Inducible Displacement of Cementless Components at Increasing Knee Flexion Angles

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INTRODUCTION: Cementless total knee replacement (TKR) designs have porous metal surfaces that allow for bone ingrowth to create a biological fixation mechanism that may provide an advantage for long-term fixation. Multiple radiostereometric analysis (RSA) studies have shown sufficient fixation of cementless components, however only a limited number have investigated inducible displacement. Of these studies, few if any examine the displacement of both the femoral and tibial component. The objective of this study was to assess inducible displacement of cementless femoral and tibial TKR components during a knee bend.

METHODS: Ethics approval was obtained from our institutional ethics review board, and all subjects provided written informed consent. Supine and static weightbearing RSA exams were performed at 1-year post-operation. The weightbearing exams consisted of a standing exam (0°), and multiple squat positions with the operated knee at flexion angles of 20°, 40°, and 60°. Model-based RSA (MBRSA) software was used to measure inducible displacement, the micromotion measured between supine and weightbearing exams. Inducible displacements were reported as maximum total point motion (MTPM) and as 3D translations at different points of interest, called fictive points, placed around both the femoral and tibial component (Figure 1). The poses of the femoral and tibial components were also used to calculate the true flexion angle of the operated knee for each examination. Correlations between the flexion angle of the operated knee and inducible displacement were calculated.

RESULTS SECTION: Thirty-four subjects were analyzed. For inducible displacement of the femoral component, MTPM was 0.70 ± 0.36 mm at the 0° exam, 0.84 ± 0.46 mm at the 20° exam, 1.01 ± 0.45 mm at the 40° exam, and 1.20 ± 0.71 mm at the 60° exam. For inducible displacement of the tibial component, MTPM was 1.22 ± 0.67 mm at the 0° exam, 1.25 ± 0.46 mm at the 20° exam, 1.56 ± 0.41 mm at the 40° exam, and 1.63 ± 0.46 mm at the 60° exam. Inducible displacement of the femoral component increased with knee flexion angle, with the strongest correlations at the anterior flange tip ($r^2 = 0.18$, $p = 0.0001$, Figure 2), medial peg ($r^2 = 0.15$, $p = 0.0005$), and lateral posterior condyle fictive points ($r^2 = 0.13$, $p = 0.0013$). Inducible displacement of the tibial component also increased with knee flexion angle, with the strongest correlations at the stem tip ($r^2 = 0.51$, $p < 0.0001$, Figure 3), anterolateral ($r^2 = 0.22$, $p < 0.0001$), and anteromedial fictive points ($r^2 = 0.19$, $p < 0.0001$).

DISCUSSION: The MTPM for the standing displacements were, on average, within ranges expected for stable implants for both the femoral and tibial components. Tibial components had greater inducible displacements, on average, than femoral components. For both components, an increased knee flexion angle in a weightbearing squat position correlated with greater inducible displacements. The strongest correlation was observed at the anterior flange tip for the femoral component and at the stem tip for the tibial component.

SIGNIFICANCE/CLINICAL RELEVANCE: Inducible displacement of both the femoral and tibial component increased with knee flexion angle. As many activities of daily living require ranges of knee flexion, it is important to consider the increased inducible displacement of cementless TKR components at higher knee flexion angles.

IMAGES:

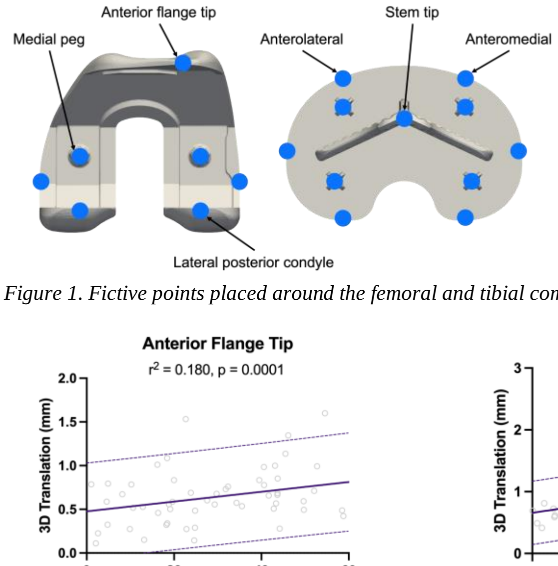

Figure 1. Fictive points placed around the femoral and tibial component.

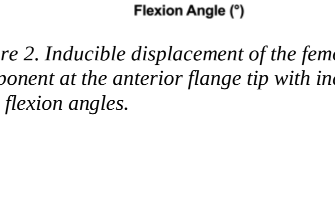

Figure 2. Inducible displacement of the femoral component at the anterior flange tip with increasing knee flexion angles.

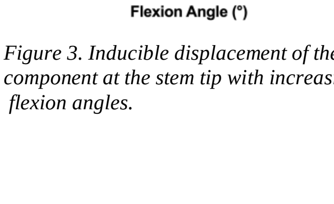

Figure 3. Inducible displacement of the tibial component at the stem tip with increasing knee flexion angles.