Assessment of 3D acetabular offset in total hip arthroplasty using conventional reaming technique

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Research Article

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Abstract

**Background:** Reconstruction of the hip center and appropriate offset is meaningful in total hip arthroplasty (THA). In our institution, THA is performed using the anterolateral supine (ALS) approach with intraoperative fluoroscopy, wherein the acetabulum is reamed using the conventional reaming technique. This study aimed to investigate and review 3D acetabular offset in ALS-THA and compare changes between the post-THA and the normal hips.

**Methods:** Seventy-three patients with unilateral disease and 73 joints (mean age 62.8 years, all female patients) underwent ALS-THA using the conventional reaming technique with intraoperative fluoroscopy at the same institution. The acetabular medial offset (AMO), acetabular superior offset (ASO), and acetabular anterior offset (AAO, posterior +) were measured, and the amount of change in the unaffected hip joint and implanted hip joint was examined.

**Results:** The mean AMO (±SD) in the normal hip was 33.8 mm (±1.6), the mean ASO (±SD) was 14.3 mm (±1.6), and the mean AAO (±SD) was 1.2 mm (±1.1). the mean AMO (±SD) in the implanted hip was 27.5 mm (±1.2), the mean ASO (±SD) was 16.8 mm (±1.8), and the AAO (±SD) was 3.7 mm (±0.9) in THA. There was a significant difference between the unaffected side and the post-THA offset in the AMO, ASO, and AAO groups (p < 0.001, p < 0.001, and p = 0.03 respectively). The difference in mean values between the normal side and the THA side was ΔAMO (±SD) 6.3 mm (±1.9), ΔASO (±SD) 2.5 mm (±1.2), and ΔAAO (±SD) 2.4 mm (±1.0).

**Conclusion:** 3D-CT was used to evaluate the acetabular offset by comparing the post-THA and normal hips after unilateral ALS-THA. Under fluoroscopic reaming, the center of rotation of the hip joint moved inward, upward, and backward.

Trial Registration: retrospectively registered

**Background**

Acquiring an appropriate hip joint offset in total hip arthroplasty (THA) is important to improve range of motion and avoid prosthetic impingement. In THA for hip osteoarthritis, a conventional reaming technique is commonly performed wherein a prosthetic cup is fixed by reaming the acetabulum to remove the remaining bone until it reaches the desired size to receive the prosthetic cup. This technique provides stability but reduces acetabular offset. [1, 2].

In general, the global offset is the sum of the acetabular offset and the femoral offset in simple X-ray images. Decrease in the global offset of the post-THA hip compared to that of unaffected hip indicates abductor muscle dysfunction, limping, and high dislocation rate [3-5]; therefore, it is important to acquire a global offset equivalent to that of the normal side. A femoral offset with implant correction can compensate for the acetabular offset that has been reduced by the conventional reaming technique.
The hip joint offset is generally evaluated by measuring the medial-lateral offset using a 2D X-ray image; however, 3D evaluation is important for a more accurate understanding of the offset [6]. In this study, we used 3D-CT to evaluate the difference between the center of the cup placed using the conventional reaming technique and the center of the normal hip joint on the contralateral side employing intraoperative fluoroscopy in unilateral THA cases.

Methods

The study was approved by a single institution. This retrospective study included 73 hips in 73 patients (all women) who underwent primary THA via the anterolateral supine (ALS) approach. The mean age was 62.8 years. Evaluation of dysplasia of the hip on the operated side was Crowe classification type I in 66 cases and type II in 7 cases, all of which were normal hip joints with a center edge angle of 20° or more on the contralateral side.

All patients admitted to the study underwent CT examinations for the postoperative assessment of the acetabular offset. CT with a 1-mm slice interval was performed from the anterior superior iliac spine to the knee in all the patients. The acetabular offset was evaluated by the 3D method using a 3D-template system (ZedHip; LEXI Co., Ltd., Tokyo, Japan).

