TRIBOLOGICAL CHARACTERISTICS OF A NEW HIGH FLEXION GUIDED MOTION TKA DESIGN

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INTRODUCTION

A common complaint of total knee arthroplasty patients is that their operated knee does not feel like their healthy, unresurfaced knee. The goal of a guided motion knee design is to mimic the kinematics and kinetics of the healthy knee. Figure 1 shows a new design that has been developed to allow for controlled rotation and rollback during flexion which may permit kinematics similar to the healthy knee. The lateral surface of the tibial insert slopes distally from anterior to posterior, promoting lateral femoral condyle rollback during flexion. The sagittal low-point on the medial side is located near the AP center of the insert, minimizing anterior translation of the medial femoral condyle. Together, these two features facilitate external femoral rotation during flexion.

UHMWPE wear in TKA typically results from rolling and sliding motion at the bearing surface causing abrasive, adhesive, and fatigue wear mechanisms. Guided motion TKA designs are intended to restrict sliding motion by controlling femoral rotation and rollback during knee flexion which may be beneficial for wear reduction. However, higher constraint at the bearing surface may be required to control kinematic motions which could result in greater UHMWPE stresses. The purpose of this study was to determine the effect of implant design modifications which are intended to result in high flexion and more normal knee kinematics on wear in TKA.

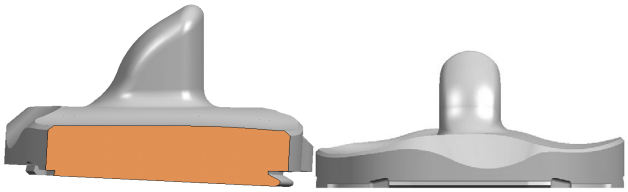

Figure 1: A cross section of the guided motion knee insert (left) displays a slight distal slope of the lateral surface from anterior to posterior, while maintaining conformity in the frontal plane (right).

METHODS

A new guided motion knee design, JOURNEY (Smith & Nephew, Memphis TN) total knee system, was evaluated for its wear performance. Wear testing was performed on a displacement-controlled knee simulator (Shore Western Manufacturing, Monrovia CA). The tibial inserts (n=3) were ethylene oxide sterilized, compression molded machined, GUR 1020 UHMWPE and the femoral components were OXINIUM. Established simulator inputs [1] based on a study of healthy patients [2] were used to develop the kinematic/kinetic gait profiles. Testing was conducted to five million cycles with a cyclic frequency of 1 Hz. The lubricant was alpha calf fraction (Hyclone Labs, Logan, UT), with sodium azide and EDTA, diluted to 50% to obtain a protein concentration of approximately 20 mg/ml. The serum solution was replaced, and the tibial inserts were weighed weekly. Gravimetric measurements were corrected for fluid absorption using three soak controls.

The lubricant from each station was collected at the time of gravimetric measurements, and debris was isolated and characterized using acid digestion, vacuum filtration (using 0.05 µm pore-size filters [3]), and scanning electron microscopy as previously described [4].

RESULTS

Wear testing yielded an average wear rate (±standard deviation) of 7.9±1.1 mm^3/Mcycle for the guided motion knee design. The predominant wear feature displayed on the articular surface of the UHMWPE tibial insert was burnishing. There were no signs of fatigue wear or of delamination, which is consistent with the expectation of implants that were not sterilized using gamma irradiation in air. UHMWPE particles analyzed ranged from fibrous to ellipsoidal in shape, displaying morphology similar to previously published experiments (Figure 2) [5,6].

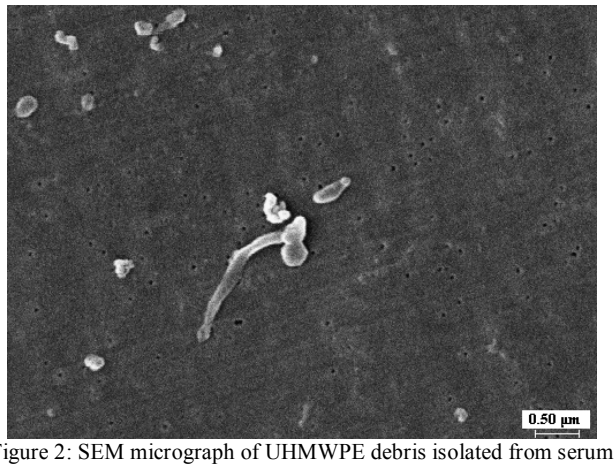

Figure 2: SEM micrograph of UHMWPE debris isolated from serum

CONCLUSION

The wear rate of the guided motion knee was within the range of knee simulator wear rates reported in literature, which has been as high as approximately 35 mm^3/Mcycle[6]. UHMWPE wear rates can vary based on implant design, test conditions, and bearing material. Wear rates of some clinically successful devices tested under similarly aggressive gait kinematic/kinetic conditions appear in Table 1. The UHMWPE wear rate of the guided motion knee design was within the lower 25% of the range of reported simulator wear rates and would, therefore, be expected to produce wear similar to different designs of clinically available implants. This testing has shown that this unique articular surface geometry can be expected to show wear behavior within the range of clinically proven devices.

Table 1: UHMWPE wear rates of clinically available TKA implants

	This Study	C/R 1[a] Ref [1]	C/R 2[a] Ref [1]	C/R 3[b] Ref [7]
I/E rotation (deg)	10	10	10	7.6
Peak load (N)	2600	2600	2600	3200
Flexion (deg)	0-58	0-58	0-58	0-58
A/P displacement (mm)	8.8	5	10	5
Femoral Material	OxZr	CoCr	CoCr	CoCr
Wear rate (mm^3/Mcycle) ± 95% CI	7.9±2.6	9.8±3.7	23.0±5.9	15.1±9.9

[a] C/R 1 and C/R 2 refer to cruciate retaining implants of the same design tested using different inputs, as shown above.
[b] C/R 3 refers to a second cruciate retaining design.

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