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Original research

Is the time to revision surgery after peri-prosthetic fracture of the knee associated with increased rates of post-operative complications?

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ABSTRACT

Background: This registry study assesses 30-day outcomes, including complications, length of stay (LOS), transfusions, and discharge disposition, as a function of time to revision surgery for knee periprosthetic fracture (PPF).

Methods: We compared outcomes when surgery occurred ≤ (expedited) or > 24 hours (nonexpedited) after admission using the 2005-2016 National Surgical Quality Improvement Program registry. Outcome variables were assessed using bivariate and multivariate analyses.

Results: Of 484 patients undergoing revision knee arthroplasty for PPF, 337 (77.9%) had expedited surgery and 107 (22.1%) had nonexpedited surgery. The average time to surgery in the nonexpedited group was 3.2 days (range 0-11). Patients with nonexpedited surgery were more likely to be older, female, and diabetic, received general anesthesia, and had a higher American Society of Anesthesiologists class, dependent functional status, and longer operative time. On multivariate analysis, nonexpedited patients had more complications (odds ratio [OR], 2.35; $P = 0.037$), surgical site infections (OR, 12.87; $P = 0.029$), urinary tract infections (OR, 10.46; $P = 0.048$), nonhome discharge (OR, 4.27; $P < 0.001$), need for blood transfusion (OR, 4.53; $P < 0.001$), and longer LOS (2.4 days; $P < 0.001$). There was no difference in mortality ($P = 0.352$).

Conclusions: Nonexpedited revision surgery for knee PPF had worse outcomes, specifically more surgical site and urinary tract infections, longer LOS, need for blood products, and more discharge to acute care facilities. This registry study cannot assess reasons for unavoidable delay, such as medical optimization and team or implant availability.

Level of Evidence: III.

Introduction

Total knee arthroplasty (TKA) is a successful and commonly performed procedure for the relief of symptoms secondary to degenerative disorders of the knee. It is estimated that as of 2010 there are over 4.7 million individuals in the United States living with a total knee replacement, with a 161% growth in procedure volume between 1999 and 2010 [1,2]. This demand for TKA is expected to continue to grow due to improving access to care, expanding medical coverage, increasing life expectancy, and the desire for improved functional mobility [3].

An estimated 55,000-67,000 revision TKA procedures were performed in 2010, with an expected increase in revision procedures in coming years [3,4]. Previous studies have identified an increased risk in post-operative complications following revision TKA; however, there is a dearth of well-powered, multi-institutional studies assessing outcomes specifically in the peri-prosthetic fracture (PPF) cohort. PPF following primary TKA occurs in an estimated 0.3%-2.5% of all primary TKAs at an average of 6.3 years following the initial operation [5-7]. Of all revision procedures performed for PPF in this study, the most frequently performed was

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revision of all the components followed by femoral component alone, followed by revision of the tibia component alone [8]. The treatment algorithm for TKA PPF ranges from non-operative treatment with immobilization in non-displaced fractures with stable implants to operative intervention. Operative treatment for femoral PPFs ranges from intramedullary nails for supracondylar fractures with stable implants, to fixed angle implants, and to revision arthroplasty which is typically used for fractures distal to the anterior flange of the femoral component with a loose femoral component and poor underlying bone quality. Tibial PPFs can be treated with immobilization for non-displaced fractures with a stable prosthesis, open reduction and internal fixation for unstable fractures but a stable prosthesis, or revision arthroplasty for displaced fractures with an unstable prosthesis. Patellar PPFs can be treated with immobilization for stable implants with an intact extensor mechanism and with a non-displaced fracture, or with component revision with or without open reduction and internal fixation for a loose prosthesis.

There are no consensus clinical guidelines regarding optimal time to fixation after PPF. Previous literature has demonstrated improvements in morbidity and possibly mortality with expedited surgery after native hip fractures [9,10]. In other fractures, time to surgery is often determined based on the availability of an appropriate surgical team and resources, or are performed more urgently in cases of open fractures, fractures associated with compartment syndrome, or in cases of neurovascular injury. PPF of the knee is generally fixed urgently given the severity of pain and the complications associated with decreased patient immobility and bed rest. Expedited surgery requires balancing the risks of a prompt procedure in the setting of patients with complex medical backgrounds vs delaying the time to surgery with a period of prolonged immobilization for pre-operative medical optimization or diagnostic testing such as culture results [11]. The literature is sparse and conflicting on whether the time to definitive fixation of PPF after TKA affects overall morbidity and mortality in the post-operative period [12-14].

