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RESEARCH ARTICLE

Pertrochanteric Femur Fractures in Adults Younger Than 65: A Retrospective Analysis of Outcomes After Proximal Femoral Nailing

Altmış Beş Yaşından Küçük Erişkinlerde Pertrokanterik Femur Kırıkları: Proksimal Femur Çivileme Sonrası Sonuçların Retrospektif Analizi

 Murat Tasci¹,  Furkan Ucar¹,  Ozkan Ozturk¹,  Savas Camur¹

¹Umranıye Training and Research Hospital, Department of Orthopaedics and Traumatology, Istanbul, Türkiye

ABSTRACT

Objective: This study aimed to evaluate fracture healing patterns and factors affecting outcomes in patients under 65 years of age who were treated with proximal femoral nail (PFN) fixation for pertrochanteric femur fractures.

Materials and Methods: A retrospective analysis was conducted on 158 patients under 65 years of age treated with PFN fixation between 2013 and 2024. Demographic data, trauma mechanisms, fracture classifications, reduction quality, bone quality, presence of femoroacetabular impingement (FAI), osteoarthritis progression, and complication rates were evaluated.

Results: The mean age was 51.1 years and 63.3% of the patients were male. High-energy trauma was the leading mechanism (43%), particularly in male patients ($p<0.01$). Good reduction quality was significantly associated with earlier mobilization ($p<0.05$). FAI lesions were present in 39.9% of patients, and cam- or pincer-type FAI was more frequently associated with low-energy trauma ($p=0.06$). Osteoarthritis progression was observed in 35.4% of patients, but no significant associations were found with reduction quality, bone quality, or the presence of coxa valga. The complication rate was 24.1%, with heterotopic ossification being the most common type of complication. Smoking was significantly associated with delayed healing ($p<0.05$).

Conclusions: Pertrochanteric femur fractures in patients younger than 65 are more commonly associated with high-energy trauma and occur more frequently in male individuals. Reduction quality was significantly associated with earlier mobilization. Although preoperative FAI was more frequently observed in patients with low-energy trauma, the association was not statistically significant. These findings highlight the importance of fracture characteristics and reduction quality for functional recovery in younger patients.

Keywords: Pertrochanteric femur fracture, proximal femoral nail, young adult, femoroacetabular impingement

ÖZET

Amaç: Bu çalışmanın amacı, pertrokanterik femur kırığı nedeniyle proksimal femoral çivi (PFN) ile tedavi edilen 65 yaş altı hastalarda kırık kaynama paternlerini ve klinik sonuçları etkileyen faktörleri değerlendirmektir.

Gereç ve Yöntemler: 2013–2024 yılları arasında PFN ile tedavi edilen 65 yaş altı 158 hasta retrospektif olarak incelendi. Hastaların demografik verileri, travma mekanizması, kırık sınıflaması, redüksiyon kalitesi, kemik kalitesi, femoroasetabular impingement (FAI) varlığı, osteoartrit progresyonu ve komplikasyon oranları değerlendirildi.

Bulgular: Hastaların ortalama yaşı 51.1 yıl olup, %63.3'ü erkekti. En sık travma mekanizması yüksek enerjili travma (%43) olup, özellikle erkek hastalarda daha sık görüldü ($p<0.01$). Ortalama kırık kaynama süresi 2.3 ay olarak saptandı. İyi redüksiyon kalitesi, erken mobilizasyon ile anlamlı olarak ilişkiliydi ($p<0.05$). Hastaların %39.9'unda FAI lezyonu mevcuttu ve cam veya pincer tipi FAI'nin düşük enerjili travma ile daha sık ilişkili olduğu görüldü ($p=0.06$). Osteoartrit progresyonu hastaların %35.4'ünde izlenmiş olup; redüksiyon kalitesi, kemik kalitesi veya coxa valga varlığı ile anlamlı bir ilişki saptanmadı. Komplikasyon oranı %24.1 olup, en sık görülen komplikasyon heterotopik ossifikasyondur. Sigara kullanımı gecikmiş kaynama ile anlamlı olarak ilişkili bulundu ($p<0.05$).

Sonuçlar: 65 yaş altı hastalarda pertrokanterik femur kırıkları daha sıklıkla yüksek enerjili travma ile ilişkilidir ve erkeklerde daha sık görülür. Redüksiyon kalitesi, daha erken mobilizasyon ile anlamlı derecede ilişkiliydi. Ameliyat öncesi FAI düşük enerjili travma geçiren hastalarda daha sık gözlemlenmiş olsa da, bu ilişki istatistiksel olarak anlamlı değildi. Bu bulgular, genç hastalarda fonksiyonel iyileşmede kırık özelliklerinin ve redüksiyon kalitesinin önemini vurgulamaktadır.

Anahtar Kelimeler: Pertrokanterik femur kırığı, proksimal femoral çivi, genç yetişkin, femoroasetabüler sıkışma

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Corresponding Author: Murat Tasci, Umranıye Training and Research Hospital, Department of Orthopaedics and Traumatology, Istanbul, Türkiye.
e-mail: drtascimurat@gmail.com

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INTRODUCTION

Hip fracture is a serious public health issue, causing disability in more than four million individuals annually. Approximately half of these fractures occur in the trochanteric region (1,2). The incidence varies according to bone quality, the morphological characteristics of the bone, and age (3). Since individuals between the ages of 70 and 80 years are at highest risk, studies in the literature have primarily focused on pertrochanteric fractures in the elderly population (4). In these patients, various complications may occur due to the quality of reduction, comorbidities, and smoking habits, which in turn affect remobilization and the healing duration of the fracture (5).

As nearly all studies in the literature focus on the elderly population, we have not encountered previous research analyzing pertrochanteric fractures in younger populations. The aim of this study is to examine the healing patterns of fractures in patients under the age of 65 who were treated with proximal femoral nail (PFN) fixation due to pertrochanteric fracture and to identify the factors influencing those patterns.

MATERIALS AND METHODS

Patients under the age of 65 diagnosed with pertrochanteric fractures between 2013 and 2024, who had at least 6 months of follow-up and were treated with PFN fixation, were included in this study. Patients with pathological fractures, insufficient follow-up duration, missing data, preoperative immobility, previous surgery on the contralateral hip, or hip joint conditions such as Perthes disease or developmental dysplasia were excluded.

The study was approved by the institutional ethics committee and all procedures were conducted in accordance with the Declaration of Helsinki. Informed consent for the academic use of clinical data was obtained from all patients at the time of hospitalization. Demographic data were recorded for all patients. Mechanisms of trauma were categorized into two groups: simple falls from the same level and high-energy trauma. Fractures were confirmed via radiographs and classified according to the Arbeitsgemeinschaft für Osteosynthesefragen (AO) classification. The quality of reduction was graded based on the Baumgartner criteria (6). The degree of osteoporosis in the contralateral hip was assessed using the Singh index. Bone mineral density was primarily assessed from radiographs using the Singh index. Dual-energy X-ray absorptiometry (DEXA) measurements were not routinely available for all patients due to the retrospective nature of the study. Therefore, DEXA data were analyzed only for patients for whom prior measurements were available. The collodiaphyseal angle and center-edge angle (CEA) of the contralateral hip were measured. The presence and type of femoroacetabular impingement (FAI), as well as the presence or progression of osteoarthritis in the fractured hip, were evaluated preoperatively and at the final follow-up according to the Kellgren–Lawrence classification. FAI was evaluated using preoperative and postoperative anteroposterior and lateral hip radiographs. Cam-type FAI was identified by the asphericity of the femoral head–neck

junction, while pincer-type FAI was defined by radiographic signs of acetabular overcoverage. Osteoarthritis progression was evaluated using the Kellgren–Lawrence classification by comparing radiographs obtained at the time of fracture with those at the final follow-up visit. Progression was defined as an increase in Kellgren–Lawrence grade between baseline and the last available radiographic assessment. Follow-up duration was not standardized across patients, and all available final follow-up radiographs were used for analysis.

