

Original Research Article

The accuracy of free-hand cup positioning: a CT based measurement in a South Indian hospital

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ABSTRACT

Background: In total hip arthroplasty, the restoration of normal hip center in acetabular reconstruction encourages the normal bio mechanics. The impingement, dislocation, and implant wear have increased the interest in accurate component placement in arthroplasty. This study is to determine the accuracy of the free hand technique in the acetabular cup placement in relation to native acetabulum using CT scan images.

Methods: This study was done in the Coimbatore Medical College and Hospital from June 2015 to March 2016. Twenty patients who have undergone total hip replacements were subjected to CT scan of pelvis preoperatively and postoperatively. The acetabular cup version and the inclination were measured and analyzed statistically.

Results: The mean acetabular version was $17.5^{\circ} \pm 6.5^{\circ}$ and the inclination was $46.6^{\circ} \pm 9.3^{\circ}$ pre operatively. Post operatively the mean acetabular version was $26.3^{\circ} \pm 17.3^{\circ}$ and the inclination was $41.7^{\circ} \pm 10.9^{\circ}$. With reference to the component version it ranged from 12.5° of retroversion to 62.5° anteversion with a mean of $26.3^{\circ} \pm 17.3^{\circ}$. The component inclination ranged from 15.6° to 58.4° with a mean of $41.7^{\circ} \pm 10.9^{\circ}$. On combining component version and inclination, only (50%) was within the safe zone.

Conclusions: Based on the CT finding acetabular version and inclination differs from individual to individual. During acetabular cup placement in total hip arthroplasty using free hand technique, our study shows that that inclination is better achieved and the anteversion is over targeted in most of the cases.

Keywords: Acetabular cup, Computed Tomography, Cup positioning, THA

INTRODUCTION

In total hip arthroplasty, the restoration of normal hip center in acetabular reconstruction encourages the normal bio mechanics. The impingement, dislocation, and implant wear have increased the interest in accurate component placement in total hip arthroplasty. In uncemented total hip arthroplasty (THA) the positioning of the acetabular cup during surgery is dependent on the position of the patient's pelvis on the operating table and the actual pelvic inclination is generally not taken into account during surgery. There is little published information about the cup placements in cementless

THA, and only one study has compared the cup versions with the native versions.¹ Our study is to determine the accuracy of the free hand technique in the acetabular cup placement in relation to native acetabulum using CT scan images.

METHODS

This study was done in the Coimbatore Medical College and Hospital, Coimbatore. The study period was from June 2015 to March 2016. Twenty patients who have undergone total hip replacements after ethical committee clearance were subjected to CT scan of pelvis with both

the hip joints preoperatively and postoperatively. The acetabular cup version and the inclination were measured and analyzed statistically. Patients with erosion of acetabulum, protursio acetabuli, fractures of acetabulum, and dysplasia of hip joints were excluded.

On the third postoperative day, after informed consent from all patients, acetabular version and inclination was measured using a Multislice Toshiba helical CT scanner Alexion TSX-033A. Two slices, 1mm of thickness, were made through the center of the femoral head and reconstructed.



Figure 1: Acetabular version on CT axial view.



Figure 2: Acetabular inclination on CT coronal view.

We defined the acetabular version (Figure 1) as the angle between a perpendicular drawn to the line connecting the posterior ischia and a line connecting the posterior and anterior margins of the acetabulum.²

Acetabular inclination measurements (Figure 2) were obtained by drawing a line tangential to the face of the acetabular cup on the coronal image and calculating the angle relative to a line drawn tangential to the ischial tuberosity as described by Murray et al.³

Statistical analysis was performed using SPSS (version12, SPSS Inc., Chicago, Illinois). Values for $p < 0.05$ were considered statistically significant.

RESULTS

Acetabular version

Preoperatively acetabular version as measured from the CT scans ranged from 3.4° to 26.7° of ante version with a mean of $17.5° \pm 6.5°$. The acetabular anteversion was less than 10° in 2 (10%) hips, 10°–20° in 11 (55%) hips, 20°–30° in 7 (35%) hips, 5°–25° in 18 cups (90%) and none is greater than 30°.

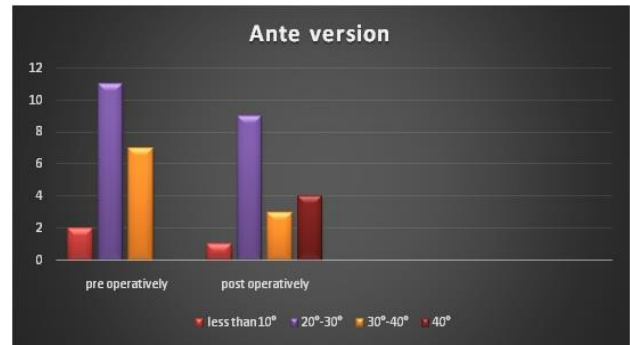


Figure 3: Comparison of preop and postoperative anteversion.

