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Costs and Risk Factors for Hospital Readmission After Periprosthetic Knee Fractures in the United States

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ABSTRACT

Background: Periprosthetic fractures (PPFX) around total knee arthroplasty (TKA) are devastating complications with significant morbidity. With growing healthcare costs, hospital readmissions have become a marker for quality healthcare delivery. However, little is known about the risk factors or costs associated with readmission after treatment of PPFX. We sought to identify the patient demographics, prevalence of treatment types (open reduction internal fixation [ORIF] vs revision TKA), 30 and 90-day readmission rates, costs of initial treatment and readmission, and risk factors for readmission.

Methods: We used the 2013 Nationwide Readmissions Database to select patients who underwent TKA, revision TKA, and treatment of PPFX with either ORIF or revision TKA. The 90-day readmission rate was determined through a survival analysis, and risk factors were identified using a cox proportional hazards model that adjusted for patient and hospital characteristics.

Results: We identified 1526 patients with PPFX treated with ORIF and 1458 treated with revision TKA. Ninety-day readmissions were 20.5% and 21.8%, respectively. Patients with ORIF were more often female and had multiple medical comorbidities. Patient factors associated with readmission included advanced age, male gender, comorbidities, discharge to a skilled nursing facility or home with health aide, and Medicare or Medicaid insurance. Treatment at a teaching hospital was the only hospital-associated risk factor identified. ORIF cost USD 25,539 and revision THA cost USD 37,680, with associated readmissions costing 15,269 and 16,806, respectively.

Conclusion: PPFX results in greater costs compared to primary and revision TKA. This study highlights risk factors for readmission after PPFX treatment.

Total knee arthroplasty (TKA) has emerged as one of the most common surgical procedures performed in the United States [1,2]. The prevalence of TKA is increasing due to an aging population, the obesity epidemic, and the growing number of knee replacements that are occurring in younger patients [3–5]. For these reasons, the number of both primary and revision TKA procedures performed each year is predicted to increase dramatically over the next decade [6].

TKA is a highly successful and relatively safe procedure [7,8]. Complications include wound healing issues, superficial and deep infections, venous thromboembolism, knee stiffness, and periprosthetic fracture (PPFX) [9]. PPFX is an especially difficult complication to treat, and is difficult to prevent [10]. An estimated 1 in 40 patients who receive a primary TKA will experience a PPFX [11]. Similarly, it has been reported that 1.7% of revision TKA patients will sustain a PPFX within 5 years postoperatively [12]. From 2000 to 2008, the number of PPFX had increased by over 4-fold due to the increasing prevalence of TKA in the United States [13]. These fractures utilize substantial healthcare resources, requiring open reduction internal fixation (ORIF) or treatment with a revision TKA [14,15]. However, little is known about the cost of treatment or associated hospital readmissions.

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Given continued growth in healthcare expenditures, there has been an increasing emphasis on improving the delivery of quality care with reduced costs [16], resulting in a movement to link reimbursement rates with defined outcome measures such as hospital readmissions [17]. Penalties for low-performing hospitals can be substantial, on the order of several million dollars per year [18]. Additionally, hospital reimbursements for orthopedic procedures have increased annually below the inflation rate [19], with the amount reimbursed for revision TKA only meeting one-third of the hospital charges in 2006 [20]. Hospitals have been able to reduce some costs of TKA by decreasing the average length of stay [21,22]. However, centers that treat patients who are at high risk for readmission due to medical and/or surgical complexities [13] may be disproportionately affected by these reimbursement regulations [23]. Identification of patients who are high risk allows for development of programs aimed at reducing hospital readmissions. However, little is known about which patient or hospital-associated risk factors contribute to readmission after treatment for PPFX.

To our knowledge, there are no published reports with longitudinal follow-up that describe the national burden of PPFX in the United States. The purpose of this study is to utilize the Nationwide Readmissions Database (NRD) to answer the following questions about PPFX in comparison to primary and revision TKA: (1) What is the incidence of PPFX that is treated with ORIF vs revision TKA? (2) What are the 30 and 90-day hospital readmission rates following PPFX treatment? (3) What are the direct costs for treatment of PPFX including hospital readmission? And (4) What are the risk factors associated with readmission?

