Comparison of the immediate post-operative stability of a novel tapered hip stem to a predicate design

INTRODUCTION:
As immediate post-operative stability of a cementless hip design is one of the key factors for osseointegration and for the long-term success of a cementless total hip replacement [1], this study compares the initial stability of a novel hip stem to a predicate standard tapered wedge stem design. The predicate is an uncemented standard flat tapered wedge stem design that is based of the original geometry of the Mueller Straight Stem [2] at a conventional length with more than 10 years of successful clinical results [3,4,5]. The novel stem is a flat tapered wedge stem design that is based on a bone morphology study of 556 CT scans to better fit a wide array of bone types [6]. The novel stem has a reduced stem length compared to the predicate to better accommodate various surgical approaches [7]. In this study the post-operative stability of both stem designs was analyzed in physical tests using composite femur replicas.

METHODS:
Test methods were based on a previous study of press-fit stems [8]. Five stems of the standard tapered wedge design (Accolade, Stryker Orthopaedics, Mahwah, NJ) and the novel stem (Accolade II, Stryker Orthopaedics, Mahwah, NJ) were implanted into a homogenous set of 10 synthetic femora (see figure 1) utilizing large left fourth generation composite femurs (Sawbones, Pacific Labs, Seattle, WA). The six-degrees-of-freedom (6DoF) motions of the implanted stems were recorded under short-cycle stair-climbing loads. Minimum head load was 0.15kN and the maximum varied between 3 Body Weights (BW) and 6BW. Loading began with 100-cycles of “normal” 3BW and was stepped up to 4BW, 5BW & 6BW for 50-cycles each. Prior to each load increase, 50 cycles of 3BW loading was applied. This strategy allowed a repeatable measure of cyclic stability after each higher load was applied. Outcome Measures: The 6DoF micromotion data, acquired during the repeated 3BW loading segments, were reduced to four outcome measures: two stem migrations (retroversion and subsidence at minimum load) and two cyclic motions (cylic retroversion and cyclic subsidence). Data were analyzed using repeated measures ANOVA with a single between-subjects factor (stem type) and repeated measures defined by load-step (3BW, 4BW, 5BW 6BW).

RESULTS:
With regard to migrations, both stems retroverted under increasing load (p = 0.0011, Fig 2). Retroversion of the novel stem was significantly smaller than that of the standard tapered wedge stem (p = 0.023). The rate of increase in retroversion with increasing load was significantly lower for the novel stem (p = 0.026). In addition, both stems subsided under increasing load (p = 0.0015, Fig 3). Subsidence of the novel stem was significantly smaller than that of the standard tapered wedge stem (p = 0.016). The rate of increase in subsidence with increasing load was significantly lower for the novel stem (p = 0.022). With regard to cyclic motions, both cyclic retroversion and cyclic subsidence were significantly lower for the novel stems (p = 0.0033 & p = 0.0098). In addition, the rate of increase in cyclic motion was significantly lower for the novel stems for both cyclic retroversion (p = 0.0021) and cyclic subsidence (p = 0.023).

DISCUSSION:
The standard flat tapered wedge stems have shown excellent clinical results [3,4,5]. Previous studies have shown that shortening an existing stem design may decrease the initial stability [9]. The Accolade II tapered stem design has an improved femoral fit based on a morphology study [10]. The stem design has a size specific medial curvature that allows more proximal fill than the standard tapered wedge design [7]. In this study, the Accolade II tapered wedge stem showed an improved stability compared to the clinically successful predicate design. It appears that through optimization of the proximal geometry, a reduced length of the stem can be accomplished without jeopardizing initial stability.

SIGNIFICANCE:
Shortening clinical successful tapered wedge stem designs may decrease the initial stability that is important for the long term success of hip stem designs. This study shows that through optimization of the proximal geometry of a tapered stem design a similar or increased initial stability can be achieved at a reduced stem length.

REFERENCES: