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Long-Term Survival of Semi-Constrained Total Knee Arthroplasty for Revision Surgery

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ABSTRACT

Semi-constrained implants provide stability in the setting of soft-tissue deficiency in revision total knee arthroplasty (TKA). This study evaluated our institution's long-term survival results with a semi-constrained implant used in the revision TKA setting. 234 semi-constrained revision total knee arthroplasties were performed in 209 patients. The average follow-up was 9 years. Forty repeat revisions were performed. 5-year survival was 91% and 10-year survival was 81%. Male gender significantly increased the risk of revision. At 10 years the average range of motion, pain level, and Knee Society score improved significantly ($P < 0.001$). Ninety percent of patients reported an improvement in their knee. The semi-constrained implant used in revision knee arthroplasty has acceptable implant survival and functional outcomes in the long-term follow-up period.

Revision total knee arthroplasty (TKA) presents numerous challenges for surgeons, including stabilization of ligamentous laxity and marked bone loss. To manage some of these challenges, the Total Condylar III (TC-III) Knee (DePuy, Warsaw, Indiana) was designed as a non-hinged, semi-constrained implant. This semi-constrained TKA system utilizes a tall tibial post to provide coronal, sagittal, and rotational stability, thus compensating for soft tissue deficiencies. In the coronal plane, the tibial post allows only 2.2° of varus and valgus motion and 0.3 mm of translation to compensate for medial and lateral collateral insufficiencies. At full extension, the tibial post allows 4.33° of internal/external rotation, compared to 5.43° at 90° of knee flexion. This greater stability provided by the semi-constrained design provides the orthopedic surgeon with a valuable option for treating the unstable knee.

Although some studies have demonstrated good short-term outcomes in a small number of patients, there is a paucity of large long-term studies evaluating the clinical outcomes and survival of the modular fixed-bearing TC-III implant [1–3]. We performed a review of patients who underwent a revision TKA with the modular fixed-bearing TC-III implant at our institution from 1995 to 2000. The purpose of this study was to examine survival rates and long-term clinical function of the semi-constrained modular fixed-bearing TC-III TKA implant used in the revision setting from January 1, 1995 to December 31, 2000.

Methods

After obtaining approval from the institutional review board (IRB), we conducted a review utilizing our institution's Total Joint Registry. The inclusion criteria were any patient who underwent a revision TKA from January 1, 1995 to December 31, 2000 with the semi-constrained modular fixed-bearing TC-III TKA implant system (DePuy, Warsaw, Indiana). During this period, 284 patients underwent 313 revision TKA procedures using the TC-III implant. We excluded all patients with a previous history of a septic TKA. This included 79 procedures, leaving 234 revision total knee arthroplasties performed in 209 patients. The authors who were not involved in the original surgeries then reviewed the patient records and outcome measures.

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, comorbidities such as diabetes or a history of inflammatory arthritis, reason for index revision surgery, number of prior operations performed on the knee, preoperative ROM, ligamentous laxity, pain, and Knee Society Scores. The ROM was determined by the range of the patient's active knee extension and terminal knee flexion. The stability was graded as greater or less than 10° 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, or severe. Knee society scores were separated into clinical and functional outcome scores as previously validated [4]. If patients were diagnosed with aseptic loosening or osteolysis as well as instability, then we considered the revision to

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be due to loosening or osteolysis primarily, with instability as a secondary factor.

Statistical analysis was performed using JMP statistical software (Cary, North Carolina). Kaplan–Meier survival analyses were used to estimate survival at 5 and 10 years. Univariate survival models were composed for each category of indication for the index revision surgeries as well as indications for repeat revision procedures. Cox proportional-hazard regression analysis accounted for the impact of each potential confounding variable on overall and etiology specific survival, expressed as hazard ratios with 95% confidence intervals.

Kaplan–Meier survival analyses were used to estimate survival at 5 and 10 years. Univariate survival models were composed for each category of indication for the index revision surgeries as well as indications for repeat revision procedures. Cox proportional-hazard regression analysis accounted for the impact of each potential confounding variable on overall and etiology specific survival, expressed as hazard ratios with 95% confidence intervals. Comparisons between preoperative and postoperative clinical outcomes were performed by the two-tailed Student's t-test with unequal variance. Univariate regression analysis of the 10-year outcomes was performed to elicit the role of the multiple confounding variables. Nominal or ordinal variables and outcome measures were compared with chi-square tests, while continuous outcomes were compared with either nominal or other continuous variables using the two-tailed Student's t-test with unequal variance. Statistical analysis was performed using JMP statistical software (Cary, North Carolina). Statistical significance was defined as a P value of ≤ 0.05.

