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Research Article/ Araştırma Makalesi

The Effect of Proximal Femoral Nail and Position in the Femur on Clinical and Radiological Outcomes of Intertrochanteric Fractures

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Purpose: Intramedullary nail treatment for intertrochanteric fractures has gained widespread popularity in recent years. Predisposing factors for mechanical failure of the proximal femoral nail include lag screw position, tip apex distance, reduction quality, and the femoral neck/shaft angle (FNSA). Our study aimed to evaluate the effect of the position of the nail end on the mechanical failure rates and radiological parameters.

Method: The data of 118 patients who underwent proximal femoral nail repair due to intertrochanteric fractures were analyzed between June 2019 and September 2022. The patients were divided into three groups according to the proximal femoral nail end positioning of the femoral canal, and tip apex distance, FNSA, reduction quality, lag screw position, union time, and complications were evaluated on postoperative and follow-up radiographs.

Results: When all patients included in the study were evaluated, cut-out was observed in 9. The cut-out rates were significantly higher in the medial group (n=7, p=0.003). Regarding FNSA, there were statistically significant differences among all three groups (<0.001M-S, M-L, S-L). In the medial group, the superiorly located lag screw, and in the lateral group, the inferiorly located lag screw was higher than in the other groups(p<0.001)

Conclusion: It has been observed that placement of the distal tip of the nail in the canal affects both these parameters and clinical results, and the clinical and radiological results were worse in cases where the distal nail was medial to the canal.

Keywords: Intertrochanteric femur fracture, Proximal femoral nail, Tip apex distance, Reduction

1.INTRODUCTION

The incidence of intertrochanteric fractures is increasing every year.[1] The incidence of intertrochanteric fractures is expected to be 6.3 million in 2050.[2] Intertrochanteric femur fracture (IFF) is a common hip fracture, representing about 31–35% of all hip fractures.[3] In recent years, intramedullary nail treatment for intertrochanteric fractures has gained widespread popularity for treating trochanteric fractures.[4] Intramedullary fixation methods in treating intertrochanteric fractures have increased significantly in the last ten years.[5] Intramedullary fixation methods offer better biomechanical properties than Extramedullary fixation methods.[6] Due to the difficulties in obtaining anatomical reduction and low bone quality, which can result in eventual implant failure and high morbidity and mortality rates associated with geriatric patients, the treatment of unstable intertrochanteric fractures in the elderly has proven problematic.[7] Mechanical complication rates after intramedullary fixation of intertrochanteric fractures are between 2-13%.[8] Among these, lag screw cut out after reduction losses and varus collapse, excessive sliding of the lag screw, are frequently encountered.[9,10] Less frequently, fractures can be seen around the nail.[11] Among the predisposing factors are improper reduction, incorrect positioning of the lag screw, short tip-apex distance (TAD), and femur neck/shaft angle (FNSA)[12,13]. Studies have been conducted on the nail position in the distal femur in intertrochanteric fractures, and these studies are focused on lateral and anterior impingement and its related com-

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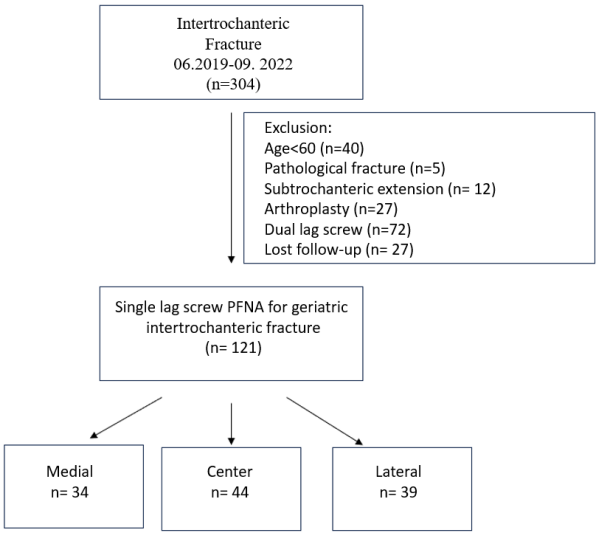
plications.[14,15] Due to proximal femur anatomical variations and canal sizes, difficulties may be encountered during nail application.[16] The nail may not be applied in the desired position. We planned a study to investigate the effect of nail position in the distal femoral canal on the lag screw position, TAD, FNSA, and clinical results.

2.MATERIALS and METHODS

The Institutional Review Board approval was obtained (IRB approval number: 2022-16/149). Retrospective review of consecutive patients aged 60 and above who underwent proximal femoral nailing for IFF in our clinic. Pathological fractures or intertrochanteric fractures with subtrochanteric extension were excluded from the study. Patients who underwent double lag or arthroplasty for intertrochanteric fractures other than proximal femoral nail anti-rotation (PFNA) were excluded from the study. Finally, 121 patients with at least one-year follow-up were included in the study. (Figure 1)

Figure 1.

Patients' flow chart



Fracture types are defined according to the AO/OTA classification system.[17] All fractures were stabilized using short PFNA II (Asian version) with a centrum-collum-diaphyseal (CCD) angle of 130°. All surgeries were performed on a traction table, following the manufacturer's guide by one surgeon. 10 mm diameter nails were preferred in all cases. In all cases, nail distal locking was done with one screw. Intraoperative and postoperative radiographs, including anterior-posterior (AP) and lateral radiographs, were reviewed in all cases. The patients were mobilized on the 1st postoperative day, using a walker with as much weight as they could tolerate. Determination of the nail position within the femur on post-operative hip AP plain radiographs. (Figure 2)

Figure 2.

Evaluation of nail distal tip location on the postoperative hip anterior-posterior radiograph

According to the location of the nail at the distal end, it was examined in 3 groups: central, medial,

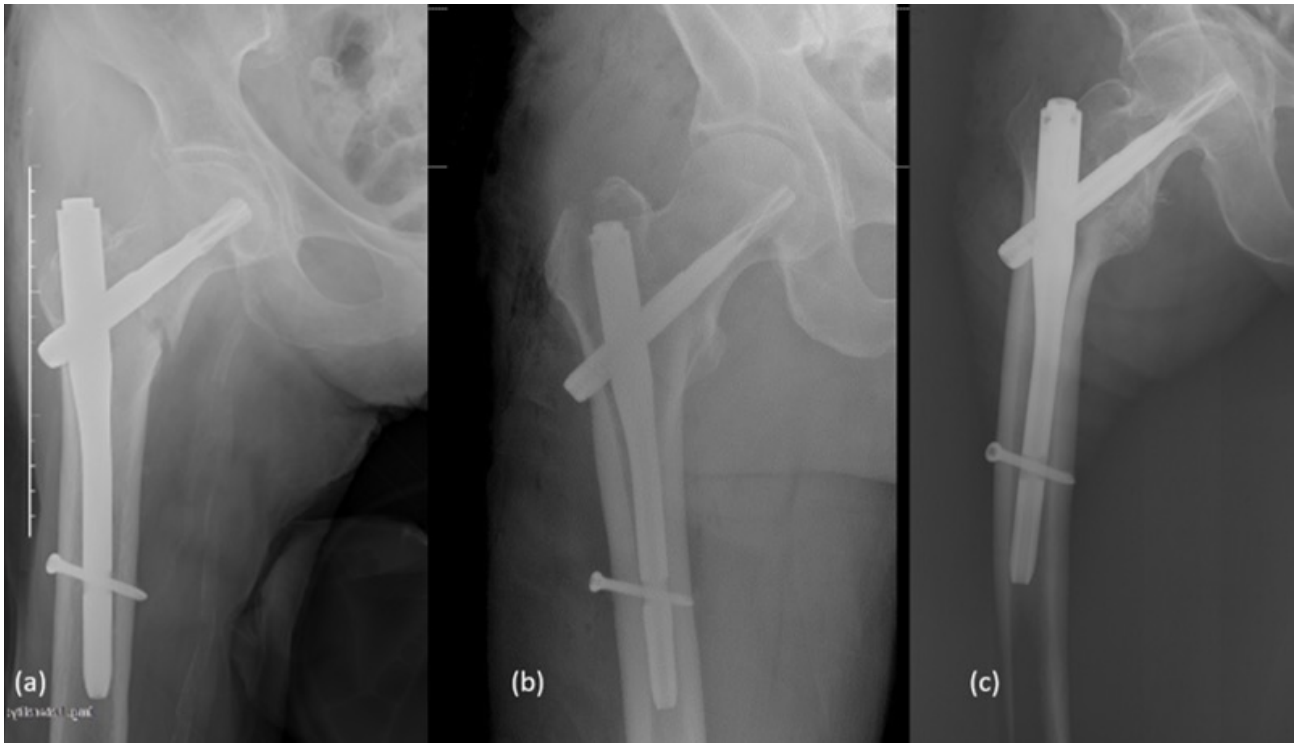
and lateral. (Figure 3) On the second postoperative day, postoperative radiographs were collected at the 1, 6, and 12-month follow-up. All images have been stored in the hospital digital archive, and digital ruler tools were used for measurements. TAD, FNSA, reduction quality, lag screw position, union time, and fractures around the implant were evaluated on postoperative follow-up radiographs. Reduction quality was graded as optimal, acceptable, and unacceptable according to the system of YC Yoon.[18] The lag screw position was assessed on radiographs as described by Cleveland et al.[19] The diameter of the medullary cavity was measured at the isthmus level using the known intramedullary nailing (IMN) diameter to correct measurement. The presence of callus in at least three cortices was interpreted in favor of fracture healing. The absence of pain during walking and the patient's ability to mobilize without support were evaluated as fracture healing. Changes in FNSA during clinical follow-ups were recorded. The data about re-operation needs and indications such as cut-out, implant breakage, fracture around the implant, nonunion, infection, and symptomatic implants were recorded.

