

Clinical Outcomes of Cephalomedullary and Static Transverse Proximal Locking Techniques in Femoral Intramedullary Nailing in Geriatric Patients

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ABSTRACT

Objective: The aim was to compare the clinical and radiological results of trochanter-inserted cephalomedullary locked and trochanter-inserted static transverse locked femoral intramedullary nails in patients over 65 years of age.

Methods: Demographic data of the patients, injury mechanism, fracture type, reduction technique, radiological and clinical union in the last follow-up, and complications occurred during the follow-up period were investigated. A subgroup analysis was also conducted to assess the impact of cephalomedullary fixation, and the need for open reduction on wound site infection.

Results: A significant correlation was found between the proximal locking technique and periimplantic secondary femoral neck fracture ($P = .019$). The further risk analysis revealed that static transverse locking system increased the risk of periimplantic femoral neck fracture by 4.8 times (odds ratio (OR) = 4.80, 95% CI: 2.20-10.47). Upon analyzing the parameters that affect wound site infections, a significant correlation was found between the reduction technique and wound site infection ($P = .030$, OR = 6.60, 95% CI: 1.47-29.66).

Conclusion: Cephalomedullary proximal locking is significantly more effective than its alternative, static transverse locking, in preventing periimplantic fractures in antegrade femoral intramedullary nailing of geriatric femoral diaphyseal fractures. Therefore, its routine application in the geriatric population is recommended. It is important to note that open reduction is associated with increased rates of wound-site infection, and closed reduction should be preferred whenever possible.

Keywords: Cephalomedullary locking, static transverse locking, femoral intramedullary nailing, geriatric patients, wound-site infection, periimplantic fractures

INTRODUCTION

Prophylactic fixation of the femoral neck with cephalomedullary screws during femoral antegrade intramedullary nailing (IMN) is a well-established concept in the orthopedic literature.¹⁻⁵ In 2001, Ziran et al.³ reported their method of transversely screwing the femoral neck by leaving one of the proximal transverse locking screws more proximally in the femoral IMN. In 2010, Collinge et al.⁴ recommended the standard cephalomedullary method of proximal locking in femoral IMN. Prophylactic cephalomedullary screw fixation during antegrade femoral IMN

can prevent periimplantic femoral neck fractures and osteoporotic femoral neck fractures that may occur in the medium to long term, especially in the elderly population. It can also aid in the treatment of possible "missed" femoral neck fractures. However, this proximal locking method has some limitations. First of all, the use of reconstruction nail systems, which allow the insertion of screws into the femoral neck, is a must for this fixation method. Furthermore, there are several challenges, such as difficulties in adjusting anteversion and prolonged surgical time. Unfortunately, prolonged surgical time, together with open reduction, is an important risk

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factor for wound infection after femoral implantation.^{6,7} Currently, the static transverse or cephalomedullary locking of the proximal femur in antegrade femoral IMN for femoral diaphyseal fractures is entirely dependent on the surgeon's preference and experience. Although there have been instructive and suggestive literature studies on this subject, a consensus has not yet been reached.^{1,3,8,9}

The aim of this study was to compare the clinical and radiological results of trochanter-inserted cephalomedullary locked and trochanter-inserted static transverse locked femoral intramedullary nails in patients over 65 years of age.

MATERIAL AND METHODS

Study Population and Data Collection

Following the ethical board approval of Ankara Bilkent City Hospital Clinical Research Ethics Committee (decision no: E1-22-2906; date: September 21, 2022), all patients aged over 65 years, who were diagnosed with femur diaphyseal fracture and operated on with antegrade trochanteric-inserted reamed femoral intramedullary nails between May 2019 and March 2023, were analyzed retrospectively. Patients who had pathological fractures (2 patients), periprosthetic fractures (2 patients), patients whose fracture extends to the proximal or distal articular surface (1 patient), and patients who were lost to follow-up (5 patients) were excluded from the study. Considering the inclusion and exclusion criteria, 10 patients were excluded and a total of 27 patients were analyzed.

Operative Techniques

In our clinic, the standard approach for femoral diaphyseal fractures of the elderly is the antegrade trochanteric-inserted reamed intramedullary nails, as described in the literature.⁹ For all patients, closed reduction techniques are applied at first, and in patients in which closed reduction cannot be obtained, open reduction through lateral approach was preferred. Cable fixation is preferred only

when absolutely necessary in cases where reduction cannot be achieved by any other means. The Universal Femoral Nail (UFN) II (Double Medical, Xiamen, China), which allows for both standard (static transverse) and reconstruction (cephalomedullary) proximal locking, is the standard choice of implant. Both standard (static transverse) and reconstruction (cephalomedullary) proximal locking are used routinely in our clinic (Figures 1 and 2), based purely on the choice of the primary surgeon, as recommended in the literature.¹ Regardless of the proximal locking method or reduction technique used, patients are mobilized with full weight-bearing within the first 24 hours postoperatively and discharged within the first 48 hours after wound site follow-up. Patients are routinely called for outpatient follow-up at 3 weeks, 6 weeks, 3 months, 6 months, and 1 year postoperatively. During all outpatient follow-ups, the physician records the patients' complaints and current status, documents physical examination findings and gait patterns, and performs radiographic controls.

