

Influence of Surgical Experience on Accuracy of Acetabular Cup Positioning in Total Hip Arthroplasty

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ABSTRACT

Acetabular cup positioning with respect to inclination and anteversion is important in total hip arthroplasty. Positioning affects wear, range of motion, dislocation, and aseptic loosening and is essential for the prognosis after surgery.

In this study, we sought to determine the accuracy of surgeons' cup positioning and to test for any differences in accuracy among surgeons with different levels of surgical experience. Using a lateral transgluteal approach, 2 groups of surgeons with different levels of surgical experience positioned 85 cups. Fifty-nine percent of the cups were outside the safe zone of Lewinnek. There was no significant difference between the 2 groups.

In total hip arthroplasty (THA), correct positioning of the acetabular cup with respect to inclination and anteversion is important. Positioning affects range of motion, dislocation, and aseptic loosening and is essential for the prognosis after surgery and wear.¹⁻⁴

In a series of 300 THAs, Lewinnek and colleagues⁵ measured the orientation of the acetabular cup on standardized postoperative radiographs and studied the incidence of dislocation. The authors indicated a zone outside of which the incidence of dislocation seemed to increase or, conversely, a so-called safe zone (30°-50° of inclination, 5°-25° of anteversion). Implanted cups outside this zone were 4 times more likely to dislocate.

Other studies have found that nonoptimal initial cup inclination increased wear and penetration rates.^{6,7} Hips with a cup inclination angle of more than 45° had superior and

lateral penetration patterns of the polyethylene, and hips with an inclination angle of less than 35° and medial placement had medial head penetration patterns.⁸ Kligman and colleagues⁹ found that an increased annual wear rate correlated with a discrepancy of more than 18.3° between contralateral acetabular angle and acetabular cup inclination ($P<.005$).

Inclination and anteversion in acetabular cup positioning can be assessed anatomically during surgery or radiologically (Figures 1 and 2).

In the present study, we sought to determine the accuracy of surgeons' acetabular cup positioning in primary THA and to test for any differences in accuracy among surgeons with different levels of surgical experience.

MATERIAL AND METHODS

After obtaining ethics committee approval and informed consent, we conducted a clinical prospective study involving 84 consecutive patients: 42 women (53.8%) and 36 men (46.2%). Mean age was 67 years (SD, 10.5 years; range, 39-89 years). Eighty-five THAs were performed. We used the Plasmacup SC cup (Aesculap, Tuttlingen, Germany), a porous titanium acetabular cup with a polyethylene or ceramic insert. Data for 7 cups had to be excluded because of technical difficulties in radiologic projection, leaving 78 cups for analysis—48 in right hips (61.5%) and 30 in left hips (38.5%). Surgery was performed for primary osteoarthritis (65 cases), developmental dysplasia of the hip (5 cases), and avascular necrosis (8 cases).

In all surgeries, a supine position and a lateral transgluteal approach (Bauer and Russe¹⁰) were adopted, and the cup's

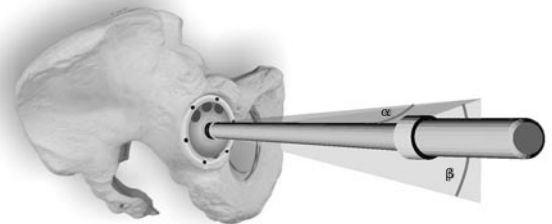


Figure 1. Operative inclination and anteversion of the acetabular cup. Inclination is the angle between the acetabular axis and the sagittal plane (α); anteversion is the angle between the acetabular axis projected onto the sagittal plane and the longitudinal axis of the patient (β).

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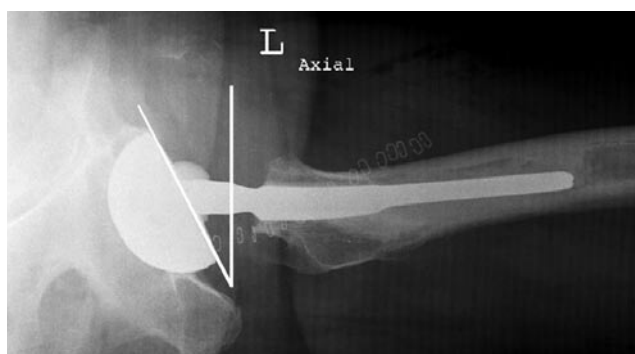


Figure 2: The axiolateral view of the hip, a cross-table lateral radiograph with measurement of the anteversion. Anteversion is measured between a plumb line to the x-ray table and a tangent to the cup.

insertion rod was used to place the cup and orient it inside the safe zone (Lewinnek and colleagues⁵). The surgeries were done by 2 groups of surgeons: those who had previously performed 200 hip arthroplasties (“more experienced surgeons”) and those who had performed fewer than 20 hip arthroplasties (“less experienced surgeons”). Of the 78 THAs, 45 (57.7%) were performed by 5 more experienced surgeons (3-13 THAs per surgeon), and 33 (42.3%) were performed by 7 less experienced surgeons (3-7 THAs per surgeon). The less experienced surgeons were allowed to choose inclination and anteversion and were supervised by, but not corrected by, the more experienced surgeons. No cup positioning had to be corrected.