2.1.Statistical analysis

The data collected in the study were analyzed using the IBM SPSS 25.0 software (SPSS Inc., Chicago, IL, USA). Descriptive statistics such as frequency (%), mean ± standard deviation (SD), and minimum, median, and maximum values were used to present the data. Different statistical tests were utilized for comparisons between the three groups based on the data type. The chi-square test was used for categorical data. The independent t-test was applied to parametric data with a normal distribution, allowing for the comparison of means between three independent groups. On the other hand, the Mann-Whitney U test was used for non-parametric data, which does not assume a normal distribution, and it compares the medians of three independent groups.

Figure 3.

According to the location of the nail end in the distal intramedullary area; (a) medial, (b) central, (c) lateral



3.RESULT

After the exclusion criteria, a total of 118 patients who were operated on for intertrochanteric fractures between June 2019 and September 2022 were included in the study. They were evaluated into three groups: 34 patients in the medial group, 45 in the center group, and 39 in the lateral group. There was no significant difference in demographic data such as age and gender and preoperative baseline data such as AO/OTA classification system.(Table 1) When the FNSA was examined, it was observed that the mean was 124.56±4.54° in the medial group, 130.56±3.20° in the central group, and 132.13±3.47° in the lateral group. There were differences in the FNSA evaluation in all three groups (p<0.001M-S. M-L, S-L). A statistically significant difference was found when the lag screw placement was compared according to the groups (p<0.001). In the medial group, the superiorly located lag screw, and the lateral group, the inferiorly located lag screw was higher than in the other groups. Mean TAD values were 23.59±2.49 in the medial group, 16.62±3.64 in the center group, and 19.05±2.88 in the lateral group (p<0.001). When the groups were evaluated in terms of reduction quality, poor reduction quality was observed in 6 patients in the medial group, one patient in the central group, and two patients in the lateral group, and a statistically high rate of poor reduction quality was observed in the medial group (p=0.004). When the lag screw cut-out rates were examined, they were significantly higher in the medial group (n=7, p=0.003). Three groups were compared in terms of femoral canal width. There was no statistically significant difference between the Medial Group (14.26±0.81), Center Group (14.03±0.70), and Lateral Group (14.11±0.84). (Table 2) When complications were examined, arthroplasty was performed as a result of 7 cut-outs in the medial group, 1 in the central group, and 1 in the lateral group. No difference was observed in all three groups regarding varus displacement that developed without cut-out below 10° in FNSA. While there was no difference in terms of union time in the medial and lateral groups, a difference was observed between the central and medial groups. Union was significantly higher in the medial group over six months than in the central group. Superficial infection was observed in 1 patient in each central and lateral group. The patients were fol-

Table 1.

