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Comparative outcomes after treatment of peri-implant, periprosthetic, and interprosthetic femur fractures: which factors increase mortality risk?

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Abstract

Objectives: To compare mortality rates between patients treated surgically for periprosthetic fractures (PPF) after total hip arthroplasty (THA), total knee arthroplasty (TKA), peri-implant (PI), and interprosthetic (IP) fractures while identifying risk factors associated with mortality following PPF.

Design: Retrospective.

Setting: Single, Level II Trauma Center.

Patients/Participants: A retrospective review was conducted of 129 consecutive patients treated surgically for fractures around a pre-existing prosthesis or implant from 2013 to 2020. Patients were separated into 4 comparison groups: THA, TKA, PI, and IP fractures.

Intervention: Revision implant or arthroplasty, open reduction and internal fixation (ORIF), intramedullary nailing (IMN), percutaneous screws, or a combination of techniques.

Main Outcome Measurements: Primary outcome measures include mortality rates of different types of PPF, PI, and IP fractures at 1-month, 3-month, 6-month, 1-year, and 2-year postoperative. We analyzed risk factors associated with mortality aimed to determine whether treatment type affects mortality.

Results: One hundred twenty-nine patients were included for final analysis. Average follow-up was similar between all groups. The overall 1-year mortality rate was 1 month (5%), 3 months (12%), 6 months (13%), 1 year (15%), and 2 years (22%). There were no differences in mortality rates between each group at 30 days, 90 days, 6 months, 1 year, and 2 years (P-value = 0.86). A Kaplan–Meier survival curve demonstrated no difference in survivorship up to 2 years. Older than 65 years, history of hypothyroidism and dementia, and discharge to a skilled nursing facility (SNF) led to increased mortality. There was no survival benefit in treating patients with PPFs with either revision, ORIF, IMN, or a combination of techniques.

Conclusion: The overall mortality rates observed were 1 month (5%), 3 months (12%), 6 months (13%), 1 year (15%), and 2 years (22%), and no differences were found between each group at all follow-up time points. Patients aged 65 and older with a history of hypothyroidism and/or dementia discharged to an SNF are at increased risk for mortality. From a mortality perspective, surgeons should not hesitate to choose the surgical treatment they feel most comfortable performing.

Level of Evidence: Level III.

Keywords: periprosthetic, femur fractures, peri-implant, interprosthetic, mortality, risk factors, treatment

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1. Introduction

Total hip arthroplasty (THA) and total knee arthroplasty (TKA) have become markedly successful orthopaedic procedures with rapidly increasing utility in an aging population that is living longer.[1–3] In addition, as the population continues to age, the incidence of native hip fractures is also rising.[4] As such, the rising usage of both primary and revision joint arthroplasties in conjunction with the growing prevalence of patients with already existing hip fracture prostheses portends an increase in managing associated complications. A periprosthetic fracture (PPF) has proven to be particularly morbid for patients among these complications.[5,6] The incidence of periprosthetic fractures around hip and knee implants is approximately 0.1% to 4% and 0.3% to 2.5%, respectively.[7] Therefore, a thorough understanding of the risk factors, sequelae, morbidity, and mortality of PPF will become imperative for the efficient management in treating these increasingly common complications.

While there is copious research on surgical treatment options and functional outcomes of periprosthetic fractures, there are still limited data pertaining to their associated morbidity and mortality. On the other hand, the natural history, mortality, and risk factors associated with increased mortality are well elucidated in the literature for native hip fractures, allowing for optimal treatment strategies, risk stratification, and prognosis prediction.[4,8–11] While studies on mortality in patients with a periprosthetic hip exist, small sample sizes limit their statistical power.[12–14] A few studies have adequate power to compare these variables in periprosthetic hip fractures and native hip fractures, but the data collected are largely derived from comprehensive data reporting systems.[15,16] In addition, fewer studies comment on mortality after periprosthetic distal femur fractures, PPF around hip fracture implants, and interprosthetic (IP) PPF. Therefore, current data regarding mortality rates and risk factors for mortality after sustaining a fracture of the hip or knee around a pre-existing prosthesis or implant are in demand. Because there are multiple options for treating PPF (ie, surgical fixation, revision implant or arthroplasty, or a combination), an analysis of the effect different treatment options have on mortality after periprosthetic femur fracture would be valuable to the current literature.[17,18]

Therefore, the purpose of this study was to (1) compare mortality rates between patients treated surgically for a PPF after THA, TKA, peri-implant (PI), and IP fractures; (2) identify risk factors associated with mortality after PPF; and (3) determine whether treatment type affects mortality among different methods of fixation.

