ISSN 0973-2063 (online) 0973-8894 (print)

Bioinformation 22(8): 5422-5425 (2026)

BIOINFORMATION
Discovery at the interface of physical and biological sciences

BIOMEDICAL INFORMATICS

www.bioinformation.net

Volume 22(8)

Research Article

Received August 1, 2026; Revised August 31, 2026; Accepted August 31, 2026, Published August 31, 2026

DOI: 10.6026/973206300225422

SJIF 2026 (Scientific Journal Impact Factor for 2026) = 8.478
2022 Impact Factor (2023 Clarivate Inc. release) is 1.9

Edited by Hiroj Bagde
E-mail: hirojbagde8@gmail.com
Phone: +91 9766105900
Citation: Kabir *et al.* Bioinformation 22(8): 5422-5425 (2026)

Predictive factors for fracture union after femoral nail dynamization, including age, smoking and fracture characteristics

Md. Humayun Kabir*, Fahmida Ahmed Tanni, Khandoker Abdur Rahim, Mahi Nur Rahman, Suman Kallyan Bose & SK. Murad Ahmed

Departments of Orthopaedic Surgery, Bangladesh Medical University, Dhaka, Bangladesh; *Corresponding author

Affiliation URL:
https://bmu.ac.bd/

ISSN 0973-2063 (online) 0973-8894 (print)
Bioinformation 22(8): 5422-5425 (2026)

Author contact:
Md. Humayun Kabir - E-mail: mhkabir204@bsmmu.edu.bd
Fahmida Ahmed Tanni - E-mail: fahmidakabirtanni@gmail.com
Khandoker Abdur Rahim - E-mail: dr.khandoker7@gmail.com
Mahi Nur Rahman - E-mail: nur.azad@gmail.com
Suman Kallyan Bose - E-mail: dr.suman1979@bsmmu.edu.bd
SK. Murad Ahmed - E-mail: drskmurad@gmail.com

Abstract:
Femoral shaft fractures are commonly treated with intramedullary nailing, but delayed union remains a concern and nail dynamization is a simple procedure that promotes fracture healing by improving the mechanical environment. This prospective observational study was conducted at NITOR, Dhaka, Bangladesh from March 2019 to August 2019 and March 2022 to March 2024, including 24 patients with delayed union following intramedullary nailing for femoral diaphyseal fractures who underwent dynamization. Data on age, sex, smoking status, fracture type (AO classification) and reduction method were analyzed; the mean age was 29.6±8.9 years, 87% were male, 37.5% were smokers, 62.5% were nonsmokers, fracture types included 37.5% AO 32A and 62.5% AO 32B and open and closed reduction were performed in 62.5% and 37.5% of patients, respectively. Smoking was identified as a significant predictor of non-union after femoral nail dynamization, while fracture characteristics, including AO fracture type and reduction method, also influenced fracture union. Thus, data shows that smoking and fracture characteristics should be considered when predicting fracture healing after femoral nail dynamization.

Keywords: Femoral fracture, dynamization, delayed union, smoking, intramedullary nailing

Background:
Femoral shaft fractures are among the most common long-bone injuries encountered in orthopedic practice and are frequently associated with high-energy trauma **[1]**. These fractures can result in prolonged disability, loss of productivity and substantial socioeconomic burden if fracture healing is delayed. Intramedullary interlocking nailing has become the standard treatment for femoral shaft fractures because it provides stable fixation, preserves the biological environment of the fracture and allows early mobilization **[2]**. Despite its high success rate, delayed union remains a significant complication that may prolong recovery and necessitate additional intervention. Femoral nail dynamization is a widely accepted and minimally invasive procedure for the management of delayed union following intramedullary nailing **[3]**. The procedure involves the removal of one or more locking screws to permit controlled axial compression at the fracture site during weight bearing, thereby promoting callus formation and fracture healing **[4]**. Compared with more invasive procedures such as exchange nailing or bone grafting, dynamization is technically simple, cost-effective and associated with lower morbidity **[5]**. However, the success of dynamization varies considerably among patients, indicating that several patient- and fracture-related factors may influence the likelihood of fracture union. Identification of predictive factors associated with successful fracture healing after dynamization is important for optimizing patient selection and improving treatment outcomes **[6]**. Patient characteristics such as age and smoking status may affect the biological capacity for bone regeneration. Advancing age is associated with reduced osteogenic potential, while cigarette smoking has been shown to impair blood supply, cellular activity and bone metabolism, leading to delayed healing **[7]**. Similarly, fracture-related characteristics, including fracture pattern, degree of comminution and initial fracture configuration, may influence mechanical stability and the biological environment required for successful union **[8]**. Understanding the relationship between these factors and fracture healing after femoral nail dynamization can assist orthopedic surgeons in predicting treatment success, counseling patients regarding prognosis and selecting the most appropriate management strategy **[9]**. Recognition of patients with a lower probability of union following dynamization may facilitate timely consideration of alternative interventions, thereby reducing treatment delays and improving functional recovery **[10]**. Therefore, it is of interest to evaluate the predictive factors for fracture union after femoral nail dynamization, with particular emphasis on the influence of smoking, age and fracture characteristics on radiological fracture healing.

