Influence of Surgical Approach on Pelvic Lift in Hip Arthroplasty During Cup Insertion

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abstract

The position of the acetabular cup is a major factor in the long-term outcome of total hip arthroplasty (THA). Malpositioning of the acetabular cup frequently has been reported with the use of a minimally invasive implantation technique. It remains unclear whether the limited visibility or the increased retractor traction and thus tilting of the pelvis during cup implantation is the cause. This study investigated the influence of iatrogenically related pelvic lift using an anterolateral minimally invasive THA technique. In a group of 30 consecutive patients who underwent THA via a minimally invasive anterolateral approach, iatrogenic lifting of the pelvis was measured with a smartphone using a 3-axis accelerometer and compared with patients in a historical age- and sex-matched control group who underwent THA using a transgluteal approach. Postoperatively, the inclination and anteversion of the cup was determined on pelvic radiographs. In the anterolateral group, the pelvis was lifted by a maximum of 6.3° and by an average of 3.9° when the acetabular cup was impacted; no difference was noted compared with the transgluteal group. In contrast, the cups in the anterolateral group showed significantly increased inclination and reduced anteversion. In both techniques, the iatrogenic tilting of the pelvis at the time of cup implantation occurred to a comparable extent. Therefore, the significant differences in postoperative radiographs cannot be attributed to increased retractor traction on exposure of the acetabulum, which means that the limited visibility must be responsible.

There are many different surgical approaches to the hip joint during arthroplasty. Whereas the posterior approach is widely used in the English-speaking world, lateral or anterolateral approaches to the hip are commonly used in Europe. The long-term clinical outcomes for both approaches are comparable. During the past decade, minimally invasive (MIS) anterolateral approaches have become increasingly popular. Besides the cosmetic appearance of the skin incision, which is functionally irrelevant but important to the patient, advantages include lower perioperative blood loss, reduced postoperative need for analgesics, shorter duration of surgery, better range of motion, and slightly earlier immediate postoperative mobilization.

No selection criteria for the anterolateral approach have been described in the literature. Nevertheless, some authors have excluded patients with a body mass
During surgery, the contralateral approach is used as the standard approach for primary total hip arthroplasty (THA) except in patients who have severe dysplasia, need osteotomies, or require revision of the femoral stem.

A common criticism leveled against the anterolateral approach, besides injury to the superior gluteal nerve, is the increased risk of component misplacement. As a result of the different anatomic and postoperative treatment schedules, results reported in the literature are difficult to compare; consequently, general conclusions and those limited to surgical approach alone remain problematic despite the large number of publications. In addition, the number of articles comparing anterolateral and transgluteal approaches is limited.

Immann et al reported an increased risk of cup malpositioning for the anterolateral approach compared with the conventional transgluteal approach, both in inclination and in anteversion. However, the MIS anterolateral approach was performed with patients in a lateral position, whereas the transgluteal approach was performed with patients in a supine position. Increased inclination of the cup leads to more wear and a greater risk of dislocation. Reduced anteversion also results in an increased risk of posterior dislocation and greater wear due to higher peak contact forces.

In addition, in the case of reduced anteversion with anterior implant overhang, the occurrence of an impingement syndrome has been described. If hard-hard articular pairings are used, unfavorable cup positioning can lead to the risk of ceramic fracture as well as the phenomenon known as “squeaking.” Furthermore, connections have been reported between positioning of the cup and serum ion concentrations of chrome and cobalt in the case of metal-metal articular pairings.

The mechanism that leads to a systematic error of cup positioning in the MIS technique remains unclear. Besides obviously compromised visibility, the increased retractor traction during preparation until implantation of the cup may lead to displacement of the pelvis on the operating table. Assuming orientation of the implant position to the table plane, this would lead to an avoidable error. Therefore, this study investigated whether the type of surgical approach (MIS vs conventional) influences pelvic lift during cup insertion in THA.

Materials and Methods

A power analysis indicated that 60 THA patients treated with a pressfit cup needed to be included in this study. Study approval was obtained from the university hospital’s ethics committee (No. 4440-04/15). Prior to inclusion in the study, patients were informed about the study and provided verbal and written consent.

Thirty consecutive patients underwent surgery via an anterolateral approach in supine position according to Watson-Jones. During surgery, the contralateral leg was placed in a leg holder to facilitate hyperextension of the operative leg. The hip joint was placed above the pivotal point of the operating table to enable hyperextension of the operative leg.