All surgeons were asked to use the cup’s insertion rod (but not its aligning device) to position the cup. They were also asked to record their intraoperative assessment of inclination and anteversion immediately after surgery. Postoperative anteversion and inclination were measured on standard anteroposterior (AP) and axiolateral radiographs. The inclination angle was obtained from a standing AP radiograph of the pelvis by measuring the angle between the long axis of the acetabular cup and the transverse axis. Anteversion was measured on the axiolateral radiograph, an angled, cross-table lateral radiograph of the hip. The angles were measured between the projected long axis of the acetabular cup and the AP axis.¹¹ One investigator performed all radiologic measurements, and radiographs were presented in a random sequence to ensure that the rater was blinded to surgeon identity and experience group.

All data were analyzed with SPSS for Windows 9.0. Equality of variance was subjected to the Levene test. As our hypothesis regarding accuracy of cup positioning was 2-sided—we expected a difference in accuracy—we compared the figures with a paired *t* test.¹²

RESULTS

In all but 2 cases, the surgeon thought the implanted cup was inside the safe zone of 30° to 50° of inclination and 5° to 25° of anteversion (Figure 3). Radiologic inclination and anteversion data were available for 78 cups (Figure 4).

Mean radiologic inclination was 44.8° (SD, 6.7°; range, 31°-64°) for the surgeon groups combined; it was 43.9°

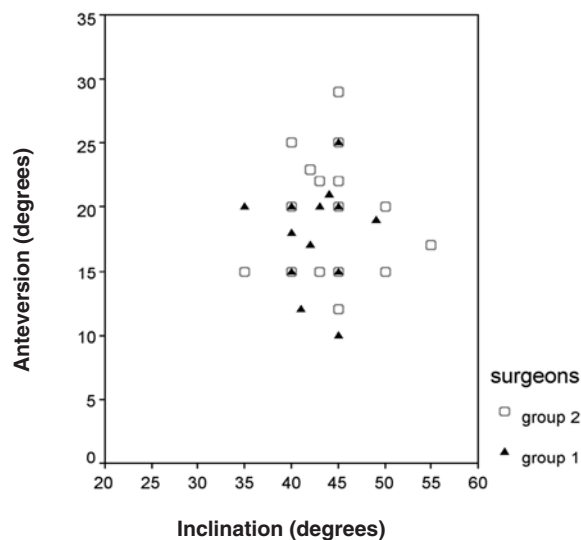


Figure 3. Surgeons’ intraoperative estimation of inclination and anteversion.

(SD, 6.2°; range, 31°-56°) for the more experienced surgeons and 45.9° (SD, 7.3°; range, 32°-64°) for the less experienced surgeons ($P = .211$).

Mean radiologic anteversion was 24.4° (SD, 7.7°; range, 8°-42°) for the surgeon groups combined; it was 23.2° (SD, 7.6°; range, 10°-38°) for the more experienced surgeons and 26.0° (SD, 7.6°; range, 8°-42°) for the less experienced surgeons ($P = .114$).

Differences between radiologic angles obtained for inclination and anteversion and the surgeons’ intraoperative assessment of inclination and anteversion were examined (Figure 5).

Mean and median differences for inclination between the 2 surgeon groups were 5.2° and 5° (SD, 3.8°; range, 0°-14°). Mean difference was 4.7° (SD, 3.7°; range, 0°-14°) for the more experienced surgeons and 5.8° (SD, 4°; range, 0°-14°) for the less experienced surgeons ($P = .247$).

Mean and median differences for anteversion between the 2 surgeon groups were 8.3° and 7° (SD, 5.8°; range, 0°-27°). Mean difference was 7.8° (SD, 5.5°; range, 0°-18°) for the more experienced surgeons and 9.1° (SD, 6.3°; range, 1°-27°) for the less experienced surgeons ($P = .330$).

In 46 (59%) of the 78 total cases—25 (55.6%) of the 45 cases treated by the more experienced surgeons plus 21 (63.6%) of the 33 cases treated by the less experienced surgeons—the cup was outside the safe zone. Thirteen (16.7%) of the 78 inclination measurements were outside the safe zone, 8 (17.8%) of 45 in the more experienced group and 5 (15.2%) of 33 in the less experienced group, and 33 (42.3%) of the 78 anteversion measurements were outside the safe zone, 17 (37.8%) of 45 in the more experienced group and 16 (48.5%) of 33 in the less experienced group.

