Cheating the Acetabular Component Horizontally in Total Hip Arthroplasty

SCOTT M. ESKILDSN, MD; PETER T. MOSKAL, MD; CHRISTOPHER W. OLCOTT, MD; DANIEL J. DEL GAIZO, MD

abstract

To avoid inadvertent vertical positioning of the acetabular component during total hip arthroplasty (THA), the authors routinely “cheat” component abduction an additional 10° horizontal (goal=30°). This likely increases the incidence of components placed into abduction of less than 30°, the clinical consequences of which are not well studied. The purpose of this study was to determine the clinical and radiographic outcomes in patients undergoing THA with acetabular components positioned in less than 30° of abduction as compared with those with components positioned between 30° and 50°. A retrospective review was performed of consecutive patients undergoing primary THA with horizontally cheated acetabular component position performed by a single surgeon. Patients were grouped into cohorts with either component abduction less than 30° or between 30° and 50°. Demographic data, operative data, and complications were recorded. Harris Hip Scores (HHS) and radiographic analysis were obtained from preoperative and most recent clinic visits. Between September 2004 and September 2010, 320 consecutive THA procedures were performed. A total of 149 hips had component abduction less than 30° (mean, 25.8°; range, 15.7°-29.4°). No components had greater than 50° of abduction. At an average 37-month follow-up, no significant difference in HHS was found between the 2 cohorts (*P*=.137). The horizontal cohort had no dislocations, component loosening, or osteolysis. By cheating the acetabular component more horizontal, an excessively vertical position was avoided. Component abduction less than 30° yielded equivalent clinical outcomes to component abduction between 30° and 50°.


Since Lewinnek et al1 established the safe zone to be 40°±10° of acetabular component inclination, numerous studies have aimed to better characterize the relationship between acetabular component positioning and clinical outcomes. Excessive vertical positioning of the acetabular component has been linked to impingement,2-5 dislocation,1,3,6,7 and accelerated polyethylene wear,2,8-14 with subsequent poor survivorship and increased revision rates. Conversely, there is a paucity of literature addressing the negative clinical consequences of placing the acetabular component in excessive horizontal inclination. Such positioning theoretically decreases the surface area available for osseointegration and increases the rate of symptomatic impingement but has not been well documented in the literature.

Due to significant evidence for negative outcomes related to vertical positioning and a lack of evidence regarding negative outcomes of horizontal positioning, the current authors routinely “cheat” comp-
ponent abduction an additional 10° horizontal (goal=30°). This likely decreases the incidence of vertical positioning while increasing the incidence of components placed with an abduction angle of less than 30°, the clinical consequences of which have not been well studied. The purpose of this study was to determine the clinical and radiographic outcomes in patients undergoing total hip arthroplasty (THA) where acetabular component abduction is cheated horizontally, with the result being an abduction angle below 30°.

**Materials and Methods**

All described investigations and procedures were performed in accordance with the ethical standards outlined in the Helsinki Declaration of 1975, as revised in 2000, as well as national law. Local institutional review board approval was obtained prior to proceeding with this study.

A retrospective review using the authors’ institutional database was performed to identify consecutive patients with at least 2-year follow-up who had undergone primary or conversion THA where the horizontal component was cheated horizontally. Patients were identified in the institution’s electronic medical record where radiographs and clinical information were obtained. All procedures were performed by a single surgeon (C.W.O.) and occurred between July 2004 and December 2012. During this period, 432 consecutive primary THAs were performed (Table 1). Of these patients, 320 (74.1%) had at least 1 year of follow-up (112 excluded for lack of adequate follow-up). Average follow-up time was 37.22 months (range, 12-122 months). No patients were excluded due to diagnosis, comorbidity, or any other demographic factor. A review of complications in the patients excluded due to inadequate follow-up revealed no dislocations or revisions for any reason at the time of last follow-up. The majority of patients underwent surgery for osteoarthritis (n=194); other indications included avascular necrosis (n=74), femoral neck fracture (n=21), acetabular dysplasia (n=14), traumatic arthritis (n=9), inflammatory arthritis (n=4), and hemophilic arthropathy (n=4). The study group comprised 116 men (135 hips) and 174 women (185 hips). Mean patient age at the time of surgery was 60.0 years (range, 19-94 years).

