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Comparative Analysis of Radiologic Outcomes and Mechanical Complications Associated with Four Different Proximal Femoral Nail Designs

4 Farklı PFN Tasarımı ile Tedavi Edilen Kalça Kırıklarının Radyolojik Sonuçlarının ve Mekanik Komplikasyonlarının Karşılaştırmalı Analizi

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ABSTRACT

Aim: This study aimed to retrospectively assess the efficacy of four commonly used Proximal Femoral Nail (PFN) designs in the surgical treatment of hip fractures, focusing on factors that influence patient outcomes.

Patients and Methods: We evaluated 220 patients treated for extracapsular hip fractures with different PFN designs from January 1, 2017, to January 1, 2023. We reviewed patient demographics, comorbidities, anesthesia type, operative details, and postoperative radiographs.

Results: A cohort of 220 patients was analyzed. Of these, 138 were female, and 82 were male. Patients were divided into four groups based on the type of PFN used. Group 1 (double lag screw PFN) had the best radiological outcomes with superior reduction quality and fewer complications. The groups showed no significant differences in terms of age, gender, type of anesthesia, or comorbidities. However, Group 3 (Intertan PFN) had a lower tip-apex distance, and Group 1 showed the fewest complications overall.

Conclusion: This study demonstrates that the use of PFN with double lag screws in extracapsular hip fractures is associated with superior fracture reduction, fewer complications, and a lower incidence of nonunion.

Keywords: Double lag screws, Extracapsular hip fracture, Mechanical complications, PFN-A, Proximal Femoral Nail, Radiologic outcomes, Talon.

ÖZ

Amaç: Bu retrospektif gözlemsel kohort çalışması, ekstrakapsüler kalça kırığı ameliyatı geçiren hastalarda dört farklı Proksimal Femoral Çivi (PFN) tasarımının etkinliğini değerlendirmek ve hasta sonuçlarını etkileyen faktörleri araştırmayı amaçlamaktadır.

Hastalar ve Yöntemler: 1 Ocak 2017'den 1 Ocak 2023'e kadar farklı PFN tasarımları ile ekstrakapsüler kalça kırığı nedeniyle tedavi edilen 220 hasta değerlendirildi. Hasta demografisi, komorbiditeler, anestezi tipi, ameliyat detayları ve ameliyat sonrası radyografiler incelendi.

Bulgular: 220 hastadan retrospektif analiz edildi. Bu hastaların 138'i kadın, 82'si erkekti. Hastalar kullanılan PFN tipine göre dört gruba ayrıldı. Grup 1(çift lag vadalı PFN), en iyi radyolojik sonuçlara sahip olup, daha iyi redüksiyon kalitesi ve en az komplikasyon ile öne çıktı. Gruplar arasında yaş, cinsiyet, anestezi türü veya komorbiditeler açısından anlamlı bir fark gözlenmedi. Ancak Grup 3 (İntertan PFN), daha düşük tip-apeks mesafesine sahipti ve Grup 1 genel olarak en az komplikasyona sahiptir.

Sonuç: Bu çalışma, ekstrakapsüler kalça kırıklarının tedavisinde çift lag vidalı PFN kullanımının daha iyi kırık redüksiyonu, daha az komplikasyon ve daha düşük kaynamama oranı ile ilişkili olduğunu göstermektedir.

Anahtar kelimeler: Çift yivli vidalar, Ekstrakapsüler kalça kırığı, Mekanik komplikasyonlar, PFN-A, Proksimal Femoral Çivi, Radyolojik sonuçlar, Talon.

