Predictive value of MAKO robotic guidance in cup positioning in total hip arthroplasty

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Background: Proper acetabular cup placement is a critical step when performing Total Hip Arthroplasty (THA), regardless of the approach used or the implant type. The placement of the cup within an abduction and anteversion safe zone¹, ² results in well-documented reduction in the rates of post-operative complications, mainly dislocation, leg length discrepancy and accelerated bearing surface wear. Therefore, there is a constant search for the best possible tools that can aid in cup positioning in an accurate and reproducible manner.

Computer-assisted surgery has been gaining significant popularity over the past few decades in the field of arthroplasty. The need to address individual variations in hip anatomy has led to the development of patient-specific surgeries³. These relatively new technologies allow for pre-operative planning and intra-operative execution tailored to every patient’s anatomy. Several systems have been devised aiming at optimizing the placement of the components for better clinical outcomes and longer implant longevity. Robot-assisted THA has been introduced to clinical use in 1992⁴, and since then multiple efforts have been aimed at perfecting the robotic-assisted systems to aid in precise surgical techniques.

The MAKO robotic hip system, also known as MAKOplasty® Total Hip Application v1.0 (MAKO Surgical Corp.®), is one of the newest robot-assisted THA systems. This system is designed to allow placement of the THA components in a precise reproducible manner in addition to reducing technical errors. It is based on the use of computer tomography scan (CT) with three dimensional (3D) reconstructions of the patient’s hip, resulting in a 3D model. This model is used intra-operatively by the MAKO system to assist in the implantation of the THA components in the proper 3D orientation. The intra-operative measurements of the cup position are then recorded by the MAKO system and, in theory, should be an estimate of the measurements of the cup position taken post-operatively on radiographs.

The purpose of this prospective cohort study was to assess whether the MAKO robotic hip system is accurate and reproducible in measuring the acetabular cup position in THA. The hypothesis was that the MAKO system is accurate in measuring the acetabular cup position intra-operatively and is predictive of the post-operative radiographic measurements.

Methods: This study is a prospective cohort study looking at the accuracy of the MAKO system in predicting acetabular cup position following THA. All THAs that were performed between June 2011 and May 2012 by the senior surgeon (B.G.D.) through a mini-posterior approach were reviewed. Patients who underwent robotic-assisted THA using the MAKO system and who had proper post-operative supine antero-posterior (AP) pelvis radiographs were included in this study. Excluded patients were those who underwent THA without the use of the MAKO system, and those who had improper post-operative radiographs (rotated or tilted pelvis). Thirty three cases of robotic-assisted THA done using the MAKO system met the inclusion and exclusion criteria.

The Trauma-Cad™ software (build number 2.2.535.0, Voyant Health®, 2012) was used to perform the radiographic measurements. The Restoris Trinity Cup (Corin Group PLC®, Cirencester, U.K.) was used in all cases. Two different observers collected the radiographic measurements. They were blinded from each other’s results, and from the intra-operative measurements provided by the MAKO system. The
measurements of the anteversion and abduction angles were done twice by each observer with both measurements done two months apart for correlation. The intra-operative measurements provided by MAKO system were calculated once for each patient when the final cup was implanted.

**Results:** After exclusions, 33 THAs that were performed using the MAKO system were included. A very strong inter- and intra-observer correlation was found for the radiographic measurements of both cup anteversion and abduction ($r > 0.95$ for all). Our sample consisted of 33 patients with 18 males and 15 females. Their average age was $60.0 \pm 8.6$ years, and their average BMI was $29.2 \pm 4.7$.

The targeted cup anteversion measure inputted into the MAKO system at the beginning of each surgery was 20 degrees. The targeted cup abduction measure inputted into the MAKO system at the beginning of each surgery was 40 degrees. The average cup anteversion was $20.0 \pm 3.9$ degrees for the intra-operative MAKO measurements and $13.7 \pm 4.3$ degrees for the post-operative radiographic measurements. The average cup abduction was $40.1 \pm 3.1$ degrees for the intra-operative MAKO measurements and $40.3 \pm 4.2$ degrees for the post-operative radiographic measurements.

For the anteversion angle measurements, 18.2% of cups measured intra-operatively by the MAKO system were within 3 degrees of the post-operative radiographic measurements, 39.4% within 5 degrees, and 81.8% within 10 degrees. For the abduction angle measurements, 60.6% of cups measured intra-operatively by the MAKO system were within 3 degrees of the post-operative radiographic measurements, 78.8% within 5 degrees, and 97.0% within 10 degrees.