Demographic and baseline data of patients

Group	Medial Group	Center Group	Lateral Group	p-value
Sex n (%)				
Female	31 (91.20%)	41 (91.10%)	36 (92.30%)	0.977
Male	3 (8.80%)	4 (8.90%)	3 (7.70%)	
Age				
Mean±SD	73.44±6.51	73.60±5.71	73.56±5.14	0.871
Min/Med/Max	65.00/71.50/87.00	65.00/72.00/87.00	65.00/72.00/86.00	
AO/OTA class n (%)				
A1.2	2 (5.90%)	4 (8.90%)	3 (7.70%)	0.941
A1.3	3 (8.80%)	4 (8.90%)	2 (5.10%)	
A2.2	22 (64.70%)	29 (64.40%)	29 (74.40%)	
A2.3	7 (20.60%)	8 (17.80%)	5 (12.80%)	
n: Number, Mean±SD: Mean and standard deviation, Min: Minimum, Med: Median, Max: Maximum, AO/OTA class n: AO/OTA classification number				

Table 2.

Postoperative variables and clinical outcomes comparison between the three groups.

	Medial Group	Center Group	Lateral Group	P value
Femoral canal width (mm)				
Mean±SD	14.26±0.81	14.03±0.70	14.11±0.84	0.313
Min/Med/Max	12.50/14.40/15.90	12.50/14.10/15.70	12.50/13.90/15.70	
Femur neck/shaft angle				
Mean±SD	124.56±4.54	130.56±3.20	132.13±3.47	<0.001
Min/Med/Max	115.00/125.00/132.00	120.00/130.00/137.00	122.00/132.00/139.00	<0.001$^{M\text{-}C.\ M\text{-}L}$
Tip apex distance				
Mean±SD	23.59±2.49	16.62±3.64	19.05±2.88	<0.001
Min/Med/Max	19.00/23.50/28.00	11.00/15.00/26.00	14.00/19.00/24.00	<0.001$^{M\text{-}C.\ M\text{-}L}$ 0.026C-L
Reduction quality				
Poor	6(17.60%)	1(2.20%)	2(5.10%)	0.004
Optimal	10(29.40%)	29(64.40%)	26(66.70%)	
Acceptable	18(52.90%)	15(33.30%)	11(28.20%)	
Lag screw position at the coronal plane				
İnferior	1(2.90%)	9(20.0%)	16(41.0%)	<0.001
Central	25(73.50%)	34(75.60%)	22(56.40%)	
Superior	8(23.50%)	2(4.40%)	1(2.60%)	
Lag screw position at the sagittal plane				
Posterior	7(20.60%)	7(15.60%)	8(20.50%)	0.928
Central	24(70.60%)	35(77.80%)	29(74.40%)	
Anterior	3(8.80%)	3(6.70%)	2(5.10%)	
Union time				
>6 month	3(8.80%)	2(4.40%)	4(10.30%)	0.018$^{M\text{-}C}$
<6 month	24(70.60%)	42(93.30%)	34(87.20%)	
Varus collapse <10 degrees without cut-out				
No	33(97.10%)	43(95.60%)	36(92.30%)	0.634
Yes	1(2.90%)	2(4.40%)	3(7.70%)	
Cut-out				
No	27(79.40%)	44(97.80%)	38(97.40%)	0.003
Yes	7(20.60%)	1(2.20%)	1(2.60%)	
Mean±SD: Mean and standard deviation, Min: Minimum, Med: Median, Max: Maximum, M: Medial, C: Center, L: Lateral, M-C: Medial – Center, M-L: Medial – lateral, C-L: Central - Lateral				

lowed up with dressing and antibiotics. In the lateral group, a revision nail was applied to the patient due to a nail breakage in one patient. Data related to complications are given in Table 3.

Table 3.

