, intramedullary nailing techniques include antegrade and retrograde both reamed and undreamed methods, static and dynamic locked nails respectively. Use of the techniques is increasing on a daily basis, possibly related to the technological improvements and the production of implants and surely to improvements of surgical techniques [6,7]. For static nail fixation, there is one proximal and two distal locking screws that prohibit rotation and shortening. Dynamization is accomplished by a single locking screw in the proximal dynamization screw hole and two locking screws on the distal side of the fracture or by placing the locking screws only in a smaller segment of the fracture fragment and avoiding to install screws in a larger segment [8,9].

Dynamized mode of interlocking nails allows early weight bearing which accelerates fracture healing [10]. The main target of fracture treatment and management especially in the lower extremities is to rapidly maintain the integrity of the bone and to twitch physical therapy. The consequence of fracture healing is highly associated with the quality and performance of surgery [11].

Dynamic nails had an earlier fracture healing time (15th week) compared to static nailing (22nd week) in the study by Qureshi et al [12]. Good or excellent functional outcome was accomplished in 84% of patients of Group I and in 22% of Group II. Delayed union was observed in 8% patients in dynamic and 26% in static while nonunion in 2% patients in dynamic and 16% patients in static. Another study reported the mean healing time in static interlocking nails was 16.11±3.09 weeks and in dynamic interlocking nails 19.37±5.13 weeks. However, the delayed union was observed in 8% of the static interlocking group and limb shortening was observed in 4% in the dynamic interlocking group [13].

The purpose of our study is to compare the results of static and dynamic interlocking intramedullary nailing in patients with transverse or oblique femoral shaft fractures. Numerous reports have been published on the results of the treatment of patients treated by intramedullary nailing following femoral shaft fractures. But there is no established protocol in locking an interlocking nail as evidence is sparse. Again, in our environment the treatment of preference for fracture of the femoral shaft is interlocking Nail. Unfortunately, because of a lack of local clinical evidence and standard protocol, the mode of locking interlocking nails is subject to the surgeon's personal experience and choice. The results of our study will provide insight to the orthopaedic surgeon in forming a standard protocol for interlocking nails which ultimately helps in improving postoperative outcomes of patients with femoral shaft fractures. Furthermore, Continued research is essential for achieving better results and strengthening conclusions, allowing for improvements in the current standard of care.

METHODOLOGY

The present study was a randomized controlled trial, carried out in the Department of Orthopaedic Surgery, Chandka Medical College, SMBBMU, Larkana, to analyse and compare the results of static vs dynamic interlocking intramedullary nailing in patients with transverse/oblique fractures of femoral shaft un-united after middle or distal third of femur.

Using non-probability consecutive sampling, a total of 136 patients of 18–65 years of age with ASA status I–III were included.

Inclusion criteria were transverse or oblique fractures with horizontal or angled fracture lines, respectively (both radiographically confirmed). Patients with pathological or bilateral fractures, polytrauma, diabetes, osteoarthritis, previous surgeries on the affected limb, or neuromuscular compromise were excluded. At the time of the surgery, after obtaining an informed consent, the patients were randomly allocated into two groups by using sealed opaque envelopes: Group A underwent reamed antegrade nailing with dynamic interlocking, and Group B underwent static interlocking fixation.

After the general anesthesia, the patients were placed in a supine position on a traction table with the foot of the affected side, using piriformis fossa entry point and flexible reamers for canal preparation. The largest appropriate nail was placed with locking patterns determined by group. Reduction was confirmed fluoroscopically, and all patients received preoperative second-generation cephalosporins. Physiotherapy started on the first postoperative day with hip and knee mobilizations, and partial weight bearing was allowed within the 1st week. Full weight bearing was permitted according to tolerance. Patients were usually discharged on day two or three and given three days of intravenous sulbactam-cefoperazone. Follow-up visits were performed at two weeks, monthly for three months, and at five months postoperatively. The main outcomes assessed at 24 weeks were non-union (no radiographic healing 6 months after injury), delayed union (no progression after 4 months), and surgical site infection (clinical signs, fever >100°F, WBC >12,000, or positive cultures). At five months, functional outcomes were assessed using Thorensen´s criteria. All data analyses were conducted in SPSS version 26, and the quantitative data were presented as mean ± SD and the qualitative data as frequencies and percentages accordingly. Intergroup comparisons were performed using the Chi-square test, and the statistical significance threshold was set at $p \leq 0.05$.

