Reduced UHMWPE Wear Using Magnesia-Stabilized Zirconia Femoral Components in High Kinematics/High Load Knee Simulator Tests

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Purpose: Magnesia-stabilized zirconia (Mg-PSZ, ASTM F2393) has long been used as a bearing surface in the hip [1,2], and was shown to result in lower UHMWPE wear compared to CoCr alloy in a hip simulator [3]. Recently, we found Mg-PSZ femoral components also led to a significant reduction in UHMWPE wear compared to CoCr in knee simulator tests using ISO waveforms [4]. The purpose of this study was to evaluate whether Mg-PSZ femoral components led to less UHMWPE wear under high kinematics/high load conditions.

Methods: Stock CoCr (ASTM F75) and custom Mg-PSZ femoral components, and tibial inserts made of non-cross-linked, EtO-sterilized UHMWPE (GUR 1020), had previously been tested for 9M cycles [4] in a knee wear simulator (AMTI; ISO 14243-3). For the current test, the AP displacement and the IE rotation waveforms were modified to match the "natural knee" kinematics [5,6], and the vertical load (Fz) was scaled to a peak of 3.6 kN:

Parameter	ISO 14243-3	Current study
Flexion range	0º to 58º	0º to 58º
Peak Fz	2.6 kN	3.6 kN
AP displ. range	0 to 5.2mm	-1.5 to 10mm
IE rotation range	-5.7º to 1.9º	-4.9º to 5.0º

Table 1. Comparison of the ISO waveform to the high kinematics/load wavesforms used in the current study.

Results and Discussion: Over the 6M cycles of this high kinematics/high load test, the use of Mg-PSZ femoral components reduced the steady-state UHMWPE wear rate by a factor of 2.5 compared to inserts bearing against CoCr femoral components ($p < 0.0001$; from 9M to 15M cycles in Figure 1). The 59% reduction in wear rate was not as pronounced as the 73% reduction observed previously [4], but Mg-PSZ provided a greater reduction in wear compared to studies that used OxZr femoral components [7,8], even under aggressive wear conditions. However, comparisons to knee simulator studies that used other types of ceramics, such as Y-TZP [9-11] and Al_2O_3 [11], are difficult to make due to the use of cross-linked UHMWPE [9,10] and different metrics of wear rate [11].

Conclusions: This study found that the reduction in wear using Mg-PSZ femoral components achieved under "normal" loads and kinematics is likewise observed in high kinematics/high load conditions. Given its low wear rate, Mg-PSZ femoral components may be indicated for younger/more active/high demand patients, and might also be useful to patients with metal sensitivity.

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References: 1. Roy et al., *CORR* 465:220; 2007. 2. Sebastian et al., *Trans ORS* 1288; 2011. 3. Roy et al., *CORR* 469:2337, 2011. 4. Roy et al., *Trans ORS* 1037, 2013. 5. LaFortune et al., *J Biomech* 25:347, 1992. 6. McEwen et al., *J Biomech* 38:357, 2005. 7. Ezzet et al., *CORR* 428:120, 2004. 8. Ezzet et al., *J Arthroplasty* 27:116, 2012. 9. Tsukamoto et al., *Acta Orthop* 77:505; 2006. 10. Tsukamoto et al., *Acta Orthop* 77:505; 2006. 11. Oonishi et al., *J Arthroplasty* 24:374; 2009.

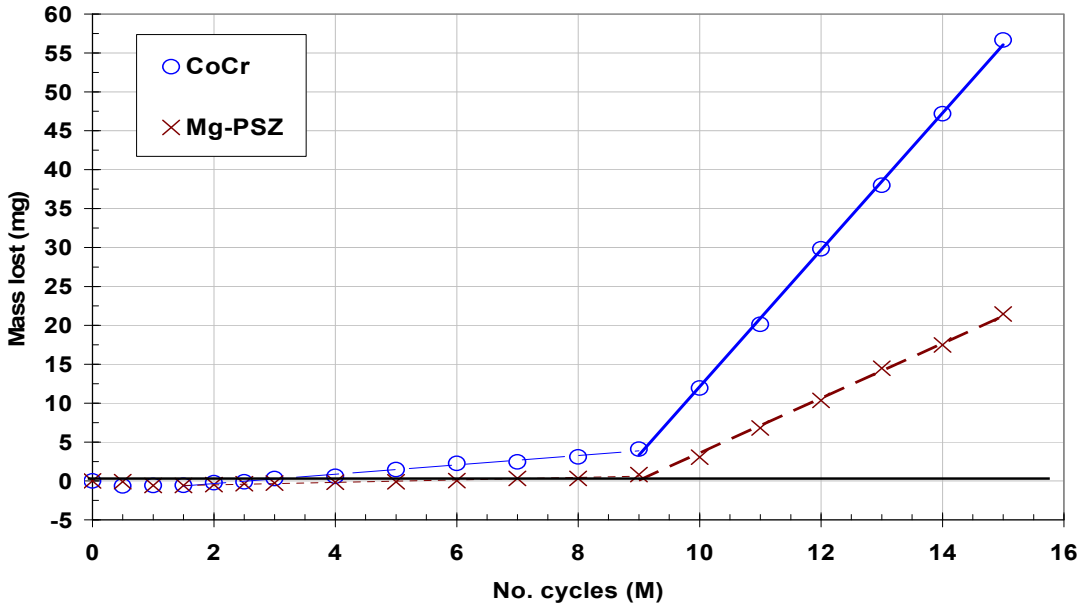

Figure 1. Gravimetric wear (corrected to load/soaks) of tibial inserts bearing against CoCr (o) and Mg-PSZ (x) femoral components. Steady state wear rates are indicated by linear regression.