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Mortality Rate in Periprosthetic Proximal Femoral Fractures: Impact of Time to Surgery

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Abstract: Hip replacement surgery is increasingly being performed on older patients, raising the risk of periprosthetic proximal femur fractures (PPFFs). While the impact of surgery timing on mortality in proximal femoral fractures is established, its effect on PPFFs remains unclear. This study aims to examine the correlation between surgery timing and mortality in PPFF patients. In a historical cohort study, we analyzed data from 79 PPFF patients treated from 2012 to 2022. Patients were categorized by surgery timing (≤48 h, 32 patients vs. >48 h, 47 patients). Outcomes and mortality rates were compared. No significant difference in mortality was observed between patients undergoing early (<48 h) and delayed (>48 h) surgery at 30 days and 1 year. Factors such as age ($p = 0.154$), gender ($p = 0.058$), ASA score ($p = 0.893$), Vancouver classification ($p = 0.577$), and surgery type (implant revision $p = 0.691$, OR = 0.667) did not affect 30-day mortality. However, 1-year mortality was influenced by gender (male $p = 0.045$) and age ($p = 0.004$), but not by other variables (Vancouver classification $p = 0.443$, implant revision $p = 0.196$). These findings indicate no association between surgery timing and mortality in PPFF patients, suggesting that other factors may influence outcomes. Further research is needed to optimize PPFF management.

Keywords: early surgery; periprosthetic; fracture; proximal femur

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1. Introduction

The mix of excellent clinical outcomes as well as an aging population has led to a steady increase in the number of patients undergoing hip replacement surgery over the last decade [1]. Associated with this increase in demand for hip arthroplasty, there has been an increase in complications, and one of the most common and problematic for patients is periprosthetic femoral fractures (PPFFs). The current literature estimates that the incidence of post-operative periprosthetic proximal femur fractures is around 0.1–2.1% for primary total hip replacement and approximately 3.6–20.0% for revision total hip replacement [2–4], and it is believed that this incidence will increase by 4.6% every 10 years between 2015 and 2060 [5,6]. Additionally, PPFFs are challenging as they mostly occur in patients with complex medical comorbidities and poor bone quality.

Surgery requires good abilities in hip arthroplasty and trauma surgery, as well as dedicated implants and instrumentation. This could lead to a significant delay from fracture presentation to definitive surgery, especially in smaller institutions.

In the literature, it is widely recognized that in the case of native hip fractures, a delay in performing surgery of more than 48 h is correlated with increased post-operative mortality and morbidity rates [7–9]. On the other hand, it is not clear if the time to surgery for PPFFs can affect outcomes. The modern literature on this topic is still limited and often contradictory. A few studies [10–16] have tried to correlate time to surgery in PPFFs with post-operative mortality, but have not obtained conclusive results. Two large registry studies in the United States found no increasing mortality rates when comparing a surgery

delay of 24 h or of more than 48 h [10,13], while reporting an increased complication rate with time. This was confirmed in various studies reporting no differences in the post-operative mortality rate but an increased complication rate with delayed surgery [11,12], but unfortunately these data are inconsistent in the actual literature [2,14].

The most recent systematic review on this topic was published in 2020 [15] and reported a small increase in mortality rates at 30 days, without any difference at 12 months based on time to surgery; furthermore, many studies available are of low quality and cannot be used to analyze the real impact of this aspect on outcomes [16].

By analyzing the population of patients with PPFFs and collecting demographical data, clinical comorbidities and walking anomalies, Bliemel et al. realized that in many aspects, these patients were similar to those who are treated for fragility fractures of the hip and distal femur [17]. With this in mind and by understanding that many studies recognize a correlation between time to surgery in fragility fractures and post-operative clinical and mortality outcomes, we hypothesize that a similar correlation may also exist for patients suffering from PPFFs, with a shorter time to surgery being correlated with lower mortality and complication rates.

The main aim of this study is to evaluate the effect of timing in surgery treatment on the 30-day and 1-year post-operative mortality rates of patients with periprosthetic fractures of the proximal femur by comparing delayed (>48 h) to early ($\leq$48 h) surgical treatment.

2. Materials and Methods

This study was a historical cohort study based on data from a single trauma unit in Italy.

