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Outcome of dynamization in delayed union of femoral shaft fracture

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ABSTRACT

Background: Delayed union in femoral shaft fractures presents a significant clinical challenge despite the widespread success of intramedullary nailing (IMN). Nail dynamization is a minimally invasive and cost-effective intervention that promotes healing by increasing interfragmentary motion. This study evaluates the clinical and radiological outcomes of nail dynamization in delayed union cases and identifies key prognostic factors influencing healing.
Methods: This prospective observational study was conducted at the National Institute of Traumatology and Orthopedic Rehabilitation (NITOR), Bangladesh, between March 2019 and March 2024. Twenty-four patients with delayed union of femoral shaft fractures, initially treated with static interlocking IMN, underwent dynamization. Radiological and functional outcomes were assessed, and statistical analyses were performed to identify predictors of union**.**
Results: The mean time from nailing to dynamization was 21.1±2.6 weeks, with a mean union time of 21.4±1.4 weeks. 79.17% of patients achieved union, while 20.83% progressed to nonunion. Earlier dynamization correlated significantly with higher union rates (p=0.01). Smoking was a major risk factor for nonunion (p=0.047), with 93.33% of nonunion cases occurring in smokers. FHI was a strong predictor of union (p=0.002), with higher FHI values associated with successful healing. Functional outcomes were excellent in 62.50% of patients, and 66.67% reported no pain at the final follow-up.
Conclusion: Nail dynamization is a clinically effective and low-cost intervention for delayed union of femoral shaft fractures. Timely dynamization and higher FHI values significantly predict successful healing, while smoking negatively impacts outcomes. These findings highlight the need for early intervention and patient-specific treatment strategies to optimize fracture healing.

Keywords: Nail dynamization, Femoral shaft fracture, Delayed union, Intramedullary nailing, Fracture healing index, Smoking and fracture healing, Orthopedic surgery.

INTRODUCTION

Femoral shaft fractures are among the most common and severe long-bone injuries, particularly in younger adults involved in high-energy trauma such as road traffic accidents and falls from heights.[1] Globally, it is estimated that between 1.0 and 2.9 million femoral shaft fractures occur annually, with a significantly higher incidence in low- and middle-income countries (LMICs), where rates range from 15.7 to 45.5 per 100,000 people per year.[2] Bangladesh, like many other LMICs, faces a considerable burden from femoral fractures due to a combination of rising motor vehicle accidents, delayed access to surgical treatment, and limited healthcare infrastructure.[3]

The financial and social implications of femoral fractures in resource-limited settings are substantial, as many affected individuals experience prolonged disability, loss of employment, and increased economic hardship.[4] Studies indicate that up to 40% of patients with femoral fractures in LMICs remain unable to return to work a year after injury, with 29% experiencing decreased household

income and 49% suffering from food insecurity.[4] The standard of care for femoral shaft fractures is IMN, which has evolved significantly since its introduction. IMN provides superior biomechanical stability, allowing for early weight-bearing and high union rates.[5] Reported success rates of IMN range from 90% to 100%, making it the gold-standard treatment for femoral fractures worldwide.[6] IMN has demonstrated advantages over traditional plate fixation, particularly in reducing stress shielding and improving long-term functional outcomes.[7]

However, despite the overall success of IMN, some fractures fail to unite within the expected time frame, leading to delayed union and, in some cases, nonunion. Studies indicate that the incidence of delayed union ranges from 8.1% to 26.5%, with risk factors including smoking, infection, high-energy trauma, open fractures, and patient comorbidities such as osteoporosis and diabetes.[8,9] Additionally, fracture characteristics such as segmental involvement or comminuted patterns significantly increase the likelihood of delayed healing.[10] Delayed union is typically defined as the absence of progressive radiological healing by six months post-injury or persistent fracture line visibility despite adequate stabilization.[10]

Clinically, delayed union is associated with prolonged pain, functional impairment, and increased economic burden due to extended hospitalization and multiple interventions.[8] Nonunion, in contrast, is defined as the cessation of all healing activity and typically requires more invasive treatment approaches. Given the significant morbidity associated with delayed union, timely secondary interventions are crucial to enhance healing and prevent progression to nonunion.

