Influence of Head Size and Implant Position on Impingement-Free Range of Motion in Primary Total Hip Arthroplasty: A Simulation Study

Heather Roberts[1], Sergio Felipe Guarin Perez, Mark W Pagnano[1], Rafael Jose Sierra[1]
[1]Mayo Clinic

INTRODUCTION:
Dislocation is a known risk after primary total hip arthroplasty (THA). Previous studies have suggested an optimal range of combined anteversion to maximize impingement-free range of motion. However, the impact of head size on impingement-free range of motion has not been elucidated. We performed a simulation using CT-based robotic planning software to determine the impact of head size on 1) impingement-free range of motion and 2) range of femoral and acetabular component version that allows for a functional impingement-free range of motion.
METHODS:
We retrospectively reviewed five patients who underwent robotic-assisted THA. Mean patient age was 63.2 years, and three were female. Using CT-based robotic planning software, we varied femoral and acetabular version from 0 to 37 degrees and simulated bony and implant impingement testing with flexion and internal rotation as well as extension and external rotation. Maximum impingement-free range of motion was recorded with each version combination. We performed these measurements with 28, 32, 36, and 40mm heads, resulting in 57,760 simulation trials. We calculated the sum of internal rotation in flexion and external rotation in extension to estimate impingement-free motion. We defined functional range of motion as at least 40º of internal rotation at 90º flexion and at least 10º external rotation at 20º extension.
RESULTS:
For every 4mm increase in head size, impingement-free motion increased by an average of 4.6 degrees ($p<0.001$). The range of acceptable femoral and acetabular version angles to achieve a functional range of motion increased by an average of 150% when head size increased from 28mm to 32mm. This increase was 83% when head size increased from 32mm to 36mm and 31% when head size increased from 36mm to 40mm. The range of anteversion values to maximize impingement-free motion was different for each patient and dependent on underlying anatomy.
DISCUSSION AND CONCLUSION:
Impingement-free range of motion increases with increasing head size. The range of femoral and acetabular implant position that achieves a functional impingement-free motion varies by both head size and individual anatomy.