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Evaluation of Variables Influencing Mortality in Periprosthetic Femur Fractures: Do Fracture Type and Surgical Method Affect Mortality?

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ABSTRACT

Introduction: We investigated the factors influencing mortality in patients with periprosthetic femur fractures (PFF). Our aim was to assess the effects of fracture types and treatment methods on mortality.

Methods: We identified 52 patients who met the inclusion criteria and underwent surgery for PFF between January 1996 and December 2020. Patient records were analyzed retrospectively to collect reports on patient demographics, hospitalization, and surgical details. The following parameters were assessed: age, sex, side, time to PFF, surgical procedure, fracture pattern, and American Society of Anesthesiologists Classification. The Vancouver classification was used to identify fracture patterns.

Results: The mean age was 73.6±13.5 years. Average of 5 years elapsed until PFF (range, one month to twenty years). Open reduction and internal fixation were performed in 61.5% of the patients, and revision arthroplasty was performed in 38.5%. Significant differences were found between patients' ages (p=0.033) and fracture types (p<0.001). The overall 30-day and 12-month mortality rates were 19.2%, and the 12-month mortality was 36.5%. The survival time of those who underwent surgical osteosynthesis was significantly longer than that of those who underwent revision arthroplasty (p=0.048). The risk of mortality for fracture classification B1 was higher than that for type A [odds ratio (OR): 6.93; confidence interval (CI): 95% (1.16-41.09) p=0.033], and the risk of mortality for fracture type B3 was higher than that for type A [OR: 16.75; CI: 95% (1.12-248.45) p=0.041].

Conclusion: The surgical method and type of fracture affected mortality. Mortality was higher among patients who underwent revision arthroplasty and had Vancouver type B3 fractures.

Keywords: Periprosthetic femur fractures, mortality, Vancouver classification, osteosynthesis, arthroplasty

Introduction

Major joint arthroplasty is one of the most popular and effective orthopedic surgeries, and its demand is increasing worldwide according to all relevant registries. The aging populations, which are projected to live longer, the broadening of indications for replacement surgery in younger populations, and the desire for a better quality of life and increased activity levels are all contributing factors to this trend (1-3).

The incidence of periprosthetic femur fractures (PFF) related to hip replacement has increased over time. This increase in prevalence may be due to several factors, including the increasing number of patients requiring arthroplasty, the growing number of elderly individuals with osteoporosis, the preference for cementless fixation techniques that emphasize the use of oversized press-fit implants, and recent advancements in surgical techniques that minimize surgical exposure. Furthermore, the prevalence of PFFs is expected to continue to increase by 4.6% every decade until 2045 (4,5). The incidence of PFF varies, with some reports stating that it occurs in 1% of primary hip arthroplasty cases and 4% of revision cases (6). After total hip arthroplasty (THA), PFFs are the third most common cause of revision (7).

Periprosthetic fractures are linked to high mortality rates. In a recent study, periprosthetic hip fractures were found to carry a similar mortality risk to that of femoral neck fractures in elderly patients. However, the risk appears to decrease after the first six months following surgery, with a reported 1-year mortality rate of 9.7% (8). Another study found that the overall complication rate for PFFs within 30 days after surgery was 45% (22% serious and 13% mild), with a 30-day mortality rate of 10% (9).

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Periprosthetic fractures are complex issues that require in-depth knowledge for prevention, recognition, and treatment. PFFs present a surgical challenge for orthopedic surgeons and require advanced trauma and arthroplasty skills. The Vancouver classification system, which serves as a management framework, is still frequently used and preferred. It classifies postoperative PFF according to the site of the fracture, implant stability, and quality of the surrounding bone (10).

We aimed to investigate the variables influencing mortality in patients with PFF. The objective of this study was to assess the impact of fracture types and treatment methods on patient mortality. A comparative analysis was performed to evaluate mortality rates between patients with PFF who underwent revision arthroplasty and those who received open reduction and internal fixation treatment. Additionally, the effects of various fracture types on mortality were thoroughly examined.

