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Original Research

Patient-Related Risk Factors for Periprosthetic Ankle Joint Infection: An Analysis of 6977 Total Ankle Arthroplasties

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ABSTRACT

Periprosthetic joint infection (PJI) after total ankle arthroplasty (TAA) is a devastating complication that often results in explantation to resolve the infection. The purpose of the present investigation was to determine the patient-related risk factors for PJI after TAA. A national insurance database was queried for patients undergoing TAA using the Current Procedural Terminology and International Classification of Diseases, ninth revision, procedure codes from 2005 to 2012. Patients undergoing TAA with concomitant fusion procedures or more complex forefoot procedures were excluded. PJI within 6 months was then assessed using the International Classification of Diseases, ninth revision, codes for diagnosis or treatment of postoperative PJI. Multivariate binomial logistic regression analysis was performed to evaluate the patient-related risk factors for PJI. Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were calculated for each risk factor, with $p < .05$ considered statistically significant. A total of 6977 patients were included in the present study. Of these 6977 patients, 294 (4%) had a diagnosis of, or had undergone a procedure for, PJI. The independent risk factors for PJI included age <65 years (OR 1.44; $p = .036$), body mass index <19 kg/m^2 (OR 3.35; $p = .013$), body mass index >30 kg/m^2 (OR 1.49; $p = .034$), tobacco use (OR 1.59; $p = .002$), diabetes mellitus (OR 1.36; $p = .017$), inflammatory arthritis (OR 2.38; $p < .0001$), peripheral vascular disease (OR 1.64; $p < .0001$), chronic lung disease (OR 1.37; $p = .022$), and hypothyroidism (OR 1.32; $p = .022$). The independent patient-related risk factors identified in the present study should help guide physicians and patients considering elective TAA and develop risk stratification algorithms that could decrease the risk of deep, postoperative infection.

End-stage ankle arthritis is a debilitating condition that affects comfort, function, and health-related quality of life (1). Ankle osteoarthritis is an increasingly prevalent condition, affecting approximately 1% of the population (1). Posttraumatic osteoarthritis accounts for ~12% of symptomatic lower extremity osteoarthritis, correlating to 5.6 million individuals in the United States and increasing (2). Unlike hip or knee osteoarthritis, the development of symptomatic ankle arthritis is predominately posttraumatic, occurring after an ankle sprain, fracture, or ligament instability (3–5). Conservative management of end-stage ankle arthritis often involves physical therapy, administration of nonsteroidal antiinflammatory drugs, intraarticular corticosteroid injections, and modification of physical activity and footwear (6). However, the surgical treatment of end-stage ankle arthritis is indicated when conservative treatment does not alleviate the symptoms (7). Ankle arthrodesis has previously been widely accepted as the reference standard for surgical treatment of ankle arthritis; however, total ankle arthroplasty (TAA) has gained favor in recent years as an effective alternative that preserves some tibiotalar motion (2,8–11).

The goal of TAA is to restore functional range of motion, eliminate pain, and improve quality of life (12). During the past 10 years, the number of TAAs performed has dramatically increased in total volume and hospital usage (11,13), and the indications for surgery have expanded (12,14,15). Subsequent generations of implants since the initial introduction in the 1970s have reportedly decreased both the mechanical failure rate and the risk of infection (7,16).

Despite these improvements, periprosthetic ankle joint infection remains a significant complication after TAA, often resulting in implant failure (16). The reported rate of infection ranges from 2.4% to 8.9% (6,17,18), greater than the rate of infection after total knee and hip replacements (19). Thus, it is critical to identify the patient-related risk factors associated with periprosthetic infection after TAA.

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Although published reports have identified some risk factors associated with postoperative infection after TAA within small cohorts (17), to the best of our knowledge, no studies have yet demonstrated the pervasiveness of these factors in a larger population. Accordingly, the purposes of the present study were to use a national database to determine the incidence of postoperative infection and identify independent variables that increase patients' risk of periprosthetic infection after TAA.

