**Development of an Aggressive Wear Test for Patellar Implants**

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**Introduction:** Patellofemoral complications are one of the most common postoperative problems in total knee arthroplasty, with incidences ranging from 1.5% to 24%.[1] Studies have reported the kinematics of the patella in vivo to determine modes of failure. However, few studies have been conducted to assess the wear performance of patellar implants. Burroughs et al. developed an in vitro simulator, yet the authors reported only qualitative data. The purpose of this study was to develop an aggressive wear test to evaluate the wear performance using quantitative data of all-polyethylene patellar implants.

**Materials and Methods:** Six patellar implants were tested. All were machined from GUR 1020 conventional polyethylene (PE). Three were nitrogen packaged and gamma sterilized (30 kGy). The other three, or the highly crosslinked PE (HCPE), were γ-irradiated to 30 kGy followed by annealing three times then gas plasma sterilized (X3™). All implants were asymmetric, anatomically shaped with a medialized dome, and had a thickness of 10 mm (Scorpio®, Stryker Orthopaedics, Mahwah, NJ). The implants were mounted on 40 pcf polyurethane foam (Pacific Research Laboratories, Vashon, WA) and were tested against corresponding CoCr femoral components. A 6-station knee simulator (MTS, Eden Prairie, MN) was used for testing. Testing was conducted at a frequency of 1 Hz for 1 million cycles with a lubricant of Alpha Calf Fraction serum (Hyclone Labs, Logan, UT) diluted to 50% with a pH-balanced 20-mMole solution of deionized water and EDTA (protein level = 20 g/l). The serum solution was replaced and implants were weighed for gravimetric wear at least every 0.5 million cycles. Soak control specimens for each material were used to correct for fluid absorption with weight loss data converted to volumetric data (by material density). Statistical analysis was performed using the Student’s t-test (p<0.05). Two variations of experimental setup were tested with stair climbing conditions. The first set allowed passive medial/lateral (M/L) translation via linear bearings, while the second had M/L translation constrained. Both variations had maximums of 2450 N axial load and a patello-femoral flexion angle of 54 degrees. The stair climbing loading profile was derived from the work of Costigan et al, while the patello-femoral angles were derived from the work of Van Eijden et al. Figure 1 shows the input waveforms for loading and flexion angle. Superior/inferior positioning was controlled for both test setups to maintain a 35 mm distance between the joint line and the inferior edge of the patella, which is based off the work of Norman et al.

**Results:** Results for 1 million cycles are shown in Figure 2, along with a comparison to a walking profile with fixed M/L translation for the conventional PE. The patellae under stair climb conditions with fixed M/L showed higher wear rates when compared to the walking results. However, the patellae under stair climb conditions with passive M/L translation showed significantly less wear than walking with fixed M/L translation (p<0.05). A comparison of the stair climb conditions shows that fixing the M/L translation results in significant increases of 79% in wear rate for the conventional PE and 74% for the HCPE (p<0.05). However, the overall wear of HCPE is still lower for both test setups. Figure 3 shows the locations of the wears scars for each setup. Patellar implants that underwent M/L translation show a larger wear scar on the lateral surface and a scar on the medial side of the dome. In comparison, the wear scar on the dome of the implants that did not undergo M/L translation is centrally located atop of the dome. When comparing the two materials under stair climb conditions, there is only a significant difference under fixed ML conditions (p<0.05).

**Discussion:** The results demonstrate that fixing the M/L translation provides the most aggressive conditions for wear testing of patellar implants. However, allowing M/L motion is more clinically relevant since the patella naturally displaces several millimeters during flexion.[6] The results show that the additional degree of freedom may allow for better tracking within the patellar groove, which reduces the wear rate. However, constrained M/L translation provides a “worst case” scenario for assessment and may provide a “factor of safety” in patellar component design. The results suggest that the methodology described in this study represent an aggressive wear test using stair climb conditions that allows for comparison of quantitative wear data for patellar implants.

**References:**


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**Figure 1:** The loading profile and patello-femoral angle are shown.

**Figure 2:** Wear rates for stair climbing and walking.

**Figure 3:** Left - Wear scars with passive M/L translation; Right - Wear scars with fixed M/L translation.