We evaluated a series of 79 consecutive patients who underwent surgical fixation or revision surgery for PPFFs (Vancouver A, B and C) between 2012 and 2022, and all fracture types were included, except for prosthetic neck and stem implant fractures, which were excluded.

Patients were divided into two cohorts according to the time from diagnosis to surgery, namely under or equal to 48 h and over 48 h, with the aim of assessing the effect of time from diagnosis to surgery on 30-day and 1-year post-operative mortality rates.

2.1. Data Extraction

For every patient, demographic information was systematically collected and incorporated into a standardized template, including sex, age at the time of surgery, and date of death if applicable. Patients were categorized based on age groups, i.e., younger than 65 years old vs. aged 65 years and older, as well as by gender (female vs. male) and by survival status at 30 days and 1-year post-operation.

The date and time of emergency room admission was designated as the date of diagnosis, while the time of incision was used to establish the timing of surgery. Patient characteristics such as American Society of Anesthesiologists (ASA) classification, periprosthetic femur fracture classification (Vancouver classification), surgical procedure type, and post-operative outcomes including mortality rates at 30 days and 1 year were extracted from comprehensive case note reviews.

Patients were further stratified into categories based on the type of surgery performed (implant revision surgery with or without fixation vs. surgical fixation) and the time interval from diagnosis to surgery, specifically under or equal to 48 h vs. over 48 h.

2.2. Statistical Analysis

All data were analyzed using XL-STAT software, version 2023.2.0 (Lumivero, 2024).

A descriptive statistical analysis was conducted to assess the demographic and surgical data of the population cohort. A chi-square test, with a significance level (alpha) set at 0.05, was employed to examine the impact of sex, age groups, type of surgery, Vancouver classification groups and time to surgery on mortality rates. Additionally, a two-sample

Student's *t*-test was utilized to compare the mean age and mean time to surgery between the groups. A *p*-value less than 0.05 was considered statistically significant.

Multivariate regression analysis was used to correct for confounders, and so to determine the effect of various parameters on patient mortality and to measure odds ratios (OR).

3. Results

A comprehensive analysis was conducted on a cohort of 79 patients, among whom 47 (59%) underwent implant revision and 32 (41%) received surgical fixation. Table 1 summarizes key demographic characteristics of the patients.

Table 1. Patients' characteristics. * Percentage out of the total number of patients. ** Percentage out of the number of patients in the specific subgroup.

	Total Patients	**Patients Dead within 30 Days**	**Patients Dead within 1 Year**	**Patient Alive after 1 Year**
Number of patients	79	4 (5% *)	21 (26.6% *)	58 (73.4% *)
Age at the time of surgery (mean ± SD)	82 ± 8.9	88 ± 5.2	86.5 ± 6.5	80 ± 9.0
Aged 64 yo and under	5% *	0% **	0% **	7% **
Aged 65 yo and over	95% *	100% **	100% **	93% **
Sex Female (%)	69.6% *	75% **	52% **	76% **
Sex Male (%)	30.4% *	25% **	48% **	24% **
Vancouver classification				
A (AL, AG)	2.53% *	0% **	0% **	3.45% **
B1	22.78% *	50% **	33% **	19% **
B2	67% *	50% **	57% **	70.7% **
B3	0% *	0% **	0% **	0% **
C	7.6% *	0% **	9.5% **	7% **
Type of surgery				
Implant revision with or without fixation (%)	60% *	50% **	48% **	64% **
Surgical fixation (%)	40% *	50% **	52% **	36% **
Time to Surgery in hours (mean ± SD)	79 ± 51.0	84 ± 41.6	75.4 ± 45.1	80.3 ± 53.3
Time to Surgery ≤ 48 h (%)	32 (40% *)	25% **	43% **	40% **
Time to Surgery > 48 h (%)	47 (60% *)	75% **	57% **	60% **

3.1. Mortality at 30 Days

Our analysis revealed no statistical difference between the groups of patients 30 days post-surgery. Detailed statistical findings are reported in Table 2, indicating that all patients that died within 30 days were aged over 65 years.

Specifically, no significant differences were observed regarding the time to surgery in the first 30 days between the group of patients who died (25% underwent surgery within the 48 h time limit, with a mean time to surgery of 84 h) and those who survived (41% underwent surgery within the 48 h time limit, with a mean time to surgery of 78.7 h). Multivariate regression analysis further confirmed that these parameters have no statistically significant effect on patient mortality.