Materials and Methods

Database

The PearlDiver Patient Records Database (Fort Wayne, IN; available at: www.pearldiverinc.com), an insurance claim-based database of patient records, was used for the present study. The database contains data from several different insurers, including both Medicare and private insurers. The 100% Medicare Standard Analytical Files database within PearlDiver was chosen for the present study, because it contains data from the largest number of patients, and most patients undergoing TAA are of Medicare age.

The PearlDiver Medicare database contains patient demographic and procedure volume data, among numerous other data for patients with International Classification of Diseases, ninth revision (ICD-9), diagnosis and procedure codes or Current Procedural Terminology (CPT) codes. The database covers patients insured from 2005 through 2012. Overall, the database contains the data from ~100 million patients. All data have been de-identified and anonymous and were thus deemed exempt by our institutional review board.

Study Cohort

Patients who had undergone TAA were identified using ICD-9 procedure code 81.56 (total ankle replacement) and/or CPT code 27702 (arthroplasty, ankle; with implant, total ankle). Patients with a concomitant revision arthroplasty code (ICD-9 code 81.59 and/or CPT codes 27703 and 27704) were excluded.

Covariates and Predictors

The covariates included in the present study were identified using specific ICD-9 diagnostic codes. These included age, sex, tobacco use, alcohol abuse, inflammatory arthritis, depression, diabetes mellitus, hyperlipidemia, hypertension, peripheral vascular disease, congestive heart failure, coronary artery disease, chronic kidney disease, chronic lung disease, chronic liver disease, hypercoagulable state, hypothyroidism, preoperative chronic anemia, body mass index (BMI) <19 kg/m^2, and current hemodialysis use. The specific BMI was also included in the analysis. Separate ICD-9 diagnostic codes are used for obesity (BMI 30 to 40 kg/m^2) and morbid obesity (BMI >40 kg/m^2), which thus could be evaluated as 2 separate covariates. This method has been used in previous studies of administrative databases (20,21). Several of these covariates are also included in several comorbidity indexes, including the Charlson comorbidity score, Elixhauser comorbidity score, and the combined comorbidity score (22). In addition, several of these covariates have been evaluated in previous studies examining the risk factors for deep infection after TAA (17,18,23).

Infection

The study endpoint of interest was infection within 3 to 6 months after TAA. Although most of the current data have focused on the occurrence of early infection after TAA, studies have reported the development of chronic deep infections occurring >6 months postoperatively (17,18,23). After an institutional review of >900 total ankle arthroplasties, Patton et al (23) reported that deep infection after surgery was diagnosed <3 months after the index surgery in 38% of patients, 3 to 12 months in 38% of patients, and >12 months in 24% of patients. Thus, it is important to identify the factors that contribute to infection both within 3 months and >6 months postoperatively. However, many of the infection codes are not specific to TAA. Thus, a period >6 months was not appropriate, because any infection could have resulted from another procedure or event as the interval between the infection and TAA increased. Infection was defined as the diagnosis of periprosthetic infection or septic ankle and/or a procedure for postoperative infection or septic ankle arthritis. The diagnosis codes included ICD-9 codes 998.51, 998.59, 996.66-7, 996.69, 711.07, 711.47, 711.87, and 711.97. The CPT procedure codes included 10180, 20005, 27603, 27607, and 27610.

Statistical Analysis

The overall infection rate from 2005 to 2012 and the annual infection rate were calculated from the database output. Linear regression analysis was used to examine any change in the infection rate over time. A descriptive analysis was conducted at 3 and 6 months detailing the distribution of patient variables and infection rates. Multivariable binomial logistic regression analysis was then performed to examine the independent effect of the included covariates on the incidence of infection after TAA. The odds ratios (ORs), 95% confidence intervals (CIs), and p values were calculated for all variables; $p < .05$ was considered statistically significant for all statistical tests. All statistical testing was performed within the PearlDiver system using R, an open source statistical package (R Foundation, Vienna, Austria; available at: https://www.r-project.org/).