Patients in this anterolateral approach group were then matched by age (±2 years) and sex to patients in a historical control group who underwent surgery via a transgluteal approach in supine position. For each patient in the anterolateral group, a patient in the control group was identified who fulfilled the matching criteria. If several control patients fulfilled the criteria, the patient with the lowest age difference to the corresponding anterolateral patient was selected. All operations were performed by the same surgeon (S.B.).

Intraoperative measurement of pelvic tilt was performed with a 3-axis accelerometer, which was installed in a commercially available smartphone (iPhone 5; Apple, Cupertino, California) and displayed via a dedicated app (SensorLog version 1.8; Bernd Thomas, Wurzburg, Germany). The smartphone was packed in a protective covering, and in all cases, the smartphone was attached by the same surgeon (S.B.) to the contralateral anterosuperior iliac spine using standard medical tape (Figure). The skin underneath the smartphone was protected using a 15x15-cm flexible wound dressing (Comfeel Plus; Coloplast GmbH, Hamburg, Germany). The measurement method was validated beforehand on a human anatomical skeletal model in a computed tomography scanner.

Throughout the operation, the app recorded the spatial position of the smartphone via 3 accelerometers with a sampling rate of 5 measurements per second and an absolute timestamp. Raw data were imported into Excel, version 14.5.7 (Microsoft, Redmond, Washington), for further analysis.

Before the start of the study, 8 relevant surgical steps were defined, and during surgery, the time of the surgical steps was recorded by an unsterile surgical nurse. These surgical steps were (1) skin incision, (2) capsule resection, (3) osteotomy of the femoral neck, (4) maximum tension on the acetabular rim retractors, (5) implantation of the cup, (6) placement in the figure-of-4 position, (7) implantation of the stem, and (8) repositioning. The respective spatial position of the pelvis was allocated to these 8 surgical steps according to the absolute time. The position at the time of skin incision was defined as 0.

Postoperatively, cup inclination and anteversion were determined on a radiograph of the pelvis with the patient supine. All radiographs were taken on a low setting by an independent radiologist. MediCAD Classic software, version 2.55 (HECTEC, Landshut, Germany), was used for this purpose.
Patient-specific data documented included sex, primary diagnosis (primary osteoarthritis of the hip, dysplastic osteoarthritis of the hip, or posttraumatic osteoarthritis of the hip), age, operative side, abdominal and pelvic circumference, waist-hip ratio, height, weight, and body mass index. In addition, the operative time from incision to suture was recorded as a possible influencing variable.

The study groups were compared by Mann-Whitney U test for unpaired samples. The significance level was set as \( P<.05 \) (XLStat; Addinsoft, Paris, France).

**RESULTS**

Mean (SD) patient age for the 2 groups was 62.3 (8.4) years. Mean (SD) age in the anterolateral group was 62.1 (8.8) years compared with 62.2 (8.2) years in the transgluteal group. The operative hips included 34 right hips and 26 left hips. There were no significant differences between the 2 groups for patient-specific data such as height, weight, body mass index, abdominal circumference, pelvic circumference, and waist-hip ratio.

For pelvic lift during the course of the operation, until cup implantation, there were no significant differences between the anterolateral and transgluteal groups (Table 1). A significant difference was noted after completion of cup implantation when the leg was placed in the figure-of-4 position for preparation of the femoral medullary space and stem implantation. A markedly stronger pelvic lift occurred in the transgluteal group (11.8°±8.4°) than in the anterolateral group (-0.5°±4.2°) \( (P<.0001) \).

In the postoperative radiographic evaluation of the cup position (Table 2), inclination was higher in the anterolateral group (44.5°±4.5°) compared with the transgluteal group (40.6°±5.4°) \( (P=.012) \). In contrast, anteversion was reduced in the anterolateral group (11.5°±3.8°) compared with the transgluteal group (14.1°±5.3°) \( (P=.024) \).

For the safe zone according to Lewinnek et al, there was no significant difference between the 2 groups. In the transgluteal group, 29 (97%) cups were within the safe zone, and in the anterolateral group, 27 (90%) cups were within the safe zone.