2. Materials and Methods

After obtaining Institutional Review Board approval (WCG IRB, protocol #20171537, principal investigator: Frank A. Liporace) in accordance with the Declaration of the World Medical Association, a retrospective review was performed at a single academic medical center of all PPF between January 2013 and February 2020 with a minimum follow-up time of 2 years. Inclusion criteria were any skeletally mature patient who is 18 years or older with surgically treated PPF around either a THA, TKA, both, or an implant used to treat a previous extracapsular hip fracture, such as a dynamic hip screw or an intramedullary fixation device, confirmed on plain radiography. Exclusion criteria included patients with less than 2 years of follow-up for any reason outside of mortality, no radiographic images available to review, intraoperative fractures, and periprosthetic femur fractures after surgical fixation of the patella or acetabulum. After screening our institutional trauma registry, there were 47 PPFF after THA, 43 TKA, 26 PI, and 13 IP fractures that met inclusion criteria.

The Vancouver and Su classification systems were used to categorize PPF around the hip and knee, respectively. The Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA) classification system was also used to categorize PPFs. All fractures were reviewed by 3 authors independently, and in those with debate about classification, a consensus decision was made with the senior author.

A manual retrospective chart review was performed to identify patient demographics, comorbidities, preoperative mobility, and smoking status. A review of the operative notes was undertaken to determine the type of implant around the periprosthetic fracture, time to surgery, and fixation method [open reduction internal fixation (ORIF), revision implant or arthroplasty, or a combination of the techniques]. Discharge records were also studied to determine weight-bearing on discharge and discharge disposition. Outpatient clinic notes, phone calls to family members and/or close contacts, and publicly available online obituaries were used to assess and confirm mortality.

2.1. Statistical Analysis

Groups were separated based on PPF type for comparative analyses: THA, TKA, PI, and IP. Kaplan–Meier survival estimates were calculated using patients' most recent follow-up dates or dates of death. A log-rank test was used to compare Kaplan–Meier survival curves. Groups were also compared using one-way analysis of variance (ANOVA) for continuous variables and χ^2 test for categorical variables. A post hoc Tukey honest significant difference (HSD) test or the Games–Howell test was used to determine where the exact differences were between each study group. A univariate Cox proportional hazard model was used to identify which demographic or perioperative risk factors influence survival. These findings were reported as a hazard ratio (HR) with an associated confidence interval (CI). A P-value ≤ 0.05 was considered to be statistically significant. All statistical analyses were performed using SPSS version 25 (Armonk, NY).

3. Results

Average follow-up time was similar between all groups (2.9 ± 2.3 years THA vs. 2.5 ± 1.4 years TKA vs. 3.2 ± 2.4 years PI vs. 2.3 ± 1.2 years IP, $P = 0.33$). Patients in the PI cohort were the youngest compared with the other groups (61.1 ± 21.3 years PI vs. 74.0 ± 13.8 years THA vs. 73.8 ± 11.4 years TKA vs. 76.0 ± 11.2 years IP, $P = 0.038$); however, comorbidity profiles were similar between groups (Table 1). A small proportion of patients in the PI cohort ambulated independently before surgery compared with the other study groups (46.7% vs. 51.3% THA vs. 55.0% TKA vs. 90.9% IP, $P = 0.02$) and at latest postoperative follow-up (40.0% vs. 59.5% THA vs. 55% TKA vs. 54.5% IP, $P = 0.04$). More importantly, each study group was treated differently ($P < 0.001$) (Table 2). Overall, a majority of fixation was revision arthroplasty (47, 36.4%), followed by ORIF (32, 24.8%) and IMN combined with ORIF (19, 14.7%) (Table 3). Each cohort also experienced different types of fracture

