INTRODUCTION:
Skepticism has been rife about the efficacy of knee simulators in screening implants, let alone their dependability as design tools. Designers do however need accurate “what-if” wear tests to verify the effectiveness of minor design changes of already successful implants. Such tests are faster, more economical and should pre-empt slow-coming clinical results. This study examined whether this is plausible on small design changes. A suitable opportunity occurred with the Biomet “Vanguard” and the “Maxim” Total Knee Replacement systems. The Vanguard is a new design upgrade to the Maxim, which primarily, but only incrementally, improved the geometry of the posterior stabilization post against wear. Only slight changes in kinematics were expected but they targeted ambitious wear reduction. We hypothesized that the much debated force-control simulation method [1,2] would not only produce reasonable wear rates for these two knee implants, but should yield differences in the TKR kinematics and wear rates to suitably reflect the expectations from the incremental design changes.

METHODS:
A force-control wear test was conducted on two Vanguard and two Maxim specimens. Both designs had similar femoral components, and identical tibial trays, and conventional UHMWPE bearing insert material, but with slightly different shapes of the stabilizing post as shown in Fig. 1.

RESULTS:
The logged kinematics (Fig. 2) were not only consistent throughout the test, but those of each pair matched closely. Astoundingly, the kinematics of one pair differed from the other in the small predictable way. The Vanguard had slightly less axial rotation with tiny reduction in overall laxity compared to the Maxim due to the different shape of the stabilizing post. After correction for liquid absorption, the AP-displacement and axial-rotation and all input variables were measured at tens of intervals to verify their consistency with the desired (input) waveforms of [2].

DISCUSSION AND CONCLUSION:
In a posterior stabilized design which is supposed to exhibit above moderate constraint, the small decrease in the laxity of the Vanguard compared to the Maxim in both AP translational and rotational constraint was insignificant compared to the substantial improvement in the Vanguard’s wear resistance.

The force control wear simulation method has indeed produced from identical force and torque inputs, slightly but appropriately different TKR kinematics, which suggested significantly different wear rates of only slightly modified knee designs. If these improvements in wear are proven clinically, then properly tuned knee simulators would have come of age, and will continue to be useful as discriminatory and screening design tools for the benefit of future patients.

REFERENCES:

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Fig. 1: Vanguard (left) and Maxim (right) UHMWPE bearings

Fig. 2: kinematics averaged over 20 cycles near the start and at the end of the test. 43 other sets of results have been logged and observed in this manner throughout the test.

Fig. 3: Wear results

y = 31.715x + 10.977 
R² = 0.9958

y = 9.046x + 1.352 
R² = 0.9985