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Introduction

Proximal Femoral Nail (PFN) is one of the most commonly used osteosynthesis methods in the surgical treatment of extracapsular hip fractures. PFN has biomechanical advantages, fewer postoperative complications, and good clinical outcomes [1]. Although PFN has superior results in treating hip fractures, some mechanical complications can be troublesome. Mechanical complications such as cut out, femoral shaft fracture at the nail dissection, and Z effect can be seen after PFN [2]. Although improvements in implant design have reduced these complications, they have not been eliminated. Surgical technique is as crucial as implant design in developing these complications. The quality of reduction, Tip apex distance, and placement of the lag screw in the femoral neck are directly related to the complication [3, 4]. While previous studies have explored the outcomes of hip fractures treated with various PFN designs, there remains a notable gap in the literature regarding a comprehensive comparative analysis of the most commonly employed systems. Although some research has compared the results of two or three different PFN designs, to the best of our knowledge, no study has yet evaluated patients treated with the four widely utilized designs: the double delayed screw PFN (DLS-PFN), PFN Antiglide (PFN-A), Talon PFN, and PFN Intertrochanteric Antegrade Nail (PFN-Intertan). This retrospective study aimed to assess the efficacy of surgical treatment using these four distinct PFN designs, focusing on identifying the factors that influence patient outcomes.

Patients and Methods

This retrospective observational cohort study was conducted according to the principles of the Declaration of Helsinki. This study was approved by the authors' IRB (decision date and number: 01/10/2024, 01/025). The study center was the Department of Orthopaedic Surgery of our regional trauma center in a city with a population of more than 1,500,000. A retrospective analysis was performed on data from patients who underwent surgery for an extracapsular hip fracture using a proximal femoral nail between January 1, 2017, and January 1, 2023. We followed the principles of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines in preparing this report.

The inclusion criteria for this study were as follows: patients over 18 years of age who underwent PFN for extracapsular hip fracture and had sufficient file data for at least one year. Patients with pathologic fractures, insufficient follow-up data, and multiple fractures were excluded from the study. In addition, extracapsular hip fractures treated with implants other than PFN and intracapsular fractures treated with PFN were excluded. A flow chart of the study is shown in Figure 1.

The same surgical team performed all procedures. All patients received four weeks of thromboprophylaxis with low-molecular-weight heparin. Preoperatively, patients could ambulate and perform daily activities without assistive devices. Postoperatively, patients were mobilized within 48 hours with partial weight bearing and the assistance of medical care staff.

The clinical evaluation included age, sex, side of the fracture, comorbidities, ASA score, type of anesthesia, operative position, complications, and postoperative blood transfusion. The radiologic evaluation included assessing the patients' pre- and postoperative anteroposterior and lateral hip radiographs by a senior orthopedic specialist blinded to the other patient data. The radiologic assessment assessed fracture type, reduction quality, Cleveland index, Sign index, shaft neck angle, union, type-apex distance, and mechanical complications.

Statistical Analyses

Statistical analyses were performed using SPSS for Windows 25.0 software. The conformity of the variables to normal distribution was examined using visual (histogram and probability graphs) and analytical methods (Kolmogorov-Smirnov/ Shapiro-Wilk tests). A p-value above 0.05 in the Kolmogorov-Simirnov test was accepted as a normal distribution. When normal distribution was not determined, the Kruskal-Wallis test was used for quantitative variables, and the chi-square test was used to compare qualitative variables between the four groups. Qualitative variables were presented as frequency and percentage values.

