Wear Comparison of Fixed vs. Mobile Bearing Total Knee Replacements
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INTRODUCTION:
The debate between fixed-bearing and mobile-bearing systems continues due to the lack of clinical evidence showing survivorship of one to be superior to the other [1,2]. Delport et al report similar tibiofemoral kinematic patterns with respect to axial rotation during flexion and also femorotibial translation [3]. Conversely, Huang et al show a significant difference between the two systems in terms of the prevalence of osteolysis. His work showed that 47% of the mobile-bearing knees had osteolysis, while only 13% of the fixed-bearing knees showed signs of osteolysis [4].

Literature states theoretical benefits to mobile-bearing systems in terms of wear because of the decoupling of motion onto two articulating surfaces [5]. However, Haider et al, using a force-controlled simulator, shows no difference in wear between fixed-bearing and mobile-bearing designs of the same knee system [5]. Additionally, a recent comparison of several commercially available systems using a displacement controlled simulator also showed no significant difference in wear rate between fixed-bearing and mobile-bearing systems [6]. The purpose of this study was to directly compare additional commercially available fixed-bearing and mobile-bearing systems on a displacement controlled knee simulator using normal walking kinematics.

MATERIALS AND METHODS:
The fixed-bearing system (Triathlon®, Stryker Orthopaedics, Mahwah, NJ) consisted of cobalt chrome femoral components and tibial trays, and polyethylene inserts that were manufactured from compression molded GUR 1020 UHMWPE that was sequentially irradiated to 30 kGy and annealed three times and then gas plasma sterilized (X3®, Stryker Orthopaedics, Mahwah, NJ).

Both mobile-bearing systems consisted of cobalt chrome femoral components and tibial trays. Both systems also had polyethylene inserts that were manufactured from GUR 1020 that was sterilized using gamma irradiation in a near vacuum environment (GVF, DePuy, Warsaw, IN). The first mobile-bearing system was a CR design (Mobile1) (LCS, DePuy, Warsaw, IN), while the second was a PS design (Mobile2) (Sigma, DePuy, Warsaw, IN). The three knee systems are shown in Figure 1.

A 6-station knee simulator was utilized for testing (MTS, Eden Prairie, MN). All motion and loading was computer controlled and waveforms followed ISO 14243-3 [7]. Testing was conducted at a frequency of 1 Hz for 1 million cycles. The lubricant used was 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) [8]. The serum solution was replaced at least every 0.5 million cycles and standard test protocols were used for cleaning, weighing and assessing the wear loss of the tibial inserts [9]. Soak control specimens 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.

RESULTS:
The results of testing are shown in Figure 2. There is a significant decrease of 95% and 93% for the fixed-bearing system compared to the two mobile-bearing systems (p < 0.05).

The tibial inserts of the mobile-bearing systems showed burnishing of the superior and inferior surfaces. Additionally, the central cones had signs of burnishing on the anterior face suggesting a cantilever effect. The inserts of the fixed-bearing system showed small patches of burnishing on the superior surfaces and stenciling on the backside surface. This stenciling effect indicates little micromotion between the tray and the insert and reflects transfer of the tibial tray surface finish onto the backside of the insert. This is consistent with micromotion measurements published previously [10].

The metal components of the mobile-bearing systems showed light scratching in the direction of motion. For the tibial trays, the scratches were oriented in a circular path around the central cone. The femoral components also showed light scratching in the anterior-posterior direction. This was also true for the femoral components of the fixed-bearing system.

Figure 1: The fixed-bearing system is shown on the left, while the mobile-bearing systems are shown in the middle (Mobile1) and right (Mobile2).

Figure 2: The wear rate for the different systems after 1 million cycles of testing.

DISCUSSION:
Wear testing shows that the fixed-bearing system produced significantly less wear than the mobile-bearing systems. The increase in contact area due to two articulating surfaces may predominately affect wear. While increases in contact area reduce the contact stresses, area has been shown to be the primary driver for wear [11]. The mobile-bearing systems are commercially available systems and are not available with a highly crosslinked polyethylene. The fixed-bearing system is available with a highly crosslinked polyethylene. The difference in polyethylene material may also play a large role in the differences seen in wear properties. However, the contribution of material difference cannot be determined from this study. The results in this study support the work published by Huang et al showing a higher prevalence of osteolysis on mobile bearings [4]. Based on these results a fixed bearing can be expected to clinically outperform mobile bearings in terms of wear.

REFERENCES: