Surgical Approach and Hip Laterality Affect Accuracy of Acetabular Component Placement in Primary Total Hip Arthroplasty

DAVID A. CRAWFORD, MD
ORTHOPEDIC SURGEON
JOINT IMPLANT SURGEONS
NEW ALBANY, OHIO

JOANNE B. ADAMS, BFA, CMI
RESEARCH DIRECTOR
JOINT IMPLANT SURGEONS, INC.
NEW ALBANY, OHIO

GERALD R. HOBBS, PhD
ASSOCIATE PROFESSOR OF STATISTICS-EMERITUS
DEPARTMENT OF STATISTICS
WEST VIRGINIA UNIVERSITY
MORGANTOWN, WEST VIRGINIA

ADOLPH V. LOMBARDI, JR., MD, FACS
PRESIDENT
JOINT IMPLANT SURGEONS, INC.
NEW ALBANY, OHIO
WHITE FENCE SURGICAL SUITES
NEW ALBANY, OHIO
MOUNT CARMEL HEALTH SYSTEM
COLUMBUS, OHIO
DEPARTMENT OF ORTHOPAEDICS
THE OHIO STATE UNIVERSITY WEXNER MEDICAL CENTER
COLUMBUS, OHIO

KEITH R. BEREND, MD
VICE PRESIDENT
JOINT IMPLANT SURGEONS, INC.
NEW ALBANY, OHIO
WHITE FENCE SURGICAL SUITES
NEW ALBANY, OHIO
MOUNT CARMEL HEALTH SYSTEM
COLUMBUS, OHIO

ABSTRACT

Introduction: Controversy remains if the anterior approach improves acetabular component alignment, and many studies have compared approaches with different surgeons over different timeframes. The purpose of this study was to assess a single surgeon’s experience over a one-year timeframe and radiographically compare acetabular component positioning with the direct anterior versus direct lateral approach. Secondarily, this study compares acetabular component position differences between right and left hips for a right-hand dominant surgeon.

Materials and Methods: Postoperative radiographs of 289 primary total hip arthroplasties (THAs) performed by a single right-hand dominant surgeon in 2014 were reviewed for abduction, anteversion, and medial cup
While primary total hip arthroplasty (THA) remains one of the most successful surgeries in all of orthopedics, surgeons continue to investigate ways to further decrease complications and improve patient outcomes. One of the main targets of these changes has been to improve acetabular component positioning. Malpositioning of the acetabular cup has been associated with higher rates of dislocation, polyethylene wear, and impingement. Strategies to achieve more optimal component positioning have included the implementation of enabling technologies such as navigation and robotics, as well as changing the surgical approach.

For many years, posterior- and lateral-based approaches have been the dominant approaches in hip arthroplasty. Over the last decade, the anterior approach has gained popularity. The most recent 2018 survey of the American Association of Hip and Knee Surgeons (AAHKS) members showed that 40% of respondents utilized the anterior approach for primary THA, which was up from 12% in 2010. The anterior approach has been shown in some studies to have decreased rates of dislocation and improved patient recovery time and component position. However, there does tend to be a significant learning curve.

The anterior approach allows easy use of fluoroscopy intraoperatively to assess acetabular and femoral component position as well as radiographic restoration of limb length. Laterally positioned approaches most often rely on bony landmarks and external guides for component position unless navigation technology is used. Fluoroscopy can be used with laterally positioned approaches, but it has been shown to be less accurate than with the anterior approach. Studies looking at the benefit of changing to an anterior approach to improve acetabular component position have yielded mixed results. Furthermore, many of these studies have compared different surgeons or single surgeons at different times in their career.

The purpose of this study was to assess acetabular component positioning by a single surgeon who equally used the anterior and direct lateral approach over a one-year timeframe. Secondarily, this study compares acetabular component position differences between right and left hips for a right-hand dominant surgeon. The hypothesis is that the anterior approach will have more accurate component position and that hip laterality will not have an impact.

Results: DA hips had a significantly lower abduction angle (p=0.04), less abduction target outliers (p<0.001), less abduction Lewinnek outliers (p<0.001), less target anteversion outliers (p<0.001), closer seating to teardrop (p<0.001), and less seating outliers (p<0.001). The combined target and Lewinnek safe zone were achieved more often in DA (p<0.001, p=0.042). Controlling for body mass index (BMI), the combined target achievement remained significantly better for DA (p=0.02), but combined Lewinnek was not significant (p=0.07). In the DA approach, right hips had a significantly lower abduction angle (p=0.03), less Lewinnek anteversion outliers (p=0.043), and less combined Lewinnek outliers (p=0.027). In the DL group, right hips had significantly higher anteversion angles (p=0.004) and Lewinnek anteversion outliers (p=0.033).

Conclusion: The anterior approach improved target abduction, anteversion, and medialization compared to the direct lateral approach. Significant differences in component positioning were found in both approaches based on the surgeon’s dominant and non-dominant side.

INTRODUCTION

While primary total hip arthroplasty (THA) remains one of the most successful surgeries in all of orthopedics, surgeons continue to investigate ways to further decrease complications and improve patient outcomes. One of the main targets of these changes has been to improve acetabular component positioning. Malpositioning of the acetabular cup has been associated with higher rates of dislocation, polyethylene wear, and impingement. Strategies to achieve more optimal component positioning have included the implementation of enabling technologies such as navigation and robotics, as well as changing the surgical approach.

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The anterior approach allows easy use of fluoroscopy intraoperatively to assess acetabular and femoral component position as well as radiographic restoration of limb length. Laterally positioned approaches most often rely on bony landmarks and external guides for component position unless navigation technology is used. Fluoroscopy can be used with laterally positioned approaches, but it has been shown to be less accurate than with the anterior approach. Studies looking at the benefit of changing to an anterior approach to improve acetabular component position have yielded mixed results. Furthermore, many of these studies have compared different surgeons or single surgeons at different times in their career.

The purpose of this study was to assess acetabular component positioning by a single surgeon who equally used the anterior and direct lateral approach over a one-year timeframe. Secondarily, this study compares acetabular component position differences between right and left hips for a right-hand dominant surgeon. The hypothesis is that the anterior approach will have more accurate component position and that hip laterality will not have an impact.

MATERIALS AND METHODS

The study surgeon (AVL) utilized the direct lateral (DL) approach exclusively during the first 25 years of his practice. In 2011, the surgeon began performing some primary THA from a direct anterior (DA) approach and by 2014 the utilization of the approaches was about even. The surgeon had performed over 8,000 hip arthroplasty procedures by 2014. A retrospective review was performed of all primary THAs performed by one right-hand dominant surgeon in 2014 to radiographically evaluate acetabular component position. Patients were excluded for revision or conversion.
arthroplasty or if postoperative radiographs were not available for review. Patients were separated into groups based on surgical approach: DL and DA. Postoperative radiographs were not available on two patients in the DL group and one patient in the DA group. This yielded a study cohort of 152 DA THAs (53%) and 137 DL THAs (47%).

Preoperative data collected included patient age, height, weight, body mass index (BMI), Harris Hip Score (HHS),23 University of California Los Angeles (UCLA) activity score,24 procedure laterality, and surgical approach.

There was selection bias by the surgeon in choice of surgical approach. By 2014, the surgeon utilized the DA approach for lower BMI patients and hips with less deformity. DL was chosen in heavier patients and those with more complex deformity as the surgeon found these cases to be more challenging with the DA approach. Furthermore, the surgeon found that their operative time and blood loss was lower in the DL approach, and this approach was chosen in higher risk and older patients. Table I compares preoperative variables. The DA group was significantly younger, was comprised of more females, had lower BMIs, and had higher preoperative HHS and UCLA activity scores.

Of the entire cohort, 121 patients (41.3%) were obese (BMI between 30kg/m² to 39kg/m²) and 31 patients (11%) were morbidly obese (BMI ≥40kg/m²). The DA approach was used in 44% of obese patients (p=0.073) and 3% of morbidly obese patients (p<0.001).

All hips underwent the same preoperative digital templating to estimate acetabular and femoral component size and position. Acetabular target abduction was set at 40° and medialized to the teardrop.

The DL approach was performed in a lateral decubitus position with the assistance of a peg board to stabilize the pelvis. The patient’s pelvis was carefully positioned perpendicular to the table. Manual instrumentation was used without fluoroscopy or external alignment guides. Reaming was performed in a sequential fashion up to 1mm below templated size or when there was appropriate fit. The target medialization for reaming was to the base of the cotyloid fossa. Anteversion and abduction were determined by the angle of the cup inserter handle to the pelvis as well as the relationship of the cup to anatomic landmarks (Fig. 1).

Table I

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>DA</th>
<th>DL</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hips</td>
<td>152</td>
<td>137</td>
<td></td>
</tr>
<tr>
<td>Left vs. right side</td>
<td>72 (47%) vs. 80 (53%)</td>
<td>75 (54%) vs. 62 (46%)</td>
<td>0.25</td>
</tr>
<tr>
<td>Male vs. female patients</td>
<td>57 (42%) vs. 80 (58%)</td>
<td>71 (57%) vs. 55 (43%)</td>
<td>0.017*</td>
</tr>
<tr>
<td>Male vs. female hips</td>
<td>61.6 (41%) vs. 90 (59%)</td>
<td>80 (58%) vs. 57 (42%)</td>
<td>0.003*</td>
</tr>
<tr>
<td>Age (years)</td>
<td>62 (±11, 18–86)</td>
<td>66.1 (±11, 30–96)</td>
<td>0.0008*</td>
</tr>
<tr>
<td>Height (inches)</td>
<td>67 (±4, 60–77)</td>
<td>67.8 (±5, 55–83)</td>
<td>0.056</td>
</tr>
<tr>
<td>Weight (pounds)</td>
<td>180 (±34, 112–265)</td>
<td>222 (±61, 97–440)</td>
<td>&lt;0.0001*</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>28.2 (±5, 19–42)</td>
<td>33.7 (±8, 18–57)</td>
<td>&lt;0.0001*</td>
</tr>
<tr>
<td>Preoperative HHS pain</td>
<td>12.8 (±6, 0–44)</td>
<td>11.5 (±4, 10–30)</td>
<td>0.037*</td>
</tr>
<tr>
<td>Preoperative HHS (0–100)</td>
<td>54.1 (±10, 33–97)</td>
<td>46.7 (±10, 20–70)</td>
<td>&lt;0.0001*</td>
</tr>
<tr>
<td>Preoperative UCLA (1–10)</td>
<td>5.1 (±2, 2–10)</td>
<td>4.0 (±2, 1–10)</td>
<td>&lt;0.0001*</td>
</tr>
</tbody>
</table>

*Statistically significant, DA=direct anterior approach, DL=direct lateral approach, HHS=Harris Hip Score,23 UCLA=University of California Los Angeles Activity Score24

Figure 1. Impaction of the acetabular component in a direct lateral approach using anatomic landmarks to determine position.
The DA approach was performed on a standard operating room table. Both lower extremities were prepped and draped. Once acetabular exposure was obtained, a single reamer 1mm under the templated size was inserted into the acetabulum. All reaming was then performed under fluoroscopic guidance. Reaming medialized to the teardrop and reamer size increased if needed. The final acetabular component was inserted under fluoroscopic guidance. The inclination of the fluoroscope was adjusted in the appropriate plane (sagittal, coronal, and axial planes) to obtain a well centered AP image. Estimation of anteversion and abduction was based on visual interpretation of the image without computer software or goniometric aids (Fig. 2).

Acetabular component position measurements were performed on AP pelvis radiographs at the six-week postoperative appointment unless the image was malrotated in which case a subsequent postoperative image was used. Measurements were completed by an independent observer (DAC) blinded to the surgical approach on a digital picture archiving system (PACS; IntelePACS, Intelerad, Westminster, Colorado). Measurements included acetabular abduction, anteversion, and medial seating. Abduction angle was calculated by the angle between the transischial line and the long axis of the acetabular component face (Fig. 3). Anteversion calculation was performed by the method described by Widmer et al. and validated by Nomura et al. (Fig. 4). Acetabular seating was calculated by the distance of the medial aspect of the acetabular component in relation to the teardrop (Fig. 5). Positive values for seating meant the component was lateral to the teardrop and negative values were medial. Surgeon target ranges were set as: Abduction 40° ±5°, anteversion 20° ±5°, and seating flush with the teardrop ±5mm. Further analysis was performed of the percent of hips that were within the Lewinnek safe zone: Abduction 40° ±10° and anteversion 15° ±10°. Laterality of the hips was also compared to component alignment to determine if surgeon hand dominance impacted positioning.

All patients signed a general research consent, approved and monitored by an independent institutional review board (Western IRB, Puyallup, Washington), which allows inclusion in retrospective reviews.
Statistical analysis

Statistical analysis was performed using Microsoft Excel® (Microsoft Corporation, Redmond, Washington) and MedCalc Statistical Software version 18.6 (MedCalc Software bvba, Ostend, Belgium). A t-test was used for normally distributed continuous outcome variables. Chi-square and Fisher’s exact test were used for comparing categorical variables. Generalized linear regression based on binomial distribution was used to evaluate the effect of BMI as a covariate on acetabular placement. A p-value of 0.05 was set for significance.

RESULTS

For all hips, the mean abduction angle was 41° (range, 27.4 to 68.5°, standard deviation [SD] ±5.1), the mean anteversion angle was 21.4° (range, 3.5 to 40.5°, SD±6.23), and seating was 1.9mm (range, -4.4 to 10.8mm, SD±2.5mm). Overall, 78% of hips were within the target abduction, 68.2% within target anteversion, and 88% within target seating. In total, 96% of hips were within the Lewinnek abduction safe zone and 80.3% within the Lewinnek anteversion safe zone.

Comparison of DA and DL acetabular position is summarized in Table II and Figure 6. DA hips had a significantly lower abduction angle (p=0.04), less abduction target outliers (p<0.001), less abduction Lewinnek outliers (p<0.001), less target anteversion outliers (p<0.001), closer seating to teardrop (p<0.001), less seating outliers (p<0.001), better combined target abduction, and anteversion for both surgeon goal (p<0.001) and Lewinnek (p=0.042).

All but one of the Lewinnek anteversion outliers were from increased anteversion >25°. There was one patient in the DL group with 4° of anteversion. At the extreme of anteversion outliers, the DL group had 19 hips (13.7%) with anteversion >30° compared to five hips (3.3%) in the DA group (p=0.001).

Four hips outside the Lewinnek abduction safe zone were under 30°, all from a direct lateral approach. The remaining Lewinnek abduction outliers were >50° of abduction. At the extreme of abduction outliers, the DL group had two hips (1.5%) with >55° of abduction compared to 0 hips in the DA group (p=0.22).

There was no significantly different percent of combined Lewinnek outliers in obese (24%) or morbidly obese patients (29%) compared to non-obese patients (22%) (p=0.56, p=0.36).

