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Long-term Results of Primary Hip Arthroplasty with Cup Inclination Angle Bigger than Fifty Degrees

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ABSTRACT

Background: Most of studies suggest the cup inclination angle is controversial. All of the studies previous have not control the prosthesis type and head diameter, it is difficult to determine relative or synergistic effects of cup angle.
Methods: We retrospectively reviewed 54 patients (61 hips) with primary total hip arthroplasties which cup inclination angle bigger than 50^0 after a mean 11.8 years follow-up. All the prosthesis are noncemented cup with a 28 mm metal head(Trilogy Acetabular Shell, Zimmer). The cup inclination was divided into three groups, $50–55^0$ in 26 hips, $55–60^0$ in 21 hips, and bigger than 60^0 in 14 hips. An immediate postoperative radiograph was compared with a follow-up radiograph. The polyethylene wear rates and abduction of the acetabular cups was measured in all of the patients.
Results: The preoperative mean Harris hip score improved from 47.36 to 94.3 points at 10 years. The survivorship of the cup was 100% at 10 years. The mean rate of liner wear was 0.144 ± 0.031 mm/y (0.105–0.178 mm/y) in cup inclination angle between $50^0–55^0$, and 0.260 ± 0.043 mm/y (0.215–0.394 mm/y) in angle between $55^0–60^0$, 0.403 ± 0.016 mm/y (0.378–0.423 mm/y) in angle bigger than 60^0. The different cup inclination groups are different with liner and volumetric wear.
Conclusion: For the metal-on-polyethylene prostheses, the liner wear obvious correlate with cup inclination after angle bigger than 50^0. It can be concluded that the ideal abduction angle for metal-on-polyethylene prostheses should be less than 55° in hip total replacement.

The ideal cup inclination angle has been studied extensively in THA with metal-on-polyethylene (PE) prostheses. Several studies show that cup inclination should be 45° or less because inclination greater than that is directly related to accelerated wear.[1–5] Other studies recommend the acetabular component should be positioned (for example, some would describe ideal acetabular inclination as $45^\circ \pm 10^\circ$, while others would say $40^\circ \pm 10^\circ$). Although authors disagree the absolutely ideal acetabular inclination, it is agreed suboptimal acetabular positioning can lead to construct instability and detrimental wear characteristics.[6–9] However, because previous studies have not controlled head diameter or cup angle independently it is not possible to determine relative or synergistic effects of cup angle.

1. Patients and methods

We retrospectively reviewed 54 patients (61 hips) with primary total hip arthroplasties which cup inclination bigger than 50^0 during 2001–2004. This was a selected study because we needed radiographs of patients who were alive and active and had current follow-up, also cup inclination is bigger than 50^0. These operations were performed from 2001 to 2004 using a posterior approach. All patients were implanted with the noncemented cup (Trilogy Acetabular Shell, Zimmer). The technique was to ream the bony acetabulum and implant the hemispherical cup with or without screws. The cup was titanium, with 3.5-mm-thick walls. There were 3 screw holes in the posterior-superior quadrant. All were cobalt-chromium-on-PE bearing surfaces. The locking mechanism was a circumferential polyethylene tab below the rim of the liner, which engaged a recess in the shell. The articulating femoral head was 28 mm cobalt-chrome in all hips. The mean duration of follow-up was 11.8 years (range, 10–13 years). There were 33 men (36 hips) and 21 women (25 hips). The mean age at the time of the operation was 54.5 years (range, 35–71 years), and the mean weight was 71.1 kg (range, 47.6–89.2 kg). The diagnosis at the time of the

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operation was avascular necrosis of the head in 27, acetabular dysplasia in 22, and posttraumatic arthritis in 12 hips. The cup inclination was divided into three groups, and 50^0–55^0 in 26 hips, 55^0–60^0 in 21 hips, bigger than 60^0 in 14 hips (Table 1).

Clinical and radiographic data were collected on standardized hip evaluation at immediately postoperatively, at 6 months, and at yearly follow-up visits. The radiographs were digitized. The clinical assessment included an evaluation of pain as well as of functional parameters such as walking, stair climbing, and use of external support, limp, and ability to perform daily activities involving the hip. A composite Harris hip score was calculated on the hip basis of these data.[10] Migration, lucent lines, the abduction angle, heterotopic ossification, osteolysis, and wear of PE were assessed on radiographs with a computer assisted design (ACD) system (Canvas 15.0; ACD Systems International Inc; Victoria, British Columbia, Canada) (Fig. 1). Radiolucent lines were evaluated in the 3 zones described by DeLee and Charnley.[11] Osteolysis was defined as a circular or oval area of distinct bone loss. Evidence of migration was measured on the follow-up radiographs. The acetabular component was considered loose if there was 2 mm of migration from either the interteardrop or vertical lines or a change of 4° in the abduction angle.[12] Heterotopic ossification was measured with the method of Brooker et al.[13] Liner polyethylene wear was measured using a digital hip analysis suite.[14,15] Five measurements were taken for each patient, and a mean value was calculated. The analysis was performed on digitized radiographs. The underlying approach of the computer-assisted vector analysis of wear was to find the circles that best fitted the prosthetic femoral head and the acetabular component. The magnitude and direction of the displacement of the femoral head vector from the acetabular center were calculated on the latest follow-up radiographs.