TABLE 1

Demographic Information

Demographics		THA	SD or %	TKA	SD or %	PI	SD or %	IP	SD or %	*P*
Age		74.0	13.8	73.8	11.4	61.1	21.3	76.0	11.2	0.038
Sex	Male	17	36.2%	8	18.6%	11	42.3%	2	15.4%	0.08
	Female	30	63.8%	35	81.4%	15	57.7%	11	84.6%	
Laterality	Left	26	55.3%	21	48.8%	14	53.8%	3	23.1%	0.21
	Right	21	44.7%	22	51.2%	12	46.2%	10	62.9%	
Length of stay		7.0	6.5	5.7	3.76	9.8	13.8	5.9	2.4	0.47
Comorbidities	HTN	28	26.4%	29	27.9%	13	38.2%	6	28.6%	0.39
	CVA	6	5.7%	4	3.8%	2	5.9%	1	4.8%	0.89
	CAD	14	13.2%	11	10.6%	3	8.8%	2	9.5%	0.3
	CHF	3	2.8%	5	4.8%	1	2.9%	1	4.8%	0.66
	COPD	8	7.5%	5	4.8%	1	2.9%	2	9.5%	0.42
	DM	8	7.5%	11	10.6%	3	8.8%	0	0.0%	0.14
	HLD	10	9.4%	11	10.6%	5	14.7%	1	4.8%	0.58
	Hypothyroid	6	5.7%	3	2.9%	1	2.9%	3	14.3%	0.22
	OA	13	12.3%	12	11.5%	1	2.9%	2	9.5%	0.07
	Osteoporosis	3	2.8%	3	2.9%	1	2.9%	1	4.8%	0.95
	ESRD	1	0.9%	1	1.0%	1	2.9%	0	0.0%	0.9
	Dementia	6	5.7%	9	8.7%	2	5.9%	2	9.5%	0.48
Smoking status	Never	32	69.6%	32	76.2%	16	76.2%	9	81.8%	0.88
	Former	7	15.2%	5	11.9%	1	4.8%	1	9.1%	
	Current	7	15.2%	5	11.9%	4	19.0%	1	9.1%	

CAD = coronary artery disease; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; CVA = cerebrovascular accident; DM = diabetes mellitus; ESRD = end-stage renal disease; HLD = hyperlipidemia; HTN = hypertension; IP = interprosthetic; OA = osteoarthritis; PI = peri-implant; THA = total hip arthroplasty; TKA = total knee arthroplasty.

patterns based on the AO/OTA classification (Table 4). Most PPFs in the THA cohort suffered from 31A type fractures (19, 40.4%). In the TKA cohort, most patients had a 33A type fracture (16, 37.2%). In the PI cohort, 7 (26.9%) patients experienced a 32A type fracture. The IP cohort had 4 (30.8%) patients with a 32A and 33A fracture classification, respectively.

TABLE 2

Perioperative Variables

Perioperative Variables		THA	%	TKA	%	PI	%	IP	%	*P*
Preoperative ambulatory status	Independent	20	51.3%	22	55.0%	7	46.7%	10	90.9%	0.02
	Assistance	17	43.6%	16	40.0%	4	26.7%	1	9.1%	
	Nonambulatory	2	5.1%	2	5.0%	4	26.7%	0	0.0%	
Assistive device used postoperatively	None	11	28.9%	3	7.7%	2	14.3%	1	9.1%	0.26
	Cane	3	7.9%	2	5.1%	0	0.0%	1	9.1%	
	Crutches	1	2.6%	2	5.1%	4	28.6%	2	18.2%	
	Walker	18	47.4%	21	53.8%	4	28.6%	6	54.5%	
	Wheelchair	5	13.2%	11	28.2%	4	28.6%	1	9.1%	
Postoperative ambulatory status	Independent	11	28.9%	3	7.7%	2	14.3%	1	9.1%	0.13
	Assistance	22	57.9%	25	64.1%	8	57.1%	9	81.8%	
	Nonambulatory	5	13.2%	11	28.2%	4	28.6%	1	9.1%	
Discharge disposition	Home	11	26.2%	17	42.5%	6	42.9%	6	54.5%	0.18
	Rehab	28	66.7%	20	50.0%	5	35.7%	5	45.5%	
	SNF	1	2.4%	3	7.5%	1	7.1%	0	0.0%	
	Other hospital	2	4.8%	0	0.0%	0	0.0%	0	0.0%	
	Death before discharge	0	0.0%	0	0.0%	2	14.3%	0	0.0%	
Weight-bearing (WB) on discharge	NWB	7	16.7%	16	40.0%	6	40.0%	2	18.2%	0.04
	WBAT	25	59.5%	22	55.0%	6	40.0%	6	54.5%	
	TTWB	1	2.4%	0	0.0%	1	6.7%	0	0.0%	
	FFWB	1	2.4%	0	0.0%	0	0.0%	0	0.0%	
	PWB	8	19.0%	2	5.0%	0	0.0%	3	27.3%	
	Death before discharge	0	0.0%	0	0.0%	2	13.3%	0	0.0%	
Fixation method	Percutaneous screw	1	2.1%	0	0.0%	0	0.0%	0	0.0%	<0.001
	ORIF	10	21.3%	7	16.3%	10	38.5%	5	38.5%	
	IMN	0	0.0%	4	9.3%	5	19.2%	0	0.0%	
	IMN + ORIF	2	4.3%	7	16.3%	7	26.9%	3	23.1%	
	Revision	20	42.6%	22	51.2%	2	7.7%	3	23.1%	
	Revision + ORIF	8	17.0%	1	2.3%	1	3.8%	2	15.4%	
	Nonoperative care	6	12.8%	2	4.7%	1	3.8%	0	0.0%	

