Tibial Post Wear in Posterior-Stabilized Knee Replacements: A Study of Three Contemporary Designs

1Kelly, NH; 1Dolan, MM; 1Nguyen J; 1LeFloh C; 1Lasala R; 1Wright TM; 1Haas, SB
1Hospital for Special Surgery, New York, NY
kellyn@hss.edu

Introduction
The tibial post in posterior-stabilized (PS) knee implants has been identified as a potential source of wear debris. While most studies have been unable to link the amount of post wear to differences in design, a recent study found a significant difference in location of post wear between two very similar designs, the IB I and IB II, which had only subtle differences in post location [1].

Based on these results from designs with similar bearing surfaces, the question arises as to the influence of post design on other contemporary PS knee implants and how changes in post design and location made to improve function may also affect post damage.

This study examines the tibial post damage in three contemporary PS total knee designs. We hypothesized that differences in the tibial post design between these implants correlate with different damage patterns.

Materials and Methods
274 PS polyethylene inserts were obtained as part of an ongoing IRB-approved implant retrieval system at our institution. These consisted of 133 Zimmer NexGen, 103 Exactech Optetrak, and 58 Smith and Nephew Genesis II PS components. These three designs represent the largest contemporary PS knee designs in our retrieval collection (Fig. 1).

Figure 1: (A) a NexGen, (B) an Optetrak and (C) a Genesis II PS polyethylene tibial component.

Patient demographic data including age, body mass index (BMI), reason for revision, and length of implantation (LOI) were obtained for the retrieved inserts. Radiographic evaluation was performed to determine femoral varus-valgus angle, tibial varus-valgus angle, femoral component flexion-extension angle, and tibial posterior slope [2].

All inserts were examined for evidence of surface damage to the anterior, medial, lateral, posterior, and superior surfaces of the tibial post using the Hoad et al. grading system [3]. The damage scores were analyzed to determine the most prevalent mode and location of wear for each design.

Total damage scores, dominant damage locations, patient demographics, and radiographic data of the three designs were compared using an analysis of variance (ANOVA). A p-value ≤ 0.05 was considered significant. Multivariate linear regression models were developed to predict total tibial post damage and anterior tibial post damage.

Objective measurements of the tibial post damage were performed on an unimplanted specimen of a similar size from each design using a 3D scanner (NextEngine, Inc.) The overall width of the implant, the width of the tibial post, and the anterior-posterior location of the tibial post was measured in millimeters.

Results
The implants were retrieved from more women (59%) than men (41%). The average age at the time of revision was 65 years, and the average patient BMI was 31. The reasons for revision were infection (35%), instability (23%), stiffness (18%), aseptic loosening (16%), and other miscellaneous causes (8%). Age, BMI, and reason for revision did not differ significantly among groups. The average LOI was similar for the Optetrak (12.6 ± 2 years) and NexGen (21.2 ± 2 years) designs, but the Genesis II inserts were implanted for significantly less time (1.5 ± 1 years) than the Optetrak components.

Radiographs showed that on average the components were implanted in good alignment. No significant differences in component positioning were found among designs.

Average total damage scores were significantly different among designs: 20 ± 4 for the Optetrak, 13 ± 4 for the NexGen, and 8 ± 3 for the Genesis II. The primary location of post damage also differed among designs. The Optetrak design had significantly more damage to the anterior surface (27% of the total damage) than the other surfaces of the post. In the NexGen design, global damage was observed with an equal distribution of damage among the anterior (22%), posterior (24%), medial (23%), and lateral (22%) surfaces of the post. In the Genesis II design, the posterior surface of the post was the predominant location of damage (44% of total damage). Differences found in the amount of anterior post damage among designs were significant, with the mean total damage being: Optetrak 5.3 ± 1.4, NexGen 2.8 ± 1.5, and Genesis II 0.8 ± 1.4.

Regression analysis demonstrated that design, reason for revision, and length of implantation were independent variables significantly associated with both total post damage and anterior post damage. The variable most affecting total damage score and anterior damage score was implant design, with NexGen and Genesis II implants associated with less total damage and anterior damage than the Optetrak design.

The measurements obtained from the 3D scanner analysis revealed that the implants were of similar sizes. The Optetrak design had the most anteriorly placed tibial post. In the NexGen design, the anterior and posterior surfaces of the post were 9.6mm anterior and 1.7mm posterior to the dwell point, respectively. The Genesis II design had the most posteriorly positioned tibial post. The tibial post of the NexGen implant was wider (14.9mm) than the Genesis II (13.5mm) and the Optetrak (15.2mm) implants (Fig. 2).

Figure 2: Dimensions taken from sample implants with the specific measurements shown arbitrarily on an Optetrak implant.

Discussion
The purpose of this study was to evaluate three contemporary PS TKA designs to determine differences in the degree and location of post damage. While considering the tibial post in isolation is oversimplified, the differences in post geometry and location corresponded to the predominant locations of damage in the three designs. The Optetrak design demonstrated predominantly anterior post damage, and relative to the other two designs has a more anteriorly placed tibial post. The NexGen implant has a wider tibial post compared to Optetrak and Genesis II, and had global damage on all surfaces of the tibial post. Genesis II has a more posteriorly positioned post, and the primary location of damage was on the posterior surface of the tibial post. While tibial post damage is clearly multifactorial, this study supports previous work in demonstrating that tibial post damage is design dependent. The retrieval analysis presented here found three distinct damage profiles for the three designs investigated, with significant differences in both the degree and location of damage. Multivariate linear regression analysis demonstrated that tibial post damage and anterior post damage are primarily determined by implant design. While PS knee designs have good long-term survival and functional results, wear of the tibial post remains a concern. Future designs should consider optimal geometry and location of the post in relation to the bearing surfaces to minimize wear damage.

Acknowledgements: The authors would like to thank Joe Lipman. The retrieval system is maintained in part by the Zimmer-HSS research fund. This investigation was conducted in a facility constructed with support from Research Facilities Improvement Program Grant Number C06-RR12538-01 from the National Center for Research Resources, National Institutes of Health.