Optimal Bone Preparation for Triple Taper Stems Improves Fixation and Stability: A Biomechanical Analysis

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INTRODUCTION: Conventional single tapered, THA stems achieve fixation namely through coronal, metaphyseal fit. Triple taper stems have a sagittal taper to optimize fixation in the anteroposterior plane as well, however limited guidance exists on appropriate bone preparation. Often, similar preparation techniques are used despite geometric differences which may lead to under-preparation. We've defined a novel technique in which a small portion of posterior femoral neck and cancellous bone is removed to permit preparation collinear to the diaphyseal sagittal femoral axis. We hypothesize this will optimize stem fit, stability, and resistance to failure compared to conventional techniques in this biomechanical investigation.

METHODS: Eighteen cadaveric femurs (9 pairs) were divided into two groups. One side underwent conventional single-taper preparation (STP), the contralateral side received the experimental triple-taper preparation (TTP) (Figure 1). Dynamic loading was performed with the hip at 30° flexion to simulate stair descent. Samples were sprayed with a stochastic pattern for digital imaging correlation (ARAMIS; GOM) (Figure 2). Each sample ran 10,000 cycles at a frequency of 1 Hz with an increment in compressive load every 2,000 cycles until reaching last load step (LS) of 2.5 times body weight or failure (≥10mm of stem displacement and/or fracture). Construct stiffness, displacement, micromotion and load to failure were recorded.

RESULTS: The overall stiffness of TTP was superior to STP (296.6 ± 31.4 N/mm vs. 196.4 ± 36.4 N/mm; $p<0.001$). The TTP had less displacement than the STP (3.6 ± 1.8 mm vs. 4.7 ± 2.5 mm; $p=0.003$). TTP had less micromotion when compared to STP ($p=0.018$). Moreover, 80% of the TTP samples survived to the last load step compared to the 20% of STP samples.

DISCUSSION AND CONCLUSION: The TTP technique for a triple tapered stem improves metaphyseal fit, stability, resistance to subsidence and fracture compared to STP.

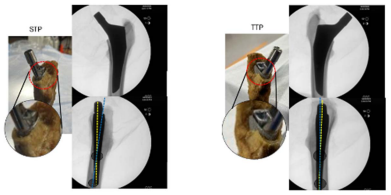

Figure 1. Illustration of STP and TTP preparation where the red dotted circle indicates area of removed bone. Radiographs represent stem fit within the canal in the AP and lateral views where the stem axis (yellow line) is overlayed the canal axis (blue line).

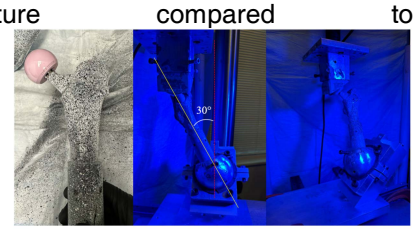

Figure 2. Sample prepped and mounted to biomechanical testing fixture