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ORIGINAL PAPER

Cup alignment in total hip arthroplasty using the muscle-sparing modified Watson-Jones approach—comparison between lateral and supine positions

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Abstract

Purpose The present study aimed to compare the cup alignment outliers in total hip arthroplasty (THA) using the same surgical approach with the patient in the supine position versus the lateral position.

Methods THA using the muscle-sparing modified Watson-Jones approach was performed in 142 consecutive hips. THA was performed with the patient in the lateral position in 84 hips (lateral group) and in the supine position in 58 hips (supine group). The cup alignment was aimed at 40° inclination and 20° anteversion by referring to the mechanical alignment guide. Cup alignment and outliers (10° > aimed alignment) were assessed using post-operative 3D-CT.

Results The absolute error from the aimed inclination was 6.0 ± 4.7° in the supine group and 4.2 ± 3.6° in the lateral group (p = 0.01). The absolute error from the aimed anteversion was 4.1 ± 3.2° in the supine group and 5.1 ± 3.7° in the lateral group (p = 0.12). The supine group showed a higher rate of outliers than the lateral group for the cup inclination (22% vs 5%; $p < 0.01$). Inclination and BMI were positively correlated in the spine position group ($p < 0.01$, $R = 0.48$), but were not correlated in the lateral position group.

Conclusion THA performed with the patient in the supine position has a higher risk of outliers of cup alignment compared with the lateral position, even when the same surgical approach is used. BMI affected the cup inclination in the supine position.

Keywords Total hip arthroplasty · Cup alignment · Supine position · Lateral position · Muscle-sparing modified Watson-Jones approach

Introduction

In total hip arthroplasty (THA), cup alignment has critically important effects on the stability of the hip [1–3] and the wear of the bearing [4]. During the cup insertion, cup alignment is affected by various factors, including pelvic position, sharp angle [5], surgical approach [6], and surgical technique. Varying degrees of pelvic tilt and movement are reportedly observed during THA with the patient in the lateral position [7, 8]; such pelvic tilt and movement can result in cup malposition. A previous report suggested that performing THA with the patient in the supine position improves the cup alignment, as surgeons can touch the anterior superior iliac spines and the pubic tubercles, and can thus confirm the pelvic position during cup insertion [9].

In the modified Watson-Jones approach, the dissection to expose the hip is performed intermuscularly between the tensor fascia lata and the gluteus medius, without incising or detaching the muscles and tendons [10]. The modified Watson-Jones approach was originally introduced for use with the patient in the lateral position, but has also recently been used with the patient in the supine position [11, 12]. However, no studies have yet compared the cup alignment in THA performed using the muscle-sparing modified Watson-Jones anterolateral approach with the patient in the supine versus the lateral position.

We hypothesized that placing the patient in the supine position improves the cup alignment compared with the lateral

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position, even when the same modified Watson-Jones approach is used. The aim of the present study was to compare the cup alignment in THA using the modified Watson-Jones approach performed with the patient in the supine versus the lateral position.

Materials and methods

The subjects included in the present study were 124 consecutive patients (142 hips) who underwent THA using the muscle-sparing modified Watson-Jones anterolateral approach between May 2013 and July 2015. THAs using other surgical approaches such as direct lateral approach and posterior approach were excluded. All operations were performed by a single surgical team. The patients were placed in the supine position for THA in 58 hips (supine group), while the lateral position was used for 84 hips (lateral group). The age at the time of surgery was 65 ± 12 years (mean ± standard deviation). There were 117 female hips and 25 male hips. The average height was 154 ± 8 cm, average bodyweight was 56 ± 10 kg, and average body mass index was 23.2 ± 4 kg/m^2. The primary diagnosis was osteoarthritis in 128 hips, osteonecrosis in 12 hips, and rapidly destructive coxarthritis in two hips. All THAs were performed using cementless acetabular components. The cup alignment was aimed at 40° inclination and 20° anteversion by referring to the offset mechanical alignment guide in both approaches. No image intensifier or radiography was used for the intra-operative estimation of cup alignment. This study was approved by the institutional review boards of our hospital, and all patients provided informed consent. On behalf of all authors, the corresponding author states that there is no conflict of interest.

In the supine group, the patients were placed on an operating table that was positioned horizontal to the floor (Fig. 1). The pelvis was fixed with a positioner on the contralateral side. The frontal plane of the pelvis (from the anterior superior iliac spines to the pubic tubercles) was checked intra-operatively. In the lateral group, the patients' trunks were positioned along the longitudinal axis of the table using a device (Universal lateral positioner; Innovative Medical Products, Inc., Plainville, CT, USA), which held the sacral bone and bilateral anterior superior iliac spines (Fig. 2).

CT was performed two weeks post-operatively. Post-operative cup alignment was measured on 3D-CT images using computer software (CT Hip 1.2, Stryker, Mahwah, NJ, USA) (Fig. 3) [13]. Cup alignment (inclination and anteversion) was calculated to one decimal place in radiographic definition [14]. Outliers of cup alignment (10° > aimed alignment; inclination was less than 30° or more than 50 °, and anteversion was less than 10° or more than 30°) were assessed.

To evaluate the intra-observer reliability, cup alignment (inclination and anteversion) was repeatedly measured by an expert surgeon (Y.K.) in 20 hips at four week intervals to evaluate reproducibility. The interobserver reliability was analyzed using intraclass and interclass correlation coefficients (ICCs). The ICCs were classified as poor (less than 0.40), moderate (0.40–0.60), good (0.61–0.80), and very good (0.81–1.00) [15, 16]. The Student's *t* test was used to compare the cup alignment among the groups. Outliers of cup alignment were analyzed with the Fisher exact test. A sample size calculation was performed using computer software (EZR; Saitama Medical Center, Jichi Medical University, Saitama, Japan) [17], and the results showed that a sample of 52 hips was required to achieve a power of 0.8 to detect a significant difference ($\alpha = 0.05$, two-sided significance level). Regression analyses were performed to determine the significance of correlations between the cup alignment (inclination or anteversion) and patient demographics (age, height, body weight, BMI, or pre-operative range of motion). All data analyses were performed with computer software (SPSS, version 23.0; SPSS Inc., Chicago, IL, USA). The level of significance was set at 0.05.

Results

There were no significant differences between the two groups in age, sex, diagnosis, height, bodyweight, body mass index, or range of motion of the hip joint (Table 1).

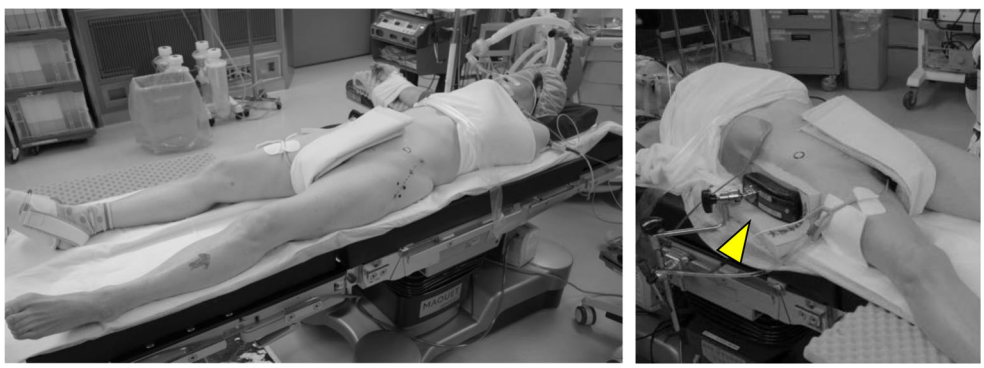

Fig. 1 Photograph showing the supine position. The patients were placed on the operating table in the supine position. The pelvis was fixed with a positioner on the contralateral side (arrow)

