Randomised controlled trial comparing 2 methods of acetabular cup positioning during total hip arthroplasty

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ABSTRACT: Background: Acetabular cup positioning is an important technical aspect in total hip arthroplasty. Most surgeons estimate cup abduction angle during surgery with the insertion rod position according to the patient’s body anatomical landmarks or other reference points in the operating room. High acetabular component abduction angle is associated with an increased risk of dislocation, premature polyethylene wear and osteolysis.

Method: To evaluate the potential benefits of a new technique for vertical acetabular cup positioning, 100 acetabular cups were randomised to be inserted with or without an inclinometer. Abduction angles were measured on postoperative radiographs by 2 evaluators blind to the treatment group.

Results: Of the cups, 57% (27/47) were positioned within the desirable abduction angle range of 40°-49° with the inclinometer, compared with 50% (27/53) by visuospatial perception (p=0.454). The proportion of cups positioned outside a safe angle range of 30°-55° was low in both groups: 6% (3/47) for the inclinometer group versus 4% (2/53) for the visuospatial perception group (p=0.536).

Conclusion: The use of an inclinometer did not significantly improve the acetabular cup abduction angle obtained by our group of surgeons when compared with visuospatial perception. Newer techniques such as navigation may be useful in further optimising cup positioning and reducing the outliers. (Hip International 2007; 17: )

KEY WORDS: Abduction angle, Acetabulum, Hip prosthesis, Inclinometer

INTRODUCTION

Total hip arthroplasty is a very successful surgical procedure (1-3). However, a significant number of total hip arthroplasty revisions are performed every year, with many of them resulting from component malposition (4). Acetabular component malposition is associated with an increased risk of dislocation (5-7), limited range of motion, and impingement (8-11). A high abduction angle of the acetabular cup correlates positively with premature polyethylene wear, osteolysis and early aseptic loosening in metal-polyethylene (12-16) and ceramic-ceramic interfaces (17, 18). The suggested explanation for this correlation is that a high abduction angle increases the articular load per unit of surface area (12, 14, 19-21), eventually leading to acetabular cup wear and superolateral migration of the femoral head. Many authors recommend positioning the acetabular cup within an abduction angle range of 30° to 50° (5, 7-9, 22-27).

It is common practice for orthopaedic surgeons to rely on their visuospatial perception (VSP) when positioning the acetabular component during total hip arthroplasty. Various referencing techniques are used including the cup insertion rod position, patient’s anatomical landmarks and reference points in the operating room (operating table, wall, floor etc.) (5). However, previous studies have shown that positioning of the acetabular component by VSP is variable and...
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lacks precision (28-30).

In a previous cadaver study (30), we found that the positioning of the acetabular cup with reference to the abduction angle significantly improved when orthopaedic trainees used an inclinometer to aid positioning. The aim of the current study was to evaluate whether there would be a significant improvement in the cup abduction angle when the inclinometer was used by consultant surgeons in a clinical setting.

MATERIALS AND METHODS

The inclinometer is made of steriliseable stainless steel and this can be attached to most acetabular insertion rods by hand-tightening a single screw. It is scaled at every 2° from 0 to 70°. Display of the abduction angle value results from displacement of the pendulum within the inclinometer over the inclinometer scale under the influence of gravity (Figs. 1 and 2). The inclinometer only measures the abduction angle; the anteversion is not measured by the device.

Seven consultant surgeons regularly performing total hip arthroplasty participated in the study. A block randomisation table was created for each surgeon using SPSS version 10.04 software (SPSS Inc, Chicago, IL, USA), and the results were kept in an opaque, sealed envelope. The study protocol was approved by the research ethics and scientific committees of our institution. All patients who participated in the study gave their written informed consent.

One hundred patients were randomised to have their acetabular component positioned either with the inclinometer or by VSP. All procedures were done in lateral position either through a posterior approach (5 surgeons) or direct lateral approach (2 surgeons). After routine acetabular preparation, the chosen acetabular cup was screwed to a standard insertion rod. For the VSP group, the acetabular cup was positioned by the surgeon’s usual method without inclinometer. After cup fixation, surgeons recorded their estimation of the acetabular cup abduction angle. For the inclinometer group, the surgeons were asked to position the acetabular cup within an abduction angle of 40°-49° as measured by the inclinometer attached to the insertion rod. Once the cup was fixed, the abduction angle read on the inclinometer was recorded.

