A New Soft Tissue Friendly Femoral Head may also Reduce Frictional Torque in Ceramic-on-Ceramic Articulation

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Introduction: Large diameter femoral heads have been used successfully to prevent dislocation after Total Hip Arthroplasty (THA). However, recent studies show that the peripheral region of contemporary femoral heads can impinge on native soft-tissues, particularly the iliopectas, leading to activity limiting anterior hip pain. To address this we developed an Anatomically Contoured large diameter femoral Head (ACH) that maintains the profile of a contemporary large diameter head over a hemispherical portion, and contours the peripheral profile for soft-tissue relief. The goal of this study was to investigate the impact of the anatomical contouring on (A) frictional torque, and (B) dislocation resistance, in ceramic-on-ceramic articulation. We hypothesized that anatomical contouring of the ACH implant for soft tissue relief would also reduce the frictional torque in ceramic-on-ceramic articulation, without affecting the implant stability.

Methods: The impact of anatomical contouring on frictional torque was studied using a pendulum comparator (Fig. 1). The pendulum comparator consisted of two stations with a 50 lbf weights pivoting around loaded ceramic-on-ceramic hip implants. Three each of the anatomically contoured and conventional ceramic femoral heads with a 36 mm diameter were tested against six ceramic liners at 100 lbf and 400 lbf of compressive joint load in a total of 72 tests. The test for each load was repeated three times. Heads and liners were also switched between stations. The pendulums were released from a starting angle of 48° and their motion was tracked with non-contact magnetic angle sensors. Bovine serum (100%) was used as lubricant. The number of swings for each test was used as the indicator of the frictional resistance of the head and liner pair.

The impact of anatomical contouring on implant stability was evaluated by simulating dynamic hip dislocation in MSC Adams. A 36mm ACH, a 36mm conventional head, and a 28mm conventional head were tested under two dislocation modes: (A) Posterior dislocation (at 90° flexion) with internal hip rotation and a posterosuperior directed joint force; (B) posterior dislocation (starting at 90° flexion) with combined hip flexion and adduction and a posterosomedial force direction. Impingement-free motion (motion without neck impingement against acetabular liner) and jump distance (head displacement prior to imminent dislocation) were measured (Fig. 2). The acetabular components were placed at 40° abduction and 20° anteversion.

Results: The ceramic ACH underwent an average of 28.7 ± 3.7 and 13.9 ± 1.8 swings at 100 lbf and 400 lbf joint load, respectively, while the ceramic conventional head underwent 23.4 ± 5.6 and 10.4 ± 2.3 swings at 100 lbf and 400 lbf joint load, respectively (Fig. 1). An ANOVA analysis showed that the head type (p < 0.0001) and joint load (p<0.0001) were both significant factors while the station and all interaction effects were not significant. The dislocation analysis did not show any differences between the 36 mm ACH implant and the conventional 36 mm head (Fig. 2). The 36 mm ACH and conventional head showed greater impingement-free motion compared to the 28 mm conventional head, with an increase of 7° for dislocation mode A, and 4° for mode B. Similarly, relative to the 28 mm conventional head, the jump distance for the 36 mm ACH and the 36 mm conventional head was increased by 1.5 mm for dislocation mode A, and 2 mm for mode B.

Discussion: During the pendulum tests the anatomically contoured femoral heads showed greater number of swings than the conventional femoral heads (22.6% greater at 100 lbf and 33.7% greater at 400 lbf). During the simulated dislocation tests the ACH implant showed increased dislocation resistance compared to a conventional small diameter head, while matching the stability of a conventional large head of the same size. This confirmed the hypothesis that anatomical contouring of the femoral head could have added benefit of reducing frictional torque in ceramic-on-ceramic articulation without compromising the implant stability.

Significance: The novel soft-tissue friendly anatomical contoured femoral heads may have added benefit of reducing frictional torque in ceramic-on-ceramic THA. This could lead to reduced torque on taper junction, decreased wear, and improved implant longevity.

Acknowledgments:
References:

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