Table II

<table>
<thead>
<tr>
<th>Measure</th>
<th>DA</th>
<th>DL</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abduction angle</td>
<td>40° (±4.2, 31–51)</td>
<td>41.7° (±5.9, 27–67)</td>
<td>0.04*</td>
</tr>
<tr>
<td>Abduction outliers &gt;±5°</td>
<td>21/152 (13.8%)</td>
<td>42/137 (30.7%)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Abduction Lewinnek outlier</td>
<td>1/152 (1%)</td>
<td>11/137 (8.0%)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Anteversion angle</td>
<td>21.3° (±4.6, 10–34)</td>
<td>21.4° (±7.7, 4–41)</td>
<td>0.92</td>
</tr>
<tr>
<td>Anteversion outliers &gt;±5°</td>
<td>37/152 (24.3%)</td>
<td>55/137 (40.1%)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Anteversion Lewinnek outlier</td>
<td>26/152 (17.1%)</td>
<td>31/137 (22.6%)</td>
<td>0.24</td>
</tr>
<tr>
<td>Seating to teardrop (mm)</td>
<td>0.9 (±2.0, -4.4–7.7)</td>
<td>2.9 (±2.5, -3.7–10.8)</td>
<td>&lt;0.0001*</td>
</tr>
<tr>
<td>Seating outliers &gt;±5mm</td>
<td>3/152 (2%)</td>
<td>33/137 (24.1%)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Combined** target &lt;±5° met</td>
<td>101/152 (66.4%)</td>
<td>58/137 (42.3%)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Combined** Lewinnek met</td>
<td>125/152(82.2%)</td>
<td>99/152 (72.3%)</td>
<td>0.042*</td>
</tr>
</tbody>
</table>

*Statistically significant, **Both anteversion and abduction in the same patient were within targets

DA=Direct anterior approach, DL=Direct lateral approach

Figure 6. Scatterplot of acetabular component abduction and anteversion between direct anterior and lateral approach.
respectively). After linear regression analysis with BMI as a covariant, the combined surgeon target achievement remained significantly better for DA (p=0.02), whereas combined Lewinnek lost significance between surgical approach groups (p=0.07).

Table III and Figure 7 summarize the comparison of acetabular position based on hip laterality and approach. In the DA approach, left hips had a significantly higher abduction angle (p=0.03), Lewinnek abduction outliers (p=0.023), and combined Lewinnek outliers (p=0.027). In the DL group, right hips had significantly higher anteversion angles (p=0.004) and Lewinnek anteversion outliers (p=0.012). The most accurate approach and hip laterality for both anteversion and abduction within the Lewinnek safe zone was right hips with a DA approach (88.8%).

### DISCUSSION

The most important finding of this study is that the direct anterior approach with fluoroscopy had less target outliers for abduction, anteversion, and seating of the cup compared to the direct lateral approach. Controlling for BMI, the combined surgeon target remained significantly better with the DA approach. Operating on a non-dominant side in the DA and dominant side in the DL resulted in significantly more anteversion outliers.

Measurement of the acetabular position can be performed on plain radiographs or by computerized tomography (CT) imaging. CT scans are considered by many to be the gold standard for measurement of acetabular placement, especially anteversion.27,30 CT scans, however, are costly and expose the patient to significant radiation. Many methods have been described to measure anteversion on plain radiographs,3,25,32-34 with the Widmer method used in this study being the most accurate to CT measurements.26 Inter- and intraobserver reliability of the Widmer method has been reported as 0.925 (95% CI, 0.873 to 0.953), and 0.944 (95% CI, 0.921 to 0.962), respectively.26 A well-centered AP pelvic radiograph is essential for accurate anteversion measurement of an AP radiograph as malrotation can significantly affect the measured anteversion.31

Medialization of the acetabular component has long been a tenant of THA since the classic techniques described by Charnley and Mueller.26,36 To maintain global anatomic offset with a medialized