Postoperative Assessment

In order to compare the clinical and radiological results of the patients, the radiographs and physician notes taken in

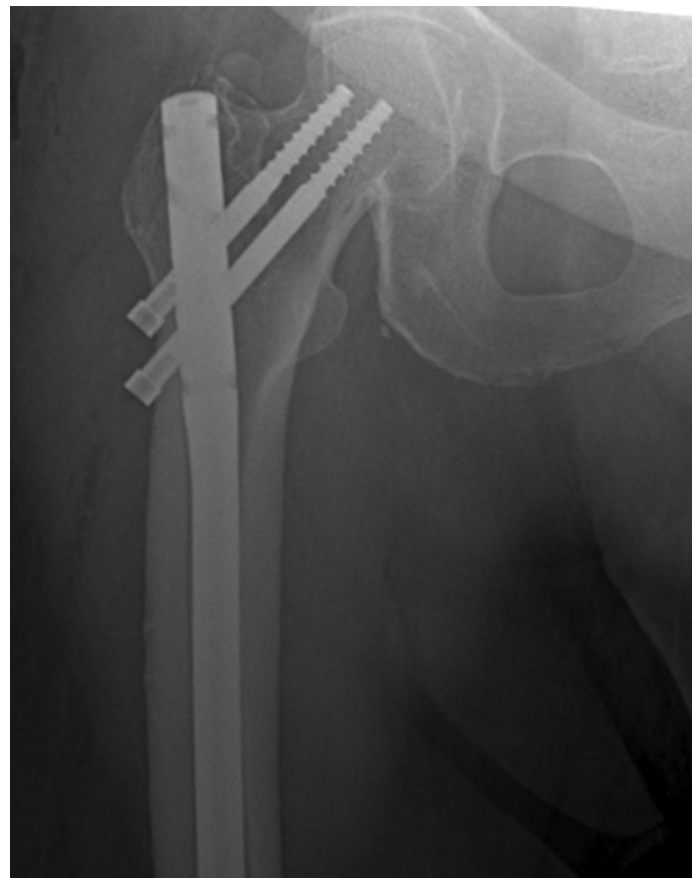


Figure 1. The antegrade femoral intramedullary nailing of a 65-years-old male patient with a reconstruction (cephalomedullary) proximal locking system.

MAIN POINTS

- The static transverse locking system significantly increases the risk of peri-implant femoral neck fracture by 4.8 times ($P = .019$, odds ratio = 4.80, 95% CI: 2.20-10.47) in geriatric patients with diaphyseal femoral fractures.
- In intramedullary nailing for geriatric patients with femoral diaphyseal fractures, open reduction increases the risk of wound-site infection ($P = .030$, odds ratio = 6.60, 95% CI: 1.47-29.66).
- Cephalomedullary proximal locking and closed reduction should be preferred whenever possible in intramedullary nailing for geriatric femoral diaphyseal fractures.



Figure 2. The antegrade femoral intramedullary nailing of an 88-year-old female patient with a standard (static transverse) proximal locking system.

the last follow-up on the hospital information system were examined. Patients and their relatives were also called to the telephone number in the patient file, and their current status and complaints were questioned. Informed consent was obtained from the patients and their relatives who agreed to take part in the study.

Demographic data of the patients, injury mechanism (low- and high-energy injuries), fracture type (transverse, spiral-oblique, segmental, comminuted), reduction technique (closed or open), radiological (callus formation through 4 cortex) and clinical (pain in the fracture site) union in the last follow-up, and complications that occurred during the follow-up period (wound-site infection, periimplantic or osteoporotic femoral neck fracture) were investigated. Wound site infection was defined as superficial, or deep infections occurring at the wound site during the first 3 weeks until sutures were removed. Due to the presence of mainly elderly patients over 80 years of age, the patients were not invited for rechecks for gait pattern analysis and abductor muscle strength measurements. A subgroup analysis was also conducted to assess the impact of prolonged surgical time resulting from cephalomedullary fixation or the need for open reduction on wound site infection.