RESULTS

The baseline demographic characteristics of the study participants (n=136) were uniformly allocated between the dynamic (n = 68) and static (n = 68) cohorts. The average age of participants within the dynamic cohort was 35.51 ± 11.92 years, whereas it was marginally elevated in the static cohort at 37.82 ± 12.16 years. The mean duration of healing was extended in the dynamic cohort (19.78 ± 2.94 weeks) in comparison to the static cohort (17.62 ± 2.47 weeks). In terms of gender composition, males represented the predominant demographic in both cohorts—75.0% in the dynamic cohort and 70.6% in the static cohort—whereas females constituted 25.0% and 29.4%, respectively. A significant proportion of injuries transpired in urban locations within both cohorts (61.8% in dynamic and 58.8% in static). The incidence of fractures was predominantly observed on the left side in both cohorts, with 75.0% in the dynamic cohort and 70.6% in the static cohort. Oblique fracture morphology was observed more frequently in the dynamic cohort (63.2%), while the static cohort exhibited a greater prevalence of transverse fractures (72.1%). In relation to the AO fracture classification, type 32A2 was more prevalent in the dynamic cohort (58.8%), whereas type 32A3 was more commonly identified in the static cohort (75.0%). General anesthesia was employed with greater frequency in the dynamic cohort (67.6%) as opposed to the static cohort (54.4%), while spinal anesthesia was more prevalent in the static cohort (45.6%) than in the dynamic cohort (32.4%), as illustrated in Table 1.

The analysis of clinical outcomes associated with dynamic versus static interlocking intramedullary nailing among a cohort of 136 patients (with 68 individuals in each respective group) demonstrated statistically significant variances. The incidence of delayed union was observed in merely 5.9% of patients within the dynamic cohort, in stark contrast to 27.9% among the static cohort, yielding a p-value of 0.001 and a 95% confidence interval (CI) ranging from 0.052 to 0.504. The occurrence of non-union was noted in 2.9% of the dynamic group, which is significantly lower than the 17.6% reported in the static group (p=0.004; 95% CI: 0.030–0.659). Likewise, the prevalence of surgical site infections was recorded at 4.4% in dynamic cases, juxtaposed with 20.6% in static cases, underscoring a significant disparity (p=0.004; 95% CI: 0.049–0.652). Functional outcomes were significantly enhanced in the dynamic

group, with 83.8% attaining excellent results, contrasted with a mere 20.6% in the static group. In contrast, poor functional outcomes were documented in 26.5% of patients in the static cohort, while none were noted within the dynamic group. These discrepancies in functional outcomes were found to be highly significant (p=0.0001; 95% CI: 3.988–15.201), thereby indicating superior clinical and functional efficacy associated with dynamic interlocking nailing, as delineated in Table II.

Table I: Baseline Demographic and Clinical Characteristics of Study Participants (n=136)

Demographic and Clinical Parameters		Groups	
		Dynamic (n=68)	Static (n=68)
Age in years, Mean ± SD		35.51 ± 11.92	37.82 ± 12.16
Healing Time in weeks, Mean ± SD		19.78 ± 2.94	17.62 ± 2.47
Gender	Male, *n* (%)	51 (75.0)	48 (70.6)
	Female, *n* (%)	17 (25.0)	20 (29.4)
Side of Injury	Urban, *n* (%)	42 (61.8)	40 (58.8)
	Rural, *n* (%)	26 (38.2)	28 (41.2)
Type of Fractures	Right, *n* (%)	17 (25.0)	20 (29.4)
	Left, *n* (%)	51 (75.0)	48 (70.6)
Fracture Geometry	Oblique, *n* (%)	43 (63.2)	19 (27.9)
	Transverse, *n* (%)	25 (36.8)	49 (72.1)
AO Fracture Type	32A2, *n* (%)	40 (58.8)	17 (25.0)
	32A3, *n* (%)	28 (41.2)	51 (75.0)
Type of Anesthesia Used	General, *n* (%)	46 (67.6)	37 (54.4)
	Spinal, *n* (%)	22 (32.4)	31 (45.6)

Table II: Comparison of Outcomes Between Dynamic and Static Interlocking Intramedullary Nailing (n=136)

Outcomes		Groups			P-Value
		Dynamic (n=68)	Static (n=68)	95% C. I	
Delayed Union, *n* (%)		4 (5.9)	19 (27.9)	(0.052–0.504)	0.001
Non-Union, *n* (%)		2 (2.9)	12 (17.6)	(0.030–0.659)	0.004
Surgical Site Infection, *n* (%)		3 (4.4)	14 (20.6)	(0.049–0.652)	0.004
Functional Outcome, *n* (%)	Excellent	57 (83.8)	14 (20.6)	(3.988–15.201)	0.0001
	Good	10 (14.7)	12 (17.6)		
	Fair	1 (1.5)	24 (35.3)		
	Poor	0 (0.0)	18 (26.5)		

DISCUSSION

Although the standard treatment for diaphyseal femoral fractures, particularly in the middle and distal third, remains intramedullary nailing (IMN). By contrast, the ongoing debate over static versus dynamic interlocking persists among the different techniques. This study supports the increasing literature identifying dynamic mode interlocking nailing as an attractive option for select femoral fractures, such as transverse and oblique fracture configuration. Dynamic interlocking nailing was superior to static nailing on a number of outcome measures in our analysis. The delayed union rate was significantly lower in the dynamic group (5.9%) than in the static group (27.9%) (p=0.001).