1.1. Statistics

The end point for survival was defined as revision or loosening in radiographs. Aseptic loosening was considered as a separate end point because “revision for any reason” included nonimplant-related operations. Kaplan-Meier survival data were used to construct the survival probabilities of implants at 10 years. Paired *t*-tests were used to investigate liner wear differences among different cup inclination groups. The SPSS 11.5 software package (SPSS Inc, Chicago, IL, USA) was used for the calculations with the significance level of $p < 0.05$.

2. Results

2.1. Clinical result

The overall clinical result was satisfactory with a mean preoperative Harris hip score at 47.36 points (range, 8–72 points) and a mean postoperative score at 94.3 points(range, 70–100 points) at the most recent examination. There was no pain in 48 hips (54 patients). When the patients with pain were questioned about location, only three (slight pain, no medication taken) stated it was “thigh” pain, and the others stated it was in the “hip” (2) or “buttock” (2).

Table 1
Three groups of different inclination.

Angle of cup inclination	Hip number
50–55^0	26
55^0–60^0	21
$>60^0$	14

2.2. Radiologic analysis

Two hips had a lucency of 2 mm, and 10 hips had a lucency less than 2 mm around the component on the initial postoperative radiograph. Of these, 6 hips had a lucency in 2 zones, 4 hips had a lucency in 1 zone, and 2 had a lucency in 3 zones. At the last follow-up, only 2 hips had a lucency in 1 zone. Acetabular osteolysis was not found in all the hips. The horizontal migration of cup is from −1.612 to 2.386 mm, and the vertical migration is from −0.932 to 2.019 mm after 10 years. No hip had a more than 4°change in acetabular abduction after 10 years. The mean rate of liner wear was 0.144 ± 0.031 mm/y (0.105–0.178 mm/y) in cup inclination angle between 50^0–55^0, and 0.260 ± 0.043 mm/y (0.215–0.394 mm/y) in angle between 55^0–60^0, 0. 403 ± 0.016 mm/y (0.378–0.423 mm/y) in angle bigger than 60^0.The mean volumetric wear was 89.033 mm^3/y (64.621–131.088 mm^3/y), 160.190 mm^3/y (132.319–219.096 mm^3/y), 248.443 mm^3/y (232.636–260.331 mm^3/y) accordingly. The liner and volumetric wear were no relationship to sex, weight, or height. The different cup inclination groups are different with liner and volumetric wear (Fig. 2). Acetabular heterotopic ossification was seen in 2 hips (18.7%): 1 were Brooker grade 1, 1 were grade 2.

2.3. Survival of the component

No acetabular component was revised for aseptic loosening. The rate of survival at 10 years for loosening is 100%.

3. Discussion

This study confirmed that polyethylene wear, one of the principal, if not the most important, reasons for failure in THA today, was related to the inclination angle of the cup. A vertical angle of inclination of the acetabular component of more than 45° has been shown to increase the load per unit area in the superior aspect of the polyethylene.[16–18] Several studies have correlated cup inclination of more than 45° to the occurrence of increased wear [19–23] while other studies showed have no correlation.[24,25] The reasons of the different results may due to different prosthesis, head and liner.

Several studies had showed that cup inclination should be 45° or less because inclination greater than that is directly related to accelerated wear. The principle that inclination must be kept below 45° creates a technical dilemma in acetabular preparation for cup implantation for total hip arthroplasty. Our study showed average liner wear of the inclination angle between 50°–55° is 0.144 ± 0.031 mm/y, this result was similar with most of studies.[26,27] For inclination angle bigger than 55°, the liner wear increase significantly, especially for inclination angle bigger than 60°. From our study there was increased wear in the group of patients who had a higher acetabular inclination angle although there was no effect on the clinical outcomes for patients.

