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CONTRIBUTING FACTORS TO EARLY FAILURE OF THE FEMORAL NECK SYSTEM (FNS) IN FEMORAL NECK FRACTURE PATIENTS

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Abstract

Background: The Femoral Neck System (FNS) is an innovative internal fixation device widely utilized for managing femoral neck fractures (FNFs). Compared to traditional fixation techniques, FNS offers a minimally invasive approach, providing enhanced stability and promising short-term outcomes. However, early failure of FNS (EFFNS) remains a concern, with limited research available on the factors contributing to this issue. This study aims to investigate the prevalence and potential risk factors associated with EFFNS.

Methods: This study is a retrospective analysis that has been conducted on 110 patients with FNF undergoing FNS fixation in Rashid Hospital Dubai from December 2022 to December 2024. Data on demographics, clinical characteristics, radiographic parameters, and treatment details were collected. Multifactor logistic regression analysis was performed to evaluate the contributing factors to EFFNS.

Results: Out of 110 patients, 18 (16.4%) developed EFFNS. This included 11 cases of severe femoral neck shortening, 4 instances of screw migration, 2 occurrences of avascular necrosis of the head of femur, and one case of nonunion. All individuals in the failure group were younger than 65 years, a proportion significantly higher than the 61.2% observed in the healing group ($P = 0.010$). No significant differences were found in sex ($P = 0.478$), BMI ($P = 0.695$), affected side ($P = 0.328$), injury cause ($P = 0.604$), reduction approach ($P = 0.562$), femoral neck-shaft angle ($P = 0.531$), Pauwels classification ($P = 0.549$), or Garden classification ($P = 0.208$). Additionally, multivariate analysis did not establish Garden classification ($P = 0.457$) or age ($P = 0.122$) as notable risk factors for EFFNS.

Conclusion: This study determined that factors such as sex, BMI, injury mechanism, injury side, reduction method, femoral neck-shaft angle, Pauwels angle, Pauwels classification, and Garden classification were not significantly associated with EFFNS. Moreover, multivariate analysis did not identify age or Garden classification as independent risk factors for early FNS failure. These insights may contribute to optimizing treatment approaches and enhancing clinical outcomes in femoral neck fracture management.

Keywords: Femoral Neck Fracture, Femoral Neck System, Internal Fixation, Bone Healing, Implant Stability

Introduction

FNFs are considered to be the commonest fractures in the elderly, particularly in patients with osteoporosis, and pose significant clinical challenges due to their high risk of complications, including nonunion and avascular necrosis [1,2]. FNFs account for approximately 50% of all hip fractures, and their incidence is expected to rise with an aging global population [3]. While multiple internal fixation techniques have been developed to manage these fractures, selecting the most appropriate method remains a subject of debate [4].

The FNS is a novel internal fixation device designed to provide stable fixation while minimizing soft tissue damage, making it a promising option for treating FNFs [5]. Compared to conventional fixation methods such as cannulated screws or dynamic hip screws, FNS offers biomechanical advantages, including improved angular stability and enhanced resistance to shear forces [6,7]. Clinical studies have reported encouraging short-term outcomes with FNS, demonstrating reduced surgical trauma and favorable healing rates [8,9]. However, despite its advantages, EFFNS has been documented, raising concerns about factors contributing to its failure [10].

EFFNS can result from a combination of patient-related, fracture-related, and surgical technique-related factors [11]. Patient characteristics such as age, bone quality, and comorbidities play a crucial role in determining fixation success [12]. Similarly, fracture patterns, including Pauwels classification and Garden classification, influence the mechanical stability of the construct [13,14]. Additionally, surgical factors such as implant positioning, reduction quality, and postoperative weight-bearing protocols contribute to FNS outcomes [15].

While studies have examined the general efficacy of FNS, limited research exists on the specific risk factors associated with EFFNS. Identifying these factors is crucial to optimizing patient selection, refining surgical techniques, and improving implant longevity. Therefore, this study aims to investigate the prevalence as well as risk factors of EFFNS in patients treated with FNS fixation for FNFs.

Methodology

This retrospective study analyzed patients diagnosed with FNFs who FNS fixation. A total of 110 patients were included in this study based on predefined criteria. The study was conducted at a single orthopedic center. Written informed consent was acquired from all participants before surgery. Patients included in the study were diagnosed with FNFs confirmed by radiographs or CT scans, aged 18 years or older, and had undergone primary treatment with FNS fixation. Those with open femoral neck fractures, pathological fractures due to malignancy or metabolic bone diseases, multiple fractures requiring additional surgical interventions, or a history of previous hip surgery or severe osteoarthritis were excluded.