THA = total hip arthroplasty; TKA = total knee arthroplasty; PI = peri-implant; IP = interprosthetic; SNF = skilled nursing facility; NWB = non-weight bearing; WBAT = weight-bearing as tolerated; TTWB = toe-touch weight-bearing; FFWB = flat-foot weight-bearing; PWB = partial weight-bearing; ORIF = open reduction and internal fixation; IMN = intramedullary nail.

TABLE 3

Total Number of Previous Implants, Fracture Classification Type, and Fixation Method Across All Subgroups

Previous implant	Percutaneous screws	2
	Plate	9
	THA	46
	DHS	5
	IMN	9
	Hemi HA	1
	THA & TKA	6
	TKA	40
	rIMN	2
	TKA & rIMN	2
	THA & TKA & plate	1
	TKA & IMN	4
	IMN & rIMN & TKA & plate	1
	THA & rIMN & plate	1
Classification	Vancouver A	3
	Vancouver B1	5
	Vancouver B2	25
	Vancouver B3	8
	Vancouver C	22
	Su 1	15
	Su 2	13
	Su 3	15
	Judet and Letournel anterior column	1
	Judet and Letournel posterior column	4
	Judet and Letournel transverse	3
	Tibia fractures	11
	Fibula fracture	1
	Patella fracture	3
Fixation method	Percutaneous screw	1
	ORIF	32
	IMN	9
	IMN + ORIF	19
	Revision	47
	Revision + ORIF	12
	Nonoperative care	9

DHS = dynamic hip screw; HA = hemiarthroplasty; IMN = intramedullary nail; ORIF = open reduction and internal fixation; rIMN = retrograde intramedullary nail; THA = total hip arthroplasty; TKA = total knee arthroplasty.

Overall, the mortality rates after management of PPF for any type were 1 month (5%), 3 months (12%), 6 months (13%), 1 year (15%), and 2 years (22%). When analyzing these data separately, the mortality rates at various time points were as follows: THA group, 1 month (2%), 3 months (15%), 6 months (15%), 1 year (17%), 2 years (26%); TKA group, 1 month (5%), 3 months (9%), 6 months (12%), 1 year (14%), 2 years (19%); PI group, 1 month (12%), 3 months (15%), 6 months (15%), 1 year (15%), 2 years (23%); IP group, 1 month (0%), 3 months (8%), 6 months (8%), 1 year (8%), 2 years (15%). There were no differences in mortality rates between THA, TKA, PI, and IP groups at 1 month ($P = 0.25$), 3 months ($P = 0.77$), 6 months ($P = 0.88$), 1 year ($P = 0.86$), and 2 years ($P = 0.81$) (Table 5). A Kaplan–Meier survival curve demonstrated no difference in survivorship up to 2-year follow-up (74.5% THA vs. 81.4% TKA vs. 76.9% PI vs. 84.6% IP, $P = 0.83$) (Fig. 1 and Table 6).

A univariate Cox regression analysis revealed that age 65 year or older (HR 4.242, $P = 0.011$), history of hypothyroidism (HR 2.897, $P = 0.026$) and dementia (HR 4.091, $P = 0.001$), and discharge disposition to a skilled nursing facility (HR 14.112, $P = 0.001$) were associated with increased risk of mortality. Length of hospital stay ≥5 days trended toward increased risk of mortality but did not quite reach statistical significance (HR 2.428, $P = 0.061$). With regard to fixation methods, the mortality rates were nonoperative (22%), percutaneous screws (0%), ORIF (31%), IMN (22%), IMN + ORIF (32%), revision (23%), and revision + ORIF (42%). Univariate Cox regression using the nonoperative group as the reference showed no significant association in mortality risk based on fixation method: percutaneous screws ($P = 1.0$), ORIF ($P = 0.924$), IMN ($P = 0.924$), IMN + ORIF ($P = 0.919$), revision ($P = 0.926$), and revision + ORIF ($P = 0.918$) (Table 7).