The short-term clinical outcomes and rates of post-operative complications as a function of time to revision following PPF of the knee are not well characterized. The purpose of this study is to assess the independent associations between post-operative complications rates and the time to revision arthroplasty following PPF of the knee. We hypothesized that delaying the time to revision surgery for greater than 24 hours after PPF of the knee is an independent risk factor for post-operative morbidity and mortality.

Material and methods

This study is a retrospective cohort study of data that were prospectively collected by the American College of Surgeons National Surgical Quality Improvement Program. This registry includes a wide variety of participating sites across the United States ranging from community to academic hospitals [15]. At participating sites, surgical cases are randomly selected for inclusion into the registry. These patients are followed from hospital admission until 30 days after the index procedure and a variety of information from pre-operative baseline patient characteristics (eg, age, medical comorbidities, etc.), to intra-operative events (eg, blood transfusions), to post-operative complications are collected. These data are trained by site-specific surgical clinical reviewers that manually enter and audit the registry data for accuracy. This has led to an accurate database with robust data [16] that is increasingly being used in outcome-based orthopedic surgery research [9,17].

All patients who underwent a revision TKA for PPF between 2005 and 2016 were identified using Current Procedural Terminology codes 27486 and 27487. Post-operative International Classification of Disease Codes version 9 and 10 were screened to identify cases of revision arthroplasty for PPF (Appendix I). Patients were split into 2 cohorts based on the time from hospital admission to revision arthroplasty: (1) less than or equal to 24 hours from hospital admission (expedited surgery) or (2) greater than 24 hours from hospital admission (non-expedited surgery). Time to surgery from hospital admission is available as discrete variables, for instance a time to surgery of 0 days implies that a patient received an expedited surgery less than or equal to 24 hours.

Baseline and operative characteristics were collected for all patients. Baseline characteristics included gender, body mass index, age, functional status, and medical co-morbidities including diabetes mellitus, chronic obstructive pulmonary disease, cigarette consumption, pre-operative steroid use, and hypertension. Operative characteristics included anesthesia type (general vs regional), operative duration, and American Society of Anesthesiologists class. Patients with missing baseline or operative characteristics (6 patients) or who had procedures that were considered emergent (2 patients) were excluded from this study. Early post-operative outcomes up to 30 days post-operatively were also assessed. Outcomes included respiratory complications (including pneumonia, failure to wean from the ventilator post-operatively, unplanned re-intubation), renal complications (including acute or progressive renal insufficiency), and cardiac complications (including myocardial infarction or cardiac arrest requiring cardiopulmonary resuscitation); return to the operating room; deep vein thrombosis; sepsis; surgical site infection (SSI; including deep, superficial, and organ space infections), and urinary tract infections (UTIs). The aggregate of these complications was defined as any complication. Other outcomes that were assessed included non-home discharge, peri-operative blood transfusion, and unplanned 30-day hospital readmissions.

All statistical analyses were performed using SPSS, version 25 (IBM Corp, Armonk, NY). Baseline patient and operative characteristics with bivariate analysis were performed using Pearson's chi-squared test. Multivariate analysis was also used to compare post-operative complications, which adjusted for all baseline patient and operative characteristics that had a *P*-value less than .20.

Results

In total, 484 patients undergoing revision TKA for PPF of the knee were identified during this time period (Table 1). Of these, 377 (77.9%) patients had expedited surgery and 107 (22.1%) had non-expedited surgery. Patients who underwent expedited surgery were more likely to be younger ($P < .001$), male ($P < .001$), have a higher body mass index ($P = .035$), have regional anesthesia ($P = .011$), and a shorter operative duration ($P < .001$). They were also less likely to have a history of diabetes mellitus ($P < .001$) and dependent functional status ($P = .003$). The average time to surgery in the non-expedited group was 3.2 days (range 0-11).

The total rate of complications in patients who had expedited surgery (5.84%) was lower than those with non-expedited surgery (17.76%) on both bivariate analysis ($P < .001$) and multivariate analysis (odds ratio [OR] 2.35, $P = .037$) (Table 2). Multivariate analysis also identified a significant increase in SSI (OR 12.87, $P = .029$), UTI (OR 10.46, $P = .048$), non-home discharge (OR 4.27, $P < .001$), and blood transfusion (OR 4.53, $P < .001$) in patients with non-expedited surgery.

On multivariate linear regression that adjusted for baseline patient and operative characteristics, patients who underwent non-expedited surgery had longer total length of hospital stay (8.5 ± 5.5 days) relative to those with expedited surgery (3.5 ± 2.5 days, beta +2.2 days, $P < .001$) (Table 3). Similarly, there was also an increase in post-operative length of stay (LOS) in patients who underwent non-expedited surgery (+2.4 days, $P < .001$).