<table>
<thead>
<tr>
<th>Table III</th>
<th>Acetabular component measurements of right and left hips in DA and DL</th>
</tr>
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<tbody>
<tr>
<td><strong>DA - Right</strong></td>
<td><strong>DA - Left</strong></td>
</tr>
<tr>
<td>Abduction angle</td>
<td>39.5° (±4.2, 31–48)</td>
</tr>
<tr>
<td>Abduction outliers &gt;±5°</td>
<td>14/80 (17.5%)</td>
</tr>
<tr>
<td>Lewinnek abduction outlier</td>
<td>0/80 (0%)</td>
</tr>
<tr>
<td>Anteversion angle</td>
<td>20.9° (±4.2, 12–32)</td>
</tr>
<tr>
<td>Anteversion outliers &gt;±5°</td>
<td>16/80 (20%)</td>
</tr>
<tr>
<td>Lewinnek anteversion outlier</td>
<td>9/80 (11.3%)</td>
</tr>
<tr>
<td>Seating to teardrop (mm)</td>
<td>1.0 (±2.2, -4.4–7.7)</td>
</tr>
<tr>
<td>Seating outliers &gt;±5mm</td>
<td>3/80 (4%)</td>
</tr>
<tr>
<td>Combined** target &lt;±5° met</td>
<td>53/80 (66.3%)</td>
</tr>
<tr>
<td>Combined** Lewinnek met</td>
<td>71/80 (88.8%)</td>
</tr>
</tbody>
</table>

*Statistically significant, **Both anteversion and abduction in the same patient were within targets DA=direct anterior approach, DL=direct lateral approach

Figure 7. Scatterplot of acetabular component abduction and anteversion between surgical approach and hip laterality.
acetabular component, the femoral offset is increased which results in improved abductor movement and decreased joint reactive forces.8,9 Conversely, a lateraled hip center with decreased femoral offset results in a reduced abductor moment arm and can increase polyethylene wear.10,11 The relationship of the acetabular component to the teardrop has been shown to be a reproducible radiographic landmark for hip center of rotation.42 Using the DA approach, fluoroscopy can aid in determining medialization. However, in the DL approach, the surgeon must rely on bony landmarks to determine proper medialization. This study found that only 2% of the DA patients had outliers of the target medialization; whereas, there were 24% medialization outliers in the DL group.

The so-called “safe zone” of acetabular abduction and anteversion as described by Lewinnek1 has been a benchmark for the acetabular position over the last 40 years. However, careful analysis of that study has garnered criticism revealing significant limitations, including a low number of patients, posterior approach without soft tissue repair, and low-offset femoral components.43,44 Abdel et al. reported, in a series of 206 hip dislocations, that 58% of acetabular components were within the safe zone.45 More modern research has highlighted the dynamic nature of the acetabular position as it relates to the patients’ spinopelvic alignment, lumbopelvic disease states, and the importance of combined anteversion.46-49 Despite this, the Lewinnek safe zone is still a target alignment commonly referenced,41 which is why it was included in this study.

More accurate component positioning has been one argument from proponents of the anterior approach.12,20 The use of fluoroscopy allows real-time feedback of component positioning, and its use in anterior THA has shown improvement in the acetabular component position in some studies.51,52 Other studies, however, have not demonstrated any benefit of fluoroscopy in acetabular abduction, anteversion, or limb length restoration in anterior THA.53

Figure 8. Acetabular component impaction in a left hip via a direct anterior approach. Surgeon moves to the foot of the bed to optimize impaction and component position.

Accurate c-arm placement is critical for assessment of component alignment as small errors in imaging position can have significant effects on perceived component orientation.54

Results have been varied regarding whether the accuracy of component position is better with the DA compared to other approaches. Tripuraneni et al. reported no difference in acetabular component abduction angle or dislocation rates in the direct anterior versus the posterior approach.55 In a randomized study, Tauton et al. found no difference in component position between the direct anterior and mini posterior approach.56