TABLE 4

AO/OTA Classification by Subgroup

AO/OTA		THA	%	TKA	%	PI	%	IP	%	P
AO/OTA	2R2A	0	0.0%	0	0.0%	1	3.8%	0	0.0%	0.002
	2R2C	0	0.0%	0	0.0%	0	0.0%	0	0.0%	
	31A	19	40.4%	1	2.3%	3	11.5%	0	0.0%	
	31B	2	4.3%	0	0.0%	0	0.0%	0	0.0%	
	32A	13	27.7%	6	14.0%	7	26.9%	4	30.8%	
	32B	0	0.0%	3	7.0%	0	0.0%	0	0.0%	
	32C	1	2.1%	0	0.0%	2	7.7%	0	0.0%	
	33A	3	6.4%	16	37.2%	4	15.4%	4	30.8%	
	33B	2	4.3%	4	9.3%	0	0.0%	1	7.7%	
	33C	0	0.0%	5	11.6%	3	11.5%	1	7.7%	
	34A	0	0.0%	1	2.3%	0	0.0%	0	0.0%	
	34B	0	0.0%	1	2.3%	0	0.0%	0	0.0%	
	34C	0	0.0%	1	2.3%	1	3.8%	0	0.0%	
	41A	0	0.0%	1	2.3%	0	0.0%	1	7.7%	
	41C	0	0.0%	1	2.3%	0	0.0%	1	7.7%	
	42A	0	0.0%	2	4.7%	4	15.4%	0	0.0%	
	4F2A	0	0.0%	1	2.3%	1	3.8%	0	0.0%	
	61A	2	4.3%	0	0.0%	0	0.0%	0	0.0%	
	61B	1	2.1%	0	0.0%	0	0.0%	0	0.0%	
	61C	1	2.1%	0	0.0%	0	0.0%	0	0.0%	
	62A	1	2.1%	0	0.0%	0	0.0%	0	0.0%	
	62B	2	4.3%	0	0.0%	0	0.0%	1	7.7%	

AO/OTA = Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association; IP = interprosthetic; PI = peri-implant; THA = total hip arthroplasty; TKA = total knee arthroplasty.

4. Discussion

Total joint arthroplasty about the hip and knee and hip fracture surgery have continued to be some of the most successful orthopaedic operations, allowing for almost immediately improved function and alleviation of pain. With the population living and staying active longer, the volume of these procedures continues to grow exponentially. Current estimates and registry data predict increasing utilization of these procedures in the coming decades.[1–3] As expected, these models also predict a mirrored increase in the incidence of periprosthetic femur fractures.[7,19] Some authors have raised concerns regarding an impending epidemic of periprosthetic femur fractures in the near future.[20] As such, it is critical that we make every effort to understand the natural history, morbidity and mortality, and functional outcomes after periprosthetic femur fractures.

There are a plethora of studies that have analyzed mortality data after native hip fractures, which have led to efficient, cost-effective, and high quality of care in these patients.[4,21] The literature for periprosthetic femur fractures however is not as robust, especially when looking at mortality data. Most of the literature surrounding this specific injury emphasizes different surgical techniques, outcomes, and complications.[5,8,11,18,22–26] There are only a few studies that look into potential morbidity and mortality of these fractures or the variables that affect these outcomes.[12,13,15,27–32] Therefore, our goal in this study was to

TABLE 5

Mortality of Subgroups

Follow-up		Overall	%	THA	%	TKA	%	PI	%	IP	%	*P*
Mortality	1 month	6	4.7%	1	2.1%	2	4.7%	3	11.5%	0	0.0%	0.25
	3 months	16	12.4%	7	14.9%	4	9.3%	4	15.4%	1	7.7%	0.77
	6 months	17	13.2%	7	14.9%	5	11.6%	4	15.4%	1	7.7%	0.88
	1 year	19	14.7%	8	17.0%	6	14.0%	4	15.4%	1	7.7%	0.86
	2 years	28	21.7%	12	25.5%	8	18.6%	6	23.1%	2	15.4%	0.81

IP = interprosthetic; PI = peri-implant; THA = total hip arthroplasty; TKA = total knee arthroplasty.

quantify the mortality rates of periprosthetic and PI femur fractures around different prosthetics and implants and to identify variables that could affect the potentially life-threatening nature of this injury. In doing so, we hoped to better understand the natural history of periprosthetic, PI, and IP femur fractures; optimize their management; and help develop a gold standard of treatment.