Pre- and postoperative radiographs were evaluated, and acetabular cup abduction angles were measured between the long elliptical axis of the cup obliquely and the radiographic inter-teardrop line horizontally on anteroposterior (AP) pelvis radiographs using the institutional picture archiving and communication system (IMPAX version 6; Agfa, Mortsel, Belgium) (Figure 1).5,15 The 320 patients were divided into 3 cohorts depending on their acetabular abduction angle: 0° to 29.9° (n=149), 30° to 50° (n=171), and over 50° (n=0). Average acetabular angle was 30.5° (range, 15.7°-48.4°).

**Surgical Technique**

All procedures were performed through a posteriorlateral approach in the lateral decubitus position. The hip was dislocated and a femoral osteotomy was made based on preoperative templating. Soft tissue was removed circumferentially to allow for clear visualization of the acetabular rim. The socket was then reamed medially, and the size of the reamer was increased sequentially by 1-mm increments until the desired size was obtained. The amount of abduction was determined through a combination of preoperative templates and intraoperative coverage of the acetabular trial, with a goal of 30° of abduction. The primary surgeon ultimately determined final abduction angle. All cups used were cementless with supplemental screw fixation. Intraoperatively, all cups appeared to have a stable fit, and no structural graft was used in any case. The hip was then reduced and trialed, and the wound was closed in layers. Acetabular components used in this series included 186 DePuy Pinnacle (DePuy, Warsaw, Indiana) acetabular shells and 134 Biomet Ranawat-Burstein (Biomet, Warsaw, Indiana) acetabular shells. All were used in conjunction with ultra-high-molecular-weight polyethylene liners.

All patients were placed on appropriate venous thromboembolism precautions, and all patients underwent standard postoperative therapy with hip precautions. All patients were allowed to partially bear weight immediately postoperatively and increased weight bearing during their postoperative rehabilitation.

Postoperative follow-up was recommended to include visits at 2 weeks, 6 weeks, 6 months, and yearly. Follow-up evaluation consisted of clinical, functional, and radiographic evaluations at all

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**Table 1**

<table>
<thead>
<tr>
<th>Procedure</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consecutive primary THA</td>
<td>432</td>
</tr>
<tr>
<td>THA with 1-year follow-up</td>
<td>320</td>
</tr>
<tr>
<td>THA with acetabular component abduction from 30° to 50° safe zone</td>
<td>171 (53.4%)</td>
</tr>
<tr>
<td>THA with acetabular component abduction &lt;30°</td>
<td>149 (46.6%)</td>
</tr>
<tr>
<td>THA with acetabular component abduction &gt;50°</td>
<td>0 (0.0%)</td>
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</tbody>
</table>

*Abbreviation: THA, total hip arthroplasty.*

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**Figure 1:** Anteroposterior pelvis radiograph showing measurement of abduction in a horizontally “cheated” component. Abduction was measured as the angle of intersection between the long axis of the cup (solid yellow line) and the inter-teardrop line (dashed yellow line).
visits. Evaluation included a history and physical that included all components of the Harris Hip Score (HHS), including pain, presence of a limp, ambulation aids, stair use, ability to put on socks and shoes, comfort during sitting, ability to use public transportation, and distance the patient could ambulate. Clinical outcomes were assessed via postoperative HHS obtained at each clinical visit. A blinded author (P.T.M.) evaluated the most recent postoperative follow-up clinical examination and AP pelvis, AP hip, and lateral hip radiographs. Bony ingrowth of the acetabular cup was evaluated by the presence or absence of significant radiolucencies at the cup-bone interface. The presence of radiolucencies was recorded and categorized by DeLee and Charnley zones. Radiographic outcomes were assessed with comparison of the immediate postoperative and most recent postoperative radiographs to evaluate for signs of loosening or failure. Loosening was defined as greater than 3 mm of migration or greater than a 4° change in abduction angle.

All statistical evaluations were performed using SPSS version 22 statistical software (IBM, Armonk, New York). A P value of .05 or less was considered significant. Chi-square test was used for nominal data, and 2-sample t test and Pearson correlation coefficient were used to evaluate ordinal data.

**RESULTS**

There were no statistically significant differences between the 2 cohorts with regard to patient age, sex, or follow-up time (Table 2). Mean postoperative HHS for all study patients was 89.9 (range, 40-100). Mean postoperative HHS was 90.1 (range, 40-100) for the 0° to 29.9° cohort and 89.9 (range, 45-100) for the 30° to 50° cohort. This was not statistically significant (P=.667), and no significant correlation between angle and HHS was found (Figure 2). An HHS over 90 is determined to be an excellent result, and a score of 80 or greater is a good result. In the 0° to 29.9° cohort, 103 procedures were determined to have an excellent result, and 34 were determined to have a good result. In the 30° to 50° cohort, 109 procedures were determined to have an excellent result, and 44 were determined to have a good result. There were no significant differences in good and excellent results in the 2 groups (P=.449) (Table 2).

Final radiographs demonstrated good overall alignment and fixation with all cups ingrown. At final follow-up in the 0° to 29.9° cohort, 14 acetabular components had radiolucencies on radiograph, although all radiolucencies were less than 3 mm and were determined to be stable. Intraoperatively, there were no iatrogenic pelvic fractures or injuries to intrapelvic structures. There were no revisions for ac-

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**Table 2**

Patient Demographics, Clinical Outcomes, and Radiographic Findings by Cohort

<table>
<thead>
<tr>
<th>Parameter</th>
<th>0° to 29.9°</th>
<th>30.0° to 50°</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hips, No.</td>
<td>149</td>
<td>171</td>
<td>N/A</td>
</tr>
<tr>
<td>HHS, mean±SD</td>
<td>90.1±9.1</td>
<td>89.9±8.5</td>
<td>.667a</td>
</tr>
<tr>
<td>Result, excellent/good, No.</td>
<td>103/34</td>
<td>109/44</td>
<td>.449b</td>
</tr>
<tr>
<td>Follow-up, mean±SD, mo</td>
<td>38.1±22.8</td>
<td>36.5±22.7</td>
<td>.863a</td>
</tr>
<tr>
<td>Age, mean±SD, y</td>
<td>58.4±15.8</td>
<td>61.4±14.7</td>
<td>.187a</td>
</tr>
<tr>
<td>Sex, M/F, No.</td>
<td>90/59</td>
<td>95/76</td>
<td>.381b</td>
</tr>
<tr>
<td>Revisions, No.</td>
<td>2</td>
<td>4</td>
<td>.430a</td>
</tr>
<tr>
<td>Radiolucency, No.</td>
<td>14</td>
<td>19</td>
<td>.253b</td>
</tr>
</tbody>
</table>

**Abbreviations:** F, female; HHS, Harris Hip Score; M, male; N/A, not applicable.

a Two-sample t test.

b Chi-square test.

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**Figure 2:** Scatterplot showing all Harris Hip Scores in patients with less than 30° of cup abduction (black dots) and patients with 30° to 50° of cup abduction (white circles). No components were placed in excessive vertical orientation with greater than 50° of abduction (red line).
etabular loosening or malposition, and all acetabular components were in place and stable with no signs of radiographic loosening at the time of most recent follow-up. Two patients required revision for femoral component loosening with preservation of the acetabular component, and 1 patient experienced an early dislocation and underwent successful nonoperative treatment. No acetabular components required revision.

At final follow-up in the 30° to 50° cohort, 19 acetabular components had radioluencies on radiograph, although all radioluencies were less than 3 mm and were determined to be stable. Intraoperatively, there were no iatrogenic pelvic fractures or injuries to intrapelvic structures. There were no revisions for acetabular loosening or malposition, and all acetabular components were in place and stable with no signs of radiographic loosening at the time of most recent follow-up. Four patients required acetabular revisions, including 2 for periprosthetic infections and 2 postoperative periprosthetic fractures. There were no dislocations. There were no statistically significant differences between the 2 cohorts with regard to revision rate or radiolucency found on radiograph (Table 2).

**DISCUSSION**

In an effort to guide surgeons’ practice, Lewinnek et al1 described a safe zone comprising a range of component abduction from 30° to 50° and anteversion of 5° to 25°, within which the risk of dislocation was minimized. Following this, numerous studies sought to refine this range. Although based on a limited series of small cohort studies, the concept of the safe zone persisted and has remained widely accepted in practice for decades.

