Cup positioning in total hip arthroplasty using the Mako robotic hip system: a pilot study with a matched-pair control group

EL BITAR Y¹, STAKE CE¹, BOTSER IB¹, JACKSON TJ¹, LINDNER D¹, DOMB BG²

¹American Hip Institute, Westmont, IL, USA
²Hinsdale Orthopaedics, American Hip Institute, Westmont, IL, USA

DrDomb@americanhipinstitute.org

Background: Acetabular cup positioning is an extremely delicate step when performing total hip arthroplasty (THA). Several methods have been developed to improve the accuracy and consistency of placement of the THA components in the correct three-dimensional (3D) orientation. Improper implantation of the cup has been associated with several complications including dislocation, component impingement, leg length discrepancy, altered hip biomechanics, accelerated bearing surface wear, and revision surgery. The placement of the cup within a “safe zone” of inclination and anteversion has been described by Lewinnek et al.¹ and later modified by Callanan et al.² Placing the cup outside that “safe zone” is associated with an increased rate of significant complications, which affects both clinical outcomes and quality of life of patients undergoing THA.

The standard technique of using manually manipulated instrumentation is still the most widely used when placing the THA implant components. Multiple intra-operative landmarks have been described in order to place the acetabular cup within the safe zone, including anatomic landmarks, the transverse acetabular ligament (TAL), and alignment guides. Several other techniques and tools have been developed to try to minimize errors and obtain reproducible results in all patients. Image-assisted navigation, imageless navigation and robotic-assisted THA have all been developed for the purpose of improving the placement of the THA components, which would lead to improved implant longevity, and the avoidance of complex revision surgeries. The MAKO robotic hip system, also known as MAKOplasty® Total Hip Application v1.0 (MAKO Surgical Corp.®), is a robot-assisted system that uses the RIO® (Robotic Arm Interactive Orthopedic System). It is designed to facilitate the placement of the THA components in a calculated reproducible manner.

The purpose of this prospective matched-pair controlled study was to compare the acetabular cup placement of two groups of patients who underwent THA by the same surgeon through a posterior approach: one using the standard technique and the other using the robotic-assisted technique. The hypothesis was that the robotic-assisted THA using the MAKO system improves cup positioning when compared to the standard manual THA.

Methods: This study is a matched-pair controlled study using prospectively collected data for THAs done between June 2011 and May 2012. All the THAs were performed by the senior surgeon (B.G.D.) through a mini-posterior approach. Inclusion criteria included patients who underwent THA who had proper post-operative supine antero-posterior (AP) pelvis radiographs. Excluded patients had radiographs with a rotated pelvis or tilted pelvis. Thirty three robotic-assisted THAs done using the MAKO system met the inclusion criteria. These were matched to a control group of 33 THAs performed using the standard technique, subject to the same inclusion criteria, by the same surgeon according to age, gender and body mass index (BMI). The radiographic measurements were done using the Trauma-Cad™ software (build number 2.2.535.0, Voyant Health®, 2012).

Every patient scheduled for robotic-assisted THA using the MAKO system underwent a pre-operative computed tomography (CT) scan with the creation of a 3D model of each patient’s pelvis and proximal
femur. These models allowed the creation of specific points that helped the software determine the patient’s position intra-operatively. The robot used the CT model of each patient to guide the reaming and cup implantation in each case. The target anteversion in both the robotic-assisted THA and the standard THA groups was 20 degrees, and the target inclination was 40 degrees.

In the standard THA group, the acetabular cup implant used was the R3 Cup (Smith & Nephew®, London, U.K.). In the robotic-assisted THA group, the acetabular cup implant used was the Restoris Trinity Cup (Corin Group PLC®, Cirencester, U.K.).

**Results:** After exclusions, a total of 33 THAs were included in each group. A very strong inter- and intra-observer correlation was found for both the cup anteversion and inclination measurements (r > 0.95 for all). The average patient age was 60.0 ± 8.6 years in the robotic-assisted group and 58.3 ± 8.9 years in the standard group (p = 0.44). The gender distribution was 18 males and 15 females in both groups. The average BMI was 29.2 ± 4.7 in the robotic-assisted group and 28.9 ± 3.6 in the standard group (p = 0.76).

The average cup anteversion was 13.7 ± 4.3 degrees in the robotic-assisted group and 12.0 ± 7.0 degrees in the standard group (p = 0.22). The average cup inclination was 40.3 ± 4.2 degrees in the robotic-assisted group and 43.2 ± 5.6 degrees in the standard group (p = 0.02).

Using the Lewinnek safe zone (5 to 25 degrees of anteversion, and 30 to 50 degrees of inclination), 100% of cups in the robotic-assisted group were within the anteversion safe zone as well as 84.8% of cups in the standard group (p = 0.02). 100% of the cups in the robotic-assisted group were within the inclination safe zone as well as 93.9% of cups in the standard group (p = 0.15). 100% of cups in the robotic-assisted group were within the combined safe zone (anteversion and inclination) as well as 78.8% of cups in the standard group (p = 0.005). Using the Callanan modified safe zone (5 to 25 degrees of anteversion, and 30 to 45 degrees of inclination), 100% of cups in the robotic-assisted group were within the anteversion safe zone as well as 83.9% of cups in the standard group (p = 0.02).
as well as 84.8% of cups in the standard group (p = 0.02). 84.8% of cups in the robotic-assisted group were within the inclination safe zone as well as 60.6% of cups in the standard group (p = 0.03). 84.8% of cups in the robotic-assisted group were within the combined safe zone (anteversion and inclination) as well as 54.5% of cups in the standard group (p = 0.007).

**Conclusions:** Posterior approach THA performed with the assistance of the MAKO system had very consistent cup positioning, with all cups (100%) placed within the Lewinnek “safe zone”, and 84.8% within the Callanan “modified safe zone”. When compared to standard posterior approach THA without the assistance of the MAKO system, performed by the same surgeon, robotic-assisted THAs cups were significantly more likely to be within both safe zones.

**References**