Abstract
Title: Risk Factors of Intramedullary Nail Breakage in Femur Fractures: Analysis of 253 Broken SIGN Nails

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Purpose:
Femur fractures are devastating orthopedic injuries often treated with intramedullary nails (IMN). While intramedullary nailing is effective, rare complications like nail breakage can lead to nonunion, malunion, and revision surgery. This study aims to identify risk and protective factors associated with nail breakage.

Methods:
This is a retrospective analysis of data collected by Surgical Implant Generation Network (SIGN) Fracture Care International on adults treated with the SIGN standard (interlocked) or Fin (partially interlocked) nail for femoral fractures. SIGN nails are widely used globally, particularly in low-resource settings. The database includes patient demographics, fracture characteristics, and surgical information. Given the rarity of nail breakage, we utilized a nested case-control design with a 2:1 matching on age, gender, person-time of follow up, and Gustilo-Anderson open fracture type. Conditional logistic regression analysis was used to determine risk factors of nail breakage.

Results:
Of 136,631 femur fractures, 253 cases (incidence = 0.2%) of broken SIGN nails with accurate clinical and radiographic data were successfully matched to at least one control. A multivariable conditional regression showed a significant association between surgery for nonunion at presentation and nail breakage (adjusted OR: 2.92, 95% CI: 1.88 – 4.52). For nails with a diameter greater than or equal to 10mm, there is a significant decrease in the odds of nail breakage by 56% (adjusted OR: 0.44, 95% CI: 0.30 – 0.63). The type of nail (standard vs fin), nail length, and reaming method showed no association with nail breakage.

Discussion:
These findings suggest that surgery for nonunion at the time of presentation is a strong risk factor for nail breakage, while using larger-diameter nails may be protective. The lack of association with nail type, length, or reaming method implies that implant size may be a more critical factor than technique or design. Two fellowship-trained orthopaedic trauma surgeons are currently reviewing reduction quality and optimization of nail diameter/length to further explore their relationship with failure risk. Data from this ongoing analysis is still pending.

Conclusion:

This study leverages the global SIGN network to identify risk factors for implant failure, highlighting nail diameter and nonunion surgery as key contributors, offering insights for mitigating catastrophic implant failure.