In cases of ambiguity in radiographic interpretation, all images were independently reviewed by two authors and a consensus was reached through joint evaluation. All surgical procedures were performed by experienced orthopedic surgeons within the same clinic. A single type of PFN was used for all patients. Data on complications during follow-up, comorbidities, smoking status, the season in which the trauma occurred, time to unsupported mobilization, Charlson Comorbidity Index (CCI) (7), and fracture healing time were also recorded. Healing was defined radiographically by callus formation or clinically by the patient's ability to mobilize without support and the absence of hip pain during movement. Comorbidities were categorized as follows: Group 1 included patients without any comorbid conditions; Group 2 included patients with systemic diseases such as hypertension, diabetes, or heart failure; Group 3 included patients with neurological diseases such as multiple sclerosis, cerebrovascular events, or Parkinson's disease; and Group 4 included patients with other conditions not fitting the previous categories, such as hypo/hyperthyroidism.

Statistical Analyses

Data were analyzed using IBM SPSS Statistics 22.0 (IBM Corp., Armonk, NY, USA). Chi-square tests were conducted to assess qualitative parameters. Parametric variables were compared using Student's t-test, while non-parametric variables were analyzed using the Mann–Whitney U test or Kruskal–Wallis test as appropriate. Spearman's correlation coefficient was employed to assess relationships between quantitative variables, while Pearson's correlation coefficient was utilized to evaluate associations among categorical variables. A value of 1 signifies a perfect positive correlation, whereas a value of -1 indicates a perfect negative correlation. Quantitative variables were expressed as mean $\pm$ standard deviation and minimum and maximum values. Qualitative variables were expressed as frequencies or ratios. Values of $p < 0.05$ were accepted as indicating statistical significance.

RESULTS

A total of 158 patients were included in this study, comprising 58 female patients (36.7%) and 100 male patients (63.3%). The mean age of all patients was 51.1 years (range: 17–65); the mean age was 55 years for female patients and 48.8 years for male patients. The mean follow-up duration was 20.8 months. The mean time to union was 2.3 months (range: 1–16). The distribution of patients according to the AO classification is presented in Table 1. Seasonal distribution analysis revealed that 25.3% of the fractures occurred in winter, 20.9% in spring,

Table 1. Number of patients in AO classification groups

AO classification	n (%)
3A11	5 (3%)
3A12	25 (15%)
3A13	9 (5%)
3A21	8 (5%)
3A22	38 (24%)
3A23	22 (13%)
3A31	20 (12%)
3A32	10 (6%)
3A33	21 (13%)

Table 2. Patient characteristics and FAI findings

Parameter	Category	Number of patients
FAI lesions	No lesion	95
FAI lesions	Pincer-type	31
FAI lesions	Cam-type	32
Smoking status	Non-smoker	89
Smoking status	Smoker	69
DEXA results (n=35)	Osteopenia	19
DEXA results (n=35)	Osteoporosis	16

Table 3. Comorbidity distribution

Comorbidity category	n (%)
No comorbidities	72 (45.5%)
Systemic diseases *	58 (36.7%)
Neurological diseases **	14 (8.9%)
Others	14 (8.9%)