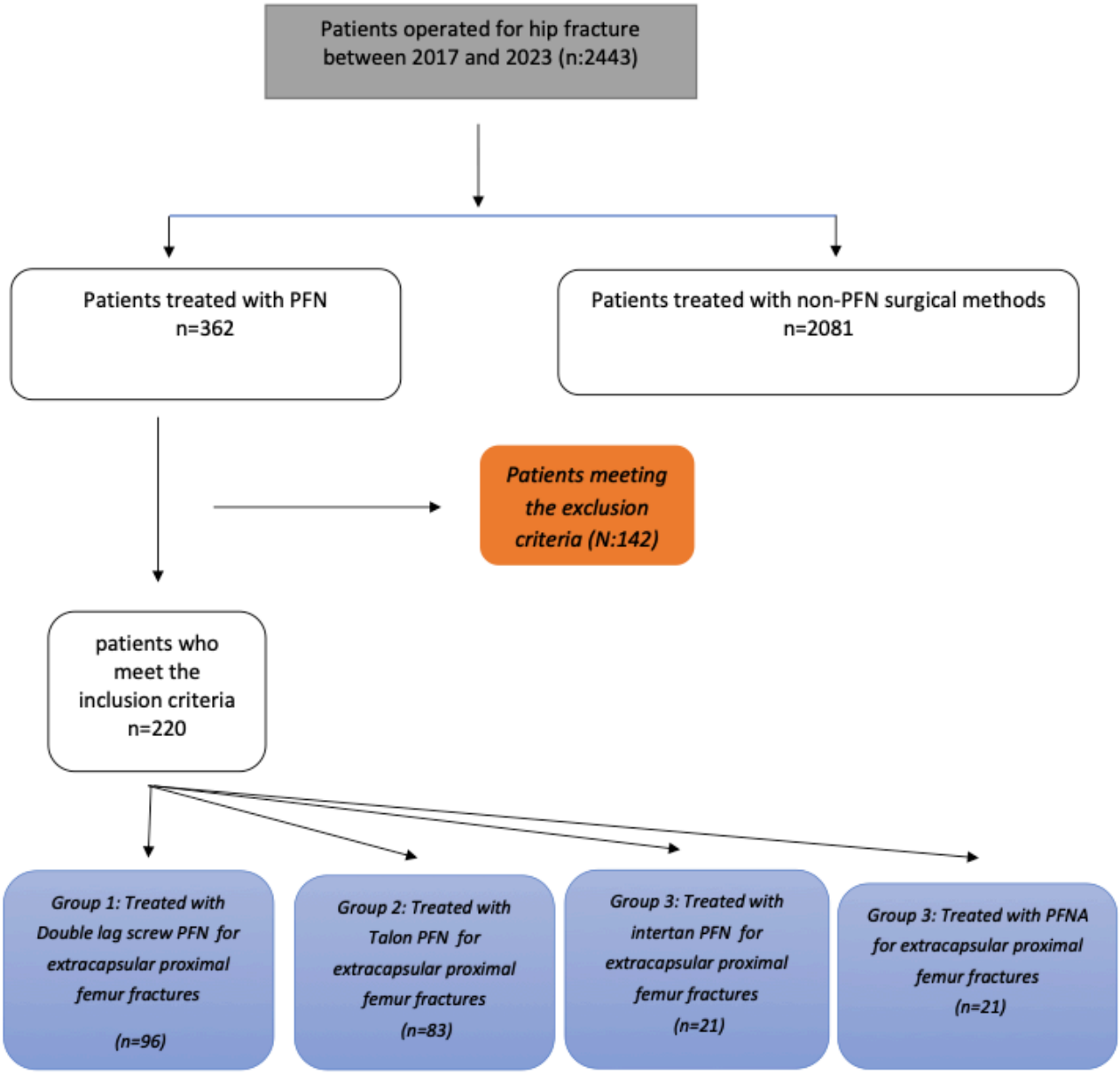

Figure 1. Flowchart of the study

Results

A cohort of 220 patients meeting the inclusion criteria was evaluated. Of these, 138 were female, and 82 were male. Most patients had left-sided fractures (125) compared to those with right-sided fractures (95). The ASA classification system was used to assess the physical status of the patients, with 8.2% classified as ASA 1, 15.5% as ASA 2, 63.2% as ASA 3, and 13.2% as ASA 4.

Patients were categorized according to the type of PFN used: Group 1 consisted of 96 patients, Group 2 had 83 patients, Group 3 had 21 patients, and Group 4 had 20 patients. The general characteristics of the groups are summarized in Table 1.

The groups were similar in terms of age, gender, type of anesthesia, postoperative blood transfusion, and surgical positions.

A comparison of the groups in terms of comorbidities revealed no significant differences.

When the patients were evaluated using the Singh Index, they were found to be similar. Evaluation

of the reduction quality from postoperative radiographs showed no statistically significant difference between the groups, but it was observed that Group 1 had a better reduction. The postoperative diaphysis/neck ratios of patients with similar Cleveland indices were observed to be identical. Additionally, patients in group 3 had a lower type-apex distance. The radiologic union evaluation shows the superiority of group 1. The results of the radiological assessment of the patient are summarized in Table 2.

Table 1. The general characteristics of the groups

	Group 1	Group 2	Group 3	Group 4	p
Age, Median (min-max)	77 (26-98)	74 (31-89)	75 (37-83)	73,5 (57-82)	0.051
Gender Median (%)					
Female	60 (62.5)	49 (59)	13 (61.9)	16 (80)	0.385**
Male	36 (37.5)	34 (41)	8 (38.1)	4 (20)	
Anesthesia n(%)					
General anesthesia	11(11.5)	10(12)	-	-	0.215*
Spinal anesthesia	85(88.5)	73(88)	21(100)	20(100)	
Blood Transfusion unit n(%)					
0	76 (79.29	68 (81.9)	10 (47.69)	12 (60)	0.149*
1	13 (13.5)	13 (15.79)	8 (38.1)	6 (30)	
2	7 (7.3)	2 (2.4)	3 (14.3)	2 (10)	
Surgical Position n(%)					
Supine	41 (42.7)	35 (42.2)	9 (42.9)	10 (50)	0.935*
Lateral Decubitus	55 (57.3)	48 (57.8)	12 (51.1)	10 (50)	
Orthopedic Traction Table	-	-	-	-	

n= number of individuals. * Chi-square test, ** Kruskal–Wallis test.

The distribution of fracture types was evaluated according to the AO classification. The most common fracture type was 31a1.2 (simple intertrochanteric femoral fracture- ITFF), followed by 31a1.3 (two-part ITFF) and 31a2 (multi-part ITFF). Fracture type 31a3 (reverse oblique fracture) was less frequent, with 31b2.3 (basicervical fracture) being the least common.

A significant difference was observed in the distribution of fracture types across the groups, particularly with 31a1.2 fractures, which were more frequent in Group 1 compared to other groups (p = 0.038). The distribution of groups according to AO classification is shown in Table 3.

Table 2. Comorbidities of the groups

Comorbities	Group 1	Group 2	Group 3	Group 4	p value
pulmonary n(%)	21(21.9)	18(21.7)	4(21)	6(20)	0.840*
nephrological n(%)	10(10.4)	10(12	-	-	0.159*
neurological n(%)	9(9.4)	15(18.1)	-	-	0.022*
cardiac n(%)	53(55.2)	46(55.4)	13(61.9)	4(20)	0.02*
DM n(%)	14(14.6)	18(21.7)	4(19)	4(20)	0.665*

n= number of individuals. * Chi-square test, ** Kruskal–Wallis test.

Table 3: AO classification of the patients

Fracture Type	Group	Counts (n)	% of Total
31a1.2	1	11	11.2%
	2	16	16.3%
	3	2	2.0%
	4	4	4.1%
31a1.3	1	11	11.2%
	2	9	9.2%
	3	0	0.0%
	4	3	3.1%
31a2.	1	7	7.1%
	2	6	6.1%
	3	3	3.1%
	4	1	1.0%
31 a3.	1	5	5.1%
	2	3	3.1%
	3	2	2.0%
	4	1	1.0%
31b 2.3	1	7	7.1%
	2	3	3.1%
	3	3	3.1%
	4	1	1.0%

When evaluating the patients' complications, group 1 had the fewest occurrences. Five patients in group 1 had heterotrophic ossification, nine patients in group 2, and two patients in group 3 had fractures. A summary of the complications is given in Table 4.