Methods

Study Design

We received approval to conduct this study from University of Health Sciences Turkey, İstanbul Training and Research Hospital Institutional Review Board (approval number: 39, date: 28.01.2022). All procedures were performed in accordance with the Helsinki Declaration and institutional and national ethical guidelines for human experimentation (11). Informed consent was obtained from each participant included in the study. The research was conducted in a single trauma unit.

By searching our trauma database and billing information, we identified individuals who had undergone surgical treatment for a PFF following uncemented THA and uncemented hemiarthroplasty. Surgical and anesthetic procedures were essentially the same in all patients. The rehabilitation program was tailored specifically for each patient, with the rehabilitation process being supervised by a physical therapy and rehabilitation specialist, as well as a specialist physiotherapist. The approach was based on fracture type and patient characteristics.

Patients with intraoperative fractures, prosthesis infections, high-velocity trauma, metastatic diseases, metabolic bone diseases other than osteoporosis, non-union at presentation, and those treated conservatively were excluded. All injuries were caused by low-energy trauma, typically resulting from falling from one's own height.

We identified 52 patients who met the inclusion criteria and underwent surgery for PFF between January 1996 and December 2020.

We retrospectively analyzed patient records to collect information on patient demographics, hospitalization, and surgical details. The collected parameters included age, sex, side, time to PFF, surgical procedure, fracture pattern, and American Society of Anesthesiologists Classification (ASA).

The Vancouver classification was used to identify fracture patterns. The appropriate treatment was determined by the operating surgeon, who considered the patient's condition during surgery and the Vancouver classification. Fractures with stable and well-fixed implants were treated with open reduction and internal fixation, whereas those with loose stems were revised (10).

Patients were invited to our outpatient clinic for follow-up. Those unable to visit our hospital completed the questionnaires via telephone. Information on deaths was obtained from hospital records, and relatives were contacted to determine the time of death for deceased patients.

Statistical Analysis

Statistical analyses were conducted using SPSS version 23.0. The normality of variables was assessed using histograms and the Kolmogorov-Smirnov/Shapiro-Wilk test. Descriptive analyses were performed using mean, standard deviation, and median values. The independent two samples test was used to evaluate normally distributed (parametric) variables between the two groups, while the Mann-Whitney U test was utilized to evaluate non-normally distributed (non-parametric) variables between the two groups.

For categorical variables, frequency and percentage values were used, and their analysis was performed with the chi-square (exact) test. Kaplan-Meier analysis was performed to determine differences in patients' life spans according to variable groups. Logistic regression analysis was used to investigate the impact of variables on survival. Odds ratios (OR) were calculated with 95% confidence intervals, and p-values 0.05 were considered statistically significant.

Results

Of the 52 patients included in the study, 40 (76.9%) were female and 12 (23.1%) were male. The mean age was 73.6±13.5 (48-102) years. Twenty-five patients had fractures on the right side, whereas 27 had fractures on the left. Regarding prosthesis type, 19 (36.5%) patients had un-cemented hemiarthroplasty (F40 stem, Zimmer-Biomet, Warsaw, Indiana), and 33 (63.5%) had non-cemented THA (F40 stem, Zimmer-Biomet, Warsaw, Indiana; CLS-Spotorno stems, Zimmer, Germany; Synergy stem, Smith & Nephew, Memphis, Tenn) with an average period of 5 years until PFF (range, one month to twenty years). All patients experienced PFF after a simple fall or low-energy trauma.

Open reduction and internal fixation with a single plate (locking plate, TST, İstanbul, Turkey; cable and/or trochanteric claw plate, Cable-ready, Zimmer Biomet, Warsaw, Indiana) was performed in 32 (61.5%) patients, while revision arthroplasty (Arcos stem, Zimmer Biomet, Warsaw, Indiana) was performed in 20 (38.5%).

The complications included two sacral pressure ulcers, four heel pressure ulcers, and five superficial surgical wound infections. Eight patients required intraoperative blood transfusions.