Results

Two-hundred thirty-four revision procedures in 209 patients were performed at our institution by multiple surgeons with an average follow-up of 9 years (0.25–17.7) (Table 1). Of the 234 procedures, 103 were performed in male patients. The average age at surgery was 69.3 years (33–89 years). Twenty-four patients were actively smoking during the study period. Thirty-five patients had a diagnosis of inflammatory arthritis. The average BMI of the patient population was 30.6 kg/m^2 (16.4–53.7). Thirty-six patients had more than 3 operations on the knee performed prior to implantation of the TC-III components. Femoral and tibial stems were used in 232 of the revision procedures. Five stems were press-fit while 229 were cemented. Bone grafting was performed in 90 knees (38%), with 32 utilizing autograft and 58 requiring allograft. To restore bone loss, 194 (82%) required femoral augments, 61 (26%) required tibial wedges and 57 knees (24%) required both tibial wedges and femoral augments.

Repeat revision surgeries were performed in 40 knees (17%), including 4 isolated polyethylene exchange procedures, 4 revisions of the femoral component only, 2 isolated revisions of the tibial component, and 30 revisions of all components. The most common reason for revision was for aseptic loosening, osteolysis, or pain (22, 55%). Revisions for infection occurred in 18 knees (45%). Kaplan Meier survival analysis demonstrated a 91% overall 5-year survival and a 10-year survival of 81% (Fig. 1).

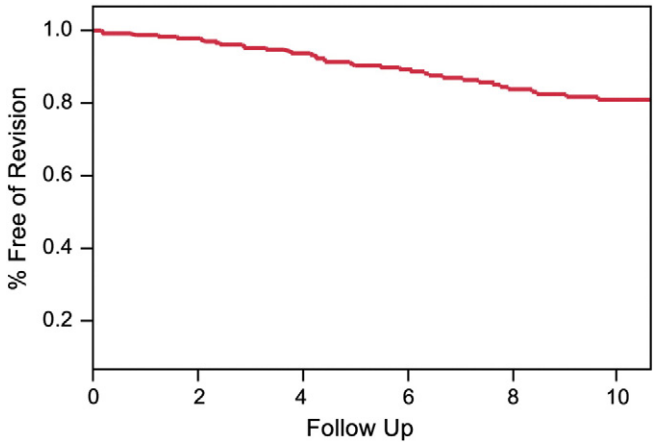

Fig. 1. Kaplan–Meier survival curve for overall 10 year survival.

The survivorship estimates of the TC-III based on different revision endpoints were performed (Table 2). If repeat revision for infection was used as the end point, the survival at 5 years was 95% and the survival at 10 years was 90%. When repeat revision for aseptic loosening, osteolysis, or pain was used as the end point, the 5 and 10 year survivals were 95% and 90%, respectively. If revision of the polyethylene only was used as the end point, the 5 and 10 year survivals were 99% and 98%, respectively. Finally, if repeat revision of the femoral and/or tibial component was used as an end point, the 5-year survival was 92% and the 10 year survival was 83%.

The hazard ratios were calculated for selected variables, including age at the time of surgery, BMI, male gender, a history of inflammatory arthritis, greater than 3 prior surgical procedures on the operative knee, and preoperative laxity greater than 10° of angulation (valgus/varus) or 10 mm of translation (anterior–posterior) (Table 3). Male gender was the only variable tested that was found to significantly increase the risk for revision surgery, with a hazard ratio of 2.07 (1.1–3.97) ($P = 0.02$). Inflammatory arthritis trended towards a decreased risk of revision, with a hazard ratio of 0.4, but this was not statistically significant ($P = 0.09$). A preoperative laxity greater than 10° in the coronal plane or greater than 10 mm in the sagittal plane trended towards a decreased risk of revision surgery with a hazard ratio of 0.6, however this also was not statistically significant ($P = 0.18$).

Of those with implants that had survived with 10 years of follow-up, the patients experienced a significant improvement in ROM from preoperative to their last postoperative visit, from 85.7°(±26°) to 98.6° (±16°) ($P < 0.001$) (Table 4). The pain levels also improved from 28% of patients preoperatively to 80% of patients postoperatively reporting mild or no pain ($P < 0.001$). Although the average Clinical

Table 1
Demographic Data.

Patients (knees)	209 (234)
Side (Right:Left)	115:119
Follow up (years)	9 (0.25–17.7)
Age (years)	69.3 (33–89)
Gender: Male:Female (knees)	103:131
BMI (kg/m^2) (knees)	30.6 (16–54)
Smokers (knees)	24
Knees with >3 prior surgeries	36
Inflammatory Arthritis (knee)	35

The data are based on 234 revision procedures performed using the TC III revision total knee arthroplasty system.

Table 2
Estimated Component Survivorship for Various Repeat Revision Endpoints.

	5 Years		10 Years	
Endpoint	No. at Risk	Survivorship (%)[a]	No. at Risk	Survivorship (%)[a]
Total revision	178	91 (±2)	98	81 (±3)
Revision for infection	178	95 (±1)	98	90 (±2)
Revision for aseptic loosening, osteolysis, or pain	178	95 (±2)	98	90 (±2)
Revision of polyethylene only	178	99 (±1)	98	98 (±1)
Revision of femoral and/or tibial components	178	92 (±2)	98	83 (±3)

[a] Values are given as the Kaplan–Meier survival estimate (± standard error).