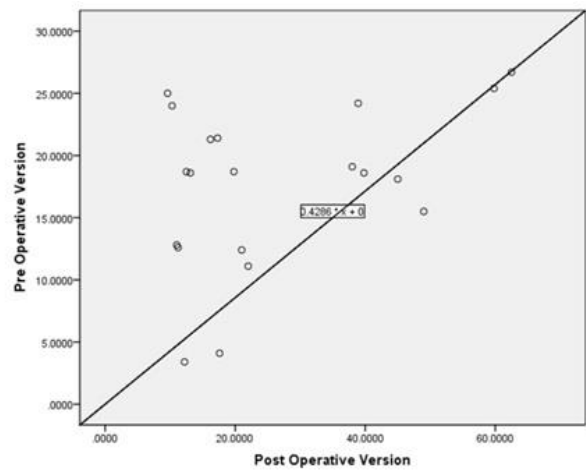


Figure 4: Pearson correlation coefficient of acetabular version.

Postoperatively the mean ante version was $26.3° \pm 17.3°$ ranged from 12.5° of retroversion to 62.5° ante version. Descriptively (Figure 3) the anteversion was less than 10° in 1 (5%) cup, 10°–20° in 9 (45%) cups, 20°–30° in 2

(10%) cups, 30°–40° in 3 (15%) cups, and greater than 40° in 4 (20%) cups, 5°-25° in 12 cups(60%) and surprisingly one was in 12.5retroverted position

We calculated Pearson’s correlation coefficient (r). P value equal 0.05 or smaller was considered significant. The correlation between native and prosthetic acetabular anteversion (Figure 4) was $r=0.395$ ($p=0.084$).

Postoperatively anteversion was significantly greater than the native version ($p=0.023$). Descriptively 12 hips (60%) were within the accepted range, while 7 hips (35%) were above the target zone and one was in retroverted position.

Acetabular inclination

The pre operatively acetabular inclination ranged from 31° to 59.5° with a mean of $46.6^{\circ} \pm 9.3^{\circ}$. None of the hips were less than 30° inclination, 30°–40° in 4 (20%) hips, 40°–50° in 7 (35%) hips, and greater than 50° in 9 (45%) hips, 30°–50° in 11 hips (55%).

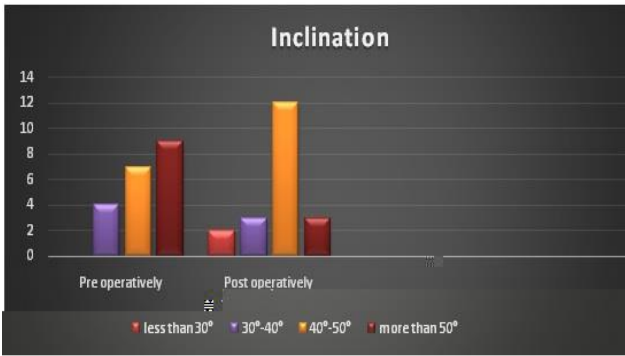


Figure 5: Comparison of preop and postoperative inclination.

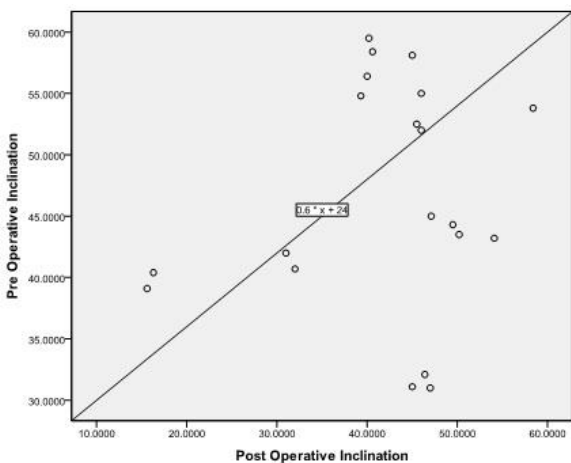


Figure 6: Pearson correlation coefficient of acetabular inclination.

Regarding the component inclination it ranged from 15.6° to 58.4° with a mean of $41.7^{\circ} \pm 10.9^{\circ}$. The inclination of the acetabular components (Figure 5) was less than 30° in

2 (10%) hips, 30°–40° in 3 (15%) hips, 40°–50° in 12 (60%) hips, and greater than 50° in 3 (15%) hips, 30°–50° in 15 hips (75%).

The Pearson’s correlation between native and prosthetic acetabular inclination (Figure 6) was $r=0.172$ ($p=0.468$).

The component inclination was less than native inclination and statistically insignificant, ($p=0.112$). Post operatively 15 hips (75%) were within the accepted range while 3 hips (15%) were above the target zone and 2 hips (10%) were below the target zone,

On combining the both ante version and inclination, it was within the safe zone only in 10 cases (50%).

DISCUSSION

Acetabular cup placement in THA can be difficult and optimal placement is required to prevent chronic instability, accelerated wear, implant migration.