Table 2. Statistical analysis for mortality rate within 30 days.

	TEST	Patients Dead within 30 Days	Patients Alive after 30 Days	Test Value	*p*-Value	OR
Number of patients		4	75			
Mean age at the time of surgery	*t*-test	88 ± 5.2	81 ± 8.9	t = 1.44	0.15	
Aged 64 yo and under	χ^2	0%	5%	χ^2 = 0.23	0.64	
Aged 65 yo and over	χ^2	100%	95%	χ^2 = 0.23	0.64	
Sex Female	χ^2	75%	69%	χ^2 = 0.06	0.81	1.33
Sex Male	χ^2	25%	31%	χ^2 = 0.06	0.81	0.75
Vancouver classification	χ^2			χ^2 = 1.98	0.58	
Type of surgery	χ^2					
Implant revision with or without fixation	χ^2	50%	60%	χ^2 = 0.16	0.69	0.67
Surgical fixation	χ^2	50%	40%	χ^2 = 0.16	0.69	1.49
Mean time to Surgery in hours	*t*-test	84 ± 41.6	79 ± 41.7	t = 0.2	0.84	
Time to Surgery ≤ 48 h	χ^2	25%	41%	χ^2 = 0.42	0.52	0.47
Time to Surgery > 48 h	χ^2	75%	59%	χ^2 = 0.42	0.52	2.13

3.2. Mortality at 1 Year

Statistically significant differences were observed between the deceased and surviving patient groups at 1-year post-surgery in terms of demographics such as age (p = 0.004) and gender distribution (p = 0.045) by performing a univariate analysis. However, there was no significant difference noted between the two groups when patients were stratified by age (≥65 years vs. <65 years). After rectifying for potential cofounding factors using logistic regression analysis, age (p = 0.011) and male sex (p = 0.008, OR = 5.26) were confirmed as being significantly associated with higher mortality rate at 1 year. Detailed statistical results are provided in Table 3.

Table 3. Statistical analysis for mortality rate within 1 year.

	TEST	Patients Dead within 1 Year	Patients Alive after 1 Year	Test Value	*p*-Value	OR
Number of patients		21	58			
Mean age at the time of surgery	*t*-test	86.5 ± 6.5	80 ± 9.0	t = 2.98	0.004	
Aged 64 yo and under	χ^2	0%	7%	χ^2 = 1.53	0.22	
Aged 65 yo and over	χ^2	100%	93%	χ^2 = 1.53	0.22	
Sex Female	χ^2	52%	76%	χ^2 = 4.02	0.045	0.19
Sex Male	χ^2	48%	24%	χ^2 = 4.02	0.045	5.26
Vancouver classification	χ^2			χ^2 = 2.68	0.44	
Type of surgery	χ^2					
Implant revision with or without fixation	χ^2	48%	64%	χ^2 = 1.67	0.20	0.52
Surgical fixation	χ^2	52%	36%	χ^2 = 1.67	0.20	1.92
Mean time to Surgery in hours	*t*-test	75.4 ± 45.1	80.3 ± 53.3	t = −0.37	0.71	
Time to Surgery ≤48 h	χ^2	43%	40%	χ^2 = 0.07	0.80	1.14
Time to Surgery >48 h	χ^2	57%	60%	χ^2 = 0.07	0.80	0.88

Of particular note, time to surgery did not affect survivorship; patients who died within the first year after surgery underwent surgery in 43% of cases in the first 48 h, with a mean time to surgery slightly exceeding 75 h, and those who survived underwent surgery in 40% of cases in the first 48 h, with a mean time to surgery of 80 h.

A post hoc analysis was performed for the variable "type of surgery": this analysis showed that the patients treated with implant revision with or without surgical fixation had a higher risk of undergoing surgery after 48 h (p = 0.005, OR = 3.822). On the other hand, most of the patients who underwent surgical fixation had a time to surgery under 48 h (59% vs. 28%). Detailed statistical results are provided in Table 4.

Table 4. Post hoc analysis for the variable "type of surgery".