In the horizontal section, the center of the approximation circle for the lunar surface of the acetabulum was set as the acetabular center, and the line passing through both acetabulum centers was set as the acetabular centerline (Fig. 1). The acetabular medial offset (AMO) is the vertical distance from the center of the head to the inner wall of the acetabulum, and the acetabular superior offset (ASO) is the vertical distance from the center of the head to the line between the tear drops in the coronal section at the midline of the acetabulum. In addition, the vertical distance from the center of the femoral head to the centerline of the acetabulum in the horizontal section was measured as the acetabular anterior offset (AAO, posterior +).

Surgical Procedures

All surgeries were performed by two surgeons (T.H, H.F) on a standard operating table using the same technique.

After general anesthesia, the patient’s bilateral hip joints were visualized using fluoroscopy. The same fluoroscopy model (12-inch, General Electric OEC 9900, USA) was used in all the cases. By referring to the anteroposterior view of both hip joints in the supine position performed preoperatively, the angle of incidence of fluoroscopy was adjusted such that the shape of the pelvic cavity and obturator foramen were similar on both sides. The acetabulum was reamed using a conventional reaming technique under fluoroscopy (Fig. 2).

Statistical Analysis
The data were analyzed using R software (version 3.6.1, The R Foundation for Statistical Computing, Vienna, Austria). Distributions of variables are presented as means with standard deviations (SD) and ranges. Unpaired t-tests were used to assess the significance of differences in categorical data between the two groups. Statistical significance was set at p < 0.05.

**Results**

The mean AMO (± SD) in normal hip was 33.8 mm (± 1.6), the mean ASO (± SD) was 14.3 mm (± 1.6), and the mean AAO (± SD) was 1.2 mm (± 1.1). The average AMO (± SD) in the implanted hip was 27.5 mm (± 1.2), the average ASO (± SD) was 16.8 mm (± 1.8), and the AAO (± SD) was 3.7 mm (± 0.9) (Table 1; Fig. 3) in THA. The difference in mean values between the normal side and the THA side was ΔAMO (± SD) 6.3 mm (± 1.9), ΔASO (± SD) 2.5 mm (± 1.2), and ΔAAO (± SD) 2.4 mm (± 1.0).

There was a significant difference in the acetabular offset between the normal side and THA side in the AMO, ASO, and AAO groups (p < 0.001, p < 0.001, and p = 0.03 respectively).

**Discussion**

Conventional and peripheral reaming techniques are used for acetabular reaming for hip osteoarthritis (Fig. 4). With conventional reaming, the contact area of the cup against the bone matrix increases by reaming to the base of the socket, enabling stable fixation. Reaming to the true floor mediates the hip center of rotation [7], and medialization of the cup is often recommended based on the assumed improvement of the moment arm [1]. However, medialization of the center of the hip joint reduces the acetabular offset, and an increase in the dislocation rate due to an increase in impingement is a matter of concern [5].

Conversely, peripheral reaming, which does not ream to the base of the acetabulum and maintains medialization to the depth of the entire acetabulum, suppresses medialization of the center of the hip joint and is useful for reproducing normal acetabular offset. However, in patients with osteoporosis or acetabular dysplasia, peripheral reaming lacks initial fixation of the acetabular cup, raising concerns about early cup movement and loosening [5, 7].

In this study, we measured and compared the 3D offset of the acetabulum between the normal and implanted hips using conventional reaming techniques under fluoroscopy. An average decrease in AMO by 6.3 mm and an average increase in ASO and AAO by 2.5 mm and 2.4 mm, respectively, were observed in the implanted hip than in the normal hip. The center of rotation of the hip joint moved medially, superiorly, and posteriorly.

Eggli et al. reported that the medial offset decreased by an average of 4.4 mm and that the superior offset increased by an average of 2.5 mm [8]. Similarly, Knight et al. reported an average medial offset reduction
of 5 mm [9]. Both reports involved 2D evaluations using X-rays. In this study, the amount of decrease in the medial offset was slightly larger than that in other studies.

