

The accuracy of a mechanical cup alignment guide in THA through direct anterior and posterior approaches measured with CT-based navigation

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Purpose: Cup alignment is critical for stability of the hip and wear of the bearing in total hip arthroplasty. To place the cup in a proper alignment, a mechanical guide is often used. However, the accuracy of mechanical guides depends on the pelvic alignment on the operating table and even if the pelvis is carefully fixed in a neutral position on the operating table, the pelvis can move and rotate during various operative procedures. The accuracy of cup alignment by using a mechanical guide has been reported to be different among various approaches. The purpose of this study is to measure the accuracy of a mechanical cup alignment guide using CT-based navigation and to compare the accuracy between a direct anterior approach and a posterior approach on the same lateral position.

Patients & Methods: The subjects of this study were 70 hips of 67 patients who underwent primary cementless total hip arthroplasty (THA) via a direct anterior approach (DAA) or a posterior approach (PA) on a lateral position by a single surgeon. The DAA group consisted of one male (one hip) and 37 females (38 hips), while the PA group consisted of four males (four hips) and 25 females (27 hips). The average of body mass index was 23.3 (SD, 3.5) in the DAA group and 23.9 (SD, 2.6) in the PA group. The average age was 63.4 years in the DAA group and 61.9 years in PA group. There were no significant differences in age, sex, and BMI between the two groups.

All THAs were performed using a CT-based navigation system (CT Hip 1.1, Stryker). After reaming acetabular bone, a trial cup was placed in the reamed acetabulum with a mechanical guide that aimed at 45° of operative inclination and 20° of operative anteversion. These operative aimed angles equaled to 47° of radiographic inclination and 14° of radiographic anteversion. After positioning the trial cup precisely according to the mechanical guide, the true alignment of the trial cup was measured using navigation. The average cup inclination and anteversion were compared between the two groups. We also examined the relationship between the deviation from the aimed alignment and physical frame factors such as BMI, Cobb angle, lumbar lordosis, and lumbosacral angle.

Results: The average radiographic inclination was 48.9° (range; 39.0-62.0°, SD±4.5) in the DAA group and 47.8° (range; 40.9-55.7°, SD±4.4) in the PA group. The average radiographic inclination in the DAA group was not significantly different from that in the PA group ($p=0.35$ unpaired t-test). The average radiographic anteversion was 19.0° (range; 0-36.8°, SD±8.5) in the DAA group and 8.5° (range; -1.5-24.0°, SD±5.6) in the PA group. The average radiographic anteversion in the DAA group was significantly larger than that in the PA group ($P<0.0001$, unpaired t-test). Scatter gram of cup orientation was shown in Fig. 1.

The average of Cobb angle was 4.7° (SD±4.5) in the DAA group and 5.8° (SD±5.4) in the PA group. The average of lumbar lordosis was 34.7° (SD±13.5) in the DAA group and 32.3° (SD±14.5) in the PA group. The average of lumbosacral angle was 35.3° (SD±11.8) in the DAA group and 34.0° (SD±10.3) in the PA group. There were no significant differences in Cobb angle, lumbar lordosis and lumbosacral angle between the two groups. The cup inclination and anteversion were not significantly correlated with BMI or those spine factors.

Discussion: This study demonstrated that even if the same mechanical cup alignment guide was used on the same lateral position, cup anteversion was significantly different between the DAA and PA approaches. In case of cup inclination, there was no significant difference between the DAA and PA

approaches. The average cup inclination indicated a quite similar value to the aimed angle of the mechanical guide, that was 47° of radiographic inclination. Because there were no relating physical factors including BMI, Cobb angle, lumbar lordosis and lumbosacral angle that affected the pelvic orientation on the operating table, the soft tissue tension should have rotated the pelvis differently between the two approaches with resulting in the different average cup anteversion. The reasons for the significantly larger average anteversion via the DAA than that via the PA can be explained as follows; the femur was retracted posteriorly during the cup procedure via the DDA and hip flexor muscles pull the pelvis to increase pelvic flexion which increased the cup anteversion relative to the mechanical guide. On the other hand, the femur was retracted anteriorly during the cup procedure via the PA and hip extensor muscles pull the pelvis to increase pelvis extension which decreased the cup anteversion relative to the mechanical guide. This characteristic deviation of the average cup alignment in each approach suggested that the aimed angle of the mechanical angle should be adjusted in each approach while the aimed inclination needed to be decreased. However, how to manage the individual variation of cup alignment was still an issue to be solved.

It was concluded that the cup anteversion with the use of a mechanical guide via the DAA was significantly larger than those via the PA on the same lateral position. This information can be used for modification of the mechanical guide for better accuracy of cup alignment.