A Device to Improve Femoral Head and Stem Taper Stability Intraoperatively in Total Hip Arthroplasty
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INTRODUCTION:
Mechanically assisted crevice corrosion has been associated with the durability and fixation of modular THA implants, adverse reaction of local tissue, and other clinical outcomes. Increased assembly load has been shown to increase the stability of the femoral head and stem taper connection, and reduce fretting corrosion. Dun and Whitaker reported that the increased mass of the impactor was correlated with higher impact force and greater absorbed energy. The objective of the current study was to investigate if the femoral head and stem taper stability can be improved when the effective mass of the stem is increased by rigidly attaching an additional mass to it.

METHODS:
Three size 8 CORAIL Cementless femoral stems and three 28 mm ARTICUL/EZE femoral heads were tested in the study. The femurs were simulated with foam blocks that had a density of 160 kg/m³ and measured 152 mm (H) X 102 mm (W) X 64 mm (L). Two stainless steel blocks, Mass 1 (215 g) and Mass 2 (639 g), were machined to be bolted to the stem through the threaded hole on the inserter platform. The two masses were designed so that they won’t interfere with the assembly of the femoral head while attached to the stem. The foam block was resected at 45° at the medial-proximal corner and then broached, and the stem was inserted following the standard surgical technique. A bi-axial digital inclinometer was attached to the stem to measure its angle in the frontal and lateral planes. The test construct was secured on an angular vise, and the plate was adjusted so that the stem was in 0° in the lateral plane and 45° in the frontal plane, which ensured that the stem taper was in the vertical direction. The femoral head was assembled to the stem taper using a drop weight method following ASTM F2009-2011 under three different conditions. In Condition 1 there was no additional mass attached to the stem, while in Conditions 2 and 3, Mass 1 and Mass 2 were rigidly bolted to the stem, respectively (Figure 1). A piezoelectric accelerometer was attached to the stem to measure its acceleration in vertical direction at 200 kHz under drop weight impaction. After the femoral head and stem were assembled, the foam block was cut open, and the stem was clamped in an angular vise with the taper in the vertical direction. With the vice secured on the baseplate of an MTS test frame, the femoral head was pulled off with a speed of 0.042 mm/s. The above assembly and disassembly process was repeated for each femoral head and stem pair. One-way ANOVA and post-hoc Tukey tests were performed to compare the peak pulloff force and peak acceleration in three assembly conditions. Significance level was 0.05.

RESULTS:
The peak pulloff force and the peak acceleration are shown in Figure 2 and 3, respectively. The peak pulloff force was significantly different among the three assembly conditions (p=0.003). The peak pulloff force in Condition 3 was significantly higher than that in Condition 2, which was significantly higher than that in Condition 1. The maximum acceleration was also significantly different among the three assembly conditions (p=0.004). The maximum acceleration in Condition 3 was significantly lower than that in Condition 2, which was significantly lower than that in Condition 1.

DISCUSSION:
A previous study has demonstrated that compliance did not affect the femoral head pulloff force probably due to the short time period of the applied impact impulse. The current study showed that the stability of the femoral head and stem was significantly improved by rigidly attaching a steel mass to the stem, which effectively increased the inertia of the stem and therefore the resistance to the impact force. Intraoperative periprosthetic fracture, change of position and compromised fixation of the stem are of concerns when excess impact forces are applied to assemble the femoral head. With additional mass rigidly attached to it, the maximum acceleration of the stem was reduced significantly, which could reduce the abovementioned risks. A micromotion study will be carried out in the future to investigate if the micromotion between the femoral head and stem will be reduced, which is correlated to the amount of fretting corrosion.

SIGNIFICANCE/CLINICAL RELEVANCE:
The current study showed that the stability of the femoral head and stem taper connection was significantly improved by rigidly attaching a steel mass to the stem when the femoral head was assembled to the stem. The method may significantly reduce mechanically assisted crevice corrosion in vivo.

REFERENCES:
4. Dun and Whitaker, 2019. ORS

Figure 1
Figure 2
Figure 3