*: Hypertension, diabetes mellitus, heart failure

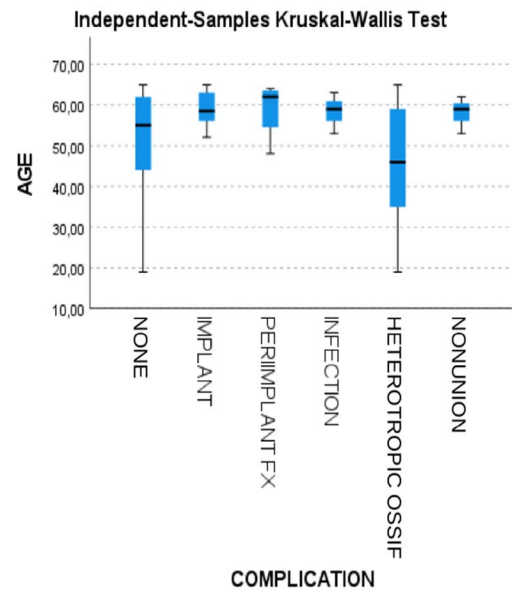
**: Cerebrovascular events, multiple sclerosis, Parkinson's disease

Table 4. Complication rates

Complication type	n (%)
No complications	120 (75.9%)
Screw-related complications	6 (3.8%)
Peri-implant fractures	4 (2.5%)
Wound drainage or infection	3 (1.9%)
Heterotopic ossification	22 (13.9%)
Nonunion	3 (1.9%)

32.9% in summer, and 20.9% in autumn. Ninety patients (57%) sustained fractures due to low-energy trauma (simple falls), while 68 patients (43%) sustained high-energy trauma.

The distribution of FAI types, smoking status, and bone mineral density findings are summarized in Table 2. The distribution of patient comorbidities is summarized in Table 3. The mean collodiaphyseal angle was 137.9° (range: 123–156°) and the mean CEA was 42.6° (range: 21.5–67.5°). The mean time to unsupported mobilization was 2.3 months (range: 1–12 months). The encountered complications are shown in Table 4. No complications were observed in 120 patients (75.9%). Coxa valga was present in 62 patients (39.2%). All complications except heterotopic ossification were observed in patients aged


Figure 1. Relationship between age and complications

50 years or older (Figure 1). Comparing trauma mechanisms by gender, it was observed that 22% of female patients experienced high-energy trauma compared to 55% of male patients. This difference was statistically significant (chi-square test, $p < 0.001$) (Figure 2). Analyzing the relationship between trauma mechanism and age, the mean age of patients who sustained injuries from simple falls was found to be 57 years, while the mean age of those who sustained high-energy trauma was 43 years, and this difference was statistically significant (Mann–Whitney U test, $p < 0.001$).

When trauma mechanisms were analyzed according to FAI type, low-energy trauma was observed in 48 patients (50%)

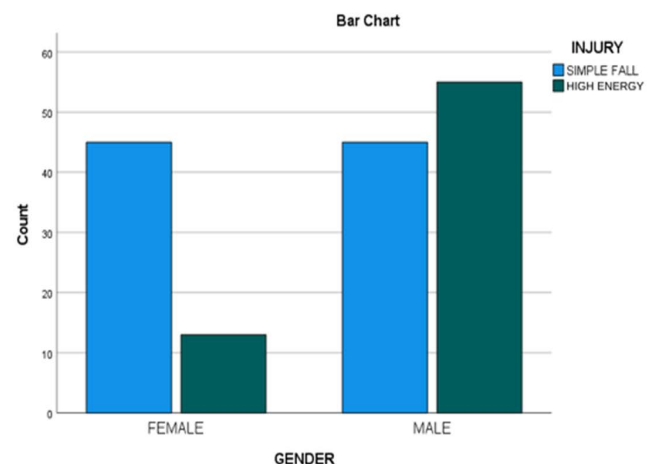

Figure 2. Relationship between gender and trauma mechanism

Table 5. Relationship between Singh index grade and trauma mechanism

Singh index grade	Low-energy trauma, n (%)	High-energy trauma, n (%)	Total	p
Grade 1	6 (75%)	2 (25%)	8	<0.050
Grade 2	22 (88%)	3 (12%)	25	
Grade 3	22 (66%)	11 (33%)	33	
Grade 4	36 (56%)	28 (43%)	64	
Grade 5	4 (14%)	24 (85%)	28	
Total	90	68	158	

