Long-Term Survival of a Semi-Constrained Implant Following Revision for Infection

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ABSTRACT

Revision total knee arthroplasty (TKA) in prosthetic joint infections (PJI) is a challenging problem. We evaluated our institutional experience with a semi-constrained implant placed in a PJI setting. Seventy-eight TKAs in 75 patients with a history of a PJI were identified. The average follow-up was 7.5 years. Twenty-three (29%) underwent repeat revision surgery. Five and 10 year survivals were 71% and 64%, respectively. The most common reason for repeat revision surgery was recurrent infection (78%). Smoking and elevated BMI increased the risk of repeat revision surgery. Significant improvements were maintained long term in pain and range of motion ($P < 0.01$ and $P = 0.02$). In the absence of repeat infection, long term pain relief and improved function may be expected with the semi-constrained implant.

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Revision total knee arthroplasty presents numerous challenges. The surgical complexity increases significantly in the setting of bone loss, ligamentous laxity, or infection. In these settings, utilization of multiple strategies to overcome these challenges enables patients to hopefully regain function and obtain long-term pain relief. One method of managing ligamentous laxity is by increasing the constraint of the implant. The Total Condylar III (TCIII) knee (DePuy, Warsaw, Indiana) was designed as a non-hinged semi-constrained implant to help stabilize the knee in the setting of ligamentous laxity. Through a tall tibial post the implant provides coronal and sagittal stability while adding less stresses at the implant, cement, and bone interfaces compared to hinged alternatives.

Prosthetic joint infection (PJI) significantly adds to the complexity of revision arthroplasty. Although bone loss and ligamentous laxity can be overcome through implant design and use of bone graft or metal augmentation, eradication of infection is very challenging. Treatment of a PJI often requires resection of the implant followed by antibiotics and a staged reimplantation. The TCIII is a particular implant that may be used in this setting. Very little is known about the implant survival in the setting of a previously septic joint. Therefore, the purpose of this study was to evaluate our institution's long-term survival of revision total knee arthroplasty in the setting of a prosthetic joint infection using the TCIII implant. We also attempted to evaluate risk factors for implant failure and recurrent infection in our patient population.

Materials and Methods

We performed our review using a single institution's total joint registry after obtaining approval from the institutional review board (IRB). Our total joint registry prospectively captures data including survival, postoperative complications, pain, and functional outcomes at specified postoperative dates from all patients who undergo a total knee arthroplasty.

Our study included any patient who underwent a revision total knee arthroplasty in the setting of a prosthetic joint infection from August 1994 through November 2002 with the semi-constrained, modular fixed-bearing TC III implant. Diagnosis of a prosthetic joint infection was made if two or more cultures yielded the same microorganism or if purulence was present at the time of resection. Seventy-eight knees fit our inclusion criteria and were included in the study.

The primary outcome was implant survival as determined by repeat revision surgery. This included removal of any component, including an isolated polyethylene exchange. Secondary outcomes included range of motion (ROM), pain, Knee Society clinical and functional scores, and patient satisfaction. Variables analyzed as potential confounders included age, gender, BMI, smoking status, immune system compromise (as determined by a history of diabetes, inflammatory arthritis, history of hematopoietic malignancy, or use of steroids), number of prior operations performed on the knee, preoperative range of motion, ligamentous laxity, pain, and Knee Society scores. The ROM was determined by the range of the patient's active knee flexion and extension, while the stability was graded as greater or less than 10 degrees in the coronal (varus-valgus) plane or 10 mm of translation in the sagittal (anterior-

posterior) plane. Pain levels were reported by the patients as none, mild, moderate with activity, moderate, or severe. Previously validated knee society scores were separated into clinical and functional outcome scores [1]. In patients with a diagnosis of aseptic loosening or osteolysis in addition to instability, we considered a repeat revision to be due to loosening or osteolysis primarily, with instability as a secondary factor.

Statistical analysis was performed using Student's T-tests with unequal variance and Fisher exact tests for continuous and categorical variables, respectively. Univariate regression analysis of the 10-year outcomes was performed to elicit the role of the multiple confounding variables. Kaplan–Meier survival models were constructed for survival estimates at five and ten years. Univariate survival models were composed for each category of indication for the index and repeat revision surgeries. Using this model, Cox proportional-hazard regression analysis was used to assess the impact of each potential confounding variable. Statistical significance was defined as a *P*-value of ≤0.05. All analyses were performed using the JMP statistical software (Cary, North Carolina).