Several treatment modalities exist for managing delayed union, each with varying degrees of invasiveness, cost, and efficacy. Exchange nailing, which involves replacing the existing nail with a larger-diameter reamed nail, is often the preferred intervention and has shown union rates of approximately 78.3%.[11] This technique enhances bone healing by increasing mechanical stability and stimulating biological response through reaming.[12]

Another widely used intervention is bone grafting, either alone or in combination with plate augmentation, which provides additional osteogenic stimulation and mechanical support, particularly in cases of atrophic nonunion.[13] External fixation is another option, particularly in infected or highly unstable fractures, though it is often associated with patient discomfort and prolonged treatment duration.[14] Among these options, nail dynamization has emerged as a minimally invasive, cost-effective alternative for promoting callus formation in cases of delayed union.

Dynamization involves the removal of interlocking screws from an IM nail to allow controlled axial micro-motion at the fracture site, which enhances interfragmentary strain and stimulates osteogenesis.[15] The biomechanical rationale for dynamization lies in its ability to restore physiologic loading at the fracture site, as static locking of an IM nail can create excessive stiffness, leading to stress shielding and inhibition of bone healing.[16] Finite element analysis studies have shown that dynamically locked nails promote better-distributed strain at the fracture interface, allowing for improved callus formation compared to rigid static fixation.

Clinical studies further support this approach, with reports indicating that dynamization achieves union in approximately 54% of cases, making it an effective first-line intervention before resorting to more invasive procedures.[15] Despite its advantages, dynamization is not universally successful. Singh et al. reported that while 66.6% of patients achieved complete union following dynamization, the procedure was less effective in fractures with large gaps or unstable configurations.[17]

Furthermore, excessive axial motion in highly unstable fractures can lead to malalignment, shortening, or even implant failure.[18] As a result, dynamization should be reserved for axially stable fractures and should be performed within 3 to 6 months post-injury for optimal results. Given the limited data on the efficacy of nail dynamization in Bangladesh, this study aims to evaluate the clinical and radiological outcomes of dynamization in cases of delayed femoral shaft fracture union.

The primary objectives are to determine the union rate following dynamization, identify prognostic factors for successful healing, and assess functional outcomes using validated scoring criteria. By providing evidence on the effectiveness and limitations of dynamization in a resource-limited setting, this research seeks to inform orthopedic surgeons and healthcare policymakers on the role of minimally invasive interventions in reducing the economic and clinical burden of delayed union.

METHODS

This prospective observational study was conducted at the NITOR in Dhaka, Bangladesh between March 2019 and August 2019, and March 2022 to March 2024. The study aimed to evaluate the effectiveness of nail dynamization in promoting fracture healing in cases of delayed union of femoral shaft fractures initially treated with a static interlocking IMN.

Patients were eligible for inclusion if they were 18 years or older, had a radiographically confirmed delayed union defined as a lack of bridging callus formation in at least three out of four cortices by 4 to 6 months postoperatively, and had no evidence of infection or implant failure. Patients with established nonunion (≥9 months without progressive healing), active infections, severely comminuted fractures (AO Type 32C), or segmental bone defects exceeding 1 cm were excluded from the study.

Dynamization was performed as a day-case procedure under spinal anesthesia. The technique involved the

removal of one or both interlocking screws to allow controlled axial micro-motion at the fracture site, thereby stimulating callus formation. Fluoroscopic imaging was used intraoperatively to confirm implant integrity and assess axial movement. Full weight-bearing was encouraged immediately after surgery, depending on pain tolerance and clinical stability.

Patients were followed up every four weeks for clinical and radiological assessment until union was achieved or for a maximum of nine months post-dynamization. Radiological union was defined as bridging callus formation in at least three of four cortices on anteroposterior and lateral X-rays. Functional outcomes were evaluated using the Thoresen criteria, which included assessments of pain, limb alignment, weight-bearing ability, and range of motion.

Additional measurements such as limb length discrepancy (LLD) and rotational deformities were recorded. The Fracture Healing Index (FHI), calculated as the callus diameter divided by the adjacent cortical diameter, was assessed preoperatively as a predictor of healing potential. The primary outcome was union following dynamization, while secondary outcomes included time to union, functional recovery, and complication rates. Cases that did not show radiological healing by nine months post-dynamization were classified as treatment failures, requiring further interventions such as exchange nailing or bone grafting.

Statistical analysis was conducted using SPSS (version XX), with descriptive statistics presented as means and standard deviations for continuous variables, and frequencies and percentages for categorical variables. The chi-square test was used to analyze categorical data, while independent t-tests and Mann-Whitney U tests were applied for continuous variables. Kaplan-Meier survival analysis was performed to estimate the probability of union over time.