Table 6. Factors associated with osteoarthritis (OA) progression

Variable	OA progression, n (%)	No OA progression, n (%)	p
Overall	56 (35.4%)	102 (64.6%)	—
Coxa valga			0.990
Present	35.5%	64.5%	
Absent	35.4%	64.6%	
Reduction quality			0.291
Good	28 (50%)	64 (62%)	
Moderate	27 (48%)	37 (36%)	
Poor	1 (2%)	1 (2%)	
Singh index grade			0.729
Grade 1	4 (7%)	4 (3%)	
Grade 2	7 (12%)	18 (17%)	
Grade 3	10 (17%)	23 (22%)	
Grade 4	25 (44%)	39 (38%)	
Grade 5	10 (17%)	18 (17%)	

without FAI, 23 patients (74%) with pincer-type FAI, and 19 patients (59%) with cam-type FAI, whereas high-energy trauma occurred in 47, 8, and 13 patients, respectively. No statistically significant association was found between trauma mechanism and FAI type (chi-square test, $p=0.060$).

Low-energy trauma occurred in 75% of patients with Singh grade 1, 88% with grade 2, 66% with grade 3, 56% with grade 4, and 14% with grade 5 bone quality. Thus, a statistically significant association was found between Singh index grade and trauma mechanism (chi-square test, $p<0.050$), with lower Singh grades being more frequently associated with low-energy trauma (Table 5). According to the Baumgartner classification, 92 patients had good reduction, 64 had moderate reduction, and 2 had poor reduction. Time to mobilization differed significantly among the reduction quality groups (Kruskal–Wallis test, $p<0.001$). Patients with good reduction experienced the shortest mobilization time (mean rank: 63.24), followed by those with moderate reduction (mean rank: 101.43) and poor reduction (mean rank: 125.50), respectively. The mean time to union was 1.98 ± 1.03 months for non-smokers and 2.93 ± 2.24 months for smokers, reflecting a significantly prolonged healing time among smokers (Mann–Whitney U test, $p=0.002$).

Regarding postoperative changes in osteoarthritis, 56 patients (35.4%) demonstrated progression in osteoarthritic grading. Osteoarthritis progression occurred in 35.5% of patients with coxa valga and 35.4% without coxa valga; thus, no significant association was detected (chi-square test,

$p=0.990$) (Table 6). Osteoarthritis progression occurred in 28 patients (50%) with good reduction, 27 patients (48%) with moderate reduction, and one patient (2%) with poor reduction. No statistically significant association was found between reduction quality and osteoarthritis progression (chi-square test, $p=0.291$) (Table 6). However, osteoarthritis progression was numerically more frequent in patients with moderate or poor reduction. No statistically significant association was found between Singh index grade and osteoarthritis progression (chi-square test, $p=0.729$) (Table 6). Similarly, CCI scores did not differ significantly between patients with and without osteoarthritis progression (mean ranks: 74.95 vs. 82.00; Mann–Whitney U test, $p=0.344$).

When the relationship between complications and the Singh index was evaluated, no statistically significant difference was found (chi-square test, $p=0.478$). No complications occurred in 59% of patients with high Singh grades (grades 4 and 5) and 41% of patients with low Singh grades (grades 1, 2, or 3). Similarly, when complications were compared according to CCI scores, no statistically significant difference was found (Mann–Whitney U test, $p=0.118$), although numerically higher CCI scores were observed in patients with complications. No significant correlation was found between CCI and time to mobilization (Spearman's rho test, $p=0.673$).

