Inducible Displacement of the Femoral Stem Measured Using Computed Tomography-Based Radiostereometric Analysis (CT-RSA)

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INTRODUCTION: Diagnosis of aseptic loosening following total hip arthroplasty (THA) remains a challenge. Radiostereometric analysis (RSA) is the gold standard for implant migration tracking, but its clinical adoption has been limited due to the need for embedded bone marker beads and specialized imaging equipment. New developments have made computed tomography-based RSA (CT-RSA) available, which leverages conventional CT scanners and does not require bone marker beads. A type of CT-RSA exam that measures the inducible displacement of the implant between back-to-back scans with different joint loading may be a viable diagnostic tool for suspected aseptic loosening. The objective of this study was to investigate the validity of CT-RSA for inducible displacement measurements of the femoral stem in comparison to RSA.

METHODS: Patients (n=48) from a previous cementless THA RSA study returned at five-years post-operation to be re-examined for femoral stem implant stability using CT-RSA and RSA imaging. Migration between two- and five-years post-operation was calculated using RSA migration as a measure of implant stability. Double examinations were taken for both CT-RSA and RSA to calculate the precision of measurements. For CT-RSA, inducible displacement was measured between CT examinations with the leg externally versus internally rotated. For RSA, inducible displacement was measured between supine and weight-bearing examinations. Inducible displacement measurements in each axis of translation and rotation were compared between CT-RSA and RSA. Inducible displacement measurements were also compared with double examination results to determine if the measured displacement in each axis was greater than measurement error.

RESULTS: All stems were well-fixed with subsidence <0.2 mm/year. Precision for CT-RSA ranged from 0.049mm-0.130mm in translation and 0.061°-0.220° in rotation and for RSA ranged from 0.093mm-0.262mm in translation and 0.118°-0.678° in rotation. Inducible displacement of the stem was lower for CT-RSA than RSA for distal translation (mean difference=0.122 mm, $p<0.0001$), total translation (mean difference=0.139 mm, $p<0.0001$), and total rotation (mean difference=0.449°, $p<0.0001$). For CT-RSA, inducible displacement and the double examination were only significantly different for total translation and total rotation. For RSA, inducible displacement and the double examination were different for medial, distal, and total translation, and total rotation.

DISCUSSION AND CONCLUSION: CT-RSA demonstrated superior precision for inducible displacement measurements compared to RSA. Measurements of rotationally loaded inducible displacement from CT-RSA were minimal, consistent for a patient cohort with well-fixed implants. These findings are encouraging, and future work should explore the reliability of CT-RSA in patients with suspected aseptic loosening prior to undergoing revision surgery.