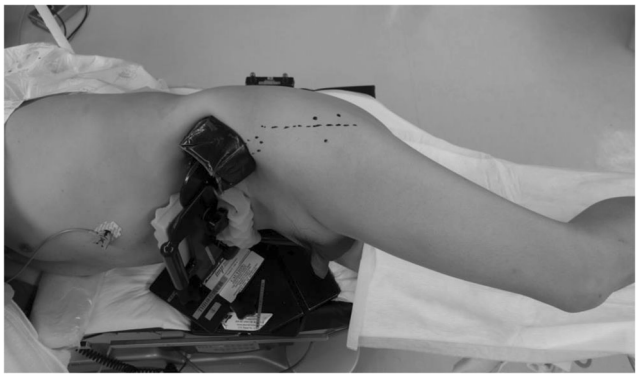

Fig. 2 Photograph showing the lateral position. The patients' trunks were positioned along the longitudinal axis of the table using a positioner that held the sacral bone and bilateral anterior superior iliac spines

The ICCs of inclination and anteversion were 0.84 (very good) and 0.91 (very good), respectively. The average inclination was 37.1 ± 7.0° in the supine group and 38.8 ± 5.4° in the lateral group ($p = 0.11$). The average anteversion in the supine position group (21.9 ± 4.9°) was significantly larger than that in the lateral position group (18.4 ± 6.1°; $p < 0.01$). The absolute error from the aimed inclination was 6.0 ± 4.7° in the supine position group and 4.2 ± 3.6° in the lateral position group ($p = 0.01$). The absolute error from the aimed anteversion was 4.1 ± 3.2° in the supine position group and 5.1 ± 3.7° in the lateral position group ($p = 0.12$).

A scatter diagram of cup position is shown in Fig. 4. Regarding the inclination, the supine position group showed a higher rate of outliers than the lateral position group (22% vs 5%; $p < 0.01$). Regarding the anteversion, there was no significant difference between groups in the rate of outliers (Table 2). Inclination and BMI were positively correlated in the spine position group ($p < 0.01$, $R = 0.48$), but were not