Merle et al. reported that the acetabular medial offset measured using CT after THA performed without fluoroscopy was reduced by ≥ 8 mm in 34% of cases, indicating excessive reaming [10]. In our study, only 4% of cases had a decrease in acetabular offset of ≥ 8 mm, This may also be due to the use of fluoroscopy-guided reaming during surgery.

Medialization of the hip joint rotation center due to excessive reaming has several drawbacks. Varying amounts of bone are removed from the medial aspect of the acetabulum. This loss of bone stock can cause problems with cup fixation [11]. Furthermore, in patients with severe osteoporosis, the subchondral hardened bone is removed, which can adversely affect the stability of the primary cup [11].

To address these problems, the use of intraoperative fluoroscopy during reaming allows visual confirmation of the reaming depth, which is considered a safe and reliable method.

Supine surgery, such as the direct anterior approach and ALS approach, has better cup placement accuracy and a lower risk of dislocation than the lateral supine position [12, 13]. In the supine position, the pelvis is stabilized during surgery, which enables precise cup placement and easier intraoperative fluoroscopy. Intraoperative fluoroscopy is useful not only for confirming cup depth but also for determining cup abduction angle and anteversion. Cho et al. reported that the accuracy of cup placement in ALS THA using fluoroscopy is good and compares favorably with other navigation systems [14]. The use of fluoroscopy in supine surgery not only confirms the position of the cup but also confirms the placement of the stem on the femoral side. The lack of acetabular offset can be corrected with femoral offset by confirming the global offset of the hip joint at the time of provisional reduction. It is also useful for femoral stem offset selection, which is routinely performed using fluoroscopy.

Our study had some limitations. First, this was a retrospective study and not a randomized study. The long-term clinical outcomes have not yet been evaluated. Second, we focused only on acetabular offset. When evaluating the global offset, it is necessary to consider the 3D femoral offset in the future.

**Conclusions**

Acetabular offset was evaluated using CT for the implanted and normal hips after unilateral ALS-THA surgery performed using fluoroscopic conventional reaming. Post-THA, the center of rotation of the hip joint moved medially, superiorly, and posteriorly.

Conventional reaming using intraoperative fluoroscopy is useful because it can confirm reaming depth and can also correct the acetabular offset using high offset femoral implant when excessive offset reduction occurs.

**Abbreviations**
THA, total hip arthroplasty
ALS, anterolateral supine
AMO, acetabular medial offset
ASO, acetabular superior offset
AAO, acetabular anterior offset

**Declarations**

Ethics approval and consent to participate

All study participants provided informed consent, and the study design was approved by the appropriate ethics review board. No funding support and no conflict of interest existed in this study.

Availability of data and materials

The data presented in this study are available upon request from the corresponding author. The data are not publicly available due to regulations of the local institutional ethics board.

Competing interests

The authors declare no competing interests.

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**References**


Table

Table 1 is available in the Supplementary Files section.

Figures
Figure 1

Acetabular offset

a: The midline was set at the center of the approximated circle for the lunar acetabulum.

White solid line: Line between tear drop marks; white dotted line: centerline of the acetabulum.
b: Acetabular medial offset    Acetabular superior offset

c: Acetabular anterior offset (posterior+)

White dotted line: center acetabulum line;

Black dot: Center of the femoral head.

Figure 2

Conventional reaming and cup positioning in anterolateral supine approach for total hip arthroplasty (ALS-THA) using fluoroscopy
Figure 3

Acetabular medial offset (AMO) in normal and implanted hips;
AMO in the implanted hip is shorter than that in the normal hip.
Figure 4

Hip center with peripheral reaming and conventional reaming technique

a: The center of the cup placed by peripheral reaming is similar to the center of the femoral head.

b: The center of the cup placed by conventional reaming is positioned medial and posterior to the center of the femoral head.

Black dot: The center of the femoral head;

White dot: The center of the cup with conventional reaming technique.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Table1.xlsx