Of the patients, four (7.7%) were classified as ASA 2, 27 (51.9%) as ASA 3, and 21 (40.4%) as ASA 4. The majority of fractures were Vancouver B1 type (23 patients). Five (9.6%) patients had B2 fractures, eight (15.4%) had B3 fractures, and 16 (30.8%) had type Ag fractures. A total of 35 (67.3%) patients died and 17 (32.7%) survived, with a mean survival time of 20.9±23.9 months.

The comparison of variables according to surgical technique is summarized in Table 1. As a result of this evaluation, significant differences were identified between patients' ages ($p=0.033$) and fracture types ($p<0.001$). Patients who underwent revision arthroplasty were older than those who underwent internal fixation.

Surgical treatment was performed for type A fractures with significant displacement to avoid non-union and related complications. Osteosynthesis was performed in 11 (34.4%) patients with type A fractures, and revision arthroplasty was performed in 5 (25.0%) patients, which were found to have insufficient intraoperative prosthesis stability.

Osteosynthesis was performed in 21 (65.6%) patients with type B1 fractures, and revision arthroplasty was performed in 2 (10%) patients for whom osteosynthesis was not possible due to poor bone quality. Revision arthroplasty was performed in all patients with type B2 and B3 fractures. According to the statistical evaluation, osteosynthesis was performed more frequently than revision arthroplasty in B1-type fractures, and this difference was found to be statistically significant (p<0.001). Additionally, although there was no statistical difference between the groups, the survival time was 26.7 months in the osteosynthesis group and 13.3 months in the revision group (p=0.093). Although the difference was not significant, patients who underwent osteosynthesis had a longer survival time (Table 1).

The relationship between survival and variables is summarized in Table 2. Age, prosthesis type, and ASA levels differed significantly according to survival. The mean age of patients who died was significantly higher (p=0.002). The PFF rate after hemiarthroplasty was significantly higher among patients who died, whereas that after THA was significantly lower (p=0.01). No deaths were observed during follow-up among patients with ASA class 2. However, the mortality rate was significantly higher in patients with ASA class 4 (p=0.003). Of the 17 surviving patients, osteosynthesis was performed in 12 and prosthesis was applied in 5, with survival rates of 70.6% and 29.4%, respectively. Osteosynthesis was performed in 20 (57.1%) patients, and revision arthroplasty was performed in 15 (42.9%) of the 35 deceased patients. Although osteosynthesis was performed more frequently in surviving patients, no significant difference was found in the results (p=0.350) (Table 2).

Survival time was evaluated in the groups using the Kaplan-Meier (log-rank) test. The results are presented in Table 3. No significant difference was found between patient survival times in terms of gender (p=0.618). Similarly, survival times were similar for the fracture side (p=0.971). However, the survival time of patients who underwent surgical osteosynthesis was significantly longer than that of patients who underwent revision arthroplasty (p=0.048). The median survival time for those who underwent surgical intervention for osteosynthesis was 52 months, whereas that for revision arthroplasty was 5 months. The median survival time for those with PFF after THA was 52 months, which is a significantly higher life expectancy compared with hemiarthroplasty (p=0.002). Unfortunately, the median survival time was only 6 months for patients treated with PFF after hemiarthroplasty. According to the fracture classification, the mean survival time was 44.9 months. Life expectancy was higher among patients with type A fractures. The life expectancy of type A fractures was 67.3 months, which was higher than that of other types of fractures (p=0.006). No statistics could be calculated when the survival analysis was performed for the ASA group, as all cases were censored. However, there was a difference in survival between the ASA categories (p=0.006) (Table 3).

Upon examining the survival curves, the overall 30-day mortality rate was 19.2% (10/52), 36.5% at 6 months (19/52), and at 12 months, mortality was 36.5% (19/52).