A p value of <0.05 was considered statistically significant. This study was approved by the Institutional Review Board (IRB) at NITOR, Dhaka, and was conducted in compliance with the ethical guidelines of the Declaration of Helsinki. Written informed consent was obtained from all participants before enrollment, ensuring their voluntary participation and adherence to ethical standards.

RESULTS

The study included 24 participants, with a mean age of 29.6 ± 8.9 years. The majority of patients (50.0%) were aged 18 to 27 years, followed by 29.17% aged 28 to 37 years and 20.83% aged 38 to 47 years. Males comprised 87.5% of the study population, while females accounted for 12.5%. A history of smoking was reported in 37.5% of participants, whereas 62.5% were nonsmokers (Table 1). The majority of fractures occurred on the right side (58.33%), while the left side was affected in 41.67% of cases. According to the AO classification, 62.50% of fractures were type 32B, whereas 37.50% were type 32A. In terms of the initial reduction method, open reduction was performed in 62.50% of cases, while 37.50% underwent closed reduction (Table 2).

The mean time from initial intramedullary nailing to dynamization was 21.1±2.6 weeks, with 54.17% of patients undergoing dynamization between 17 to 21 weeks, while 45.83% had the procedure between 22 to 26 weeks. Following dynamization, the mean time to radiological union was 21.4±1.4 weeks. Union was achieved in 79.17% of cases, with 37.50% uniting within 21 to 22 weeks, 20.83% within 19 to 20 weeks, and another 20.83% by 23 weeks. However, nonunion was observed in 20.83% of patients despite undergoing dynamization (Table 3).

At the final follow-up, the mean knee flexion was 125.4±6.1 degrees, with 58.33% of patients achieving 125–130 degrees of flexion, while 29.17% had 115–120 degrees, and 12.50% reached 135–140 degrees. An extension deficit was observed in 29.17% of patients, with 16.67% having a 5-degree deficit and 12.50% having a 10-degree deficit, while 70.83% had full extension (mean deficit: 2.1±3.6 degrees). External rotation was absent in 83.33% of patients, while 16.67% had a 5-degree external rotation deformity, with a mean external rotation of 0.8±1.9 degrees.

Femoral shortening was noted in 25% of patients, with 20.83% having a shortening of 1.5 cm and 4.17% having a 1 cm discrepancy, while 75% had no measurable shortening (mean 0.4±0.6 cm). Pain assessment using Thoresen criteria revealed that 66.67% of patients had no pain, 25% experienced sporadic pain, and 8.33% reported significant pain. Functional outcomes were rated excellent in 62.50% of patients, good in 29.17%, and fair in 8.33%, with no cases classified as poor. These findings indicate a high rate of functional recovery following dynamization, with most patients regaining satisfactory limb function and mobility (Table 4).

Univariate analysis identified several factors significantly associated with final union outcomes following dynamization. Smoking status was strongly linked to nonunion, with 93.33% of nonunion cases occurring in smokers, compared to 55.56% in the union group ($p=0.047$).

The mean time from nailing to dynamization was significantly shorter in patients who achieved union (20.5±2.4 weeks) compared to those who developed nonunion (23.4±2.1 weeks, $p=0.01$), indicating that earlier intervention was more likely to result in successful healing. Additionally, the FHI was significantly higher in the union group (1.424±0.202) compared to the nonunion group (1.119±0.096, $p=0.002$), suggesting that a higher preoperative callus-to-cortex ratio was a strong predictor of successful union after dynamization (Table 5).

Table 1: Distribution of baseline characteristics among the participants (n=24).

Baseline characteristics	N	%
Age (in years)		
18-27	12	50.00
28-37	7	29.17
38-47	5	20.83
Mean±SD	29.6±8.9	
Gender		
Male	21	87.50
Female	3	12.50
Smoking history		
Smoker	9	37.50
Nonsmoker	15	62.50

Table 2: Distribution of injury related characteristics among the participants (n=24).

Injury related characteristics	N	%
Side of injury		
Left	10	41.67
Right	14	58.33
Type of fracture		
32A	9	37.50
32B	15	62.50
Method of initial reduction		
Open	15	62.50
Close	9	37.50

Table 3: Treatment timeline and union status distribution among the participants (n=24).

