Introduction: It has been suggested that the capture mechanism of modular polyethylene tibial inserts degrades with time in-situ[2]. However, a significant correlation between insert micromotion and in-situ time has not been reported. While it is intuitive that greater micromotion would result in greater backside damage, there are few data from autopsy retrievals to support this point and large variations exist among total knee replacements (TKR) evaluated. A positive correlation between backside damage and granuloma at the screw interface has been shown in autopsy-retrieved uncemented TKR’s[4] but micromotion was not evaluated. This study evaluates insert micromotion and polyethylene damage (articular and backside surfaces) in contemporary cemented TKR’s retrieved at autopsy. It was hypothesized that 1) the average micromotion between retrieved polyethylene inserts and tibial baseplates would be greater than unused controls, 2) micromotion and backside damage would increase with time in-situ, and 3) backside damage would be associated with a granulomatous response.

Methods: Twelve posterior cruciate ligament retaining TKR’s (Series 7000, Stryker Howmedica Osteonics) were retrieved at autopsy after 41±21(15-74) months in-situ. Patient age and weight averaged 73 years and 90 kg, respectively. All polyethylene inserts were ≥6 mm thick with a full peripheral rim press-fit and supplemental anterior locking wire capture mechanism. All tibial, femoral and patellar components were fixed with cement. At autopsy, soft tissue biopsies were obtained for routine histological analysis using a semiquantitative rating scheme for macrophages and wear particles[5] and/or characterization of isolated particulate debris using scanning electron microscopy. There was no radiographic evidence of osteolysis in any knee.

In 6 knees, the polyethylene insert was undisturbed at retrieval. Micromotion between the insert and metal baseplate was measured and compared to 6 unused control components. Prior to testing, the controls were disassembled and soaked in a 37°C water bath for 2 weeks to allow for fluid absorption and retrieved components were soaked for 24 hours. Each polyethylene insert was secured in a metal frame mold and backfilled with acrylic. Micromotion was measured using a digital dial gauge (resolution, 12.5 um) with the spindle referenced against a centered bolt on the metal frame. Each baseplate was rigidly clamped in a mechanics vise bolted to the test table. Static loads up to 98 N were incrementally applied to the metal frame, displacing the polyethylene insert in the anterior-posterior and medial-lateral directions. The sum of squares insert motion index vector was calculated for both groups.

The 12 retrieved polyethylene inserts were carefully disassembled and cleaned. Articular and backside surface damage were evaluated using light microscopy. Eight different damage modes were visually assessed. For articular damage, the circumference of the medial and lateral damage regions were digitized and the damage size (% of articular surface area) was measured using digital image analysis.[3] For backside damage, the surface was divided into 4 quadrants and a semi-quantitative score method (0=no damage, 10=100% of the surface was damaged) was used to estimate the damage area.[1]

Results:
Micromotion: A significant difference between the micromotion index for retrieved inserts (mean=154±212 um) and control inserts (62±53 um) was not detected (t-test, p=0.12). Fully reversible linear micromotion occurred at loads of ±11 N before the insert was captured in the locking mechanism and elastic/plastic deformation was induced. Micromotion was negatively correlated (Spearman Correlation, p<0.05) with backside damage score (r=0.97) and in-situ time (r=0.94) (Figs. 1-2).

Surface Damage: Backside surface damage covered 38±23% and was dimpled in appearance without scratching or pitting, consistent with a cast impression of the metal baseplate against the polyethylene rather than material loss. Articular damage covered 47±7% and 45±10% of the medial and lateral surfaces, respectively. A significant correlation between backside damage score and in-situ time or articular damage area was not detected (Spearman Correlation, p>0.05).

Histology and Particulate Debris: Macrophages and wear particles were seen in every case, and granulomatous tissues were seen in half of the cases. Polyethylene particle sizes ranged from submicron granules to large flakes and shreds over 100 um. Due to the small sample number, there was no observed correlation between particle morphology and histiocyte response and the degree of articular or backside damage.

Discussion: Contrary to the stated hypothesis, a difference in the micromotion index for the autopsy and control inserts was not detected. Micromotion was greatest on inserts with the least backside damage and the shortest time in-situ. These data do not support the notion that this modular locking mechanism becomes increasingly unstable with physiologic loading. Micromotion for these autopsy-retrieved TKR’s is less than half the 380 um magnitude measured for other autopsy-retrieved designs[2]. The visual appearance of the backside damage suggests that axial compression of the polyethylene insert against the baseplate produced the observed damage rather than micromotion at the interface. Micromotion can contribute to the overall particulate load, but damage mechanisms at the polyethylene articular surface appear to dominate the histological presentation. Given the abrasive wear mechanisms and particulate debris shed during femoral condylar sliding on the articular surface,[3] efforts to control motion and wear at the articular surface appear warranted. This magnitude of micromotion appears clinically benign in this cemented TKR prosthesis.

Fig. 1-2: Inserts with the greatest amount of insert micromotion had the lowest amount of backside damage and the shortest duration of function.

Fig. 3: Backside damage score was not correlated with in-situ time.


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