Table 4. Complications

Complications n(%)	Group 1	Group 2	Group 3	Group 4	p value
None	78(81.2)	57(68.7)	15(71.5)	18(90)	p<0.001*
Cut-out					0.515*
No	83 (85.5)	66(79.5)	17(81)	18(90)	
Yes	13 (13.5)	17(20.5)	4(19)	2(10)	
Heterotrophic Ossification	1(1.1)	1(1.2)	-		p<0.001*
Fracture	-	-	2(9.5)	-	p<0.001*

n= number of individuals. * Chi-square test

Discussion

This study evaluated the radiologic outcomes and complications of patients undergoing extracapsular hip fracture surgery with four different PFN implant designs. The results of the study indicate that patients treated with double lag screws have better fracture reduction, fewer complications, and less nonunion.

A study comparing PFN and PFNA radiologically and clinically reported that PFN had less operative time, less blood loss, fewer complications, and better clinical outcomes than PFNA [5]. The study results indicate that the PFN with the double lag screw design had fewer complications, fewer cases of nonunions, and less need for post-operative blood transfusion. Our work was conducted in parallel with this study. A comparative study between PFN and PFNA with double lag screws found conflicting results: PFNA was associated with fewer complications and less blood loss. Additionally, PFNA was superior regarding radiation exposure during the application, application time, and learning curve [6]. However, the results should be considered inconclusive due to the small sample size. A comparable study of 30 patients likewise demonstrated reduced surgical time, diminished blood loss, and a relatively lower incidence of complications with PFNA in comparison to PFN with double lag screw [7].

A study comparing the efficacy of Talon and Intertan PFN revealed that while both methods resulted in successful fixation, Talon PFN exhibited more excellent stability. However, it was noted that Talon PFN also demonstrated the advantage of reduced surgical time and fluoroscopy exposure [8].

In a study comparing Talon-PFN, Intertan, and double lag screw PFN designs, all three were found to be successful in surgeries [9]. The most notable finding of this study was that better reduction was achieved in surgeries performed with the double lag screw PFN. Similarly, in our research, it was observed that double lag screw PFN provides better reduction. This is attributed to the necessity of sound reduction to be able to place two lag screws in the femoral neck. We also have the same opinion on this matter. We have the same view on this matter. More effort put into reduction results in longer surgical time increased bleeding, and radiation exposure. In their study, Yalın et al. compared three PFN designs: A-PFN, Intertan, and double lag screw PFN. The results showed that A-PFN had the worst outcomes. The results showed that A-PFN had the worst outcomes, while Intertan and double lag screw PFN had similar results [10]. In a meta-analysis comparing different PFN implant systems, it was found that the helical blade (PFNA) was not superior to screw systems, and long nails were not superior to short nails in terms of fixation stability and reoperation rates. However, the use of double lag screw systems resulted in lower rates of fixation failure and reoperation [11].

In our study, the most common complication was cut out. Cut-out rates ranging from 10-20% were observed depending on the implant design. These rates are consistent with the 3-18% cut-out rates reported in the literature [12, 13]. The lower cut-out rate in group 1 may be associated with a better reduction in those patients. However, the reliability of the low cut-out data in group 4 could be better due to the small sample size of only 20 patients.

The Z effect is a complication that can arise in PFN designs with double lag screws. It is characterized by the medial migration of the inferior and proximal lag screws and is closely related to the implant design [14]. In our study, we did not observe a Z-effect in any patient, possibly because all four nails used the locking mechanism of the locking screw to the blade.

One limitation of our study is its retrospective nature. Additionally, an unbalanced number of patients in groups 3 and 4 may affect the results.

Furthermore, we did not analyze the patients' clinical conditions before and after the fracture and surgery, which is another study limitation.

Conclusion

In conclusion, the results of this study indicate that the use of double lag screws in PFN implants is associated with superior fracture reduction, fewer complications, and a lower incidence of nonunion. Biomechanical studies and prospective randomized clinical trials are needed to understand this issue better.

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