Table 1. Comparison of variables according to surgical technique

Parameters		The type of surgery		p
		Open reduction and internal fixation, (n=32)	**Revision arthroplasty, (n=20)**	
Gender	Female	26 (81.3%)	14 (70%)	0.349
	Male	6 (18.8%)	6 (30%)	
Age (mean ± SD) (years)		70.5±14.4	78.7±10.3	**0.033**[a]
Side	R	16 (50.0%)	9 (45.0%)	0.726
	L	16 (50.0%)	11 (55.0%)	
The type of prosthesis	Hemiarthroplasty	11 (34.4%)	8 (40.0%)	0.682
	Total hip arthroplasty	21 (65.6%)	12 (60.0%)	
Time between the two surgeries (mean ± SD) (years)		5.38±5.5	4.5±5.0	0.513
ASA type	2	4 (12.5%)	0	0.255
	3	16 (50.0%)	11 (55.0%)	
	4	12 (37.5%)	9 (45.0%)	
Fracture type	A	11 (34.4%)[a]	5 (25.0%)[a]	**<0.001**
	B1	21 (65.6%)[a]	2 (10.0%)[b]	
	B2	0	5 (25.0%)[b]	
	B3	0	8 (40.0%)[b]	
Survival time (mean ± SD) (months)		26.7±26.0	13.3±18.9	0.093
Survival	Died	20 (62.5%)	15 (75.0%)	0.35
	Live	12 (37.5%)	5 (25.0%)	

Chi-square test. [a]: Independent sample test, [b]Mann Whitney U test, SD: Standard deviation, ASA: American Society of Anesthesiologists Classification

Logistic regression analysis was performed to identify the variables that had a significant effect on survival. The variables that significantly affected survival were age, prosthesis type, and fracture classification. As a result of the analysis, the effect of B1 fracture classification on survival was significant. However, multiple interrelationships were suspected between the variables, so different models were created. Accordingly, the risk of mortality was higher in those with B1 fracture classification than in those with fracture type A [OR: 6.39; CI: 95% (1.05-38.77) p=0.044].

When the variables found to be significant in the univariate model were included without the age variable in the model, the risk of mortality for fracture classification B1 was higher than that for those with A [OR: 6.93; CI: 95% (1.16-41.09) p=0.033], and the risk of mortality for fracture type B3 was higher than that for those with A [OR: 16.75; CI: 95% (1.12-248.45) p=0.041]. In addition, the risk of mortality was lower in total hip prosthesis patients than in hemiarthroplasty patients [OR: 0.11; CI: 95% (0.01-0.90) p=0.04]. When age was included in the model, its effect on

Table 2. Relationship between survival and the variables

Parameters		Died	Live	p
Gender	Female	28 (80.0%)	12 (70.6%)	0.45
	Male	7 (20.0%)	5 (29.4%)	
Age (mean ± SD) (years)		77.6±10.5	65.6±15.6	**0.002**[a]
Side	R	17 (48.6)	8 (47.1%)	0.918
	L	18 (51.4)	9 (52.9%)	
The type of surgery	Open reduction and internal fixation	20 (57.1)	12 (70.6%)	0.35
	Revision	15 (42.9)	5 (29.4%)	
The type of prosthesis	Hemiarthroplasy	17 (48.6)[a]	2 (11.8%)[b]	**0.01**
	Total hip arthroplasy	18 (51.4)[a]	15 (88.2%)[b]	
Time between the two surgeries (mean ± SD) (years)		4.2±4.7	6.8±6.2	0.13
ASA type	2	0	4 (23.5%)[b]	**0.003**
	3	17 (48.6%)[a]	10 (58.8%)[a]	
	4	18 (51.4%)[a]	3 (17.7%)[b]	
Fracture type	A	7 (20.0%)	9 (52.9%)	0.075
	B1	18 (51.4%)	5 (29.4%)	
	B2	3 (8.6%)	2 (11.8%)	
	B3	7 (20.0%)	1 (5.9%)	

Chi-square test, [a]: Independent sample test, [b]: Mann Whitney U test, SD: Standard deviation, ASA: American Society of Anesthesiologists Classification

