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All-Polyethylene Tibial Components: An Analysis of Long-Term Outcomes and Infection



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ABSTRACT

Background: There is debate regarding tibial component modularity and composition in total knee arthroplasty (TKA). Biomechanical studies have suggested improved stress distribution in metal-backed tibias; however, these results have not translated clinically. The purpose of this study was to analyze the outcomes of all-polyethylene components and to compare the results to those with metal-backed components.

Methods: We reviewed 31,939 patients undergoing a primary TKA over a 43-year period (1970–2013). There were 28,224 (88%) metal-backed and 3715 (12%) all-polyethylene tibial components. The metal-backed and all-polyethylene groups had comparable demographics with respect to gender, age and body mass index (BMI). Mean follow-up was 7 years.

Results: The mean survival for all primary TKAs at the 5-, 10-, 20- and 30-year time points was 95%, 89%, 73%, and 57%, respectively. All-polyethylene tibial components were found to have a significantly improved ($P < .0001$) survivorship when compared with their metal-backed counterparts. All-polyethylene tibial components were also found to have a significantly lower rate of infection, instability, tibial component loosening, and periprosthetic fracture. The all-polyethylene group had improved survival rates in all age groups, except in patients 85 years old or greater, where there was no significant difference. All-polyethylene tibial components had improved survival for all BMI groups except in the morbidly obese ($BMI \geq 40$) where there was no significant difference.

Conclusion: All-polyethylene tibial components had significantly improved implant survival, reduced rates of postoperative infection, fracture, and tibial component loosening. All polyethylene should be considered for most of the patients, regardless of age and BMI.

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Total knee arthroplasty (TKA) has been used to successfully treat advanced knee degenerative joint disease [1]. Many developed countries are spending billions of dollars per year on this procedure [1–4]. In the changing health care marketplace, the demand for high-volume procedures, such as the TKA, has encouraged a search for innovative, cost-effective strategies to optimize initial and long-term costs while maintaining reproducible outcomes [1–4].

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As one of the original condylar tibial component designs, the all-polyethylene tibias have been demonstrated to produce excellent outcomes, with long-term survivorship over 90% [5–9]. Despite the highly successful initial clinical outcomes, biomechanical studies performed in the 1980s questioned the implants durability [10–13]. Furthermore, in 2003, Faris et al [14] published on the results of anatomic graduated component all polyethylene tibial components and showed the disastrous results of a flat-on-flat designed all polyethylene tibia. The combination of the biomechanical studies and the results of the anatomic graduated component study led surgeons to begin to favor metal-backed tibial designs [10–14]. Although the components were more expensive, it was thought that this cost would be offset by the biomechanical and technical advantages of modularity [15–17].

In recent years, multiple studies have shown equivalent or improved long-term survivorship of all-polyethylene tibial components compared with their metal-backed counterparts [4,6,15–21].

Recently, our institution published on the influence of various tibial component designs and their impact on long-term TKA survivorship [16]. The results of this study showed that all-polyethylene tibial components had improved survival related to aseptic failure compared with metal-backed components [16]. The purpose of this study was to expand on these findings to delineate differences between outcomes and survival in all-polyethylene and metal-backed tibial components. Specifically, this study is different because we focused on (1) rates of infection, (2) tibial component failure subgrouped by body mass index (BMI) and age groups, and (3) rates of reoperation and postoperative complications.

Materials and Methods

After obtaining approval from our institutional review board, we performed a review of all patients undergoing a primary TKA using our institution's total joint database. This registry prospectively follows patients in clinic or they are contacted by the telephone and/or letter at 2 and 5 years, and then every 5 years thereafter.

Revision surgery was defined as a surgical procedure where a component of the TKA was removed and/or exchanged. Reoperation was defined as a surgical procedure occurring on the TKA where components were not removed or exchanged. It is possible that a patient could have a reoperation or revision surgery which was not performed at our institution and therefore has not been recorded by the joints registry at our institution. Infection was defined as superficial (above the fascia) or deep (below the fascia). The diagnosis of a deep infection was also based on the definition of a periprosthetic joint infection as established by the Musculoskeletal Infection Society [22]. Complications are captured in the registry if they are recorded in the patients' medical record, as such complications can be missed if there is no adequate documentation. In an attempt to match the patient cohorts for the overall survival analysis, they were subgrouped based on BMI and age at the time of surgery. Complications analyzed were noted in the patients' clinical registry record included infection, periprosthetic fracture, flexion contracture, tibial and femoral component loosening, osteolysis and component fracture.

