OUTCOME OF STATIC VERSUS PRIMARY DYNAMIC CLOSED ANTEGRADE REAMED INTRAMEDULLARY INTERLOCKING NAIL IN FEMORAL SHAFT FRACTURES: A PROSPECTIVE COHORT STUDY

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ABSTRACT

OBJECTIVES

This study aimed to compare fracture-healing rates in short oblique and transverse femoral shaft fractures treated with closed antegrade reamed intramedullary interlocking nails in static versus dynamic mode.

METHODOLOGY

A prospective comparative cohort study was conducted at Muhammad Teaching Hospital, Peshawar, including 72 patients with femoral shaft fractures (AO 32A2 and 32A3) and (Gustilo-Anderson I, II, IIIA) treated with either static (Group A) or dynamic (Group B) reamed antegrade interlocking intramedullary nails. Patients were followed for 24 weeks postoperatively. The primary outcome was fracture-healing time, assessed using clinical and radiological criteria.

RESULTS

The mean healing time was significantly shorter in the dynamic group (16.6 ± 4.0 weeks) compared to the static group (19.1 ± 4.4 weeks, $p = 0.019$). Healing at 24 weeks occurred in 94.4% of the dynamic group, compared with 77.8% in the static group ($p = 0.035$). Surgery duration was also significantly shorter in the dynamic group (47.3 ± 9.0 minutes vs. 54.9 ± 7.9 minutes, $p < 0.001$). Subgroup analysis showed faster healing in dynamic nailing for females ($p = 0.013$), patients ≤40 years ($p = 0.010$), left-sided fractures ($p = 0.049$), lower third fractures ($p = 0.021$), and transverse fracture pattern ($p = 0.008$).

CONCLUSION

Dynamic intramedullary nailing is associated with significantly faster healing and shorter surgery duration in short oblique and transverse femoral shaft fractures. Further multicentric studies with larger samples and extended follow-up are warranted.

KEYWORDS: *Dynamic Interlocking Nail, Femoral Shaft Fracture, Healing Time, Static Interlocking Nail*

INTRODUCTION

Femoral shaft fractures occur at a rate of 1 per 10,000 people and are typically caused by high-energy trauma, leading to significant morbidity and physical impairment due to mal-alignment, limb shortening, or prolonged immobilization[1,2,3,4,5]. The management of femoral shaft fractures is anatomical reduction and functional recovery of the extremity.[6] Operative treatment using interlocking intramedullary nails offers biomechanical and biological advantages and remains the gold standard over plating and external fixation, achieving union rates near 100%.[7,8] Two intramedullary techniques, antegrade and retrograde, are commonly used. There remains debate over static versus primary dynamic nailing modes and reaming versus nonreaming.[9,10] Reamed nails are associated with faster healing and a lower risk of nonunion.[10,11] Concerns exist that static interlocking may hinder healing due to stress shielding and altered biomechanics, transferring load through the implant instead of the fracture site, which may reduce callus formation[12]. Conversely, dynamic nailing allows micromotion, encouraging bone healing and early weight bearing, although it may be less rotationally stable and cause limb shortening [12,13,14]. This study compares static and primary dynamic reamed intramedullary interlocking nailing techniques for fracture healing speed in patients with short oblique and transverse femoral shaft fractures. Given the high volume of such cases in our center, this study aims to provide local evidence to guide surgical decision-making and improve patient outcomes.