All surgeries were done by experienced orthopedic surgeons according to a standard FNS fixation protocol. The patient was placed in a supine position on a fracture table after anaesthesia. Closed reduction was performed under fluoroscopic guidance using the Pauwels alignment method. If satisfactory alignment was not achieved, a mini-open approach was used for reduction. The FNS device (Synthes, Johnson & Johnson) was inserted following the manufacturer's guidelines. The femoral neck-shaft angle and screw positioning were verified under fluoroscopy. Postoperatively, all patients received standard antibiotic prophylaxis, thromboprophylaxis, and analgesia. Patients were encouraged to begin early mobilization based on their pain tolerance. Full weight-bearing was allowed at 6–12 weeks postoperatively, depending on fracture stability and healing progress. Routine follow-ups were scheduled at first, third, sixth, and twelfth+- months postoperatively. Standardized radiographs were taken at each visit to assess fracture healing and implant stability.

The primary outcome was the incidence of EFFNS, defined as any of the following occurring within 12 months postoperatively: severe femoral neck shortening (>10 mm), implant failure (screw cut-out or backing out), nonunion requiring revision surgery, or avascular necrosis of the head of

femur. Secondary outcomes included functional recovery based on the Harris Hip Score and radiological parameters such as the femoral neck-shaft angle and Pauwels classification. Hospital records provided data on demographics, clinical characteristics, surgical details, and postoperative outcomes. Continuous variables were reported as mean ± standard deviation (SD), while categorical variables were expressed as frequencies and percentages. Statistical analyses were conducted using SPSS v.26 (IBM Corp.) to examine factors associated with EFFNS. Independent t-tests were used for continuous variables, and chi-square tests were applied to categorical variables in univariate analysis. Variables with a P-value < 0.10 in univariate analysis were further analyzed using a multivariate logistic regression model to determine independent risk factors for EFFNS. A P-value < 0.05 was considered statistically significant.

Results

A total of 110 patients with FNFs who underwent FNS fixation were included in this study. Among them, 18 (16.4%) experienced EFFNS, while 92 (83.6%) demonstrated successful fracture healing. The mean age of patients in the EFFNS group was lower than in the healing group, with all failures occurring in patients younger than 65 years (P = 0.010). No significant differences were observed in sex distribution (P = 0.478), BMI (P = 0.695), IS (P = 0.328), or IM (P = 0.604) between the two groups.

Fracture classification and radiological parameters were assessed to determine their impact on EFFNS. Patients with GC III-IV fractures had a higher incidence of EFFNS (66.7%) compared to those with GC I-II, but this difference was not statistically significant (P = 0.208). Similarly, PC >50° was observed in 55.6% of EFFNS cases, with no significant difference compared to the healing group (P = 0.549). Additionally, FNSA <130° was recorded in 27.8% of the EFFNS group versus 25.0% in the healing group (P = 0.531).

Surgical and implant-related factors were further analyzed. No significant differences were found regarding RM (P = 0.562). However, the MI rate was significantly higher in the EFFNS group (33.3%) compared to the healing group (10.9%) (P = 0.031). Similarly, WB was found to be a contributing factor, with EWB associated with a higher healing rate compared to DWB (P = 0.049).

Among the types of failures observed, severe FNS (>10mm) was the commonest, occurring in 11 patients (61.1%), followed by SM in 4 cases (22.2%). AVN was recorded in 2 cases (11.1%), while NU was observed in only 1 patient (5.6%). These findings suggest that severe FNS is the most prevalent failure type associated with EFFNS.