An anteroposterior radiograph of the pelvis taken postoperatively was used to measure the abduction angle of the
cup according to the horizontal inter-teardrop line (31, 32). All measurements were made independently by 2 observers blinded to the treatment group. The average measurement of both observers was used for the analysis. Optimal positioning was defined as an abduction cup angle between 40° and 49° as determined from the postoperative radiographs. Outliers were defined as an abduction angle less than 30° or more than 55°. Precision was defined as the difference between the abduction angle estimated intraoperatively by either method and the abduction angle measured on postoperative radiographs.

**Statistical analysis**

All statistical analyses were performed using SPS software (33). Proportions were compared by the Pearson chi-square test. Mean differences between the VSP and the inclinometer methods were evaluated by Student’s t-test for equal variances. Comparison of variances was conducted by Levenes’s test. The confidence intervals presented were 95%, and the significance level accepted was p<0.05 for all statistical analyses.

**RESULTS**

Both groups were comparable with regards to the type of surgery, operated side and preoperative native acetabular abduction angle (Sharp angle) (34) (Tab. I). The number of cup implantations per surgeon is presented in Table II.

In the VSP group, 51% (27/53) of cups were positioned within the optimal abduction angle range (40°-49°) compared with 57% (27/47) in the inclinometer group (p=0.454). There was no significant difference in the proportion of the outliers (<30°, >55°) between the 2 groups: 4% (2/53) in the VSP group and 6% (3/47) in the inclinometer group (p=0.536; Fig. 3). There was also no significant difference in the mean abduction angle between the 2 groups (Tab. III).

No significant difference was found in precision between the 2 methods: ±5.4° (standard deviation 4.7) for the VSP group and ±4.8° (standard deviation 4.8) for the inclinometer group (p=0.553). The mean differences between the abduction angle estimated peroperatively and the abduction angle measured on postoperative radiographs were -0.6° for the VSP group and -1.5° for the inclinometer group (p=0.550).

The 95% confidence interval of the ratio of the standard deviations for both methods showed that the VSP method was not more variable than positioning the cup with the inclinometer (p=0.880).
DISCUSSION

As reported by Moran et al, orthopaedic surgeons are not always accurate in estimating angles (35). Suboptimal cup positioning has been reported in various studies (36-39). Many techniques have been developed to improve acetabular cup positioning. A commonly used technique involves attaching an alignment rod at 45° to the insertion rod (28) on the presumption that it is easier for surgeons to evaluate a 90° angle than a 45° angle. However, this was not substantiated in a previous study (28). The surgeons who participated in the current study did not use an alignment rod as part of their VSP technique.

Peroperative radiographic control is being used in some orthopaedic centres, especially with minimally invasive techniques. Disadvantages of this technique include increased risk of contamination, longer operating time and radiation exposure. Moreover, no study of the precision of this technique has ever been published. Another technique is a computer-assisted approach. Seki et al reported encouraging results with this approach, but it is time-consuming and requires a complex set-up that most orthopaedic centres cannot afford (25).

In a previous cadaver study, we found the use of an inclinometer on the insertion rod by orthopaedic trainees reduced the variability of acetabular cup abduction angle by a factor of 2.0-4.5 in comparison with VSP (Fig. 4) (30). There were no outliers in either group. In the current clinical study involving consultant orthopaedic surgeons, we found that the use of the inclinometer did not significantly improve the acetabular cup abduction angle when compared with VSP. This suggests that the VSP skills of orthopaedic surgeons improve with experience. The use of the inclinometer may help surgeons during the learning curve of their training and if they perform hip replacements infrequently.

The results of this study revealed that in both groups there was a greater tendency to underestimate the abduction angle intraoperatively. The mean difference between the peroperative angle measured and the postoperative ra-
diographic angle was -1.5° with the inclinometer and -0.6° by VSP. This may be explained by the tendency of the pelvis to tilt caudally during the surgery. Particularly, when employing an inclinometer, the surgeon should pay special attention to vertical positioning of the patient’s pelvis on the operating table, since this tool uses a pendulum oriented by gravity.

Acetabular cup positioning with regards to the abduction angle could be considered satisfactory in both groups in our study. However, there were still a small proportion of outliers (abduction angle less than 30° or more than 55°) in both groups (4% in the VSP group and 6% in the inclinometer group). This suggests that even when the cup positioning was done by experienced surgeons, neither VSP nor gravity-referenced devices like the inclinometer can completely eliminate the outliers. This is most probably due to the pelvic tilt in the coronal plane which can occur in the lateral decubitus position. Improvement in newer techniques such as navigation may help to eliminate such outliers in the future.

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