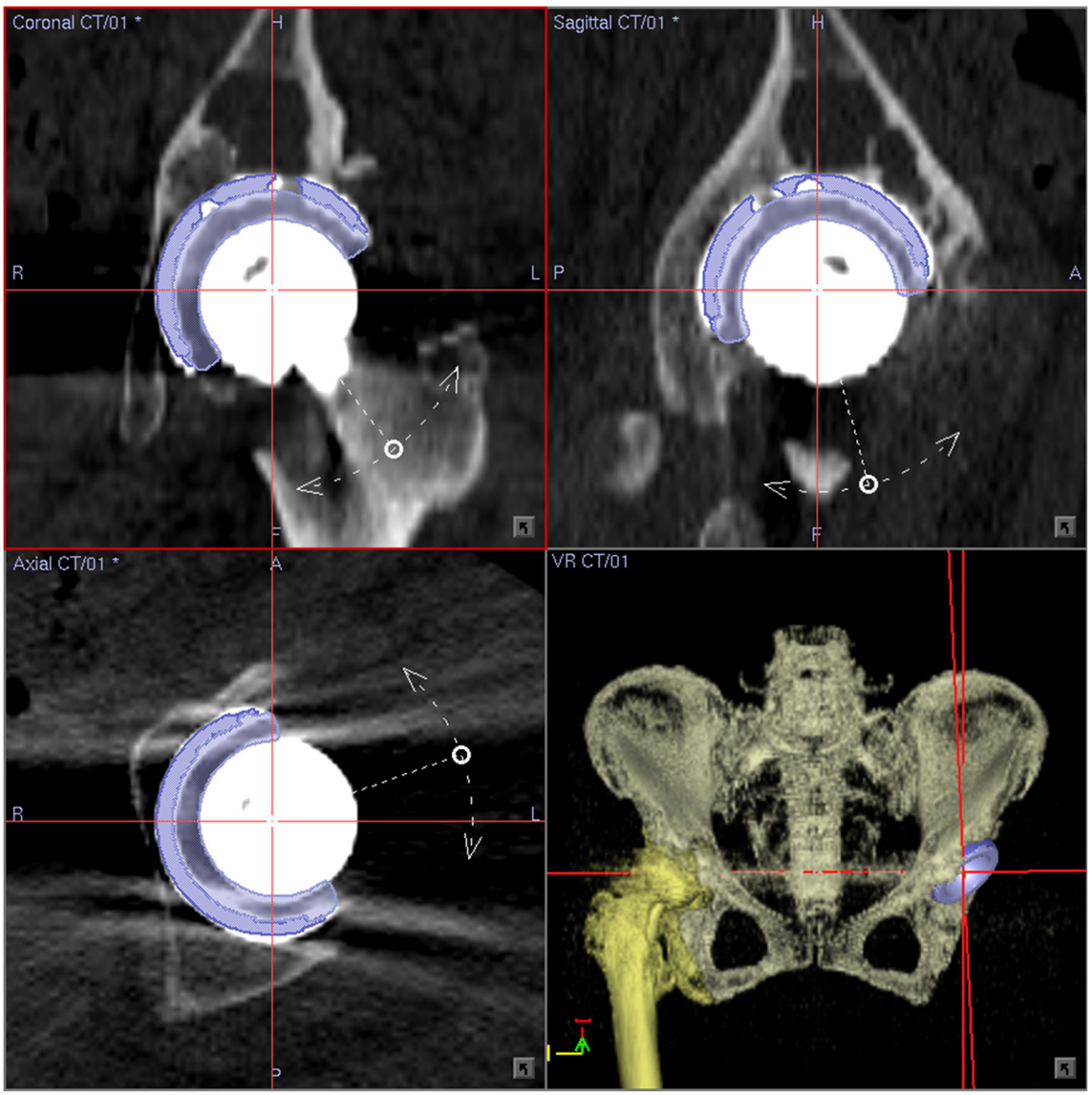

Fig. 3 Cup alignment was measured using computer software. The CAD data of the acetabular component was superimposed on the 3D-CT image

Table 1 Patient demographics

Parameters	Supine position (58 hips)	Lateral position (84 hips)	*p* value
Age (years old)	63.6 (SD 13.6)	66.7 (SD 10.5)	0.12
Male/female	9/49	16/68	0.65
Diagnosis: OA/ON/RDC	50/7/1	78/5/1	0.40
Height (cm)	156.3 (SD 9.0)	153.6 (SD 7.8)	0.06
Body weight (kg)	57.6 (SD 11.4)	54.5 (SD 9.2)	0.09
Body mass index (kg/m^2)	23.4 (SD 4.3)	23.0 (SD 3.3)	0.53
Pre-operative range of motion (°)			
Flexion	82.5 (SD 27.4)	86.4 (SD 18.8)	0.31
Extension	− 2.9 (SD 7.4)	− 2.0 (SD 6.4)	0.44
Abduction	20.6 (SD 12.3)	23.0 (SD 11.0)	0.21
Adduction	13.7 (SD 9.1)	12.9 (SD 6.7)	0.58
External rotation	18.0 (SD 12.5)	18.9 (SD 14.5)	0.68
Internal rotation	6.5 (SD 14.7)	9.4 (SD 11.7)	0.20

OA: osteoarthritis, *ON*: osteonecrosis, *RDC*: rapidly destructive coxarthritis

correlated in the lateral position group (Fig. 5). There was no correlation between cup alignment and other patient demographics.

Discussion

The most important finding was that the supine position increased the outliers of inclination (22%) compared with the lateral position (5%), even when the same modified Watson-Jones approach was used. Previous reports using the muscle-sparing modified Watson-Jones approach showed that the error from the aimed angle was 6.1 ± 4.5° in inclination and 8.8 ± 5.8° in anteversion with the supine position [18], and was 3.5 ± 3.1° in inclination and 4.6 ± 4.6° in anteversion with the lateral position [19]. A larger error was observed with the supine position. However, there has been no report which compared the cup alignment using the modified Watson-Jones approach performed with the patient in the supine versus the lateral position. The present study is the first to compare the cup alignment in THA using the muscle-sparing modified Watson-Jones approach performed with the patient in the supine versus the lateral position.