Statistical Analysis

Statistical analyses were conducted using International Business Machines (IBM®) Statistical Package for the Social Sciences (SPSS®) Statistics for Windows, version 26.0.0.0 (IBM SPSS Corp.; Armonk, NY, USA). Descriptive analyses were performed using mean, standard deviation, minimum–maximum values, frequency, and percentiles. The normal distribution compliance of variables was examined through visual (histogram and probability graphs) and analytical (Kolmogorov–Smirnov test) methods. The Mann–Whitney *U*-test was used to compare the numerical data, and the chi-square test was used to compare categorical data. Fisher's exact test was used when the chi-square assumption was not met. Statistical significance was considered at $P < .05$. For further risk analysis, 2×2 cross-tabulation was created, and odds ratio (OR) and confidence interval measurements were performed.

RESULTS

Nineteen out of 27 patients (70.4%) underwent proximal locking using the cephalomedullary technique, while the remaining 8 patients (29.6%) underwent the static transverse technique. There were no significant differences between the groups in terms of age, gender, injury energy, and fracture type ($P > .05$). No patients experienced any delayed-union, nonunion, or pseudoarthrosis during the follow-up period. Femoral neck fracture was observed in



Figure 3. Periimplantic femoral neck fracture in a static transversely proximal-locked femoral intramedullary nail patient.

Table 1. Comparison of Clinical Outcomes of Different Proximal Locking Systems

		Cephalomedullary Locked IMN (N = 19)	Static Transverse Locked IMN (N = 8)	P
Age (years)		75.58 ± 7.65 (67-91)	74.25 ± 9.42 (65-90)	.558
Sex	Female	15 (78.9%)	4 (50%)	.133
	Male	4 (21.1%)	4 (50%)	
Injury mechanism	Low-energy	16 (84.2%)	7 (87.5%)	.826
	High-energy	3 (15.8%)	1 (12.5%)	
Fracture type	Transverse	7 (36.8%)	4 (50%)	.178
	Spiral-oblique	12 (63.2%)	3 (37.5%)	
	Segmental	0	1 (12.5%)	
	Comminuted	0	0	
Reduction technique	Closed	16 (84.2%)	6 (75%)	.574
	Open	3 (15.8%)	2 (25%)	
Follow-up (months)		24.26 ± 9.5 (8-42)	20.13 ± 8.71 (6-30)	.312
Fracture union	Completed	19 (100%)	8 (100%)	N/A
	Nonunion	0	0	
Wound-site Infection	None	15 (78.9%)	7 (87.5%)	.601
	Yes	4 (21.1%)	1 (12.5%)	
Femoral neck fracture	None	19 (100%)	5 (62.5%)	.019 (OR = 4.80, 95% CI: 2.20-10.47)
	Yes	0	3 (37.5%)	

CI, confidence interval; IMN, intramedullary nail; N/A, non-applicable; OR, odds ratio.

3 patients (7.4%) during regular follow-up (Figure 3) and treated with nail removal and arthroplasty through partial prosthesis. A significant correlation was found between the proximal locking technique and periimplantic secondary femoral neck fracture ($P = .019$). The further risk analysis revealed that the static transverse locking system increased the risk of periimplantic femoral neck fracture by 4.8 times (OR = 4.80, 95% CI: 2.20-10.47) (Table 1).

Out of the 27 patients who underwent surgery, 5 (18.5%) of them experienced wound-site infections. All infections were treated with local wound care and antibiotics, and

none of the patients required sequential debridement. Upon analyzing the parameters that affect wound site infections, a significant correlation was found between the reduction technique and wound site infection ($P = .030$, OR = 6.60, 95% CI: 1.47-29.66) (Table 2).

DISCUSSION

Prophylactic fixation of the femoral neck in femoral diaphyseal fractures is a common concept in orthopedics and traumatology.¹⁻⁵ This is particularly important in cases of atypical fractures, metastatic involvement, and

Table 2. Further Risk Analysis of Reduction Technique and Risk of Wound-Site Infection

		Wound-Site Infection		P
		Yes (N = 5)	No (N = 22)	
Proximal locking System	Cephalomedullary locked IMN (N = 19)	4 (80%)	15 (68.2%)	.601
	Static transverse locked IMN (N = 8)	1 (20%)	7 (31.8%)	
Reduction technique	Open reduction (N = 5)	3 (60%)	2 (9.1%)	.030 (OR = 6.60, 95% CI: 1.47-29.66)
	Closed Reduction (N = 22)	2 (40%)	20 (90.9%)	
Femoral neck fracture	Yes (N = 3)	0	3 (13.6%)	.381
	None (N = 24)	5 (100%)	19 (86.4%)	

CI, confidence interval; IMN, intramedullary nail; N/A, non-applicable; OR, odds ratio.