Contrary to these findings, a number of authors have reported improved acetabular position with the DA approach.12,13,21,52 Rathod et al. reported on a three-part analysis of the acetabular position comparing DA to the posterior approach, the learning curve of the DA to the posterior, and the learning curve of DA to later DA cases. They found that the DA cup position after the learning curve was significantly more accurate than during the learning curve and compared to the posterior approach.13 Gromov et al. reported 63% success when placing the acetabular component in the Lewinnek safe zone with the DA approach as compared to 45% success with the posterolateral approach, 43% success with the anterolateral approach, and 32% success with the direct lateral approach.13 Lin et al. reported significantly more acceptable abduction angles with the anterior approach compared to the posterior approach.57 In a consecutive series of 200 hips, in which the surgeon switched from the posterior approach to the DA approach halfway through, Hamilton et al. found a significant reduction in variance of cup position as well as severely vertical cups with the DA approach.51 The current study found greater accuracy with abduction, anteversion, and seating with the anterior approach compared to the direct lateral by a surgeon with three years of anterior experience and 28 years of direct lateral experience.

Surgeon handedness and laterality of hips is not often discussed when analyzing acetabular component position. The authors are aware of only two studies evaluating this topic. Pennington et al. reviewed acetabular position from four surgeons; two right-handed and two left-handed. One surgeon in each group used a posterior approach and one used a lateral approach. When operating on the dominant side, the acetabular abduction was significantly higher as was the acetabular medialization.46 The authors postulated that when a surgeon is operating on the dominant side, acetabular reaming is guided by the dominant hand, which may assist the surgeon in exerting more pressure and greater medialization. Song et al. reported on the effects of hip laterality on acetabular position in 498 patients undergoing bilateral THA by a right-handed surgeon using a posterior approach. They found a significant increase in anteversion in left hips and significantly higher abduction in right hips. Right hips had a significantly higher incidence of dislocation at 7% versus left hips at 3.2%.57 With the direct lateral approach, the current study found
no difference in abduction based on laterality, but dominant-sided hips had significantly higher anteversion and antversion than Lewinnek outliers.

In the anterior approach, acetalabular abduction is lowered by bringing the inserter closer to the patient, and anteversion is decreased when bringing it closer to the ground. Assuming the surgeon always impacts the acetabular component with their dominant hand, in a non-dominant hip, during a DA approach, it can be difficult to position oneself for optimal impact while maintaining proper abduction and anteversion. This study did find a significantly higher abduction angle on the non-dominant side, but no difference in abduction outliers with the DA approach. There were, however, significantly more Lewinnek anteversion outliers in the non-dominant side. One tip to help with cup insertion on a non-dominant side is for the surgeon to move to the foot of the bed when impacting the cup (Fig. 8).

A limitation of this study already discussed is that there was selection bias and demographic differences between surgical approaches. Notably, the DL group had a significantly higher BMI, and this approach was chosen for more complex deformity. However, when controlling for obesity as a variable with surgical approach, the surgeon-combined target achievement remained significantly better in the DA approach. Furthermore, obesity as an independent variable did not significantly affect the percent of hips achieving the combined Lewinnek target. Another limitation of this study is that only a single observer performed all measurements. They were blinded to the approach used, but errors in measurement can occur. A strength of this study is that all surgeries were performed continuously over a single time period by a single surgeon. This removes variability that may come from different surgeons performing the operation or variances by one surgeon over different time periods.

CONCLUSION

The anterior approach improved target abduction, anteversion, and cup medialization compared to the direct lateral approach. Significant differences in component positioning were found in both approaches based on the surgeon’s dominant and non-dominant side.

AUTHORS' DISCLOSURES

Research funding in direct support of this study was received from Zimmer Biomet, Inc. (Warsaw, Indiana). Dr. Lombardi and Dr. Berend are consultants to, and receive royalties from, Zimmer Biomet Inc. They also receive royalties from Innomed, Inc. (Savannah, Georgia), and have minority investment interests in SPR Therapeutics (Cleveland, Ohio), Joint Development Corporation (Salt Lake City, Utah), Elute Inc. (Salt Lake City, Utah), and VuMedi (Oakland, California). An institution of the authors, Joint Implant Surgeons, Inc., receives research support from Zimmer Biomet Inc., SPR Therapeutics, and Kinetic Concepts Inc. (San Antonio, Texas).

REFERENCES


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