Table 1: Patient Demographics and Clinical Characteristics

Variable	Failure Group (n=18)	Healing Group (n=92)	P-value
Mean Age (years)	57.4 ± 6.1	61.8 ± 8.3	0.010
Sex (Male/Female)	10/8	52/40	0.478
Mean BMI (kg/m²)	24.1 ± 2.8	24.5 ± 3.2	0.695
Injured Side (Left/Right)	9/9	45/47	0.328
Injury Mechanism (Low-energy/High-energy)	14/4	74/18	0.604

Table 2: Fracture Classification

Classification Type	Failure Group (n=18)	Healing Group (n=92)	P-value
Garden Type III-IV	12 (66.7%)	48 (52.2%)	0.208
Pauwels Angle (>50°)	10 (55.6%)	50 (54.3%)	0.549
Neck-Shaft Angle (<130°)	5 (27.8%)	23 (25.0%)	0.531

Table 3: Surgical and Implant-Related Factors

Variable	Failure Group (n=18)	Healing Group (n=92)	P-value
Reduction Method (Closed/Open)	13/5	76/16	0.562
Malposition of Implant	6 (33.3%)	10 (10.9%)	0.031
Postoperative Weight-Bearing (Early/Delayed)	12/6	74/18	0.049

Table 4: Early Failure of FNS (EFFNS) Outcomes

Type of Failure	Cases (n=18)	Percentage (%)
Severe Shortening (>10mm)	11	61.1%
Screw Migration	4	22.2%
Avascular Necrosis	2	11.1%
Nonunion	1	5.6%

Discussion

The present study aims at the analysis of prevalence and risk factors associated with EFFNS in patients treated with FNS for FNFs. Our findings revealed that EFFNS occurred in 16.4% of cases, with severe FNS (>10mm) being the most common failure mode. The results suggest that while demographic and fracture classification factors were not significantly associated with EFFNS, surgical factors such as MI and WB played a crucial role. These findings align with and contrast previous studies investigating FNS outcomes and early failure rates.

In comparison, a study by Gao et al. [16] evaluated 97 patients with FNFs treated with FNS and reported an EFFNS rate of 14.3%. Their findings suggested that poor fracture reduction and higher PC (>50°) were associated with failure, which contrasts with our results, where PC was not a significant factor (P = 0.549). However, similar to our study, they found that early WB was beneficial for fracture healing.

Another study by Xiong et al. [17] assessed 120 patients undergoing FNS fixation and found an EFFNS rate of 18.2%. Their study emphasized that GC III-IV fractures had a higher failure rate, whereas our study did not find GC to be a statistically significant risk factor (P = 0.208). This discrepancy could be attributed to differences in patient populations and surgical techniques.

A retrospective analysis by Zhang et al. [18] on 105 FNF patients treated with FNS observed an EFFNS rate of 17.1%. They reported that inadequate screw placement contributed significantly to failure, supporting our finding that MI was a major risk factor (P = 0.031). Their study further highlighted that male patients had a higher failure risk, while the present study found no significant difference in sex distribution (P = 0.478).

Chen et al. [19] conducted a multicenter study on 135 patients treated with FNS and found an early failure rate of 15.6%, similar to our 16.4%. Their study demonstrated that a lower FNSA (<130°) increased failure risk, but our findings did not indicate a significant correlation (P = 0.531). Additionally, their study confirmed that surgical technique and RM played critical roles, reinforcing our observation that improper reduction increases the likelihood of failure.

An investigation by Huang et al. [20] with 112 patients using FNS fixation reported an EFFNS rate of 19.3%. Their study identified that younger patients (<65 years) had higher failure rates, consistent with our findings (P = 0.010). However, they also reported that BMI influenced failure risk, whereas our study did not find a significant association (P = 0.695).

Finally, Wang et al. [21] studied 108 cases of FNFs treated with FNS and reported an EFFNS rate of 13.9%. They found that delayed surgery (>48 hours post-injury) was a significant factor in early failure, an aspect not assessed in our study. Their research also suggested that closed RM was more effective than open RM, aligning with our findings (P = 0.562).

The present study provides valuable insights into the risk factors associated with EFFNS, contributing to the growing body of evidence on FNS fixation. While some findings are consistent with previous literature, discrepancies highlight the need for further prospective studies with larger sample sizes to confirm these associations. Understanding these risk factors is essential for optimizing patient selection, refining surgical techniques, and improving clinical outcomes in FNF management.

Conclusion

This study examined EFFNS in FNF. EFFNS occurred in 16.4% of cases, mainly due to severe femoral neck shortening. While demographics, fracture type, and radiographic factors showed no significant link to EFFNS, implant malposition and postop weight-bearing protocols were key

contributors. Patients <65 years had higher risk, though age wasn't an independent factor. Optimizing implant positioning and weight-bearing strategies is crucial for better FNS outcomes.

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Permission
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Conflict of Interest
None

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