pathological fractures.^{10,11} In the geriatric population, femoral diaphyseal fractures typically result from low-energy injuries and do not involve fragmentation. Antegrade IMN of the femoral neck can yield excellent outcomes.¹²⁻¹⁴ Periimplant fractures of the femoral neck after femoral IMN may occur due to surgical stress, loss of bone quality caused by osteoporosis, and bone damage caused by piriformis-entered nails. Therefore, several authors recommend prophylactic fixation of the femoral neck in femoral diaphyseal fractures in patients over 65 years of age.^{1-5,10,11} However, this approach has some drawbacks, such as the need for reconstruction screws, anteversion adjustment, and prolonged surgical time. Although there are several studies in the literature comparing the clinical and radiological results of different proximal locking techniques,¹⁻⁸ to the best of our knowledge, there are an insufficient number of studies focusing solely on the geriatric population.^{15,16} Our study's primary strength is its ability to compare 2 proximal locking techniques in the geriatric population. The study's most significant finding is that patients with static transverse locking have a higher incidence of femoral neck fractures ($P=.019$).

Our study found that proximal static transverse locking in geriatric patients with diaphyseal femoral fractures increased the risk of periimplant fracture of the femoral neck by a factor of 4.8 compared with cephalomedullary locking. This finding is consistent with the literature. Patton et al.¹⁵ reported a 3% incidence of femoral neck fractures in geriatric patients with femoral diaphyseal fractures treated with IMN. The authors emphasized the importance of prophylactic screw fixation of the femoral neck during fixation of femoral diaphysis. Bögl et al.¹⁶ reported that late femoral neck and proximal periimplant fractures may occur after IMN fixation without femoral neck protection in elderly patients with femoral shaft fractures. The primary reason for this increased risk is the damage caused to the bone during the entry site carving process, which is particularly higher with piriformis-entered nails.¹ Furthermore, the risk of fracture is increased by postoperative immobilization and increased stress around the proximal locking screw. Additionally, underlying and progressive osteoporosis is a significant risk factor for secondary femoral neck fractures. Considering all these, cephalomedullary locking may be preferred as a routine procedure for femoral diaphyseal fixation in geriatric patients, as suggested in a number of studies in the literature. However, randomized controlled studies are still needed to confirm this preference, considering its potential drawbacks such as prolonged surgical time and technical difficulties.

Wound site infections can increase morbidity and mortality rates due to prolonged antibiotic use and the need

for secondary debridement when necessary. Therefore, it is essential to identify the factors that contribute to the development of wound infections and take preventive measures if possible. This study investigates the relationship between the proximal locking system and wound infection. The hypothesis is that prolonged surgical time due to the need for anteversion adjustment increases the susceptibility to wound infection. The literature has clearly demonstrated the relationship between prolonged surgical time and wound site infections.^{6,7} However, our findings do not support this hypothesis. The study found no correlation between the proximal locking system and wound site infection. On the other hand, a significant relationship was found between reduction technique and infection ($P=.030$). The analysis supported existing literature, indicating that the most significant factor in the development of wound infection was the need for open reduction. A further risk analysis demonstrated that open reduction increased the rate of wound infection by 6.6 times (OR=6.60, 95% CI: 1.47-29.66). Considering these findings, closed reduction should always be the first choice in the treatment of femoral IMN in geriatric patients. If closed reduction of the fracture is not feasible, open reduction can be achieved through mini-open or open incisions with a lateral approach.

The study has several limitations. First, it is retrospective and based on a relatively small sample size. Secondly, direct evaluation of the duration of surgery was not possible. Although it was assumed that cephalomedullary fixation would result in longer surgical times, this was not directly measured due to the retrospective nature of the study. Furthermore, it is important to note that the size of the wound-site could not be evaluated in cases where open reduction was performed, which is a significant limitation. Last but not least, no comorbidity analysis was performed. On the other hand, the existence of comorbidities directly affects the surgical duration, postoperative complications, and postoperative rehabilitation. To address these limitations, large-scale prospective randomized studies are necessary. Additionally, the inability to perform objective measurements, such as gait analysis and muscle strength assessment during the postoperative period is also a noteworthy limitation. However, as our study was conducted on a geriatric population with a mean age of 75.2 years (range: 65-91), patients were not recalled to visit the hospital for further evaluations.

Although there are some limitations, cephalomedullary proximal locking is significantly more effective than its alternative, static transverse locking, in preventing periimplant fractures in antegrade femoral IMN of geriatric femoral diaphyseal fractures. Therefore, its routine application in the geriatric population is recommended.

It is important to note that open reduction is associated with increased rates of wound-site infection, and closed reduction should be preferred whenever possible.

Availability of Data and Materials: All data have been deposited in a repository.

Ethics Committee Approval: Ankara Bilkent City Hospital Clinical Research Ethics Committee (decision no: E1-22-2906; date: September 21, 2022).

Informed Consent: Informed consent was obtained from all patients and their relatives who agreed to take part in the study.

Peer-review: Externally peer-reviewed.

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