There were several limitations of this study. First, this was a retrospective selected analysis with a specific criterion of a primary total hip arthroplasty in situ at least 10 years. The most accurate method of assessing the effect of any variable on clinical wear behavior is with a prospective, randomized study. In the absence of such data, however, we believe that the examination of retrospective data with T-test analysis in different inclination angle groups provides information that is clinically important to the orthopedic surgeon. A second limitation for some would be that the amount of the sample is too small. In fact, it is unusually in our primary hip arthroplasty with a cup inclination bigger than 55^0. Additionally, the effect of anteversion was not accounted for in this study. This omission may be considered minor with respect to results.

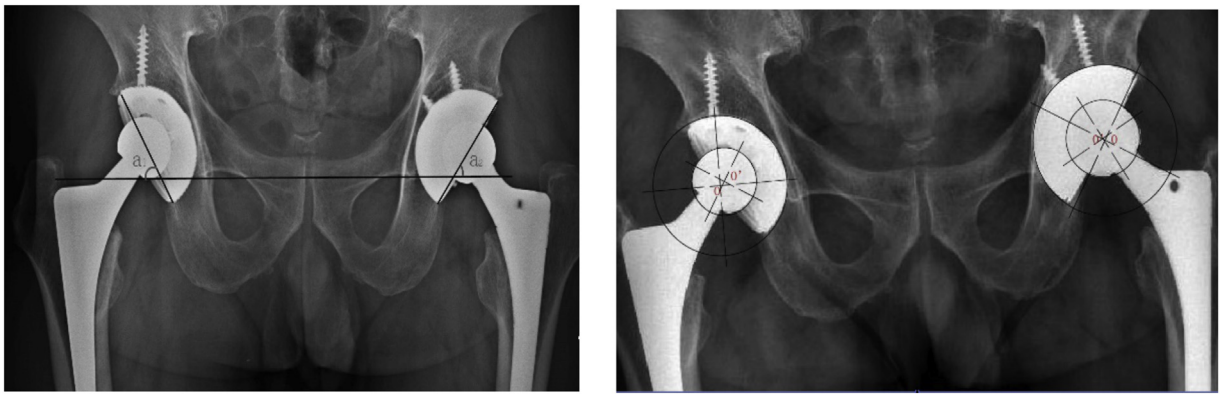

Fig. 1. Radiograph showing measurements made. A horizontal line was drawn across the bottom of the acetabular teardrops, and a line that connected the superior and inferior edges of the acetabular component was connected to this horizontal line to measure the angle of inclination. The polyethylene wear rates were calculated by measuring the shortest radius from the center of the prosthetic femoral head to a point on the outer surface of the acetabular cup. In this figure. Cup inclination in left hip (a1) is 61.5^0, and right (a2) is 54.5^0. Liner wear of left side(o-o') is 4.191 mm, and right side is 2.921 mm.

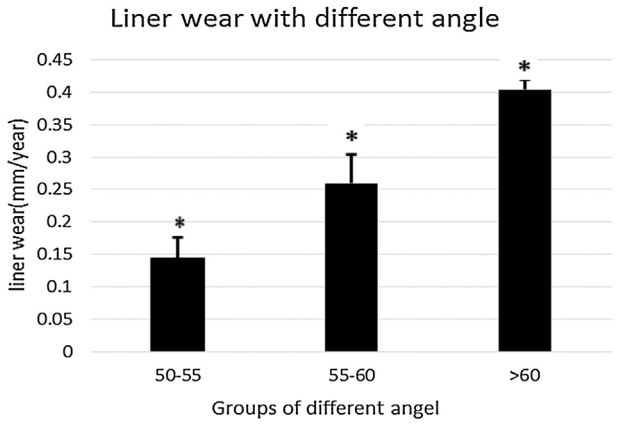

Fig. 2. The mean rate of liner wear was 0.144 ± 0.031 mm/y (0.105–0.178 mm/y) in cup inclination angle between 50^0–55^0, and 0.260 ± 0.043 mm/y (0.215–0.394 mm/y) in angle between 55^0–60^0, 0.403 ± 0.016 mm/y (0.378–0.423 mm/y) in angle bigger than 60^0. There are significant difference between three groups after paired *T*-test ($P < 0.05$).

Of interest also are the effects of creep on wear rates. This study did not attempt to distinguish between real wear and creep, focusing instead on radiographic assessment of wear. Given that this is a clinical study and not a specific biomaterials study, we felt this omission was justified.

Given the growing clinical wisdom that wear and polyethylene deformation may contribute significantly to long-term failure, it is more important than ever to identify all factors contributing to wear in THA. Our study sought to establish a correlation between acetabular abduction of all-polyethylene cementless acetabular components and increased contact forces resulting in greater wear rates. In this study, we successes to demonstrate a correlation between abduction bigger than 50^0 of the acetabular components and polyethylene wear and we suggest the ideal abduction angle should be less than 55°.

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