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Original Article

Medial Tibial Stress Shielding: A Limitation of Cobalt Chromium Tibial Baseplates

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ABSTRACT

Background: Stress shielding is a well-recognized complication associated with total knee arthroplasty. However, this phenomenon has not been thoroughly described. Specifically, no study to our knowledge has evaluated the radiographic impact of utilizing various tibial component compositions on tibial stress shielding.
Methods: We retrospectively reviewed 3 cohorts of 50 patients that had a preoperative varus deformity and were implanted with a titanium, cobalt chromium (CoCr), or an all polyethylene tibial implant. A radiographic comparative analysis was performed to evaluate the amount of medial tibial bone loss in each cohort. In addition, a clinical outcomes analysis was performed on the 3 cohorts.
Results: The CoCr was noted to have a statistically significant increase in medial tibial bone loss compared with the other 2 cohorts. The all polyethylene cohort had a statistically significantly higher final Knee Society Score and was associated with the least amount of stress shielding.
Conclusion: The CoCr tray is the most rigid of 3 implants that were compared in this study. Interestingly, this cohort had the highest amount of medial tibial bone loss. In addition, 1 patient in the CoCr cohort had medial soft tissue irritation which was attributed to a prominent medial tibial tray which required revision surgery to mitigate the symptoms.

Total knee arthroplasty (TKA) has been associated with excellent outcomes in the vast majority of patients [1-4]. There has been a dramatic increase in implant options in recent years, with certain factors potentially affecting long-term outcomes [5-7]. One particular implant variable surgeons can control is composition of the tibial tray, with the most common options including titanium (Ti) alloy, cobalt chromium (CoCr) alloy, or all polyethylene (all-poly).

Outcome studies have shown favorable long-term results for each baseplate type, though all-poly components may have marginally improved longevity [8-10]. However, potential advantages of Ti and CoCr trays include modularity for "fine-tuning' knee stability after cementation and the ability to perform a polyethylene exchange revision in the setting of global instability or polyethylene wear [11]. Advocates of all-poly tibial components site decreased cost and decreased "backside wear" over the modular implants [12]. An additional consideration related to the tibia after TKA is stress shielding of the proximal tibia after TKA [13-16]. However no study, to our knowledge, has radiographically evaluated the impact of stress shielding related to tibial component composition.

With this in mind, we sought to evaluate the effects of tibial component composition of medial tibial stress shielding between groups of all-poly, modular Ti, and modular CoCr tibial components. Specifically, we evaluated (1) medial-to-lateral distance of bone resorption, (2) risk of revision, and (3) clinical outcomes. The primary goal for this study was to evaluate whether CoCr tibial trays were associated with increased medial tibial stress shielding than patients with Ti and or polyethylene tibial implants. A retrospective radiographic review was performed on 3 cohorts of 50 patients: an all-poly tibial component cohort, a CoCr modular tibial

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Table 1
Patient Demographic Data.

Variable	CoCr	Ti	All-Poly	*P* Value
Age	64.0 (±7)	63.7 (±9)	75.3 (±5)	<.001
Female sex	30 (60%)	27 (54%)	25 (50%)	.63
BMI (kg/m^2)	28.9 (±4)	31.7 (±8)	28.9 (±4)	.017
Preoperative hip–knee angle	3.3 varus (±2)	4.6 varus (±2)	3.3 varus (±3)	.007
Postoperative hip–knee angle	3.4 valgus (±2)	3.9 valgus (±2)	3.6 valgus (±2)	.33
Follow-up (y)	2.8 (±1)	2.7 (±1)	3.6 (±2)	.003

CoCr, cobalt chromium; Ti, titanium; all-poly, all polyethylene; BMI, body mass index.

tray cohort, and a Ti modular tibial tray cohort. Medial tibial bone loss under the medial tibial tray was utilized as a surrogate for tibial stress shielding. Secondary outcomes included a comparative analysis of clinical outcomes among the 3 cohorts.

Materials and Methods

Institutional Review Board (IRB) approval was obtained before commencing the following study. We utilized the joint registry at our institution to identify all patients that underwent a posterior stabilized TKA from 2009 to 2012 with a minimum radiographic follow-up of 1 year. Patients were limited to those with a known preoperative radiographic varus deformity and those that underwent implantation utilizing one of 3 implant designs: a DePuy Sigma (Warsaw, IN) all-poly tibial implant, a DePuy Sigma rotating platform CoCr tibial baseplate, or a Zimmer NexGen (Warsaw, IN) fixed-bearing Ti tibial baseplate.