However, the optimal orientation of the acetabular component in THA remains unknown. Improper positioning of the acetabular component has been linked to impingement,2-5 dislocation,1,2,6,7 and accelerated polyethylene wear,5,8-14 all of which are associated with poor clinical outcomes. Whereas the risks of improper vertical orientation of the acetabular component are well described, there is a paucity of literature addressing the disadvantages of excessive horizontal component orientation. At the current authors’ institution, they routinely cheat the component orientation toward the horizontal, with a goal of 30° of cup abduction to eliminate improper vertical positioning. Nearly half of the patients in the current study cohort were found to have acetabular components placed in less than 30° of abduction, outside of the Lewinnek safe zone, whereas no components were placed over 50° of abduction. At short- to mid-term follow-up, the authors were unable to detect any clinical or radiographic differences between this horizontal cohort and the remainder of patients whose components were placed within the safe zone of 30° to 50°.

Numerous studies have attempted to identify a relationship between cup orientation and dislocation risk, with variable and contradictory results.2,6,7,19-21 Recent data suggest that cup orientation plays only a small role in the risk of dislocation.22 Esposito et al22 conducted a prospective registry trial of 7040 patients undergoing primary THA and found no significant association between perioperative dislocation rates and acetabular component inclination or anteversion angles. They concluded that early dislocations were multifactorial and attributable to patient factors and that component orientation alone cannot predict the risk of early instability.22 The current study’s findings support this observation. Only 1 (0.7%) dislocation was observed in the below 30° group, which compares favorably with the reported overall dislocation rate of 1% to 4% in primary THA.21 There were also no acetabular component revisions after short- to mid-term follow-up.

Another potential risk of horizontal component orientation is an increased risk of component impingement. Several authors have shown that, in a computer simulation model, excessive horizontal component positioning decreases superior bony contact with the pelvis and predisposes patients to anterior impingement during terminal flexion, causing pain and theoretically increasing the risk of dislocation.2-5 In the current study, care was taken intraoperatively to ensure all components were carefully medialized to provide adequate coverage and prevent impingement. Acetabular screws were also placed in all patients to ensure solid fixation and maximize ingrowth. Radiographically, all cups were solidly osseointegrated at final follow-up. Clinically, only 1 dislocation was observed, and no acetabular components required revision for any reason within the 1- to 10-year follow-up period of patients with horizontally cheated components. Furthermore, there was no difference in clinical outcomes as measured by the HHS at final follow-up. Although the authors did not assess for range of motion, they believe that any clinically significant impingement would have manifested with increased pain and worse outcome scores and likely would have resulted in additional dislocations.

Regarding the relationship between component orientation and polyethylene wear, the relatively short average follow-up period limits the ability to draw any meaningful conclusions. Excessive vertical cup orientation has been shown to increase contact stresses at the head-liner interface and has been repeatedly linked to increased rates of polyethylene wear and osteolysis,5,8-14,23 as well as to increased rates of metal ion debris in metal-on-metal constructs.24,25 Conversely, other authors have found unchanged26,27 or decreased28,29 rates of polyethylene wear with vertically oriented components. At short- to mid-term follow-up in the current study, no patient in either cohort demonstrated evidence of clinically significant osteolysis or polyethylene wear. Continued follow-up is needed to identify any long-term effect.
In addition to the relatively short duration of follow-up, this study has several other limitations. All surgeries were performed by a single surgeon at a single institution. Patients’ ages, demographic data, and comorbidities varied widely, consistent with the patient population. All data were collected retrospectively, with clinical data obtained via review of the electronic medical record. All radiographic angles were measured by a single investigator using standard AP radiographs without control for pelvic tilt or rotation. Standardized radiographs could help eliminate measurement error.

**CONCLUSION**

At 1-year follow-up, no difference was found in clinical outcomes as measured by the HHS, and no increased rate of complications in patients with an acetabular component inclination of less than 30°. By cheating the component more horizontal, an excessively vertical position was avoided while maintaining equivalent clinical outcomes. Further investigation with long-term follow-up is warranted to better define the long-term risks and benefits of horizontal cup orientation.

**REFERENCES**