Table 1
Comparison of baseline patient characteristics by time to surgery after peri-prosthetic fracture of the knee.

	All patients	Time to surgery (h)		*P*-value
		≤24	>24	
	484	377	107	
Age				**<.001**[a]
<60	22.7%	27.3%	6.5%	
60-70	32.9%	36.9%	18.7%	
71-80	29.8%	26.5%	41.1%	
>80	14.7%	9.3%	33.6%	
Female %	68.0%	63.7%	83.2%	**<.001**[a]
Body mass index (kg/m^2)				**.035**[a]
Non-obese (<30)	38.2%	35.0%	49.5%	
Obese I (30-34.9)	27.3%	28.1%	24.3%	
Obese II (35-39.9)	18.0%	18.6%	15.9%	
Obese III (>40)	16.5%	18.3%	10.3%	
Co-morbidities				
Diabetes mellitus	16.9%	12.7%	31.8%	**<.001**[a]
Smoking history	9.1%	9.5%	7.5%	.510
COPD	4.8%	4.5%	5.6%	.637
Pre-operative steroid use	6.4%	5.0%	11.2%	.021
Hypertension	68.8%	67.1%	74.8%	.131
Anesthesia type				**.011**[a]
General	69.5%	66.6%	78.6%	
Regional	30.5%	33.4%	21.4%	
Dependent functional status	8.1%	6.1%	15.0%	**.003**[a]
ASA class				**<.001**[a]
I or II	38.8%	44.0%	20.6%	
III or IV	61.2%	56.0%	79.4%	
Operative duration				**<.001**[a]
≤120	39.0%	42.7%	26.2%	
>120	61.0%	57.3%	73.8%	

ASA, American Society of Anesthesiologists; COPD, chronic obstructive pulmonary disease.
[a] Significance defined as $P < .05$, significant values are presented in bold.

Discussion

Determining the time to surgery for patients with PPF after primary TKA can be a balancing act between optimization (eg, medical optimization, assembly of dedicated orthopedic surgical teams, delivery of appropriate revision equipment) and avoidance of complications from immobility and delay. This study used a large, multi-center cohort to evaluate the rates of post-operative morbidity and mortality among patients with expedited and non-expedited revision TKA following PPF of the knee. Although we found no statistical difference in mortality between these 2 cohorts,

Table 2
Comparison of adverse outcomes by time to surgery after peri-prosthetic fracture.

	≤24 h	>24 h	Bivariate analysis	Multivariate analysis	
	377	107	*P*-value	OR	*P*-value
Any complication	5.84%	17.76%	**<.001**[a]	**2.35**	**.037**[a]
Death	0.27%	2.86%	**.010**[a]	3.21	.352
Cardiac complications	0.53%	2.80%	**.040**[a]	3.59	.248
Renal complications	0.53%	0.93%	.638	1.14	.935
Respiratory complications	0.80%	4.67%	**.006**[a]	2.96	.216
Deep vein thrombosis	2.12%	1.87%	.871	0.72	.715
Return to operating room	1.59%	4.67%	.059	1.71	.433
Sepsis	0.00%	2.80%	**.001**[a]	–	–
Surgical site infection	0.80%	2.80%	.098	**12.87**	**.029**[a]
Urinary tract infection	0.27%	6.54%	**<.001**[a]	**10.46**	**.048**[a]
Non-home discharge	34.94%	79.80%	**<.001**[a]	**4.27**	**<.001**[a]
Blood transfusion	12.20%	54.21%	**<.001**[a]	**4.53**	**<.001**[a]
Thirty-day readmission	7.23%	13.13%	.081	1.64	.252

OR, odds ratio.
[a] Significance defined as $P < .05$, significant values are presented in bold.

Table 3
Association of time to surgery for peri-prosthetic fracture on post-operative length of stay.

	≤24 h	>24 h	Beta[a]	*P*-value
	Mean ± standard deviation	Mean ± standard deviation		
Total length of hospital stay (d)	3.5 ± 2.5	8.5 ± 5.5	**2.2**	**<.001**[b]
Post-operative length of stay (d)	3.5 ± 2.5	5.3 ± 4.3	**2.4**	**<.001**[b]

[a] The unstandardized beta represents the change in length of stay (d).
[b] Significance defined as $P < .05$, significant values are presented in bold.

we did find that an expedited procedure was an independent predictor of reduced overall complication rates, primarily SSI and UTI, and was associated with fewer hospital resources including a decreased post-operative LOS, reduced usage of blood products, and less frequent discharge to acute care facilities.