Complications

Complication	Medial Group	Center Group	Lateral Group
Cut-Out	7 (19.40%)	1 (2.20%)	1 (2.50%)
Nail breakage	-	-	1 (2.50%)
Superficial infection	-	1 (2.20%)	1 (2.50%)

4.DISCUSSION

As a result of our study, fixation failure rates were significantly higher in cases where the distal tip of the nail was located medially (p=0.003). In patients where the distal end of the nail was medial, it was observed that the lag screw was placed superiorly at a higher rate compared to the other groups(p<0.001). When the reduction quality was evaluated, the poor reduction was higher in the medial group than in the other groups (p=0.004). No implant-related fracture was observed in any group due to the distal tip placement of the nail. The overall failure rate was 7.6% when all groups were evaluated together. Failure developed because of cut-out after progressive varus collapse. When the literature is examined, it is observed that the failure rates vary between 3-14%.[20] It is thought that the reason why the position of the lag screw is superior in the medial group is the superior orientation of the guide wire applied for the lag screw because of the medial placement of the nail end in the ao, even if anatomical reduction is achieved. Another reason for the order of the lag screw in the superior position in the medial group is the medial orientation of the nail after lateral entry and the deterioration of reduction due to the lateral entry point. As a result of the research, lateral entry constitutes a risk factor for mechanical failure in proximal femoral nail applications for intertrochanteric fracture.[20-22] When the FNSA was compared, the mean FNSA was found to be 124.56±4.54 degrees in the medial group. We think that the reason for the low FNSA in the medial group is the impingement of the nail in the medial cortex due to the lateral entry point and then the displacement of the fracture line into the varus by the effect of the lever. Jiamton et al. observed that fracture reduction losses occurred during nail application when the lateral entry point was preferred for proximal femoral nail application.[23] Even if the anatomical reduction was achieved during the operation, opening, and varus collapse in the fracture line associated with the wrong entry point were shown during nail application.[24] In the surgical treatment of femoral intertrochanteric fractures, failure rates have been shown to increase significantly in cases where FNSA was restored below 125°.[25] Mean FNSA was 124.56±4.54° in the medial group, and cut-out was observed in 7 patients. In the lateral and center groups, the FNSA was 132.13±3.47 and 130.56±3.20, respectively. In treating intertrochanteric fractures, fixation of the FNSA in the normal or slightly valgus position is recommended.[26,27] Lag screw placement in the inferior position in the coronal plane was found to be significantly higher in the lateral group. As a result of the research, there is a consensus that the ideal position of the lag screw is the center.[28] In addition, it has been shown that the inferior-center placement of the lag screw gives clinically and radiologically similar results to the center-center placement.[29] Fixation failure after cut-out in the lateral and central groups was observed only in 1 case in both groups, and no statistically significant difference was observed. In particular, after computational and biomechanical experimental studies, it has been shown that the inferior positioned lag screw applied from the denser inferior calcar region is mechanically superior.[30,31] Although the TAD dis-

tance was higher in the lateral group (19.05±2.88) due to the inferior-located lag screw compared to the medial group (16.62±3.64), no clinical difference was observed. It has been shown that inferior-positioned lag screws give equal or even better results than center-placed screws, even if the TAD distance is higher than 25mm.[29,31,32] In all cases included in the study, a single-size nail was applied. It has been shown that nail sizes do not affect clinical and radiological results, regardless of canal diameter. [33]

There are some limitations of this study. Retrospective nature of the study. Another limitation is the small study population due to follow-up losses. Changes in femoral bowing, which will affect the placement of the femoral nail in the femur, were not evaluated. Again, the analysis did not assess parameters such as the weight and height of the patients that would affect the femoral bowing.

5.CONCLUSION

There are many factors affecting the prognosis of intertrochanteric fractures. Among these factors, femur neck shaft angle, lag screw position, and TAD are frequently used. It has been observed that the placement of the nail end in the femur affects both these parameters and clinical results. It has been observed that the desired radiological parameters and clinical outcomes are better in cases where the nail distal is central and lateral. In addition, it was observed that the clinical and radiological results were worse in cases where the distal nail was medial in the canal. Cases where the nail distal is medial have been associated with a false entry point.

Conflict of interest statement

The authors declared that there was no conflict of interest during the preparation and publication of this article.

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Ethics Approval

This study was approved by Faculty of Medicine Clinical Research Ethics Committee (06.09.2022/2022-16/149). The procedures used in this study adhere to the tenets of the Declaration of Helsinki. All participants gave their written informed consent to participate in the study.

Authors' Contributions

MFÇ: Data Curation, Methodology, Literature search, Writing – Original Draft , Writing – Review & Editing.

LH: Data Curation, Literature search, Writing – Original Draft . Supervision, Visualization.

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