Variable	N	%
Time from nailing to dynamization		
17-21	13	54.17
22-26	11	45.83
Total	24	100.00
Mean±SD	21.1±2.6	
Time from dynamization to union (weeks)		
19-20	5	20.83
21-22	9	37.50
23	5	20.83
Non union	5	20.83
Mean±SD	21.4±1.4	

Table 4: Clinical and radiological outcomes at final follow-up (n=24).

Variables	N	%
Knee flexion		
115-120	7	29.17
125-130	14	58.33
135-140	3	12.50
Mean±SD	125.4±6.1	
Extension deficit (in degree)		
0	17	70.83
5	4	16.67
10	3	12.50
Mean±SD	2.1±3.6	

Continued.

Variables	N	%
External rotation (in degree)		
0	20	83.33
5	4	16.67
Mean±SD	0.8±1.9	
Femoral shortness		
0	18	75.00
1	1	4.17
1.5	5	20.83
Mean±SD	0.4±0.6	
Pain (According to Thoresen criteria)		
None	16	66.67
Sporadic	6	25.00
Significant	2	8.33
Functional outcome		
Excellent	15	62.50
Good	7	29.17
Fair	2	8.33

Table 5: Univariate analysis of factors associated with final union (n=24).

Factor	Outcome		P value	Test
	Union (n=9)	Non-union (n=15)		
Smoking (n, %)	5 (55.56%)	14, 93.33%	0.047	Fisher exact test
Timing (Mean weeks)	20.5±2.4	23.4±2.1	0.01	Unpaired t test
FHI (Mean±SD)	1.424±0.202	1.119±0.096	0.002	Unpaired t test

DISCUSSION

The present study investigated the efficacy of nail dynamization as a secondary intervention for delayed union of femoral shaft fractures, analyzing key factors influencing union outcomes, including smoking status, timing of dynamization, and FHI. The findings were compared with existing literature to contextualize the results within global trends in fracture management. Our study population had a mean age of 29.6±8.9 years, with a predominance of young males (87.5%), consistent with multiple studies indicating that femoral shaft fractures primarily affect young adult males due to high-energy trauma mechanisms such as road traffic accidents (RTAs).[3,19,20] Similar epidemiological trends have been reported in large-scale cohort studies, such as Weiss et al which found a median age of 27 years for males and a higher proportion of fractures in males compared to females.[21] Additionally, our study found a smoking prevalence of 37.5%, which aligns with prior research demonstrating that smoking negatively impacts fracture healing and is a significant risk factor for delayed union.[22]

Injury characteristics in this study revealed a higher proportion of right-sided fractures (58.33%), which corresponds with previous reports indicating a dominance of right-sided femoral fractures in high-energy trauma cases.[23] Additionally, AO Type 32B fractures (62.50%) were more frequent than Type 32A fractures, which is supported by findings from Hamahashi et al who reported that Type 32B fractures are more commonly associated with delayed healing due to greater instability and comminution.[10]

The study also observed that 62.50% of cases required open reduction, a figure closely matching the results of Zhu et al where open reduction was necessary for complex femoral fractures with significant displacement.[24] Regarding treatment timeline and union outcomes, our study found that the mean time from nailing to dynamization was 21.1±2.6 weeks, with union achieved in 79.17% of cases following dynamization. This success rate is comparable to that reported by Vicenti et al where dynamization resulted in a 94.12% union rate, reinforcing the efficacy of early intervention (3–6 months post-nailing) in promoting healing.[25] Conversely, Vaughn et al. reported a lower success rate of 54%, emphasizing that timely dynamization is critical in determining outcomes.[15]

The study also found that earlier dynamization was significantly associated with better union rates (p=0.01). In terms of functional and radiological outcomes, our study reported a mean knee flexion of 125.4±6.1°, with 70.83% of patients achieving full extension. These results are comparable to those of Pal et al who reported that 92% of patients regained near-complete knee range of motion.[26] Additionally, femoral shortening was observed in 25% of patients, closely mirroring the 25% shortening rate

reported by Thomas et al.[27] Importantly, pain assessment in our study revealed that 66.67% of patients were pain-free, while 8.33% reported significant pain, which aligns with Moumni et al who found that 17% of patients experienced persistent pain following femoral fracture healing.[28]

A key finding in our study was the strong association between smoking and nonunion (p=0.047), with 93.33% of nonunion cases occurring in smokers. This finding is strongly corroborated by Li et al who reported a significantly higher nonunion rate (52.9%) in smokers compared to 12.5% in non-smokers. Additionally, our study identified FHI as a significant predictor of union (p=0.002), with higher FHI values correlating with successful healing. This observation is consistent with Perumal et al., who reported that a pre-dynamization FHI greater than 1.18 had an 83% sensitivity and 72% specificity in predicting successful union.[29]

These findings reinforce the importance of early intervention, patient selection, and modifiable risk factor management in optimizing fracture healing outcomes. The study provides robust evidence supporting nail dynamization as a viable, minimally invasive, and cost-effective intervention for delayed union, with timing of dynamization and FHI emerging as key determinants of success. Further research with larger cohorts and longer follow-up durations may provide additional insights into optimizing patient-specific treatment strategies for delayed femoral fracture healing.