In this study, the overall mortality at varying time points were 1 month (5%), 3 months (12%), 6 months (13%), 1 year (15%), and 2 years (22%) among all periprosthetic or PI lower-extremity fractures. While mortality rates in the literature for native hip fractures vary widely, the consensus for 30-day and 1-year mortality has been from 4% to 6.9% and from 14% to 36%, respectively. Similarly, previous studies on mortality rates in periprosthetic femur fractures have found a wide range of mortality rates.[12,13,15,27–32] Gitajn et al[30] found a 1-year mortality rate for Vancouver B periprosthetic femur fractures to be 13%. Bhattacharyya et al[27] demonstrated a 2-year mortality rate in 106 periprosthetic femur fractures to be 21%. Jennison et al,[13] looking at only periprosthetic femur fractures around hemiarthroplasties, found a 30-day and 1-year mortality rate of 12.5% and 28.1%, respectively. Boylan et al[15] directly comparing native hip fracture and periprosthetic proximal femur fractures found a 30-day, 6-month, and 1-year mortality of 3.2%, 3.8%, and 9.7% respectively. Our findings for mortality rates in periprosthetic femur fractures fall within the literature's current range and further add to the available body of data. Importantly, our findings suggest that periprosthetic femur fractures can be just as lethal as native hip fractures in the short-term postoperative period. Of note, our 2-year mortality rate falls within the reported range for native hip fractures, despite the unique challenges encountered by periprosthetic fractures such as a higher patient age, prior surgeries, and a potentially more complex operative management because of these characteristics.

Our study is the first of its kind, to our knowledge, to analyze periprosthetic lower extremity fractures of all types around different implants including TKA, THA, previous hip fracture

