ACCURACY OF IMAGE-BASED COMPUTER ASSISTED SURGERY IN ACETABULAR CUP PLACEMENT FOR SUPINE TWO-INCISION TOTAL HIP ARTHROPLASTY

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**Introduction:** Supine patient positioning in conjunction with two-incision minimally invasive surgery (MIS-2 incision) total hip arthroplasty (THA) increases difficulty of accurate and repeatable cup orientation in accordance with pre-operative planning. Investigators have suggested advantages of utilizing computer assisted orthopaedic surgery (CAOS) to successfully eliminate extreme outlying acetabular shell placement positions (Saxler et al., 2004). The current study examines the effects of CAOS on accuracy and consistency of acetabular cup placement in supine position MIS-2 THA. The authors hypothesize that improved accuracy of cadaver cup placement will be observed with the use of CAOS in comparison to traditional mechanical guides described for this MIS-2 THA in the supine patient position, with actual cup orientation assessed by post-implantation computed tomography (CT) study.

**Methods:** Institutional review board approval was obtained for the use of human cadavers. The effects of CAOS and conventional methods were investigated in the supine position. Twelve human cadaver specimens, pelvis to toe tip were utilized. Placement of acetabular shells (Trilogy Fibromesh, Zimmer, Inc.) using computer navigation techniques on a randomized side (left vs. right) were performed on each pelvis in a laboratory simulated surgical setting. Subsequent placement of an acetabular shell component on the contra-lateral side of the pelvis using conventional instrument guide techniques were then performed. A two-incision surgical approach as described by Berger et al. was used for the supine position. Supine position was done on a flat surgical table without any bumps or padding. Clamping of L5 was done to secure stable positioning. For CAOS, a two-pin construct was placed in the respective ASIS. The camera was then placed in an accessible location. The image-based CAOS for Zimmer MIS-2 with fluoroscopic landmarks was utilized. Anterior incision and dissection to the hip joint was performed, exposing the femoral neck. Resection of the femoral neck allowed retraction and exposure of the acetabulum. Reaming and placement of the acetabular shell commenced using live real-time visualization of the cup orientation. Orientation values used were 45 degrees of inclination and 20 degrees of anteversion. Intraoperative computer assisted orientation values for both inclination and abduction were calculated using fluoroscopic landmarking. Two screws were placed through the dome of the shell to secure fixation of the cup after placement. For the contra-lateral side, traditional free-hand guides were used for reaming and placement of the cup. A single surgeon with experience in THA and supine positioning, as well as CAOS, implanted all acetabular shell components. Specimens were draped in a laboratory surgical setting to optimize the simulation of a surgical setting. For each study group, completion of acetabular shell placement using both computer and mechanical visual guides (independent variables) was followed by measurement of cup position using computed tomography (CT) scans of all pelvis specimens, performed after implantation. Computed tomography (CT) scans of the twelve pelves were made with 0.67mm slices with a Philips Brilliance 40-slice Scanner (Philips Medical Systems, Andover, MA). CT data was segmented using Mimics 3D image processing software (Materialise, Ann Arbor, MI). Three-dimensional models of pelvis were then created and measurements made in RapidForm 3D modeling software (Inus Technology, San Jose, CA). Study investigators, blinded to acetabular shell group, measured the anteversion and abduction (inclination) angles of each shell (dependent variables) as described by the methods of Murray et al., (1993). Anteversion and abduction (inclination) angles were measured a total of two times by two investigators to assess repeatability of values. CT measured inclination and abduction mean values were calculated for both the navigation and mechanical groups. Mean values for the intraoperative computer navigation system inclination and abduction angles were also calculated. Mean differences between measured CT values and those predicted by both mechanical and computer navigation system were calculated. Two factor ANOVA with replication statistical analysis was performed on the data.

**Results:** A total of twenty-four acetabular cups were implanted, twelve using computer navigation system and twelve using mechanical guide system. The values for the inclination and anteversion angles of both groups are shown in Table 1. The mean difference between intraoperative and CT measured inclination and abduction values for the mechanical guide group was 5.4 and 15.7, respectively. The mean difference between intraoperative and CT measured inclination and abduction values for the computer navigation group was 5.0 and 4.2, respectively. The ANOVA results showed that there was a significant difference between the CAOS technique and the mechanical technique (p<0.001) but there was no difference between observers measurements (p>0.5).

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Inclination (Deg)</th>
<th>Intraoperative Inclination (Deg)</th>
<th>Anteversion (Deg)</th>
<th>Intraoperative Anteversion (Deg)</th>
</tr>
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<tbody>
<tr>
<td>Navigation</td>
<td>50.4 (5.7)*</td>
<td>43.4 (5.5)*</td>
<td>27.7 (10.0)+</td>
<td>31.9 (11.7)</td>
</tr>
<tr>
<td>Mechanical</td>
<td>50.4 (5.7)*</td>
<td>43.4 (5.5)*</td>
<td>35.7 (9.1)+</td>
<td>20</td>
</tr>
</tbody>
</table>

**Discussion:** Patient positioning and inconsistent anatomical landmarks contribute to the technical difficulty of consistent acetabular cup placement, and account for a majority of malpositioned implants in THA. Cup component malposition in THA is a recognized leading mechanical source of clinical hip dislocation, as well as complications of limited range of motion, impingement, and increased bearing and fretting wear (Biedermann et al., 2005). These complications are costly to patients both financially and functionally. Increased bearing wear rates lead to shortened life and premature revision surgery, increasing costs and morbidity. Assessment of acetabular component position using mechanical alignment guides in routine total hip arthroplasty can be unreliable even in experienced hands. In our study, the mean difference between intraoperative values and CT measured values was less using the computerized navigation system than the mechanical alignment guide, suggesting computer navigation system is a more reliable intraoperative tool. Data suggests ideal positioning of the acetabular shell to avoid hip instability as being between 40 and 45 degrees of inclination in the pelvic coronal plane and between 20 and 28 degrees of anteversion based upon a computerized ball and socket model (Widner & Zurfluh, 2004). Results from our study show increase accuracy using the navigational system over the mechanical guide system. The mean value for the mechanical guide system fell outside the ideal range while the mean value for the navigational system fell within the desired range as described by Widner et al. In one prospective series, 40 percent of placed cups were outside the predetermined zone of anteversion (Hassan et al., 1998). This difficulty may be compounded when performing total hip arthroplasty in varying patient positions, such as supine, now common in a variety of less invasive surgical approaches. Investigators have shown in pelvic models that computer assisted cup placement is more accurate technique than traditional methods (Jolles et al., 2004). The data presented in the current study demonstrate the improved accuracy that attained with utilization of CAOS for THA in the supine position, and with less extensive tissue exposure. This agrees with data from previous similar studies, thus supporting our hypothesis that CAOS is a valuable tool in THA cup placement, and capable of reducing rates of post-surgical complications.

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