Patients undergoing unicompartmental procedures, revisions of prior arthroplasty procedures, or a TKA for an oncological diagnosis were excluded. Over a 43-year period (1970–2013), 31,939 patients were included in this analysis, including 28,224 (88%) metal-backed and 3715 (12%) all-polyethylene tibial components (Table 1). The metal-backed group was 57% ($n = 16,099$) female, with a mean age of 67 years (range = 13–101 years) and mean BMI of 31.6 (range = 14.1–72.7). There were 48% ($n = 13,477$) cruciate-retaining (CR) metal-backed implants. The all-polyethylene group was 57% female ($n = 2117$), with a mean age of 71 years (range = 21–99 years) and mean BMI of 31.1 (range = 16.2–59.5). In the all-polyethylene group, 28% ($n = 1058$) were CR-designed knees. The most common preoperative diagnosis was degenerative joint disease in the metal-

backed ($n = 23,691$; 74%) and all-polyethylene ($n = 3,334$; 90%) groups. The mean follow-up over this period was 7 years (range = 1–40 years). Patients in the all-polyethylene group were older (71 vs 67 years, $P < .0001$), had a lower BMI (31.1 vs 31.6, $P < .0001$), more likely to have a diagnosis of osteoarthritis (87% vs 81%, $P < .0001$), and had more cruciate-substituting (CS)–designed knees (72% vs 52%, $P < .0001$). There was no significant difference in gender composition of the cohorts ($P = 1.0$).

Statistical Analysis

Kaplan–Meier survival method was used to make survival estimates, with comparisons between the metal-backed and all-polyethylene components performed using the log-rank test. Proportional hazard regression analysis was performed to assess the association of clinically interesting covariates with the risk of implant failure, reinfection, and reoperation. Continuous variables were compared using unpaired student *t* tests, and categorical variables were compared with the Fisher exact tests and odds ratios (ORs). All statistical calculations were made using JMP version 10 (Statistical Analysis Software, Cary, NC) with statistical significance set at a *P* value $< .05$.

Results

Revision Surgery

Over the course of the study, 2973 knees (9.3%) were revised for any reason at a mean of 7 years (range = 1 week to 35 years) postoperatively. The overall revision-free survival for all primary TKAs at the 5-, 10-, 20- and 30-year time points were 95%, 89%, 73%, and 57%, respectively. The use of a metal-backed tibial component was associated with a significantly increased risk of revision (hazard ratio [HR] = 3.41, $P < .0001$; Table 2). All-polyethylene tibial components had significantly improved survivorship compared with metal-backed components across all time points ($P < .0001$), including 5-, 10-, 20-, and 30-year survival of 98% vs 94%, 96% vs 88%, 91% vs 72%, and 83% vs 55%, respectively (Fig. 1).

In comparing CS to CR designs, there was a significantly greater risk of revision surgery (HR = 3.28, $P < .0001$) for metal-backed CS tibias compared with all-polyethylene counterparts. Likewise, metal-backed CR designs had significantly increased risk of revision (HR = 3.01, $P < .0001$) compared with all-polyethylene CR tibial components.

Aseptic Revision

After removing the patients who were revised for prosthetic joint infections (PJIs), a significantly increased risk of revision for mechanical failure was maintained in the metal-backed tibial components (HR = 3.80, $P < .0001$). All-polyethylene tibial components had significantly improved survivorship free of revision for

Table 1
Comparison of Patients in Metal-Backed to All-Polyethylene Tibial Component Groups.

Demographic Factor	All Polyethylene	Metal Backed	P Value
Number of patients	3715	28,224	
Number of females	2117 (57%)	16,099 (57%)	1.0
Number males	1598 (43%)	12,125 (43%)	
Mean age at surgery (y)	71 (range = 21–99)	67 (range = 13–101)	$< .0001$
Mean body mass index (kg/m ²)	31.1 (range = 16.2–59.5)	31.6 (range = 14.1–72.7)	$< .0001$
Cruciate-substituting implant	2657 (72%)	14,747 (52%)	$< .0001$
Cruciate-retaining implant	1058 (28%)	13,477 (48%)	
Diagnosis of osteoarthritis	3228 (87%)	22,795 (81%)	$< .0001$
Diagnosis of rheumatoid arthritis	232 (6%)	3440 (12%)	$< .0001$
Post-traumatic arthritis	221 (6%)	1764 (6%)	.49

The results that reached statistical significance are indicated in bold.

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