DISCUSSION

Acetabular cup positioning is important for satisfactory long-term THA results. It affects wear, range of motion, dislocation, and aseptic loosening.¹⁻⁸

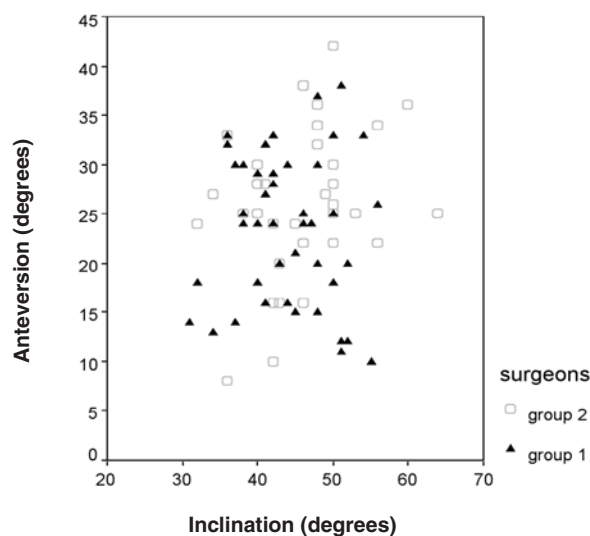


Figure 4. Inclination and anteversion angles from postoperative x-rays.

In the present study, 59% of the cups that surgeons thought they placed inside the safe zone—using the cup’s insertion rod but no alignment device—ended up outside the safe zone. So far, none of these hips has dislocated, but data regarding long-term wear and aseptic loosening are yet to come. Our measurements were taken on postoperative AP and axiolateral radiographs. Less experienced surgeons tended to position the cups with more inclination and more anteversion, but there were no statistically significant differences between less and more experienced surgeons with respect to cups being placed inside or outside the safe zone. When considered separately, intraoperative assessment of inclination was more reliable than intraoperative assessment of anteversion.

Only a few investigators have evaluated the accuracy of intraoperative assessment of acetabular cup position.^{13,14} To our knowledge, no one has compared the accuracy of intraoperative acetabular cup positioning by surgeons with different levels of experience. Hassan and colleagues¹⁴ used plain AP radiographs of the pelvis to evaluate 50 consecutive acetabular cups in THA. They reported that 42% of the cups, placed with an insertion guide, were outside the safe zone. Mean error of inclination was 5°, and mean error of anteversion was 9°. They concluded that, whereas inclination can be reasonably assessed during surgery, anteversion cannot.

DiGioia and colleagues¹³ found that even use of an alignment device did not increase the accuracy of acetabular cup positioning. Seventy-eight percent of 74 acetabular cups, positioned with an insertion guide and an alignment device, were outside the safe zone (Lewinnek and colleagues⁵).

Jolles and colleagues¹⁵ found that computer-assisted acetabular cup positioning was significantly more accurate and reproducible than conventional positioning. Further studies are needed to evaluate the benefit of using an aligning device or a computer-assisted navigation system for acetabular cup positioning, not only for dislocations, which can be examined and corrected clinically during surgery, but especially for wear and aseptic loosening.

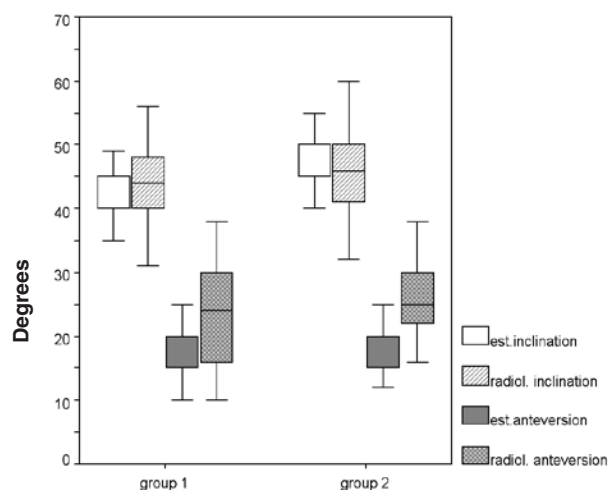


Figure 5. Comparison of intraoperative surgeon-estimated inclination and anteversion and postoperative radiologically measured inclination and anteversion. More and less experienced surgeons are the comparison groups.

Some methodologic issues and limitations should be mentioned. Our method for postoperative measurement is sound and has been described by Yao and colleagues.¹¹ Using axiolateral radiographs, we avoided radiographic measurement errors such as those considered by Hassan and colleagues.¹⁴ Inaccurate radiographic measurement of anteversion—caused by pelvic tilt—has been avoided with use of standardized axiolateral radiographs.

Consistent neutral pelvic positioning on the operating table is essential for correct acetabular cup positioning. Variance in individual pelvic tilt in the sagittal and coronal planes significantly influences cup orientation. Anda and colleagues¹⁶ found that acetabular anatomical anteversion varied by 0.5° with pelvic rotation of 1°. Increased lumbar lordosis or fixed contractures around the hip may lead to changes in acetabular orientation. Manipulation during surgery may influence acetabular orientation as well.

In summary, our data are similar to those presented by Hassan and colleagues,¹⁴ and we are able to support their conclusion that anteversion cannot be accurately assessed during surgery using only a mechanical guide. Level of surgical experience does not statistically influence the accuracy of acetabular cup positioning.

AUTHORS’ DISCLOSURE STATEMENT

The authors report no actual or potential conflict of interest in relation to this article.

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218

July 2008 363