METHODOLOGY

This prospective study was conducted in the Department of Orthopaedics and Trauma at Muhammad Teaching Hospital, Peshawar, after obtaining formal approval from the Institutional Ethical Review Board. The study duration extended from 1st July 2023 to 31st December 2024. A total sample size of 72 patients was calculated using the WHO sample size calculator, with 36 patients allocated to each group, based on a 90% power of the test, a 5% level of significance, and previously reported mean union times of 16.11 ± 3.09 weeks for static interlocking nails and 19.37 ± 5.13 weeks for dynamic interlocking nails. Patients were recruited using a non-probability consecutive sampling technique. All patients presenting with femoral shaft fractures, irrespective of the mechanism of injury, were screened for eligibility. Inclusion criteria comprised patients aged 18-65 years with closed fractures or open femoral shaft fractures of Gustilo-Anderson grades I, II, or IIIA, involving a single limb, presenting within 48 hours of injury, deemed fit for surgery (ASA physical status I or II), and willing to comply with the follow-up protocol. Patients were excluded if they had pathological fractures, polytrauma with multiple long bone injuries, previous surgery on the same limb, Gustilo-Anderson grade IIIB or IIIC open fractures, neurovascular compromise, or if they were lost to follow-up before completion of 8 weeks. Upon presentation to the Accident and Emergency Department, all eligible patients underwent initial assessment and resuscitation in accordance with Advanced Trauma Life Support (ATLS) guidelines. After hemodynamic stabilization and administration of parenteral analgesia, a detailed clinical evaluation was performed, followed by standard radiological assessment, including anteroposterior and lateral radiographs of the entire femur with adjacent joints. Fractures were classified using the AO/OTA classification system for fracture morphology and the Gustilo-Anderson classification for open fractures. Closed fractures were temporarily stabilized using a long posterior back-slab or skin traction, whereas open fractures underwent prompt wound debridement and intravenous antibiotic therapy prior to temporary stabilization. All patients underwent surgery performed by the same orthopedic surgical team using a standardized operative technique. Closed antegrade reamed intramedullary interlocking nailing was carried out under image intensifier guidance, with the same nail design used for both groups. The only intended difference between groups was the locking method, determined intraoperatively by the primary surgeon. In the dynamic locking group, locking screws were placed in the fragment closest to the fracture site, whereas in the static locking group, one proximal and two distal locking screws were applied. Standardized perioperative antibiotic prophylaxis and postoperative analgesia protocols were followed. Postoperative rehabilitation, including physiotherapy and progression of weight bearing, was guided by the fixation mode and individual clinical assessment. Patients were followed up at two-week intervals during the first month and subsequently on a monthly basis for a total duration of six months. Fracture healing was assessed using both clinical and radiological criteria. Clinical union was defined by pain-free weight bearing, absence of tenderness, and lack of abnormal movement at the fracture site, while radiological union was determined by the presence of bridging callus in at least three out of four cortices and a Radiographic Union Score for Tibial fractures (RUST) of ≥7. To minimize observer bias, all radiographs were independently assessed by an observer not involved in patient management. Statistical analysis was performed using SPSS version 25. Categorical variables were expressed as frequencies and percentages and compared using the chi-square test, whereas continuous variables were presented as mean ± standard deviation and compared using independent sample t-tests. Post-stratification t-tests were applied where appropriate, and a p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 72 patients with femoral shaft fractures were included in the study. The cohort's mean age was 39.4 ± 9.2 years, with a predominance of male patients (62.5%). Right-sided femoral fractures were more frequent, accounting for 62.5% of cases. The middle third of the femoral shaft was the most commonly involved fracture site (40.3%), followed by the distal third (31.9%) and proximal third (27.8%). According to the AO/OTA classification, transverse fractures (32A3) were the most prevalent fracture pattern, observed in 51.4% of patients. Among open fractures, Gustilo-Anderson type II injuries were the most frequent (37.5%). Road traffic accidents were identified as the leading mechanism of injury, accounting for 59.7% of cases. Comparative analysis demonstrated no statistically significant differences between the static interlocking nail group (Group A) and the dynamic interlocking nail group (Group B) with respect to age, gender distribution, fracture side, fracture location, AO fracture type, Gustilo-Anderson classification, or mechanism of injury ($p > 0.05$ for all), indicating baseline comparability between the two groups. At 24 weeks postoperatively, the fracture union rate was significantly higher in the dynamic fixation group (Group B), with 94.4% of patients achieving union,

compared to 77.8% in the static fixation group (Group A) (p = 0.035). Additionally, the mean time to fracture union was significantly shorter in Group B (16.6 ± 4.0 weeks) compared to Group A (19.1 ± 4.4 weeks), demonstrating superior healing efficiency with dynamic interlocking nailing (p = 0.019). Operative duration also differed significantly between the two groups. Patients treated with dynamic locking had a shorter mean operative time of 47.3 ± 9.0 minutes, whereas those in the static locking group had a longer operative time of 54.9 ± 7.9 minutes. This difference was statistically highly significant (p = 0.001). Subgroup analysis revealed that dynamic interlocking nailing was associated with significantly faster fracture healing across several patient and fracture characteristics. Female patients treated with dynamic fixation had significantly shorter healing times than those receiving static fixation (p = 0.013). Similarly, patients aged 40 years or younger in Group B achieved union significantly earlier than their counterparts in Group A (p = 0.010). With respect to fracture characteristics, patients with left-sided femoral fractures and those with fractures involving the distal third of the femur showed significantly faster healing in the dynamic fixation group (p = 0.049 and p = 0.021, respectively). Furthermore, among patients with transverse fractures (AO/OTA 32A3), those treated with dynamic interlocking nails had a markedly shorter mean healing time (14.9 ± 2.8 weeks) than those managed with static locking (18.9 ± 4.7 weeks), with this difference reaching strong statistical significance (p = 0.008).