DISCUSSION

While pertrochanteric femoral fractures are a particularly significant health issue in the elderly population, they are also

an important cause of disability in younger individuals. These fractures have been extensively evaluated in patients over the age of 65, but studies focusing exclusively on younger populations while excluding elderly patients, and particularly studies investigating healing outcomes and associated factors, remain limited in the literature (4). In the elderly, low-energy traumas such as simple falls are the most common mechanisms of injury, whereas in younger individuals, high-energy traumas are predominant. The high rate of high-energy trauma cases observed in the present study is attributable to the fact that the study population consisted of younger patients. Furthermore, although many studies have shown that pertrochanteric femoral fractures are more common in women, the majority of our patients were men (8,9). This may be due to the overlap of the higher involvement of men in high-energy activities and the predominance of high-energy trauma mechanisms in the younger population. Seasonal analysis of fracture occurrence in this study revealed a higher incidence during the summer months. In contrast, studies focusing on elderly patients frequently report peak incidence during the winter months (9). Our findings suggest a different seasonal pattern in the younger population, which may provide useful insight for the planning of preventive measures and healthcare resource allocation (10).

In the literature to date, osteoarthritis progression has not been extensively evaluated in younger patients with pertrochanteric fractures. In our study, no significant associations were found, which may be related to the study's relatively short and heterogeneous follow-up durations. Although no significant association was found between Singh index and osteoarthritis progression in this study, bone quality is known to play an important role in fracture characteristics and clinical outcomes. The lack of association in our study may again be related to the relatively short and heterogeneous follow-up durations. Although many studies have explored the association between FAI and femoral neck fractures, the relationship between FAI and pertrochanteric fractures has not been clearly defined (11,12). In the present study, low-energy trauma was more frequently observed in patients with FAI, but this difference did not reach the level of statistical significance. Backer et al. reported a mean CEA of 43° in patients with pertrochanteric fractures and noted the presence of underlying osteoarthritis in such cases (12). Similarly, our study showed a mean CEA of 42.6°, with 62% of patients demonstrating grade 2 or 3 osteoarthritis according to the Kellgren–Lawrence classification.

Consistent with other studies (8,9), the average age of female patients was higher than that of male patients in this study. The mean time to postoperative mobilization in our study was 2.3 months, and this was found to be significantly associated with reduction quality according to the Baumgartner classification. In a study by Schneider et al., the average CCI score was found to be higher in patients without complications (13). In contrast, our findings showed that, excluding heterotopic ossification, patients who developed complications had a numerically higher mean CCI score ($p=0.1$), suggesting that increasing CCI

scores may be associated with a greater risk of complications in younger patients.

Study Limitations

We acknowledge several limitations of this study. Preoperative radiographs were obtained in the emergency department, and due to fracture-related pain, standard pelvic radiographs could not always be achieved. Since not all types of hip fractures were included, results pertaining to other fracture types could not be provided. The relatively small sample size and retrospective design constitute further limitations of our study. Another limitation of this study is the lack of formal intra- and interobserver reliability analysis for radiographic measurements. Evaluations were performed independently by two experienced observers. Although these evaluations were finalized by consensus between the observers, the absence of reliability testing may have affected the reproducibility of the findings.

Furthermore, osteoarthritis progression was assessed in this study based on comparisons between baseline and final follow-up radiographs without standardized follow-up intervals. Given that osteoarthritis is a time-dependent process, longer and more uniform follow-up periods would be necessary for more accurate evaluations of disease progression.

CONCLUSION

Pertrochanteric femoral fractures are known to be a significant cause of morbidity and mortality in elderly populations. Evaluating these fractures in a younger patient cohort, we identified both similarities to the elderly patient population and distinct factors affecting treatment outcomes for younger patients. We found that this fracture type was more commonly observed in men within the younger population and was predominantly caused by high-energy trauma. Moreover, we demonstrated that the presence of preoperative FAI was associated with an increased incidence of fractures resulting from low-energy trauma.

DECLARATIONS

Conflict of Interest: The authors declare that they have no competing interests.

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Address correspondence to: Murat Taşçı, Umraniye Training and Research Hospital, Department of Orthopaedics and Traumatology, Istanbul, Türkiye.

e-mail: drtascimurat@gmail.com

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