	TEST	T to Surgery ≤48 h	T to Surgery >48 h	Test Value	*p*-Value	OR
Type of surgery						
Implant revision with or without fixation	χ^2	28%	72%	χ^2 = 7.50	0.005	0.26
Surgical fixation	χ^2	59%	41%	χ^2 = 7.50	0.005	3.82

4. Discussion

The aim of this study was to demonstrate the effect of time from diagnosis to definitive surgery on the mortality rates at 1 month and 1 year after PPFFs were surgically treated: our findings do not reveal any statistically significant difference in relation to time to surgery, whether it was performed within or after 48 h, regarding mortality rates.

It has already been shown in various studies that delayed surgery in native hip fractures is correlated with increased post-operative mortality and morbidity [9,13,18–20]. In a recent meta-analysis, Simunovic et al. [21] reported among 13,478 patients, divided according to the time to surgery (24, 48, or 72 h), a decreased risk of death and rates of pneumonia and post-operative bedsores among elderly patients with native hip fractures who underwent early surgery [13]. Considering this important aspect, the scientific community recommends treatment within 48 h for primary hip fractures whenever possible.

At the same time, in the current literature, there is no evidence of a relationship between delayed surgery in PPFF cases and mortality and morbidity rates. In a study by Boddice et al. [16], the mortality rate after periprosthetic femur fracture was investigated, and the authors determined that there is no increase in morbidity or mortality with delayed surgery for periprosthetic fractures after 72 h, even though the overall length of stay increases in cases of delayed surgery beyond 72 h.

The most recent systematic review and meta-analysis [15] conducted by Farrow at al. found weak evidence, as defined by the GRADE criteria, suggesting that a delayed surgery for patients with a periprosthetic hip or knee fracture is associated with a worse outcome, including an increased 30-day mortality, increased likelihood of medical complications, increased length of hospital stay, and increased risk of blood transfusion and re-intervention. Added risk of 1-year mortality and surgical site infection associated with longer time to surgery have also been reported. Thus, while some studies report positive effects of the early surgical fixation of PPFFs [13], other studies have not found clear positive effects on short- and medium-term perioperative outcomes and mortality on a time-to-surgery basis [10].

Considering the challenges resulting from PPFF patients' overall clinical complexity and from the objectively advanced surgery needed, we also questioned what main reasons are possibly responsible for the increased time to surgery in PPFF patients. Two main reasons seem to emerge from our study, especially regarding revision arthroplasty procedures: firstly, only a small number of surgeons have the necessary and sufficient expertise to perform this type of surgery, as demonstrated by the fact that all of the surgeries examined were conducted by two board-certified orthopedic surgeons (out of 13 working at the institution).

Secondly, many hospitals do not have direct access to revision arthroplasty sets, which often must be ordered, causing further delays. New studies reveal that patients treated with revision surgery have longer waiting times than those treated with fixation alone [10,22], in line with our post hoc analysis.

The results of our analysis further support the most recent literature that claims that early surgical treatment of patients with PPFFs has no influence on the reduction in mortality rates in the acute or mid-term post-operative phase. This is in contrast with what the literature shows for femoral neck fractures, despite the fact that patients with PPFFs or fragility fractures of the femoral neck are similar in terms of age and ASA classification [23]. However, for most patients, the goal should be early surgery to achieve early mobilization and reduce complications as much as possible [24].

We believe that it is of paramount importance to further investigate the reason why surgery timing does not have a significant impact on mortality rates at 30 days and 1 year after surgery in periprosthetic proximal femur fractures, as opposed to the influence it has on mortality rates after native femoral fracture surgery. One of the reasons could be after-surgery weight bearing [25]: we hypothesize that it is not so much the time to surgery that influences mortality rates, but the time delay between surgery and weight bearing on the operated lower extremity. More studies are needed to substantiate this hypothesis.

This study has several limitations, such as the bias associated with a historic cohort study design, the small sample size of patients, and the single-center study design, which may lack the external validity necessary to support widespread changes in clinical practice. As regards the methods, we set the date of diagnosis based on the patients' hospital admission because that this was the first formally registered time available.

5. Conclusions

Despite the known correlation between delayed surgery and increased mortality in native hip fractures, our study did not find a significant association between time to surgery and mortality rates at 30 days and 1 year in patients with PPFFs. This suggests that factors other than surgery timing (i.e., time to weigh bearing) may play a predominant role in determining post-operative outcomes in PPFF cases.

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