Table 1
Distribution of patient variables and infection rates (N = 6977 patients)

Variable	Population	Infection at 3 mo	Infection at 6 mo
Age <65 y	1105 (15.8)	43 (3.9)	72 (6.5)
Obesity (BMI 30 to 40 kg/m^2)	1322 (18.9)	46 (3.5)	70 (5.3)
Morbid obesity (BMI ≥40 kg/m^2)	602 (8.6)	21 (3.5)	37 (6.1)
Tobacco use	980 (14.0)	47 (4.8)	70 (7.1)
Alcohol abuse	331 (4.7)	15 (4.5)	23 (6.9)
Inflammatory arthritis	1093 (15.7)	41 (3.8)	74 (6.8)
Depression	1947 (27.9)	72 (3.7)	108 (5.5)
Hypercoagulable disorder	326 (4.7)	9 (2.8)	12 (3.7)
Diabetes mellitus	2013 (28.9)	66 (3.3)	124 (6.2)
Hyperlipidemia	5291 (75.8)	137 (2.6)	234 (4.4)
Hypertension	5857 (83.9)	159 (2.7)	270 (4.6)
Peripheral vascular disease	793 (11.4)	50 (6.3)	82 (10.3)
Congestive heart failure	1196 (17.1)	49 (4.1)	87 (7.3)
Coronary artery disease	2401 (34.4)	66 (2.7)	132 (5.5)
Chronic kidney disease	1172 (16.8)	44 (3.8)	83 (7.1)
Chronic lung disease	1505 (21.6)	61 (4.1)	111 (7.4)
Chronic liver disease	396 (5.7)	11 (2.8)	15 (3.8)
Current hemodialysis use	122 (1.7)	2 (1.6)	7 (5.7)
Hypothyroidism	2010 (28.8)	63 (3.1)	106 (5.3)
Low BMI (<19 kg/m^2)	39 (0.6)	2 (5.1)	5 (12.8)
Preoperative anemia	1020 (14.6)	45 (4.4)	62 (6.1)

Data presented as n (%).
Abbreviation: BMI, body mass index.

Results

A total of 6977 patients who had undergone TAA were included in the present study. During the study period, 294 patients developed infection within 6 months postoperatively, for an overall infection rate of 4.2%. The rate of infection ranged from 3.0% to 4.8% from 2005 to 2012; however, no significant increasing or decreasing trend was found ($p = .547$; Table 1). The distribution of the covariates and infection rates for the population studied are listed in Table 1.

Numerous independent risk factors for infection were identified using logistic regression analysis at both 3 and 6 months. Within 3 months of surgery, the significant risk factors for deep infection included age <65 years (OR 1.5, 95% CI 1.08 to 1.87), obesity (OR 1.48, 95% CI 1.08 to 2.02), low BMI (OR 2.12, 95% CI 1.78 to 2.53), tobacco use (OR 1.79, 95% CI 1.25 to 2.56), inflammatory arthritis (OR 1.42, 95% CI 1.01 to 2.01), peripheral vascular disease (OR 3.14, 95% CI 2.22 to 4.42), hypothyroid disorder (OR 1.27, 95% CI 1.02 to 1.58), and preoperative anemia (OR 1.51, 95% CI 1.07 to 2.13; Table 2). Within 6 months of surgery, the significant risk factors for deep infection included age <65 years (OR 1.61, 95% CI 1.20 to 2.16), low BMI (OR 2.67, 95% CI 1.07 to 6.67), obesity (OR 1.47, 95% CI 1.15 to 1.87), tobacco use (OR 1.44, 95% CI 1.08 to 1.92), diabetes mellitus (OR 1.35, 95% CI 1.05 to 1.73), inflammatory arthritis (OR 1.67, 95% CI 1.28 to 2.18), peripheral vascular disease (OR 2.46, 95% CI 1.87 to 3.22), chronic kidney disease (OR 1.39, 95% CI 1.05 to 1.84), chronic lung disease (OR 1.51, 95% CI 1.16 to 1.96), and hypothyroidism (OR 1.32, 95% CI 1.03 to 1.69; Table 3).

Discussion

The use of TAA has continued to gain favor over ankle arthrodesis as an effective alternative surgical treatment of end-stage ankle