The best target position about the acetabular cup placement while performing THA is still a continuous debate. Most surgeons use bony landmarks while some use target value of inclination and ante version.

The exact degree of anteversion of the acetabular cup cannot be determined from conventional radiographs unless they are done under defined conditions. Using CT-based calculation, an exact reference plane can be defined and such reference provides highly accurate information of the cup position.⁴

Acetabular cup version in THA is usually assessed from plain radiographs, which relies on accurate and reproducible patient positioning and also uses complex formulas and calculations and therefore plain radiographic methods are of limited use.⁵ Acquisition of data from CT is highly reproducible and our computer resolution allowed us for unimpaired determination of cup position despite the presence of some metal image distortion which was rectified with picture archiving and communication system.

Computed tomography (CT) is able to provide accurate information on cup orientation in THA without the use of mathematical formulas, and has only 2° and 3° of Intra- and interobserver errors have been reported respectively.⁵

Lewinnek and coworkers used a pelvic coordinate system with an anterior pelvic plane in order to define the safe zone. In the current study, the defined angles of $40^{\circ} \pm 10^{\circ}$ inclination and $15^{\circ} \pm 10^{\circ}$ ante version were the basis for the evaluation of the position of freehand implanted cups.⁶

In the present study, we obtained CT-scans with the patient in supine position to measure the version of the acetabulum in patients who underwent a cementless THA

to determine the range of ante version and inclination achieved in cementless THA.

The acetabular cup malposition has been considered a most important factor for dislocation of a total hip prosthesis. Coventry et al found a significant association between acetabular retroversion and the posterior dislocation.⁷ According to Lewinnek et al cups with more than 25° of acetabular ante version had higher incidence of anterior dislocations.⁶ Hence, both excessive anteversion and retroversion should be avoided to prevent complications. However, patient-related factors, intra operative, and variability in implant design are the factors that predispose to dislocation.⁸ Only one previous study has correlated the component versions with native versions and like us, they found poor correlations.⁹

Jolles et al comparing free hand, mechanical alignment guide and computer-assisted cup placement by ten surgeons in one hundred and fifty identical models of the pelvis (covered with artificial soft tissue of soft cast and foam). Freehand placement revealed a mean accuracy of cup ante version and abduction of 10 degrees and 3.5 degrees, respectively (maximum error, 35 degrees). With the cup positioner, these angles measured 8 degrees and 4 degrees (maximum error, 29.8 degrees), respectively, and using computer assistance, 1.5 degrees and 2.5 degrees degrees (maximum error, 8 degrees), respectively.

The mean accuracy for anteversion was 8° (5.0–10.5) for free hand with cup positioner and 4° (3.0–5.5) for abduction; with computer navigation this was 1.5° (1.0–2.0) and 2.5° (2.0–3.5), respectively.¹⁰

Hirakawa et al suggested that an inclination angle less than 40° is associated with better long-term results and few complications as compared to an angle of 45° or above. With a cup angle more than 45°, a 90% mechanical failure rate was seen follow up of 15 years after THA.¹¹

Leenders et al found a higher variability of cup inclination in conventionally implanted cups as compared to cups implanted using computer assisted technique.¹²

In a previous study on freehand cup positioning, a tendency to underestimate the ante version of the acetabular component was reported however, the study was performed with standardized x-ray films and therefore cannot be directly compared to our study.¹³ One comparable study is that of Saxler et al only 27 out of 105 cups (26%) were placed within the safe zone of Lewinnek.¹⁴ In another study, Digioia et al using mechanical alignment guide versus hip navigation system in 74 hips, only 22% of the cups were positioned in the safe zone of Lewinnek.¹⁵

Compared with these two studies, our data demonstrate better accuracy of cup positioning, regarding version 12 hips (60%) were within the accepted range, while 7 hips

(35%) were above the target zone and one was in retroverted position. From the analysis pre operatively 90% of the cups and post operatively 60% cups were within zone of 5°–25° of ante version.

Regarding inclination 15 hips (75%) were within the accepted range while 3 hips (15%) were above the target zone and 2 hips (10%) were below the target zone. Pre Operatively 55% of cups and post operatively 75% cups were within range of 30°–50°.

We with freehand conventional methods of acetabular cup positioning using a validated methodology studied the accuracy of cup placement that required CT study of all patients and only 50% of cups are within the safe zone. It is not always possible to maintain the preferred ante version and inclination even with computer-assisted techniques.¹⁶ Deviations in the position of the acetabular component can arise during impaction of press-fit components, because of under-reaming or of over sizing, and thus placement of the cup within the preoperative range during surgery is possible by preoperative CT-analysis. We believe the technological advance will allow surgeons to more precisely position the acetabular cups and thereby reduce the complications.

CONCLUSION

The ante version of hip joint varies from individual to individual. Placement of the cup within the preoperative range during surgery is possible by preoperative CT-analysis. Our study is a very small one and a large multicentric study is required to confirm the results.

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Ethical approval: Not required

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