Patient Demographics

We selected 50 consecutive patients from each of the 3 implant cohorts. The average age was similar between the CoCr and Ti cohorts but was statistically older in the all-poly cohort. The BMI was similar between the CoCr and all-poly cohorts but was statistically higher in the Ti cohort. The Ti cohort had a more severe preoperative varus deformity than the other 2 cohorts. There was no difference in the overall postoperative hip–knee angle among the 3 cohorts. Finally, the all-poly cohort had a statistically longer follow-up than the other 2 cohorts (Table 1).

Radiographic Assessment

All radiographs were reviewed by the first and second authors (J.R.M. and C.D.W.). Preoperative full-length anteroposterior (AP) radiographs of the hip to ankle were initially reviewed to determine if the patient had a preoperative varus deformity. All valgus knees were excluded at this time. Next, the immediate postoperative AP knee radiograph was reviewed to ensure that the tibial implant was not initially placed with overhang. Overhang was defined as the most medial portion of the tibial baseplate having no medial tibial bone immediately inferior to it. Finally, the most recent AP knee radiograph was evaluated to determine the amount of medial tibial

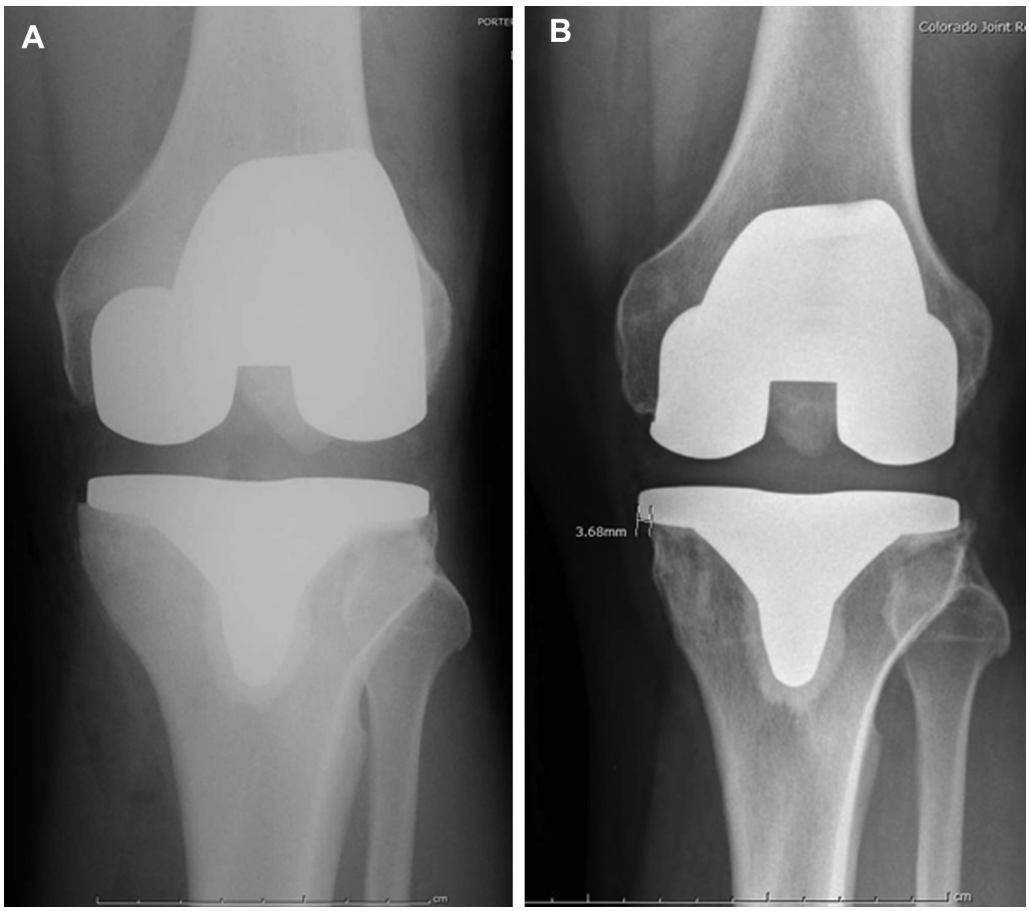

Fig. 1. (A) Immediate AP knee postoperative radiograph showing no medial tibial baseplate overhang. (B) Two-year postoperative AP knee radiographs show approximately 4 mm of medial tibial bone loss below the tibial baseplate.