Materials and Methods

Data Sources

The NRD is a national database of hospital discharges maintained by the Healthcare Cost and Utilization Project [24]. Deidentified patient data come from 22 states, which make up more than 50% of the population in the United States. The NRD contains longitudinal tracking numbers, which allow for the tracking of hospital readmissions. We used the 2013 NRD, which includes approximately 15 million patient discharges, which is an estimate of about 35 million discharges when adjusted to the national level.

The annual incidence of PPFX in the United States was estimated using the results from the NRD and US census data for 2013 [25]. We excluded patients with less than 30 days of follow-up from this study (ie, procedures in December 2013), and to estimate the annual incidence we extrapolated 11 months of data to 1 year.

Patient Selection

We used diagnosis and procedure codes (International Classification of Disease version 9) to select patients for inclusion. Patients were divided into 4 groups: those with PPFX treated with either (1) revision TKA or (2) open reduction and internal fixation. Additionally, for the control groups, we included all patients with either (3) primary TKA or (4) revision TKA for nonfracture diagnoses (see Appendix for complete listing of codes used) (Fig. 1). PPFX was identified using the specific periprosthetic diagnosis code or a specific set of codes that indicated a PPFX (eg, a distal femur fracture or a proximal tibia fracture also with a code for the presence of an existing TKA).

We required a minimum of 30-day follow-up in the NRD database, and thus excluded patients with their first procedure in December. We also excluded patients from out of state, as they may seek care outside the state if they experienced a complication, and thus follow-up may not be captured in the NRD. Patients with a primary diagnosis of fracture were excluded from the primary and revision TKA groups, which created more generalizable comparison groups for the PPFX groups.

Outcome Measures

The primary outcome was all-cause hospital readmission rate at 30 and 90 days. We also assessed length of hospital stay, mortality, and estimated inpatient costs. Groups were also compared on patient demographics such as age, gender, insurance type, and all-payer refined diagnosis-related group severity. The Elixhauser method was used to define patient's medical comorbidities [26].

Statistical Analysis

Group comparisons were performed using a chi-squared or *t*-test for categorical or continuous variables, respectively. Estimated costs were calculated from cost-to-charge ratios, which is the average multiplier for each hospital between the charge and the cost. Costs are reported in 2013 dollars.

Hospital readmission rates were calculated using Kaplan-Meier survival analysis. Patients were censored from further analysis after readmission or at the end of available follow-up. For example, patients who underwent surgery in November had a maximum follow-up of 30 days, and those with surgery in October were censored at 60 days. Survival curves were compared using a log-rank test. A multivariate cox proportional hazards model incorporated patient and hospital factors to identify risk factors for hospital readmission within 90 days after discharge. Statistical analyses were performed using STATA statistical software (Version 14.2; StataCorp, College Station, TX). *P*-values less than .05 were considered statistically significant.

Results

In the first 11 months of 2013, there was an estimated 2984 PPFXs that underwent ORIF (n = 1526) or revision TKA (n = 1458) (Table 1). For the comparison groups, there were 566,540 primary TKAs and 45,378 nonfracture revision TKA procedures identified. Compared to the control groups, the PPFX groups were older and had a higher proportion of females. Additionally, there was an increasing illness severity seen in the all-payer refined diagnosis-related group from the primary TKA group, followed by revision TKA, and finally highest in the PPFX groups. The PPFX groups also had significantly more medical comorbidities. The incidence of PPFX increased with age, and was more common in women than men (Fig. 2). The peak incidences were in the oldest age group of 85 years or older, reaching 17.1 per 100,000 females and 4.1 per 100,000 males.

The PPFX groups had numerous indicators of increased resource utilization compared to the primary and revision TKR groups (Table 2). Length of stay was nearly twice as long, and discharge to inpatient rehab occurred nearly twice as often. Mortality at 90 days was significantly elevated in the PPFX groups, at 3.08% and 2.21% in the PPFX ORIF and PPFX revision TKR groups, respectively, compared to primary TKA (0.13%; $P < .001$).

All-cause hospital readmission rates were elevated in the PPFX groups compared to the primary and nonfracture revision TKA groups (Fig. 3). At 30 days, the hospital readmission rate was 10.9% and 11.9% in the PPFX ORIF and PPFX revision TKA groups, respectively, compared to the primary TKA (4.1%) and revision nonfracture TKA groups (7.3%; $P < .001$). At 90 days, readmission rates were 20.5% and 21.8% in the PPFX ORIF and PPFX revision TKA groups, respectively, which again was significantly elevated compared to readmission rates in the primary TKA (8.8%) and