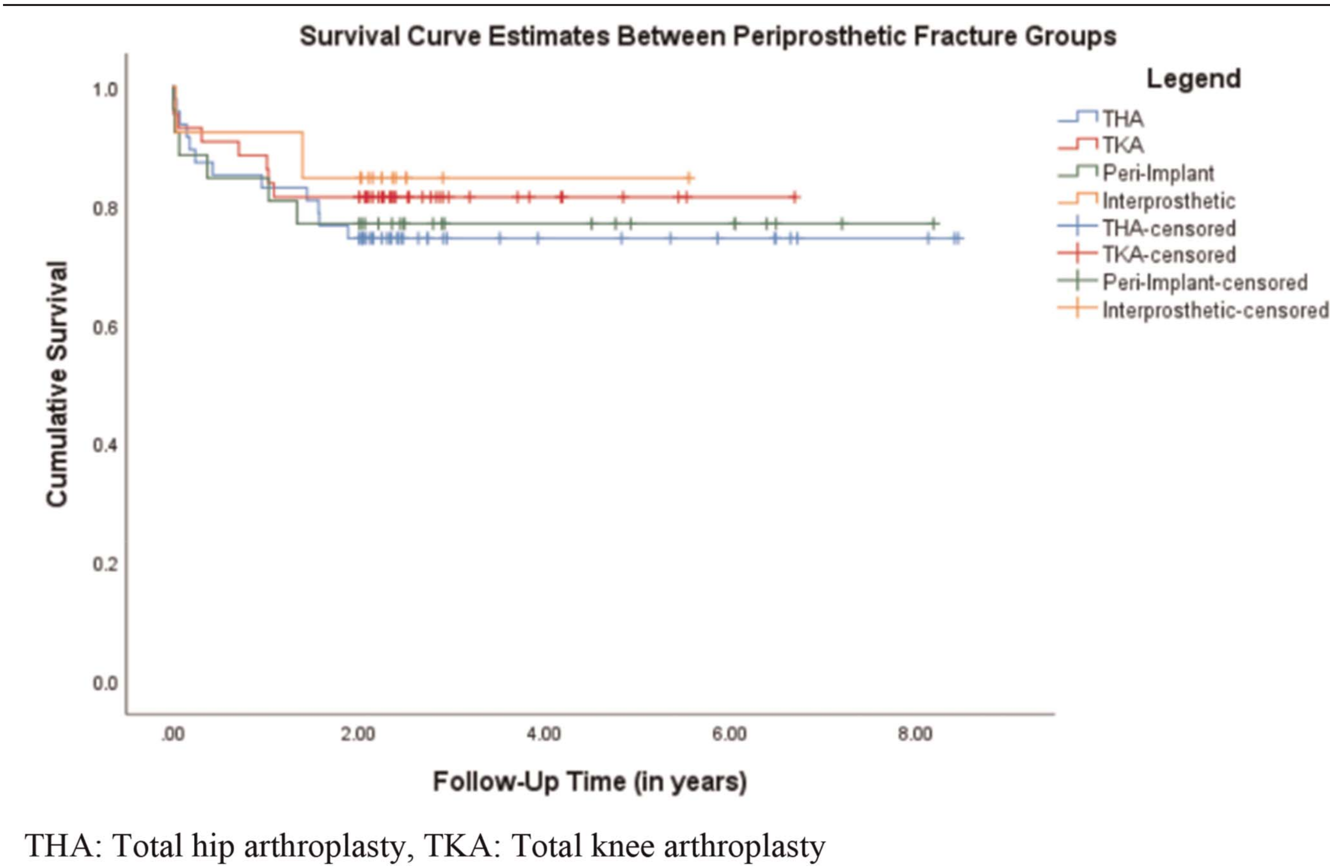

Figure 1. Kaplan–Meier survival estimate for all patients with analysis time in years.

TABLE 6

Kaplan–Meier Survival Estimate by Subgroup

KM Survival Estimates	1 Month	3 Months	6 Months	1 Year	2 Years	Log rank P
Total (n = 123)	93.6%	87.2%	85.1%	83.0%	74.5%	0.83
THA (n = 46)	93.0%	93.0%	90.7%	88.4%	81.4%	
TKA (n = 39)	96.2%	88.5%	84.6%	84.6%	76.9%	
Peri-implant (n = 25)	92.3%	84.6%	84.6%	84.6%	84.6%	
Interprosthetic (n = 13)	92.3%	84.6%	84.6%	84.6%	84.6%	

KM = Kaplan–Meier; THA = total hip arthroplasty; TKA = total knee arthroplasty.

implants, and interprosthetic fractures. There was no statistically significant difference in mortality among these 4 subgroups. However, although no statistically significant difference was found, this suggests that all periprosthetic femur fractures, regardless of the previous implant, have a similar natural history and mortality rate and can be potentially thought of similarly regarding disease process and treatment parameters.

Our study also found that the risk factors statistically significantly associated with increased mortality after periprosthetic lower-extremity fractures included age 65 years or older, history of hypothyroidism, dementia, and disposition to a skilled nursing facility. Several previous studies have found increasing

TABLE 7

Univariate Cox Regression Analysis

Univariate Cox Regression	Hazard Ratio	Lower 95% CI	Upper 95% CI	P
Age 65 years or older	4.242	1.396	12.885	**0.011**
Male	1.011	0.447	2.286	0.978
LOS ≥5 d	2.428	0.959	6.15	0.061
Smoking				
Never (ref)	—	—	—	—
Former	0.273	0.036	2.048	0.207
Current	1.597	0.635	4.02	0.32
Comorbidities				
HTN	1.42	0.62	3.254	0.407
CVA	1.433	0.495	4.15	0.507
CAD	1.313	0.567	3.039	0.525
CHF	1.617	0.482	5.427	0.437
COPD	1.564	0.58	4.221	0.377
DM	0.731	0.249	2.148	0.569
HLD	1.846	0.823	4.14	0.137
Hypothyroid	2.897	1.136	7.389	**0.026**
OA	0.859	0.339	2.176	0.748
Osteoporosis	1.688	0.507	5.62	0.393
ESRD	0.047	0	1157.655	0.554
Dementia	4.091	1.782	9.395	**0.001**
Preoperative ambulatory status				
Independent (ref)	—	—	—	—
Assistance	1.002	0.429	2.338	0.997
Nonambulatory	0	0	—	0.985
Assistive devices				
None (ref)	—	—	—	—
Cane	0.615	0.07	5.409	0.661
Crutches	0.237	0.026	2.191	0.204
Walker	0.756	0.247	2.314	0.624
Wheelchair	0.58	0.149	2.268	0.434
Postoperative ambulatory status				
Independent (ref)	—	—	—	—
Assistance	0.629	0.213	1.861	0.403
Nonambulatory	0.596	0.152	2.339	0.458
Discharge disposition				
Home (ref)	—	—	—	—
Rehabilitation	2.787	0.917	8.467	0.071
Skilled nursing facility	14.112	2.839	70.161	**0.001**
Other hospital	0	0	—	0.986
Fixation method				
Nonoperative (ref)	—	—	—	—
Percutaneous screws	0.924	0	—	1
ORIF	2.98×10^4	0	—	0.924
IMN	3.18×10^4	0	—	0.924
IMN + ORIF	5.7×10^4	0	—	0.919
Revision	2.2×10^4	0	—	0.926
Revision + ORIF	6.8×10^4	0	—	0.918

A *P*-value ≤ 0.05 was considered to be statistically signficant and bolded.
CAD = coronary artery disease; CHF = congestive heart failure; CI = confidence interval; COPD = chronic obstructive pulmonary disease; CVA = cerebrovascular accident; DM = diabetes mellitus; ESRD = end-stage renal disease; HLD = hyperlipidemia; HTN = hypertension; IMN = intramedullary nail; LOS = length of stay; OA = osteoarthritis; ORIF = open reduction and internal fixation.

age and dementia to be associated with increased mortality.[15,28] Previous studies have also found preinjury residence at a nursing facility and preoperative baseline functional level to be associated with poorer outcomes after periprosthetic femur fractures; however, our study did not find any statistical significance in those variables.[33]

One unique finding that our study revealed was that discharge disposition to a skilled nursing facility was associated with an increased mortality rate. There is a large volume of literature demonstrating improved outcomes and decreased costs in primary and revision arthroplasty when patients are discharged home instead of a rehabilitation facility.[34] It is not surprising that this would also be true in the case of periprosthetic fractures. Our findings are important as they argue for patients treated for periprosthetic fractures to be discharged home whenever possible. The same home protocols used in arthroplasty, including home visiting nursing and physical therapy, could be considered for this patient population.

Our study did not demonstrate any significant association in mortality rate after PPF when stratified by fixation strategy. This is contradictory to several previous studies in the literature. Boylan et al[15] found revision total hip arthroplasty after PPF to be associated with a high risk of mortality at 1 month and 6 months compared with ORIF, but no significant association in the long term. They attributed this to more minimally invasive techniques leading to less physiologic stress and blood loss in the ORIF group. Other studies have found the opposite, with revision total hip arthroplasty in Vancouver type B periprosthetic fractures leading to lower mortality rates in the 3-month and 6-month period compared with ORIF.[27,28] They attributed this to earlier progression to full weight-bearing with arthroplasty. In our study, treatment with revision arthroplasty, open reduction internal fixation, or a combination of the 2 had no effect on mortality rate across all periods. The periprosthetic femur fracture population is heterogeneous, presenting with a unique combination of fracture patterns, bone quality, and stability of previous implants. As such, several different treatment strategies can be used optimally in the correct situation.[19]

4.1. Limitations

This study has several limitations. First, owing to the retrospective nature of this study, our data are inherently more susceptible to selection bias. We attempted to mitigate this limitation by including a consecutive cohort of PPF patients presenting at our institution over a relatively long study period spanning over 7 years. However, a breakdown of each demographic factor, perioperative variable, and AO/OTA fracture class per PPF type revealed that the PPFs included in our study are heterogenous, although we would argue that these data may be more representative of the general population presenting to the hospital with a PPF. In addition, a univariate Cox regression model was used to account for any demographic or perioperative variable that may influence the results of the study. However, owing to the limited sample size in each group, we were unable to perform a multivariate analysis, which would have allowed us to control for multiple demographics simultaneously and enhance the robustness of our findings. Admittedly, the characteristics of our patient population is relatively younger than those reported in previous studies with an average age of 76 years or younger with fewer comorbidities. This would suggest that our reported rates would underestimate the true incidence of mortality rates after PPFs. That being said, the results of our study sample were still consistent and comparable with those reported in the literature despite these limitations.[12,13,15,27–32]

Another limitation that this study poses is that we did not have good access to the cause of death on a large number of our patients and, therefore, were unable to draw any conclusions from this variable. Looking at specific complications after PPFs would be beneficial as a future study. Nonetheless, this study fills an important void in the literature and adds to the available data on these morbid injuries. The high mortality rates found in this study highlights the need for further multicenter prospective studies for periprosthetic femur fractures, similar to those already done for native hip fractures, to help orthopedic surgeons optimize their management.

5. Conclusion

The overall mortality rates observed were 1 month (5%), 3 months (12%), 6 months (13%), 1 year (15%) and 2 years (22%), and no differences were found between each group at all follow-up time points. Patients aged 65 years or older with a history of hypothyroidism and/or dementia discharged to an SNF are at increased risk for mortality. From a mortality perspective, surgeons should not hesitate to choose the surgical treatment they feel most comfortable performing.

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