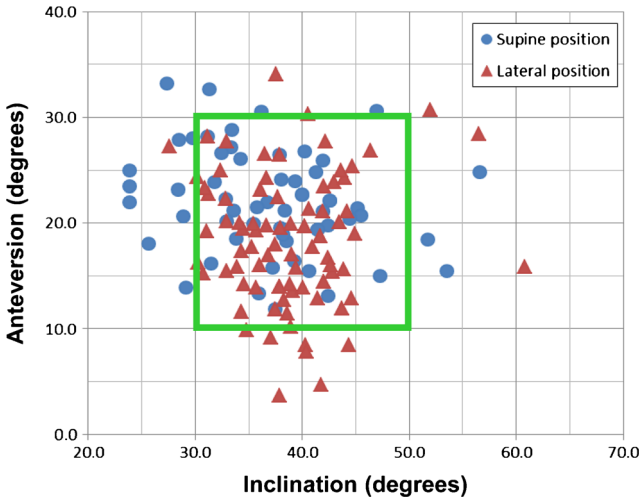

Fig. 4 Scatter diagram showing the inclination and anteversion during total hip arthroplasty in the supine and lateral positions. The green line represents 10° from the aimed angle (40° inclination and 20° anteversion)

For the cup inclination, the difference between the supine position and the lateral position was not statistically significant. However, the absolute error from the aimed inclination was significantly larger in the supine position, and thus, there were significantly more outliers of the cup inclination in the supine position (22%) than in the lateral position (5%). Our result suggested that the cup inclination varied more widely in the supine position. For the supine position group, the cup inclination was smaller in patients with lower BMI and was higher in patients with higher BMI ($p < 0.01$, $R = 0.48$). The possible cause is that when the patient was in the supine position, the pelvis tilted in the horizontal plane during cup insertion with a hammer even with the use of a lateral positioner from the contralateral side. For the patients with higher BMI, the alignment guide was impinged to the skin because the subcutaneous tissue was thick. When the cup was inserted with the hammer, the pelvis tilted toward the operative side due to the soft tissue impingement, and the cup inclination

Table 2 Outlier of cup alignment in the supine and lateral positions

Parameters	Supine position (58 hips)	Lateral position (84 hips)	*p* value
Inclination	13/58 (22%)	4/84 (5%)	< 0.01
Anteversion	4/58 (6%)	10/84 (12%)	0.40

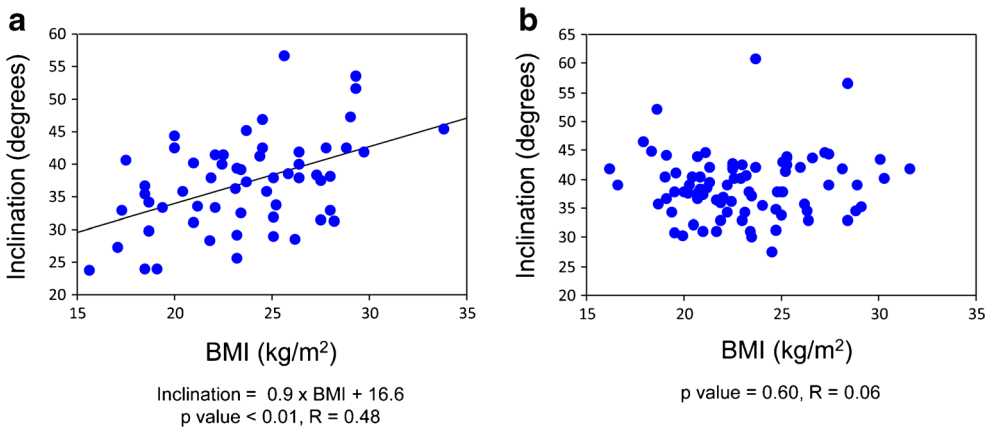

Fig. 5 Scatter diagram showing the relationship between inclination and BMI in the supine position group (A) and the lateral position group (B). Inclination and BMI was positively correlated in the supine position group ($p < 0.01$, R = 0.48)