Table 1: Comparison of Fracture Healing and Surgical Outcomes Between Static and Dynamic Interlocking Nail Groups

Parameter	Group A (Static)	Group B (Dynamic)	P-Value
Healing at 24 weeks	77.8%	94.4%	0.035
Mean healing time (weeks)	19.1 ± 4.4	16.6 ± 4.0	0.019
Surgery duration (minutes)	54.9 ± 7.9	47.3 ± 9.0	0.001

Table 2: Subgroup Analysis Demonstrating Significantly Faster Healing with Dynamic Interlocking Nailing

Subgroup	Group with Faster Healing	P-Value
Female gender	Dynamic (Group B)	0.013
Age ≤ 40 years	Dynamic (Group B)	0.010
Left-sided fractures	Dynamic (Group B)	0.049
Distal third femoral fractures	Dynamic (Group B)	0.021
Transverse fractures (AO/OTA 32A3)	Dynamic (Group B)	0.008

DISCUSSION

The management of femoral shaft fractures with interlocking nails, particularly in transverse and oblique patterns, has yielded variable outcomes in the existing literature. Our study adds to this body of evidence, showing a statistically significant difference in healing time between static and dynamic interlocking nail groups. Specifically, the dynamic group demonstrated a mean healing time of 16.59 ± 3.95 weeks, compared to 19.14 ± 4.40 weeks in the static group. This difference may be attributed to the biomechanical behavior of the fixation modes. In static nailing, the implant functions primarily as a load-bearing device, transferring axial forces through the locking screws rather than across the fracture site.[9,19] This mechanical setup can reduce callus formation and delay the healing process[17]. In contrast, dynamic nailing allows controlled micromotion at the fracture site, promoting fragment alignment and stimulating accelerated callus formation.[6,20,21]At the 24-week follow-up, 94.2% of patients in the dynamic group achieved radiographic union, compared to 77.8% in the static group (p < 0.05), highlighting the clinical relevance of this biomechanical difference. Our findings are consistent with previous studies. Khalid and Hashmi reported excellent outcomes in 66.7% of dynamic nailing cases, compared with 42.8% for static nailing, aligning with our own observations. Similarly, Qureshi et al.[13, 22] reported excellent results in 84% of dynamic group patients and only 22% in the static group, further supporting the benefits of dynamization. Study by Khalid et al. found earlier healing in the dynamic group (around the 15th week) compared to the 22nd week in the static group, which closely resembles our findings.[13] Their results are supported by Khalid and Hashmi, who reported healing times of 20 weeks for dynamic and 24 weeks for static nailing. On the other hand, not all findings in literature support the superiority of dynamic nailing. Khan and Ahmad, for example, observed better healing outcomes in the static group (mean healing time of 16.11 weeks vs 19.37 weeks in the dynamic group).[11] However, their study involved a smaller sample size (25 patients per group) and a mean follow-up of six months, which may limit the reliability of their conclusions. In our subgroup analysis, we observed that females in Group B (dynamic) healed significantly faster than those in Group A. Additionally, fractures located on the left side, in the lower third of the femur, and of the transverse pattern (32A3) also healed faster in Group B, with statistically significant p-values (<0.05). These findings further classify the impact of dynamization on healing, depending on individual fracture characteristics and patient demographics, and are supported by the outcomes reported by Khalid et al.[13]

LIMITATIONS

Our study has limitations, including a small sample size, short follow-up period, and single-center design with the same surgical team, which may limit the generalizability of the findings.

CONCLUSIONS

Dynamic interlocking nailing resulted in faster fracture healing and shorter surgery time than static nailing, supporting its use in femoral shaft fractures; however, larger multicenter studies are needed to confirm these findings.

CONFLICT OF INTEREST: None

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The authors accept responsibility for all aspects of the work and will ensure that any concerns regarding the accuracy or integrity of any part are properly investigated and resolved.