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Retrieval Analysis of Posterior Stabilized Polyethylene Tibial Inserts and Its Clinical Relevance

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ABSTRACT

This was a retrieval analysis of 83 PS inserts to assess the effect of limb alignment, implant position and joint line position on the pattern of wear in posterior stabilized (PS) tibial inserts. The total damage score was significantly higher in knees with postoperative varus alignment more than 3° ($P = 0.03$). The total damage score to the post was significantly more in knees with joint line elevation more than 5 mm (9.7 ± 3.9, compared to 6.5 ± 3.7 in knees with less joint line elevation) ($P = 0.05$). Limb malalignment and joint line elevation resulted in more damage in PS inserts. An external rotation subluxation damage pattern was found in joint line elevation.

Total knee arthroplasty (TKA) has excellent survivorship of more than 90% at ten years [1,2]. One of the main reasons for revision surgery is polyethylene wear with resultant osteolysis and aseptic loosening [2–4]. Wear in a posterior stabilized (PS) polyethylene tibial insert depends on component position, limb alignment and ligament balancing [5]. Postoperative varus knee alignment has been shown to result in poor clinical outcomes and accelerated wear [6–8], while more recent work has demonstrated that a postoperative mechanical axis of 0° ± 3° did not improve the fifteen-year implant survival rate in modern total knee arthroplasties [9]. Retrieval analysis can provide valuable information on the in-vivo wear characteristics of implants and allow clinicians to correlate damage pattern with radiographic findings in an objective and reproducible manner.

Previous reports in the literature have focused on the effect of limb alignment and implant position on polyethylene wear in cruciate-retaining designs [5,10–12]. Wasielewski et al [5] had demonstrated external rotation subluxation wear patterns in cruciate-retaining TKA. To our knowledge, there has not been a report on the effect of joint line elevation on polyethylene damage in PS TKA. The objective of this study was to report on the pattern of damage, and investigate the effect of postoperative limb alignment, implant position and joint line elevation on polyethylene damage in tibial inserts that had been retrieved from PS TKA. It was hypothesized that (1) polyethylene damage would increase with postoperative limb and component malalignment, as well as joint line elevation, and (2) external rotation subluxation damage patterns would be present in cases with joint line elevation.

Materials and Methods

Study Design

There were eighty three Genesis II posterior stabilized tibial inserts available from our Institutional Review Board-approved implant retrieval laboratory between 1999 and 2011. These inserts were selected because of their prevalence within the collected retrieved implants. The components were all cemented. Inserts that had been implanted for less than 3 months were excluded from analysis. Most patients would require 3 months to regain their normal gait. The mean age of patients was 72 years old (range, 51–96 years old). The retrieved specimens had a mean duration of implantation of 3.5 years (range, 0.3 to 10.3 years, and the mean patient BMI was 32.2 kg/m^2 (range, 20.8–58.8 kg/m^2).

Damage Assessment

Three examiners were blinded to the demographic data of the patients and performed damage analysis of the polyethylene tibial inserts. The articulating and non-articulating surfaces of the insert were divided into sixteen zones [13] and scored based on the protocol recommended by Hood and Wright et al [14]. The damage modes assessed included burnishing, abrasion, scratches, pitting, cold flow, embedded debris and delamination.

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Radiographic Measurements

Two examiners analysed the pre-revision radiographs for the anatomic tibiofemoral angle (TFA) and femoral and tibial component positions on weight-bearing anteroposterior (AP), lateral and skyline films of the knee. The joint line measurement was the distance of the tibio-femoral articulating surface from the tip of the fibula [15]. The amount of joint line elevation was determined by comparison with the contralateral side.

Statistical Analysis

Statistical analysis was performed with SPSS statistical software (version 11.0; SPSS, Chicago, Illinois). Univariate analysis was performed with Chi-square or the Fisher's exact test for comparison of proportions between two categorical data. The Mann–Whitney U test was used to compare the non-parametric data between two independent samples. A P value < 0.05 was considered significant.

Results

The majority of implants were revised as a result of infection (fifty-nine of eighty-three patients, 71%). Five (6%) were revised for aseptic loosening, five (6%) for instability, four (4%) for peri-prosthetic fractures and the rest (eleven of eighty-three patients, 13%) for other reasons such as persistent pain or stiffness. Most of the PS inserts were retrieved during the first revision (fifty-three of eighty-three, 64%), fourteen (17%) during the second revision, twelve (15%) during the third revision, and the rest (four of eighty-three, 5%) during the fourth or fifth revision.

