POLYETHYLENE INSERT MICROMOTION IN MODULAR TKR: EFFECTS OF COLD FLOW AND IMPLANTATION TIME

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Introduction: It has recently been shown that polyethylene tibial inserts exhibit wear patterns on the non-articulating backside surface. While micromotion between the polyethylene insert and the metal tibial tray is assumed to be the cause of this type of wear, the amount of micromotion present during physiologic loading and its relation to the type and severity of wear observed is unclear. The purpose of this study was to determine the amount of micromotion between the polyethylene and the metal baseplate in retrieved tibial components as a function of in situ time and severity of wear during physiologic loading.

Materials and Methods: Sixteen posterior stabilized total knee replacements of one common design (Insall-Burstein II, Zimmer) were retrieved after implantation times of 1 to 106 months. Each of the inserts was visually inspected using a stereomicroscope (32X) and rated for the severity of pitting (0 to 8 score) and burnishing (0 to 9 score). Cold flow was also quantified by measuring the depth of extrusion into the screw holes in the metal tibial baseplate. After soaking in 37°C bath for 4 days, the insert, baseplate and femoral component were loaded in a mechanical testing device which applied physiologic loads corresponding to the stance phase of gait in a temperature controlled bath (Figure 1). During the flexion cycle, 0-40° of femoral flexion, pneumatic cylinders applied a dynamic axial compressive force with a peak of 1200N and an internal/external rotation torque ranging from 5Nm of internal torque to 4Nm of external torque to the tibia. All specimens were loaded with the same force and torque profiles while anterior/posterior translation, medial/lateral translation and rotation in the transverse plane was measured between the insert and the metal baseplate.

Results: During physiologic loading, all specimens exhibited significant micromotion throughout the flexion cycle. The predominant motion of the insert relative to the tibial tray was medial/lateral sliding, with an average excursion of 99±40µm (46µm laterally and 53µm medially). During the period of the gait cycle from mid-stance to toe-off, the insert experienced a large reversal in the direction of movement from lateral to medial due to the internal/external rotation torque experienced by the tibia (Figure 2). Motion also occurred in the anterior/posterior direction with an excursion of 36±14µm (19µm posteriorly and 26µm anteriorly). The total amount of medial/lateral micromotion averaged 2.9 times the amount of anterior/posterior micromotion (Figure 3). This is explained by the design of the capture mechanism, a medial/lateral dovetail slide with a locking pin. Surprisingly, the insert also rotated in the transverse plane an average of 137±62mdeg (42mdeg externally and 95mdeg internally).

Discussion: During physiologic loading of retrieved tibial components, significant micromotion was observed between the polyethylene tibial insert and the metal baseplate, independent of the time of implantation. Interestingly, greater cold flow of the polyethylene into the screw holes of the metal tibial baseplate did not prevent or reduce micromotion. Also increased micromotion was associated with increased severity of burnishing. Our results indicate that minimizing insert micromotion should be a critical criteria in new designs of modular tibial components to prevent generation of polyethylene wear debris at the non-articulating surface.

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Figure 1. Experimental setup: backside micromotion measurements during physiologic loading of retrieved TKR components.

Figure 2. Translation of retrieved polyethylene insert relative to the tibial tray during the gait cycle.

Figure 3. Relationship between anterior/posterior and medial/lateral translation.

Figure 4. Relationship between insert micromotion and backside burnishing.

There was no significant correlation between in situ time and total micromotion (p=0.20). However, increased micromotion was correlated with increased burnishing (Fisher's r to z transformation, p<0.05; Figure 4), but not pitting (p=0.17). Increased cold flow did not predict lower levels of micromotion (p=0.74).