Limitations

The study was conducted in a single hospital with a small sample size. So, the results may not represent the whole community.

CONCLUSION

This study demonstrates that nail dynamization is an effective and minimally invasive intervention for managing delayed union of femoral shaft fractures, achieving a 79.17% union rate with earlier dynamization significantly improving outcomes (p=0.01). Smoking was strongly associated with nonunion (p=0.047), with 93.33% of nonunion cases occurring in smokers, reinforcing the detrimental effects of tobacco use on fracture healing. Additionally, the FHI emerged as a strong predictor of union (p=0.002), highlighting its potential role in clinical decision-making.

Functional outcomes were favorable, with 62.50% of patients achieving excellent recovery, and radiological healing was achieved within a mean of 21.4±1.4 weeks post-dynamization. These findings emphasize the importance of timely intervention and patient selection in optimizing fracture healing. Given the limited data on nail dynamization in resource-limited settings like Bangladesh, this study provides valuable clinical insights. Future research with larger sample sizes and longer follow-up durations is warranted to further refine patient selection criteria and optimize treatment protocols for delayed union cases.

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REFERENCES

1. Agarwal-Harding KJ, Meara JG, Greenberg SLM, Hagander LE, Zurakowski D, Dyer GSM. Estimating the global incidence of femoral fracture from road traffic collisions: a literature review. J Bone Joint Surg Am. 2015;97(6):31.
2. Agarwal-Harding KJ, Chokotho L, Young S, Mkandawire N, Losina E, Katz JN. A nationwide survey investigating the prevalence and incidence of adults with femoral shaft fractures receiving care in Malawian district and central hospitals. East Cent Afr J Surg. 2020;25(3):57.
3. Enninghorst N, McDougall D, Evans JA, Sisak K, Balogh ZJ. Population-based epidemiology of femur shaft fractures. J Trauma Acute Care Surg. 2013;74(6):1516-20.
4. Mody KS, Wu HH, Chokotho LC, Mkandawire NC, Young S, Lau BC, et al. The Socioeconomic consequences of femoral shaft fracture for patients in Malawi. Malawi Med J. 2023;35(3):141–50.
5. Wood GW. Intramedullary nailing of femoral and tibial shaft fractures. J Orthopaed Sci. 2006;11(6):657–69.
6. Wild M, Gehrmann S, Jungbluth P, Hakimi M, Thelen S, Betsch M, et al. Treatment Strategies for Intramedullary Nailing of Femoral Shaft Fractures. Orthopedics. 2010;33(10):447-9.
7. Deng JieLin DJ. Complications of 109 cases of femoral shaft fracture with interlocking intramedullary nail fixation and treatment measures. 2010.
8. Tay WH, de Steiger R, Richardson M, Gruen R, Balogh ZJ. Health outcomes of delayed union and nonunion of femoral and tibial shaft fractures. Injury. 2014;45(10):1653–8.
9. Ekegren CL, Edwards ER, de Steiger R, Gabbe BJ. Incidence, Costs and Predictors of Non-Union, Delayed Union and Mal-Union Following Long Bone Fracture. Int J Environ Res Public Health. 2018;15(12):2845.
10. Hamahashi K, Uchiyama Y, Kobayashi Y, Ebihara G, Ukai T, Watanabe M. Clinical outcomes of intramedullary nailing of femoral shaft fractures with third fragments: a retrospective analysis of risk factors for delayed union. Trauma Surg Acute Care Open. 2019;4(1):203.
11. Hak DJ, Lee SS, Goulet JA. Success of exchange reamed intramedullary nailing for femoral shaft