was increased (Fig. 6a). For the patients with lower BMI, the alignment guide was not impinged to the skin because the subcutaneous tissue was thin (Fig. 6b). When the cup was inserted with the hammer, the pelvis was pushed by the inserter and was tilted toward the contralateral side, and the cup inclination was decreased. The surgeons could not confirm this pelvic movement during the cup insertion, because the surgeon holds the cup inserter and hammer and thus could not touch the bonny landmarks such as the bilateral anterior superior iliac spines and the pubic tubercles. To improve the cup inclination in THA performed with the patient in the supine position, additional measures which enable to confirm the cup inclination should be considered, such as an image intensifier or a navigation system [20] especially for low- or high-BMI patients. In contrast, during THA performed with the patient in the lateral position, the pelvis was firmly fixed with the specially designed pelvic positioner. This positioner reduced the pelvic movement during cup insertion, and might have been the reason for the reduced number of outliers of the cup inclination.

Although there was no significant difference between the two groups in the absolute error from the aimed angle and the

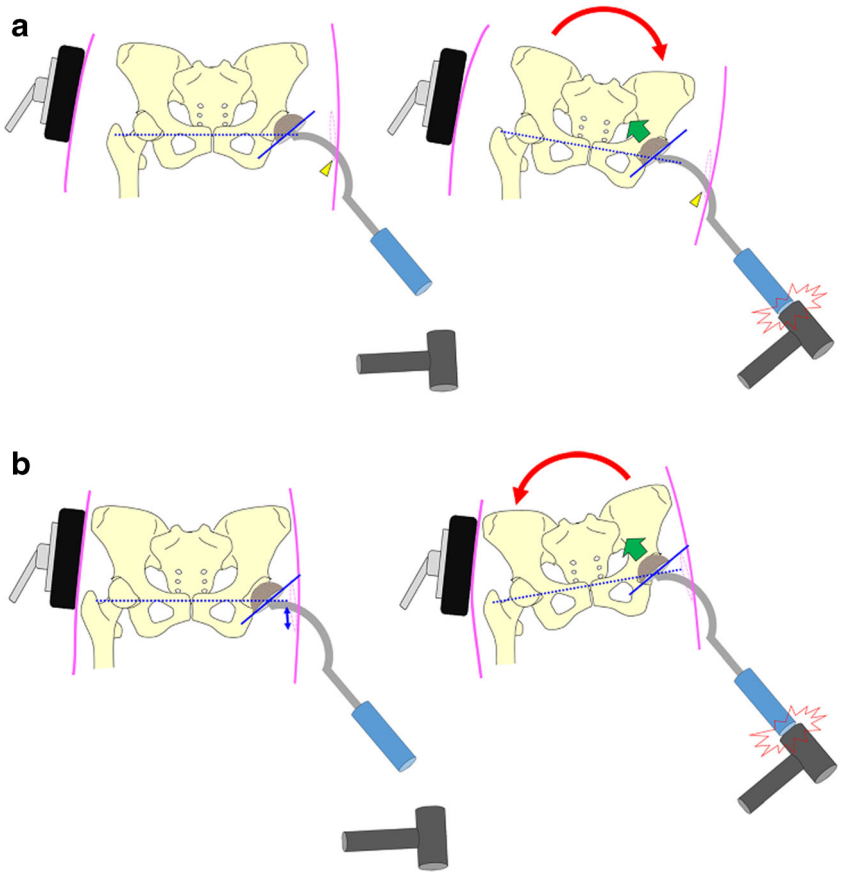

Fig. 6 Schematic drawing showing the relationship between the pelvic tilt and cup inclination in the supine position. Pelvic position influenced the cup inclination during total hip arthroplasty with the patient in the supine position. **a** For the patients with higher BMI, the alignment guide was impinged to the skin because the subcutaneous tissue was thick (yellow arrow). When the cup was inserted with the hammer, the pelvis tilted toward the operative side due to the soft tissue impingement, and the cup inclination was increased. **b** For the patients with lower BMI, the alignment guide was not impinged to the skin because the subcutaneous tissue was thin (blue arrow). When the cup was inserted with the hammer, the pelvis tilted toward the contralateral side, and the cup inclination was decreased