**Table 1** Pelvic Lift During Surgery

<table>
<thead>
<tr>
<th>Surgical Step</th>
<th>Pelvic Lift in Transgluteal Approach</th>
<th>Pelvic Lift in Anterolateral Approach</th>
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<tbody>
<tr>
<td>Skin incision</td>
<td>0°</td>
<td>0°</td>
</tr>
<tr>
<td>Capsule resection, mean±SD</td>
<td>2.4°±2.9°</td>
<td>3.7°±3.4°</td>
</tr>
<tr>
<td>Osteotomy femoral neck, mean±SD</td>
<td>3.6°±3.7°</td>
<td>4.0°±3.4°</td>
</tr>
<tr>
<td>Acetabular rim retractors maximum, mean±SD</td>
<td>6.9°±4.3°</td>
<td>6.3°±5.1°</td>
</tr>
<tr>
<td>Cup implantation, mean±SD</td>
<td>4.4°±4.8°</td>
<td>3.9°±4.0°</td>
</tr>
<tr>
<td>Figure-of-4 position, mean±SD</td>
<td>11.8°±8.4°</td>
<td>-0.5°±4.2°</td>
</tr>
<tr>
<td>Stem implantation, mean±SD</td>
<td>8.6°±9.3°</td>
<td>-0.1°±5.4°</td>
</tr>
<tr>
<td>Repositioning, mean±SD</td>
<td>2.4°±3.3°</td>
<td>1.0°±3.3°</td>
</tr>
</tbody>
</table>

**Table 2** Radiographic Evaluation of the Cup Position

<table>
<thead>
<tr>
<th>Cup Position</th>
<th>Transgluteal Approach</th>
<th>Anterolateral Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inclination</td>
<td>40.6°±5.4°</td>
<td>44.5°±4.5°</td>
</tr>
<tr>
<td>Anteversion</td>
<td>14.1°±5.3°</td>
<td>11.5°±3.8°</td>
</tr>
</tbody>
</table>
The duration of surgery differed significantly between the 2 groups. The average (SD) duration of surgery was 48.2 (±9.3) minutes in the anterolateral group and 62.7 (±15.1) minutes in the translgluteal group (P<.0001). The reason for this was attributed to the lesser degree of preparation to the joint and the quicker wound closure in the anterolateral approach.

**Discussion**

This study demonstrated that intraoperative pelvic lift at the time of cup implantation does not differ between the anterolateral and translgluteal approach. In contrast, a systematically steeper and less antverted cup was found postoperatively in the anterolateral group.

There was a significant difference in pelvic lift when the figure-of-4 position was assumed. However, this was related to positioning and resulted from the fact that in the current authors’ MIS approach, the operative leg was hypere xtended and passed underneath the contralateral leg. In the translgluteal approach, the operative leg was placed over the contralateral leg in the figure-of-4 position. However, the large difference in pelvic lift during stem preparation resulting from the 2 types of positioning no longer plays a role for the position of the cup and can be disregarded. Therefore, intraoperative movement of the pelvis can be ruled out as the cause of the systematically lower antever sion in the anterolateral approach. The only remaining explanation is the limited visibility of the osseous acetabulum afforded by an anterolateral approach.

During implantation of a THA in supine position, the pelvis does not remain fixed in the same position. Rather, it displays a certain dynamic movement. This course of pelvic tilting is caused iatrogenically by manipulative maneuvers of the surgeon and his or her assistants. A characteristic course pattern has emerged. The traction applied by the assistants on the acetabular rim retractors that are used to expose the acetabulum in cup preparation has a major influence on the tilting of the pelvis.

In the current investigation, any influence on pelvic tilting of a supposedly stronger retractor traction at the time of cup preparation and implantation could not be demonstrated. Therefore, such an influence should not be assumed. During cup preparation, the anterolateral approach in supine position thus requires a similar amount of force on the part of the assistants as with the lateral translgluteal approach in supine position. Thus, the iatrogenic tilting of the pelvis at this point in time occurs to a comparable extent.

Inclination also was increased significantly in the anterolateral approach compared with the translgluteal approach in the current investigation. However, compared with the study by Innmann et al, the current study demonstrated reduced cup antever sion in the anterolateral approach in supine position.

**Conclusion**

As a result of this study, the current authors’ soft tissue or retractor management has not changed, but in the awareness of a systematically reduced anteversion in the anterolateral approach, an approximately 5° higher anteversion is anticipated in relation to the table plane. Similarly, with an anterolateral approach in supine position with an abducted contralateral leg, an approximately 5° flatter inclination is anticipated in relation to the pelvic plane compared with the translgluteal approach.

**References**


17. den Hartog YM, Mathijssen NM, Vehmeijer SB. The less invasive anterior approach for total hip arthroplasty: a comparison to other approaches and an evaluation of the learning curve. A systematic review. *Hip Int.* 2016; 26(2):105-120.