Previous studies have identified conflicting results regarding outcomes as a function of timing to fixation after PPF of the knee. In a recent retrospective review of 69 patients with PPF of the femur after TKA or total hip arthroplasty, Sallan et al [14] found that a delay in definitive fixation of greater than 48 hours had no effect on 30-day mortality, 1 year morbidity, or LOS. On the other hand, a study by Bhattacharyya et al [15] found that a delay greater than 48 hours from admission to surgery was associated with higher 1 year mortality rates in a retrospective review of 106 patients who underwent surgery for femoral PPF. In another retrospective, single institution study assessing 60 patients with femoral PPF following hip arthroplasty, Griffiths et al [18] found that a delay to surgery greater than 72 hours was associated with a significant increase in the rate of total 30-day complications as well as a 30-day mortality rate of 10%. These complications included UTI, superficial SSI, pressure sores, cardiac events, pneumonia, pulmonary embolism, as well as dislocation and implant failure. Our study, which defines the window of expedited surgery most restrictively, did not identify a mortality difference if surgery occurred in less than 24 hours. The discordant findings in these studies may be due to variable definitions for expedited surgery and differing durations of follow-up.

We found an increase in hospital resource utilization, including an increase in post-operative LOS greater than 2 days, in patients who underwent a non-expedited revision TKA for PPF. In a large multi-center retrospective review of 1458 patients with PPF of the knee treated with revision TKA, Reeves et al [19] found an average LOS following revision TKA due to PPF to be 7.6 days, which was significantly higher than the total LOS after all revision TKAs (4.2 days) and after primary TKA (3.4 days). On the other hand, a retrospective review of 235 patients with PPF of the femur following either TKA or total hip arthroplasty found that the timing of fixation (less than 48 hours vs greater than 48 hours) did not affect post-operative LOS [14]. Patient populations differ, however, as our study assessed only revisions for the treatment of PPF, while Sallan et al also included fracture fixation patients. Our findings showing a lower LOS after expedited surgery support efforts to improve operating room and revision equipment availability, such as providing dedicated operating room time and staff. Measures such as time to surgery may also be an important driver of value-based care as we further evaluate the relationship between cost and outcome.

In this study, we also found that patients undergoing expedited vs delayed procedures had different baseline patient characteristics, including differences in age, gender, and medical co-morbidity burden. Previous studies have cited advanced age, female sex, increased number of medical co-morbidities, and osteoporosis as patient-related systemic risk factors that predispose to PPF [19,20]. There are various explanations for why surgeries are often delayed,

including but not limited to pre-operative medical optimization and diagnostic testing, and the lack of operating room time, surgical staff support, and anesthesia teams [21]. Extensive pre-operative investigation and optimization remains a controversial topic, as this results in an increase in LOS and time to surgery with evidence suggesting that few changes are actually made in patient management [22].

There are several limitations to this current study. First, we were only able to assess short-term complications up to 30 days post-operatively. We were unable to track outcomes such as mortality which may peak or increase at a time point that is greater than 30 days post-operatively. Next, our study is subject to potential confounding in the expedited vs non-expedited group, as it is possible that the non-expedited group may have increased risk of post-operative complications from medical co-morbidities that delayed time to definitive fixations. However, we attempted to control for these confounding factors by rigorously adjusting for differences in patient- and operative-specific characteristics through multivariate regression analysis. We also were only able to categorize expedited and non-expedited surgery from time of hospital admission rather than from time of injury, potentially underestimating a patient's immobility time. Additionally, we lacked relevant variables that may have contributed to this analysis including fracture type, patterns, mechanism of injury, and revision implants used. Finally, given the heterogeneity in coding practices for open reduction and internal fixation of tibia PPF fractures, these cases were excluded and therefore this study only identifies patients undergoing revision arthroplasty.

Conclusions

This study did not identify differences in mortality. We found increased rates of post-operative morbidity, specifically SSI and UTI, as well as an increased utilization of healthcare resources including post-operative length of hospital stay, usage of blood products, and discharge to acute care facilities in patients who have non-expedited revision surgery for peri-prosthetic knee fractures. Although this association is an important finding, the confounding factors that cause delay to surgery must be elucidated in non-database studies. Nonetheless, expediting revision knee surgery for peri-prosthetic knee fractures that are medically stable may decrease post-operative complications.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.artd.2019.05.002.

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