Table 3. Evaluation of survival time in different groups

Parameters		Estimate	S.E.	95% CI		p
				Lower bound	Upper bound	
Sex	Female	48	19,719	9.35	86.65	0.618
	Male	48	25,632	0	98,239	
	Overall	48	18,971	10,817	85,183	
Side	R	48	23,257	2,416	93,584	0.971
	L	48	22,531	3,838	92,162	
	Overall	48	18,971	10,817	85,183	
Surgery	Open reduction and internal fixation	52	4.86	42,474	61,526	**0.048**
	Revision	5	1,118	2,809	7,191	
	Overall	48	18,971	10,817	85,183	
The type of prosthesis	Hemiarthroplasy	6	6,965	0	19,651	**0.002**
	Total hip arthroplasy	52	6,364	39,526	64,474	
	Overall	48	18,971	10,817	85,183	
Fracture type	A	67,333	11,769	44,267	90.4	**0.006**
	B1	34,939	6,809	21,594	48,285	
	B2	19.8	10,297	0	39,982	
	B3	25	8,796	7.76	42.24	
	Overall	44,877	6,079	32,962	56,792	

Kaplan-Meier Analysis (log-rank). S.E.: Standard error, CI: Confidence interval survival was found to be significant. Accordingly, a 1-year increase in age increases the risk of mortality by 1.087 times.

Discussion

A rise in the frequency of fractures around the prosthesis has been observed globally as a result of the increasing number of arthroplasties performed (12). PFF following hip arthroplasty are complicated and clinically challenging problem (7). The type of fracture, stability of the prosthesis, and general health status of the patient must all be considered when choosing an appropriate treatment course (13). The Vancouver classification is useful for fracture classification and treatment management. In general, well-fixed stems require open reduction and internal fixation, whereas loose stems necessitate revision arthroplasty (10). The validity of the periprosthetic fracture classification system for the femur has been previously demonstrated (14).

According to our study, revision arthroplasty is more often preferred in elderly patients because the stability of the implant may be adversely affected by poor bone stock. We found that survival was longer in patients who underwent osteosynthesis, which can be explained by the fact that revision surgery is a major surgical intervention. At the same time, we believe that the deterioration of the general condition that affects survival is more common in elderly patients and the inability to perform osteosynthesis in patients with unsuitable bone quality are among the factors affecting the outcome. In addition, it may be that patients who underwent ORIF were younger than those who underwent revision THR. Moreover, patient comorbidities likely affected survival.

Our findings indicate that life span is better in patients undergoing osteosynthesis with a stable implant of good bone quality. However, some researchers have reported that the need for revision surgery is more frequent after the fixation of the periprosthetic fracture with osteosynthesis. They concluded that implant stability may have been misclassified by surgeons (3). According to Bhattacharyya et al. (15), revision arthroplasty may be associated with a lower mortality rate in patients with type B PFF than in those with osteosynthesis. At the same time, researchers have reported that revision arthroplasty may be the best option for patients for whom it is difficult to determine implant stability (15).

Patient age and ASA were found to be effective in reducing mortality. Drew et al. (16) reported that non-modifiable risk factors, such as advanced age and the number of comorbidities, were effective against mortality. It was a predictable conclusion. Similarly, it is not difficult to explain the increased mortality after PFF in patients undergoing hemiarthroplasty. Hemiarthroplasty is performed in elderly patients after trauma, and total hip replacement is performed in patients who already have high daily activity levels or elective surgical procedures. As a result, we conclude that, according to this study's outcome, the patient's age, general health status, and bone quality will affect mortality.

The data from the Swedish National Joint Registry underscore the severity of postoperative periprosthetic fractures of the femoral side, with >70% of patients having a loose femoral component, 30% requiring at least one revision, and 39% experiencing no pain relief following revision surgery (7). The high likelihood of additional surgeries and incomplete clinical recovery highlights the seriousness of this condition. Khan et al. (17) showed that revision hip arthroplasty for periprosthetic fractures carries a higher overall mortality risk than revisions for other reasons, and men aged 75 years or older have the highest mortality risk after revision hip arthroplasty for PFF. Although some researchers have identified female gender and age as independent risk factors, the evidence in the current literature is not entirely consistent (18). Our study found no gender effects on mortality.