Likewise, the dynamically nailed patients experienced a nonunion rate of only 2.9% compared with a nonunion rate of 17.6% in dynamically nailed patients (p=0.004). These results are in line with the findings of Qureshi et al. [12] also reported a delayed union of 8 % in the dynamic group and 26 % in the static group (p =0.05) and a nonunion of 2 % and 16 % respectively. Similarly, functional outcomes were also heavily in favor of the dynamic group in our study with 83.8% of patients attaining an "excellent" outcome versus only 20.6% in the static group (p=0.0001).

The study by Khan et al. In agreement, [13] noted an 8% rate of delayed union in a static group, suggesting that the limited ability of static nailing to facilitate early callus formation may reflect an inherent limitation of the technique. Meanwhile, Najafi et al. A well-designed double-blind randomized clinical trial [14] confirmed that dynamic nailing is superior to static nailing for both femoral and tibial shaft fractures. The results of their study paired well with ours, in implicating dynamic interlocking as an appropriate approach to improve fracture union rates and lower complication rates.

Dynamic interlocking permits stable controlled micromotion at the fracture site facilitating callus formation and secondary healing from a biological point of view. This is especially beneficial in transverse and short oblique fractures, as this type of micromotion does not hinder alignment but rather, promotes healing. In comparison, static interlocking can cause stress shielding, which restricts the proper biomechanical stimuli and could cause nonunion especially in low comminution fractures.

Ferreira et al. [15], in a systematic review, emphasized the overall positive effect of fixation dynamization on fracture healing, particularly in lower limb diaphyseal fractures. This review suggested that dynamization can reduce healing times and the need for secondary interventions, aligning with our current findings and supporting its application in appropriately selected patients.

However, concerns about implant instability or malalignment with dynamic nailing have led some surgeons to prefer static fixation. Krappinger et al. [16], for instance, identified risk factors like poor bone quality and fracture comminution that may predispose to nonunion after IM nailing. In such cases, static locking may be beneficial to maintain stability. Still, our data suggests that in carefully selected cases—particularly in midshaft transverse or short oblique fractures without comminution—dynamic nailing is superior.

Interestingly, surgical site infections were lower in the dynamic group in our study findings (4.4% vs. 20.6%, p=0.004) potentially secondary to less surgical manipulation or quicker healing of the fracture allowing for lower incidence of postoperative complications.

Although registry-based studies such as FROST [17] and technical advances such as the nail design described by Ziran et al. While [18] are focused on motion registration and biology of healing, our clinical data support a rationale of choosing the appropriate locking mode with the fracture pattern and patient profile in mind.

Along with the literature, our study shows that in certain types of femoral shaft fractures, dynamic interlocked nailing has better healing rates, fewer complications, and improved functional outcome. However, treatments should be guided by patient and fracture characteristics. These guidelines need to be confirmed in future large-scale, multicenter RCTs.

While this was a randomized controlled trial, there are multiple methodological limitations to this study. There are some limitations in this study. First, the non-probability consecutive sampling may generate selection bias which restricts generalizability of the results to wider populations. Despite randomization by sealed opaque envelope, lack of allocation concealment verification and neither participant nor

outcome assessors blinded, serious concerns regarding performance and detection biases remained.

Another key limitation lies in the short follow-up period of 24 weeks (six months). While this duration is sufficient to evaluate early complications such as delayed union or infection, it may not capture late-onset nonunion, hardware failure, or long-term functional deficits. Furthermore, the exclusion of patients with polytrauma, diabetes, or osteoarthritis—commonly seen in real-world fracture cases—restricts the external applicability of findings.

There was no mention of inter-observer reliability for radiographic healing assessments or consistency in applying Thorensen's criteria, which may have introduced measurement bias. Additionally, although surgical techniques were standardized, the study did not detail whether procedures were performed by a single surgeon or multiple operators, which could influence outcomes due to varying skill levels.

The primary strength of the study is that it is a randomized controlled study, the gold standard for assessing the efficacy of treatment. The homogeneity of fracture types, which the study achieved by focusing specifically on transverse and oblique fractures of the mid-to-distal femoral shaft, can also improve internal validity. Methodological rigor was strengthened by standardized surgical management, standardized postoperative care pathways, and well-defined inclusion/exclusion criteria.

Outcome measures were well-defined, with objective clinical and radiological parameters used to assess healing and infection. The application of Thorensen's functional criteria added a structured dimension to evaluating functional recovery.

Future studies should be of a larger, multi-centre design with probability sampling to increase external validity. Use of blinded outcome assessors, prolonged follow-up period (minimum of 12–18 months), and patients with co-morbidities would improve the ecological validity of the trials. More complete outcome assessment could be achieved with the inclusion of functional scoring indices, such as the SF-36 or Lower Extremity Functional Scale (LEFS). The validity of the results would also be further solidified by inter-rater reliability testing of standardized assessment of radiographs.

CONCLUSION

It can be inferred that dynamic interlocking intramedullary nailing employed in mid-to-distal transverse and oblique femoral fractures exhibited markedly reduced incidences of delayed union, non-union, and surgical site infection, alongside enhanced functional outcomes when contrasted with static nailing. These results support that dynamic fixation is a better method for helping fractures heal and recover in the right patients.

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