outlier rate in anteversion, the angle of the cup anteversion was significantly less in the lateral group than in the supine group. The mechanical alignment guide for the supine position was designed in radiographic definition. However, the mechanical alignment guide for the lateral position was designed in operative definition. Previous reports showed that the 40° inclination and the 20° anteversion in the operative definition was equivalent to the 41° inclination and the 15° anteversion in the radiographic definition [14, 21]. Postoperative cup alignment is generally measured using the radiographic definition. Therefore, the use of the mechanical alignment guide designed in operative definition for the lateral position theoretically results in smaller anteversion by 5° and in larger inclination by 1° than the surgeons expected on postoperative radiographic measurement. In this study, postoperative 3D-CT cup alignment was measured using the radiographic definition, and thus, the mean anteversion was about 4° less in the lateral position than in the supine position ($p < 0.01$). We suspected that the difference of the mean cup alignment between two groups was caused by the difference of definition between supine and lateral mechanical alignment guides. To improve the cup anteversion for lateral position, the manufacturer should be introduced the mechanical alignment guides designed in radiographic definition for the lateral position. However, the standard deviation of absolute error from the aimed alignment was smaller in anteversion than in inclination. Therefore, there was no significant difference between the two groups in the outlier rate in anteversion.

The advantage of the present study is that the cup alignment was measured using 3D-CT data. In contrast, previous reports comparing the cup alignment between THA performed with the patient in the supine versus the lateral position have used radiography [9] or a navigation system [22]. The measurement of the cup alignment using plain radiography involves substantial measurement errors, because of the lateral pelvic tilt during radiography and the corn-beam effect [23–26]. Even the use of a navigation system still results in measurement errors, and thus, measurement of the cup alignment using a navigation system has potential errors. The present study used 3D-CT image to measure the cup alignment. The ICCs of our measurement method were very good (more than 0.81). Therefore, we believe that the present results are more reliable than those from previous studies that compared the cup alignment between THA performed with the patient in the supine versus the lateral position.

The present study had several limitations. First, the learning curve of surgical approaches may affect the results of this study, and thus, the present results may not always apply to other surgical teams. Before this study, however, surgeons were skilled in the muscle-sparing modified Watson-Jones approach in each patient's position. There were no statistical differences of the cup alignment and the ratio of outliers between the first half of the patients and the latter half of the patients. The error from the aimed angle of the present study was comparable to that of the previous reports [18, 19]. Therefore, we believe that this study was performed after the learning curve of the surgical approaches. Second, we only used the muscle-sparing modified Watson-Jones approach. Therefore, the present results may not apply to other surgical approaches. Third, the present study was a pilot study performed to compare the supine and lateral positions for THA using the same muscle-sparing modified Watson-Jones approach, and so, we only compared the postoperative cup alignment between the two groups. A follow-up study of clinical results should be performed to determine the clinical impact of the operative position. Fourth, this study was a retrospective study. The surgical approaches of the two groups were fundamentally the same, but only the patients' positions were different. Although the difference of preoperative patient demographics between two positions was not statistically significant, a further prospective randomized study should be performed. Fifth, the height, body weight, and BMI of the patients in this study were much smaller than those in Western countries, because this study was performed in Japan. Therefore, the present results may apply to Asian countries, but may not always apply to Western countries.

Conclusion

The present study showed that performing THA with the patient in the supine position had a higher risk of outliers of the cup inclination compared with the lateral position, even when the same modified Watson-Jones approach was used. BMI affected the cup inclination in the supine position.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This study was approved by the institutional review boards of our hospital.

Informed consent Informed consent was obtained from all individual participants included in the study.

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