Barrow et al. (19) reported that the development of a periprosthetic fracture after arthroplasty is as important as infection and aseptic loosening. Similarly, the severity of the situation was evidenced by the 13.3-month survival time in patients undergoing revision arthroplasty in our study. This further emphasizes the need for careful evaluation and management of periprosthetic fractures, considering factors such as patient age, general health status, and bone quality, to optimize treatment outcomes and reduce the risk of complications and mortality.

PFF significantly impact mortality rates and healthcare costs, emphasizing the importance of prevention strategies (20). The following arthroplasty, maintaining muscular strength, increasing functional capacity, and providing rehabilitation programs are essential to prevent fractures.

Open reduction and internal fixation have been shown to provide positive outcomes for types A and B1 fractures. In contrast, revision arthroplasty remains the gold standard for the treatment of types B2 and B3 PFF. Our study found that surgical treatment was performed on type A fractures (34.4%) with significant displacement to avoid non-union and related complications. Revision arthroplasty was performed in type A fractures (25.0%) with insufficient intraoperative prosthesis stability. Hsieh et al. (21) reported 23 periprosthetic fractures of the greater trochanter, 16 of which required revision because of excessive wear, loosening, or non-union. In our study, revision arthroplasty was performed for B2- and B3-type fractures, thereby facilitating early weight bearing and mobilization.

Canton et al. (22) found an association between delayed weight bearing and increased mortality risk, noting that elderly patients who underwent revision arthroplasty for types B2-B3 PFF often experienced superior long-term outcomes. Malige et al. (23) reported no difference in the complication rate between different types of B fractures, consistent with the literature showing that Vancouver B PFF following hip arthroplasty are associated with high complication rates and poor outcomes.

Considering these findings, it is crucial to understand the impact of fracture types and surgical techniques on patient outcomes and to adopt appropriate prevention and treatment strategies. Nonetheless, according to Legosz et al. (24), type B3 fractures have the worst prognosis. Consistent with this study result, when comparing B3-type fractures with A-type fractures, we discovered a 16.75-fold higher mortality rate. The benefits of arthroplasty are apparent in these types of fractures, particularly in elderly patients who need to be mobilized as soon as possible, as supported by the current literature.

Drew et al. (16) revealed that at one year, patients have a 24% probability of death or requiring additional surgery. Bhattacharyya et al. (15)

reported a mortality rate of 11% at the end of 1 year following PFF surgery. The mortality rate in our study was 19.2% at 30 days and 36.5% at the end of the first year after PFF. The mortality rate in our study was higher than that reported in the current literature. This situation is believed to be related to the socioeconomic status of the society in which we live. In accordance with the literature, the results of our study on aging as well as pre-existing general health conditions have a negative impact on mortality.

The findings of the present study show that PFFs are distressing for patients, have a high mortality rate, and pose challenges for surgeons. Each surgical procedure performed on these patients is associated with an increased risk of mortality, which may provide valuable prognostic information for both patients and their families. Greater mortality is associated with advanced age and poor general health.

Study Limitations

The retrospective methodology of the study and the relatively small number of patients are among the limitations of this study. Unfortunately, the number of patients in this special patient group at single centers is limited. We recommend that prospective multicenter studies be conducted in the future. We believe that there is another limitation in our study regarding the simultaneous evaluation of type A and B fractures.

Conclusion

We found that types of fractures and surgical methods affected mortality. Among the relevant characteristics of surgical techniques are age and type of fracture. We found that patients who underwent osteosynthesis had a longer lifespan. In addition, a high mortality rate was observed in B3-type fractures.

Ethics Committee Approval: We received approval to conduct this study from University of Health Sciences Turkey, İstanbul Training and Research Hospital Institutional Review Board (approval number: 39, date: 28.01.2022).

Informed Consent: Informed consent was obtained from each participant included in the study.

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