Results

Between August 1994 and November 2002, 75 patients (78 knees) underwent revision total knee arthroplasty for a prosthetic joint infection (PJI) with a TCIII semi-constrained prosthesis. There were 34 males and 41 females. The average age was 69 years (40–86 years) at the time of the index revision surgery. The average BMI was 29 kg/m^2 (18–42). Forty-two left and 36 right knee revisions were performed. The patients were evaluated at regular time intervals and followed for an average of 7.5 years (0.1–17 years). Five patients (7%) were actively smoking during the study period. Thirteen patients (17%) had a diagnosis of inflammatory arthritis. Thirty-four patients (45%) were immunocompromised based on a diagnosis of inflammatory arthritis, diabetes mellitus, oral steroid use, or a history of hematopoietic malignancy. The average number of surgeries prior to the index revision surgery was 3.7. Seventy-four of the 78 knees underwent a two-stage exchange consisting of removal of the implant and cement followed by antibiotic impregnated spacer implantation, intravenous antibiotic therapy, and staged reimplantation of the TCIII component with high dose antibiotic impregnated cement. Four patients underwent a single-stage revision procedure with the diagnosis of a PJI obtained based on intraoperative culture results. The average time between resection and reimplantation was 9 weeks (0–51 weeks) (Table 1). The average ESR prior to the resection arthroplasty was 45 mm/h (normal: 0–29) and the average CRP was 5.0 mg/dL (normal: <0.8). All spacers were static with 80% containing vancomycin with an average concentration of 2 grams per batch of cement (range 0.5–5 grams). Sixty percent of spacers contained tobramycin with an average concentration of 2 grams per batch of cement (0.88–4.8), and 20% of spacers contained gentamicin with an average concentration of 2.7 grams per batch of cement (1–4.8).

Femoral and tibial stems were used in all of the revision procedures. All 78 knees underwent diaphyseal cementation for fixation. Fifty-nine of the knees had documented antibiotics placed in the cement during the index revision procedure. Vancomycin was used in 88% of

Table 1
Demographic Data.

Patients (knees)	75 (78)
Side (right:left)	36:42
Follow-up (y)	7.5
Age at surgery (y)	69
Gender—male:female (knees)	34.41
BMI (kg/m^2)	29
Smokers	5
Average number of previous surgeries	3.7
Immune-compromised	34
Two-stage resection	74
Avg. time from resection to revision (weeks)	9.7
Antibiotic cement	59

Table 2
Cultured Organisms.

	Initial Infection	Repeat Infection
Coagulase-negative *Staphylococcus*	10	2
S. aureus	7	9
Serratia	1	0
Enterococcus	2	3
Corynebacterium	1	1
Pseudomonas	1	1
Candida	1	0
Beta hemolytic *Streptococcus*	0	3
Actinomyces	0	1
Streptococcus viridans	0	1
Polymicrobial	4	2

patients, with an average concentration of 1 gram per batch of cement (0.5–2 grams). Tobramycin was used in 47% of patients with an average concentration of 1 gram per batch of cement (0.6–2.2). Finally, gentamicin was used in 22% of patients with an average concentration of 0.9 grams per batch of cement (0.5–2). Bone grafting was performed in 12 knees, with 3 requiring structural allograft. The organisms cultured are listed in Table 2.

Revision for Infection

Repeat revision surgeries were performed in 23 knees (29%), including 6 isolated polyethylene exchange procedures, 7 resection arthroplasty procedures, 8 repeat revision surgeries, and 2 above-knee amputations. Nineteen knees (24%) were diagnosed with a repeat infection, 18 of which underwent repeat revision surgery. One knee diagnosed with a recurrent infection was treated with chronic suppressive antibiotic therapy only. The most common reason for repeat revision surgery was for recurrent infection (78% of revisions) and the average time from the index revision procedure until a diagnosis of repeat infection was 32 months (1–122 months). Five (26%) of the 19 knees with recurrent infection had the same organism cultured as their previous infection. One of these knees was reimplanted a week following the resection arthroplasty. Positive cultures were taken during the revision procedure and the patient remains on chronic antibiotic suppressive therapy. The remaining four patients underwent the index revision at an average of 9 weeks following the surgical resection. All five patients had a diagnosis of recurrent infection within two years following the index revision procedure with an average diagnosis at 8 months, compared to 38 months for the 14 patients with a new organism cultured at the time of repeat infection. Four of the 5 patients cultured *Staphylococcus aureus*; the final patient cultured coagulase-negative *Staphylococcus* that was not further speciated. The average ESR was 43 mm/h (normal: 0–29 mm/h) in patients diagnosed with a recurrent infection. The average CRP was 10 mg/dL (normal <0.8).

Revision for Instability

Two of the TCIII knees underwent repeat revision for instability. One knee was revised to a hinged arthroplasty due to recurrent dislocation. One knee sustained a supracondylar periprosthetic femur fracture, which required revision of the femoral component only. One knee had breakage of the femoral bolt, which required a repeat revision surgery.

Survival

Kaplan–Meier survival analysis demonstrated a 71% overall 5-year survival and an estimated 64% 10-year survival using repeat revision surgery as the end-point (Fig. 1). When recurrent infection was used as the endpoint, the 5-year survival was 77% and the 10-year survival was 68% (Fig. 2). Hazard ratios were performed on selected variables to determine their effect on overall survival or risk for repeat infection (Table 3A). Of the variables tested, smoking increased the risk of repeat