nonunion or delayed union. J Orthop Trauma. 2000;14(3):178–82.
12. Sethi DA, Mishra DAK, Kaleem DMB, Badoni DN, Bhandari DA, Singh DP, et al. Exchange nailing with Uni-cortical plate augmentation +/- bone grafting for proximal 2/3rd distal 1/3rd junction shaft non-union femur. Int J Orthop Sci. 2021;7(3):404–7.
13. Syed MK, Ahmad W, Haider SI, Mazharrafique M, Ali Z, Iqbal M. Derotational Plate Augmentation with Retention of Intramedullary Interlocking Nail in Resistant Nonunion at Distal Femur Shaft. Pakistan J Med Health Sci. 2022;16(09):189.
14. Gelalis ID, Politis AN, Arnaoutoglou CM, Korompilias AV, Pakos EE, Vekris MD, et al. Diagnostic and treatment modalities in nonunions of the femoral shaft. A review. Injury. 2012;43(7):980–8.
15. Vaughn J, Gotha H, Cohen E, Fantry AJ, Feller RJ, Van Meter J, et al. Nail Dynamization for Delayed Union and Nonunion in Femur and Tibia Fractures. Orthopedics. 2016;39(6):1117–23.
16. Wang G, Pan T, Peng X, Wang J. A new intramedullary nailing device for the treatment of femoral shaft fractures: a biomechanical study. Clin Biomech (Bristol). 2008;23(3):305–12.
17. Singh VB, Chaurasia A. Study of outcome following nail dynamization for treating delayed healing femoral shaft fractures. JEMDS. 2015;4(93):15893–5.
18. Wójcik K, Bielecki T, Polak D, Pióro A, Rydel P, Jędrusik-Pawłowska M. Assessment of femur shaft fractures healing treated by closed locked intramedullary nailing in reference to other methods of osteosynthesis and including indications to dynamization. J Orthopaed Trauma Surg Related Res. 2016;2:987-9.
19. Sonbol AM, Almulla AA, Hetaimish BM, Taha WS, Mohmmedthani TS, Alfraidi TA, et al. Prevalence of femoral shaft fractures and associated injuries among adults after road traffic accidents in a Saudi Arabian trauma center. J Musculoskel Surg Res. 2018;2:62.
20. Almigdad A, Mustafa A, Alazaydeh S, Alshawish M, Bani Mustafa M, Alfukaha H. Bone Fracture Patterns and Distributions according to Trauma Energy. Vitiello R, editor. Advan Orthoped. 2022;2022:1–12.
21. Weiss RJ, Montgomery SM, Dabbagh ZA, Jansson KÅ. National data of 6409 Swedish inpatients with femoral shaft fractures: Stable incidence between 1998 and 2004. Injury. 2009;40(3):304–8.
22. Kraus KR, Flores JW, Slaven JE, Sharma I, Arnold PK, Mullis BH, et al. A Scoring System for Predicting Nonunion After Intramedullary Nailing of Femoral Shaft Fractures. J Am Acad Orthop Surg Glob Res Rev. 2024;8(9):214.
23. Giannoudis PV, Kanakaris NK, Bouamra O, Tsiridis E, Lecky F. Prevalence, characteristics and mortality of open vs closed femoral fractures. Orthopaed Proceed. 2012;94(4):69.
24. Zhu ZG, Yu YY, Lin-jun H, Gai W, Yang Y. Treatment of femoral shaft fractures by closed reduction and interlocking intramedullary nailing. China J Orthopaed Traumatol. 2014;27(10):819–22.
25. Vicenti G, Bizzoca D, Carrozzo M, Nappi V, Rifino F, Solarino G, et al. The ideal timing for nail dynamization in femoral shaft delayed union and non-union. Int Orthopaed. 2019;43(1):217–22.
26. Pal SK, Mishra D, Narayan S. Prospective study on functional outcome of fracture shaft of femur (Winquest Hansen type 1, 2 and 3) treated with intramedullary interlocking nail. Int J Orthopaed. 2021;7(1):162–9.
27. Moumni M, Voogd EH, ten Duis HJ, Wendt KW. Long-term functional outcome following intramedullary nailing of femoral shaft fractures. Injury. 2012;43(7):1154-8.
28. Gadegone WM, Lokhande V, Salphale Y, Ramteke A. Long proximal femoral nail in ipsilateral fractures proximal femur and shaft of femur. Indian J Orthopaed. 2013;47(3):272-7.
29. Perumal R, Shankar V, Basha R, Jayaramaraju D, Rajasekaran S. Is nail dynamization beneficial after twelve weeks - An analysis of 37 cases. J Clin Orthop Trauma. 2018;9(4):322–6.

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