All inserts demonstrated burnishing and pitting. The next most common modes of damage were scratches (seventy-nine of eighty-three, 96%), abrasions (seventy-four of eighty-three, 89%), cold flow (sixty-five of eighty-three, 78%), debris (thirteen of eighty-three, 16%) and delamination (two of eighty-three, 2%). The embedded debris consist of bone fragments. The total damage score was highest in the medial compartment (mean 25, SD ± 10, range 6 to 50), followed by lateral compartment (mean 24, SD ± 9, range 3 to 50), post (mean 8, SD ± 5, range 1 to 25), and backside (mean 5, SD ± 4, range 0 to 16). Backside damage was present in seventy-two inserts (87%). The most common mode of backside damage was burnishing (sixty-seven of eighty-three, 82%), followed by scratches (thirty-nine of eighty-three, 46%), and pitting (twenty-four of eighty-three, 28%). Most of the damage was located in the anterior half of the backside (mean 3, SD ± 2, range 0 to 10), compared to posterior backside (mean 2, SD ± 2, range 0 to 9).

There was damage to the post in all of the inserts retrieved (100%). The most common modes of damage were burnishing, pitting and scratches. There was damage on the posterior aspect of the post in all tibial inserts. The next most common area of damage was the medial aspect of the post (sixty-four of eighty-three, 77%), followed by lateral post (sixty-one of eighty-three, 75%), and anterior post (forty-one of eighty-three, 49%).

Factors Affecting Polyethylene Damage Scores in PS Tibial Inserts (Table 1)

Alignment of Lower Limb

The mean TFA of the lower limb was 4.5° (SD ± 3.4°, range −6.0° varus to 7.7°). Damage score was significantly higher in knees with postoperative varus deformity ($P = 0.03$). Most of the damage was located in the medial compartment of the tibial insert (Table 2).

Femoral Component Position

The mean coronal alignment of the femoral component was 0.1° valgus (SD ± 2.3°, range 5.5° varus to 4.9° valgus). In the sagittal profile, the mean was 0.2° extension (SD ± 1.8°, range 8.6° flexion to 4.0° extension). There was no correlation between the coronal alignment, sagittal profile of the femoral components and the damage scores in the numbers studied.

Table 1
Factors Affecting Damage Scores in PS Tibial Inserts.

Variable	No. of Knees[a]	Total Damage Score	*P* Value
Postoperative tibiofemoral angle			
Neutral (3°–7°)	69 (83)	66 ± 24 (23 to 122)	
Varus (<3°)	14 (17)	72 ± 19 (41 to 92)	0.03
Femoral component position in relation to mechanical axis of lower limb			
Neutral	72 (87)	66 ± 24 (23 to 122)	
> 3° varus	8 (10)	69 ± 18 (52 to 92)	
> 3° valgus	3 (4)	30 ± 16 (19 to 122)	0.12
Flexion femoral component			
Neutral	49 (59)	61 ± 24 (19 to 109)	
Flexed	28 (34)	68 ± 26 (34 to 122)	
Extended	6 (7)	75 ± 20 (55 to 95)	0.42
Tibial component position in relation to mechanical axis of lower limb			
Neutral	77 (93)	65 ± 24 (19 to 122)	
> 3° varus	6 (7)	53 ± 22 (34 to 85)	0.32
Tibial slope			
Posterior slope	68 (82)	64 ± 25 (19 to 122)	
Anterior slope	15 (18)	69 ± 25 (23 to 98)	0.42
Patellar subluxation			
No	63 (76)	63 ± 23 (23 to 122)	
Yes	20 (24)	69 ± 28 (19 to 109)	0.44
Joint line elevation			
< 5 mm	55 (66)	61 ± 21 (34 to 122)	
≥ 5 mm	28 (34)	59 ± 24 (19 to 109)	0.82

PS = posterior-stabilized.
All others listed as mean ± SD (range).
[a] The data are given as the number of patients with the percentage in parenthesis.

Tibial Component Position

None of the tibial component was implanted in more than 3° valgus. The mean coronal alignment of the tibial component was 0.2° varus (SD ± 1.8°, range 4.3° varus to 3.0° valgus). The mean posterior slope was 3.9° (SD ± 3.6°, range 4.4° anterior slope to 8.6° posterior slope). Seven patients (39%) had posterior tibial slope (mean 4.0°, SD ± 2.1°, range 2.0° to 7.0°. There was no correlation between the coronal alignment, posterior slope of the components and the damage scores in the numbers studied.

Patellar Subluxation/Dislocation

There was no significant difference in the total damage score for patients with patellar subluxation. However, scratches (mean 9, SD ± 7, $P = 0.03$) and debris (mean 2, SD ± 1, $P = 0.01$) were significantly more common in cases of patellar subluxation.

Joint Line Elevation

The mean joint line elevation was 2 mm (SD ± 6 mm, range 0 to 13 mm). Joint line elevation was strongly correlated with damage to the post ($r^2 = 0.7$, $P = 0.02$). In patients with joint line elevation more than 5 mm, there was significantly more damage especially in the posterior (mean 2, SD ± 1, $P = 0.01$) and medial (mean 3, SD ± 2, $P = 0.03$) aspects of the post (Table 3).

Discussion

Accelerated wear in polyethylene inserts can be the result of surgeon, patient and implant factors [10,16,17]. The aim of this study was to investigate the relationship between limb alignment, implant position, joint line elevation and polyethylene damage in PS inserts. Damage was found in all the posts, and backside wear was