Materials and Methods:
This prospective observational study was conducted at the National Institute of Traumatology and Orthopedic Rehabilitation (NITOR), Dhaka, Bangladesh, during March 2019 to August 2019 and March 2022 to March 2024. A total of 24 patients were enrolled by purposive (non-randomized) sampling according to the availability of eligible patients and the predefined inclusion and exclusion criteria. Adult patients (≥18 years) who had initially been treated with intramedullary interlocking nailing for femoral diaphyseal fractures and subsequently developed delayed union were included. Patients with established non-union, dynamization performed more than 6 months after nailing, infection at the fracture site, or severely unstable fracture patterns with a tendency for unacceptable shortening or deformity were excluded. After enrollment, all patients underwent preoperative evaluation, including calculation of the Fracture Healing Index (FHI). Femoral nail dynamization was performed under spinal anaesthesia. Injection ceftriaxone was administered perioperatively, followed by oral

cefuroxime for 14 days and patients were advised full weight-bearing from the first postoperative day. Follow-up assessments were performed at 2 weeks, 6 weeks, 12 weeks and every 4 weeks thereafter until radiological union was achieved, with a final assessment 8 weeks after union. Patients without union were followed for up to 9 months to establish non-union. Functional outcomes were evaluated according to the Thoresen criteria. Data were collected using a pretested structured questionnaire that included demographic characteristics, smoking history, fracture characteristics, operative details, radiological findings, complications and follow-up outcomes. Data were processed and analyzed using Microsoft Office 365. Categorical variables were expressed as frequency and percentage, while continuous variables were presented as mean ± standard deviation and range. Continuous variables were compared using the *t*-test and categorical variables were analyzed using the Fisher's exact test. A p-value <0.05 with a 95% confidence interval was considered statistically significant. Ethical approval was obtained from the Institutional Review Board of NITOR and written informed consent was obtained from all participants.

Results:

In **Table 1**, the mean age was 29.6±8.9 years ranging from 18 years to 47 years. Out of 24 patients, 21 (87%) were male and 3 (13%) were female (**Figure 1**). In **Table 2,** 15 (62.5%) patients were nonsmoker and the remaining 9 (37.5%) patients were smoker. Out of 24 cases, there was 9 (37.5%) 32A type and 15 (62.5%) 32B type fractures (**Table 3**). In **Table 4**, 15 (62.5%) patients were operated by open reduction and 9 (37.5%) were by closed reduction. In **Table 5**, smoking has been found to be significantly associated with non-union (p=0.047).

Table I: Distribution of patients according to age (n=24)

Age (in years)	n (%)
18-27	12 (50)
28-37	7 (29.2)
38-47	5 (20.8)
Total	24 (100)
Mean±SD	29.6±8.9
Range	18-47

Table 2: Distribution of patients according to smoking history (n=24)

Smoking history	n (%)
Smoker	9 (37.5)
Nonsmoker	15 (62.5)
Total	24 (100)

Table 3: Distribution of patients according to type of initial fracture (n=24)

Type of fracture (AO type)	n (%)
32A	9 (37.5)
32B	15 (62.5)
Total	24 (100)

Table 4: Distribution of the patients according to method of reduction (n=24)

Method of initial reduction	n (%)
Open	15 (62.5)
Close	9 (37.5)
Total	24 (100)

Table 5: Univariate analysis for union status (n=24)

Smoking	United	Non-union	p value
Smoker	5	4	0.047*
Nonsmoker	14	1	

**Fisher exact test*

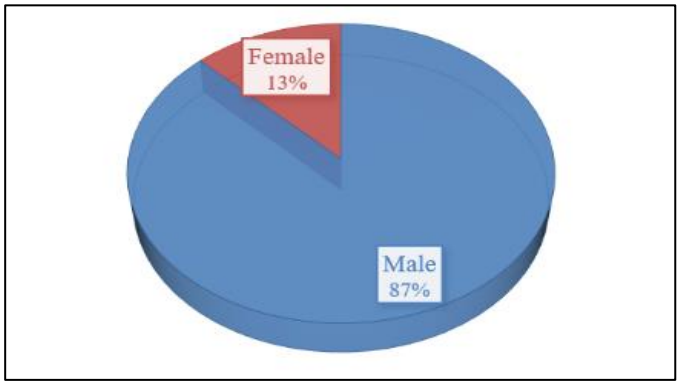

Figure 1: Distribution of patients according to gender (n=24)

Discussion:

The present study evaluated predictive factors for fracture union after femoral nail dynamization in 24 patients with delayed union following intramedullary nailing for femoral diaphyseal fractures. The mean age of our cohort was 29.6±8.9 years, with a predominance of male patients (87%). This demographic distribution is consistent with the typical epidemiology of femoral shaft fractures, which commonly affect young, active individuals following high-energy trauma **[8, 9].** The relatively young age of our study population may have favorably influenced healing potential, as younger patients generally possess superior biological capacity for bone regeneration **[10]**. Smoking emerged as the most significant predictor of non-union in our study. Among the 9 smokers (37.5%), 4 developed non-union (44.4%), compared to only 1 non-union (6.7%) among 15 non-smokers, showing a statistically significant association (p=0.047). This finding strongly corroborates the existing literature. Bowers and Anderson highlighted nicotine's deleterious effects on microcirculation and osteoblast function, which impair the cellular processes essential for bone healing **[10]**. The adverse impact of smoking on fracture healing is well-documented, with smokers having substantially higher non-union rates across various fracture types **[11, 12].** Zhang *et al.* identified smoking as a significant risk factor for aseptic femoral shaft non-union after intramedullary nailing, consistent with our observations **[11].** Yang *et al.* also reported that smoking negatively affects outcomes following exchange nailing for femoral non-union **[12]**. The 44.4% non-union rate among smokers in our series emphasizes the need for aggressive smoking cessation counseling before and after dynamization procedures. Regarding fracture characteristics, our cohort comprised 37.5% AO type 32A (simple) and 62.5% AO type 32B (wedge) fractures. Fracture morphology is known to influence mechanical stability after dynamization. Lowen *et al.* showed through finite element analysis that fracture pattern significantly affects interfragmentary strain, with more complex patterns exhibiting altered strain distributions that may compromise healing **[13].** Panteli *et al.* reported that subtrochanteric femoral

fractures with unstable patterns are associated with increased complications **[7]**. The predominance of 32B fractures in our series may have contributed to the non-union cases observed, as wedge fractures are inherently less stable after dynamization **[14]**. The method of reduction also warrants consideration, as 62.5% of our patients underwent open reduction while 37.5% had closed reduction. Open reduction requires periosteal stripping, potentially compromising the local blood supply essential for fracture healing **[15].** Mohamed *et al.* emphasized the importance of preserving biological environment during surgical intervention for femoral non-union **[15].** The combination of open reduction in smokers may represent a "double hit" to the healing environment, potentially explaining some non-union cases in our series. Recent evidence supports the importance of biological and mechanical factors in dynamization success. Elsayed *et al.* showed that primary dynamization can be effective in selected cases, though patient selection remains critical **[16]**. Heyland *et al.* showed that callus formation during healing is guided by local strain, highlighting the importance of mechanical environment in fracture union **[17]**. The timing of dynamization and fracture healing index are crucial considerations that our study reinforces **[11, 12].**

Conclusion:
Smoking significantly predicted non-union after femoral nail dynamization, with non-union occurring more frequently among smokers. Dynamization showed better outcomes in nonsmokers with simple AO type 32A fractures and closed reduction. Smoking cessation and careful patient selection may improve outcomes following femoral nail dynamization.

Limitations:
This study has several limitations. First, the small sample size limits the statistical power and generalizability of our findings and the single-center design at a tertiary referral hospital may introduce selection bias. Second, the short follow-up period may not capture all delayed unions that could eventually heal with longer observation. Third, we did not assess the fracture healing index or quantify callus formation, which are important biological predictors of dynamization success.

Conflicts of interest:
There are no conflicts of interest.

References:
[1] Hu M *et al. J Orthop Surg Res*. 2023 **18**:577. [PMID: 37550732]
[2] Stolberg-Stolberg J *et al. J Orthop Traumatol*. 2022 **23**:4. [PMID: 34997869]
[3] Marongiu G *et al. Bone Rep*. 2020 **12**:100249. [PMID: 32025538]
[4] Cognetti DJ *et al. Ann Jt.* 2026 **11**:8. [PMID: 41657675]
[5] Pasque CB *et al. World J Orthop*. 2022 **13**:528. [PMID: 35633740]
[6] Kook I *et al. Sci Rep.* 2023 **13**:7802. [PMID: 37179404]
[7] Panteli M *et al. J Orthop Traumatol*. 2022 **23**:27. [PMID: 35764711]
[8] Goudriaan WA *et al. Eur J Trauma Emerg Surg*. 2020 **46**:165. [PMID: 30244374]
[9] Lee CL *et al. Int J Med Sci.* 2021 **18**:1240. [PMID: 33526985]
[10] Bowers KM & Anderson DE. *Bioengineering (Basel).* 2024 **11**:525. [PMID: 38927761]
[11] Zhang Z *et al. BMC Musculoskelet Disord*. 2025 26:340. [PMID: 40200313]
[12] Yang KH *et al. Clin Orthop Surg*. 2023 **15**:13. [PMID: 36778995]
[13] Lowen GB *et al. J Biomech Eng*. 2022 **144**:051007. [PMID: 34802060]
[14] Panteli M *et al. Eur J Trauma Emerg Surg*. 2022 **48**:1759. [PMID: 34825927]
[15] Mohamed MA *et al. SICOT J*. 2022 **8**:19. [PMID: 35608412]
[16] Elsayed M *et al. BMC Musculoskelet Disord*. 2025 **27**:42. [PMID: 41387845]
[17] Heyland M *et al. BMC Musculoskelet Disord.* 2026 **27**:556. [PMID: 42363147]