UHMWPE Tibofemoral Contact Area Comparison of Different Designs in High Flexion

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INTRODUCTION: Wear and delamination of the ultra high molecular weight polyethylene (UHMWPE) in joint arthroplasty has long been a concern to implant designers[1]. One factor believed to contribute to higher delamination damage rates is the amount of contact stress in UHMWPE, which is directly related to the contact area between the femoral and tibial components. At a given load, higher contact stresses result when the contact area is small. Knee implant systems that properly balance design characteristics related to constraint, conformity, and contact area may provide larger contact areas at high flexion angles and avoid large contact stresses while maintaining proper joint kinematics. The objective of this study was to measure and compare the contact area and contact stress of four different commercially available knee designs at flexion angles from 120° to 162°.

MATERIALS AND METHODS: The tibiofemoral designs evaluated in this research were the following: the Zimmer NexGen CR, CR-Flex, and NKII Congruent and the Stryker Triathlon components. The flexion angles considered in this study were from 120° to 150° in increments of 5° and from 150° to as high as possible in increments of 2°. The recommended posterior slope per the surgical technique was utilized for all the designs. The internal/external rotation was set at 15° of internal tibial rotation for all flexion angles. The applied compressive load was 2470 N (600 lbs) for all flexion angles. The 2470 N (600 lbs) load is less than the largest loads potentially generated at high flexion angles, but was chosen to avoid damage to the pressure sensitive film in this relative performance test. The load rate was set at 890 N/s (200 lb/sec). The load rate was consistent between specimens in order to minimize test variability. The testing was conducted under ambient laboratory conditions using an AMTI Force 5 knee simulator (Model KS1-1-1000) as depicted in Figure 1.

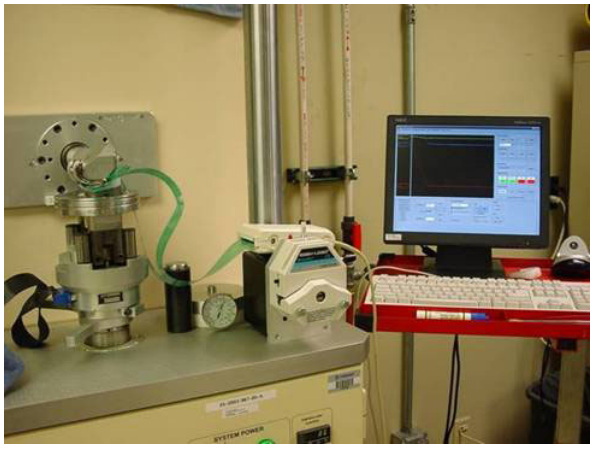

Figure 1 Experimental Setup

The initial position of the femoral component for flexion angles of 120° to 154° was placed at the low point of the articular surface in the inferior/superior direction. This measurement did take into account the posterior slope of the tibial tray. The initial position of the femoral component for flexion angles higher than 154° was 4 mm (0.16 in) anterior of the articular surface posterior lateral edge, in order to simulate femoral rollback.

Tekscan Kscan load sensors (model 4000) were used in all tests and were preconditioned following manufacturer guidelines. All scans were taken 60(±5) seconds after the desired load was attained to minimize the effect of sensor drift and polyethylene creep, which are both functions of time. All readings were taken and outputs created using Tekscan Iscan version 5.031 software. The Tekscan sensor was mounted to the articular surface using a temporary multi-purpose spray adhesive. The articular surface/Tekscan sensor was lubricated with mineral oil to minimize the frictional effects between the femoral component and the articular surface/sensor. One sample of each articular surface design was tested. Component sizes were selected to obtain similar medial/lateral and anterior/posterior dimensions across designs. The two NexGen sizes evaluated bracketed the Triathlon size.

RESULTS: Table 1 shows the sum of the contact areas for both the medial and lateral condyles versus flexion angle for all the designs tested. The CR-Flex components had larger contact areas at all flexion angles measured when compared to the other designs evaluated. The NK II design, which was commercialized over a decade ago, had slightly larger contact areas than the Triathlon design up through 156 degrees of flexion.

Table 1 Design Dependent Contact Area

Overall Contact Area Comparison [mm^2]						
Flexion Angle [deg]	**Triathlon**	**NKII**	**CR - Size CH 34**	**CR – Size CH56**	**CR-Flex – Size CH34**	**CR-Flex – Size CH56**
120	157	161	213	195	197	192
125	147	158	211	187	186	179
130	148	171	203	166	186	171
135	149	152	163	158	177	165
140	142	151	148	134	167	167
145	143	168	127	116	167	150
150	127	145	103	97	171	156
152	123	145	100	100	157	148
154	123	142	99	91	157	153
156	108	111	98	94	158	143
158	113	109	95	92	163	144
160	113	109	105	94	158	148
162	113	103	106	96	155	143

DISCUSSION: With the limited number of samples evaluated average values and statistical comparisons were not possible. However, for the samples evaluated the NexGen High Flexion designs had an average 32% larger contact area than the Triathalon design at the largest flexion angle evaluated. The ability to maintain larger contact areas in deep flexion may provide increased longevity and less potential for insert surface damage.

REFERENCES: [1] *NexGen* Complete Knee Solution Design Rationale, Zimmer, Inc., section 4.3