Changes in pelvic tilt after total hip arthroplasty: three-dimensional analysis

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Introduction
The orientation of the acetabular cup in total hip arthroplasty (THA) is important for achieving satisfactory postoperative outcomes. Precise positioning of the acetabular cup is essential for preventing postoperative complications such as polyethylene wear, implant failure, and dislocations. Pelvic tilt is expected to affect the orientation of the cup; it is clinically important to understand postoperative changes that can occur in pelvic tilt after THA. The purpose of this current study was to measure change in pelvic flexion angle, using a three-dimensional computed tomography (CT) model after THA.

Materials and Methods
The subjects of this study were 112 patients (112 hips) who underwent THA at our institution. The patients consisted of 26 men and 86 women, with a mean age of 62 years (range: 43–82 years). Antero-posterior (AP) radiographs of the pelvis were taken in the supine and standing position preoperatively and at 3, 6, and 12 months after THA. CT images of the pelvis were obtained 1 week after THA.

In order to match these with the three-dimensional CT model, we measured two parameters in AP radiographs in the supine and standing positions (Figure 1): one (A) was the distance between the line connecting the inferior margins of the bilateral sacroiliac joints and the superior margin of the pubic symphysis; the other (B) was the maximum horizontal diameter of the pelvic foramen. Distance A was then divided by Diameter B to give the A/B Ratio. The three-dimensional CT model was rotated around the horizontal axis until its A/B ratio matched that of the AP radiograph. The pelvic flexion angle was defined as the angle between the anterior pelvic plane (APP) in this position and the vertical plane. APP was defined as the plane of the bilateral superior anterior iliac spines and the superior margin of the pubic symphysis.

Results
The pelvic flexion angle in standing position of all patients was $-1.5\pm11.2^\circ$ preoperatively and $-4.7\pm9.7^\circ$ at 1 year after THA. Group A consisted of 12 patients (10.7%) (2 men and 10 women, with a mean age of 54.6 years). Their mean pelvic flexion angle in standing position was $19.2\pm5.9^\circ$ preoperatively, and $12.7\pm8.3^\circ$ at 1 year after THA. Group B consisted of 38 patients (33.9%) (10 men and 28 women, with a mean age of 59.6 years). Their mean pelvic flexion angle in standing position was $4.3\pm2.6^\circ$ preoperatively, and $-1.7\pm6.3^\circ$ at 1 year after THA. Group C consisted of 35 patients (31.3%) (10 men and 25 women, with a mean age of 62.1 years). Their mean pelvic flexion angle in standing position was $-3.8\pm2.7^\circ$ preoperatively, and $-5.1\pm5.7^\circ$ at 1 year after THA. Group D consisted of 27 patients (24.1%) (4 men and 23 women, with a mean age of 66.7 years). Their mean pelvic flexion angle in standing position was $-15.9\pm5.9^\circ$ preoperatively, and $-14.0\pm6.4^\circ$ at 1 year after THA (Table 1).

Discussion
Overall, the patients’ pelvic flexion angle decreased after THA in the present study. An important finding was that in 37% of patients in Group D, the pelvic flexion change in standing position at 1 year after THA was more posterior than preoperatively. With extension of the pelvis, anteverision and inclination of the acetabular component tend to increase. Therefore it is clinically important to understand the postoperative changes in pelvic tilt that can occur after THA and to determine the types of patients that will be more likely to show greater change in pelvic tilt after THA.

For patients with severe preoperative posterior pelvic tilt, cup anteversion should be reduced by several degrees during preoperative planning to compensate for posterior pelvic tilt. However, further studies are necessary to draw more general conclusions for patients outside of this study group, and operative decisions must be individualized. Thus, a greater understanding of postoperative changes in pelvic tilt may improve the outcomes of THA patients.

Significance
The pelvis tilted to the posterior after THA, and preoperative planning for cup placement is needed with regard to postoperative change in pelvic tilt.

References

Table 1) Demograph

<table>
<thead>
<tr>
<th></th>
<th>Group A (n = 12)</th>
<th>Group B (n = 38)</th>
<th>Group C (n = 35)</th>
<th>Group D (n = 27)</th>
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<tbody>
<tr>
<td>Age (years)</td>
<td>64.6 ± 7.3</td>
<td>59.6 ± 9.6</td>
<td>62.1 ± 12.2</td>
<td>66.7 ± 8.6</td>
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<tr>
<td>Gender</td>
<td>10/2</td>
<td>10/28</td>
<td>10/25</td>
<td>4/23</td>
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<tr>
<td>Preoperative</td>
<td></td>
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<td></td>
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<tr>
<td>pelvic flexion</td>
<td>19.2 ± 5.9</td>
<td>4.3 ± 2.6</td>
<td>-3.8 ± 2.7</td>
<td>-15.9 ± 5.9</td>
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<tr>
<td>angle (degrees)</td>
<td></td>
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<td></td>
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<tr>
<td>PO1y pelvic</td>
<td>12.7 ± 8.3</td>
<td>-1.7 ± 6.3</td>
<td>-5.1 ± 5.7</td>
<td>-14 ± 6.4</td>
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<tr>
<td>flexion angle</td>
<td></td>
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<td>angle (degrees)</td>
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At 1 year after THA, 13 patients in Group D (48%) exhibited anterior change in pelvic flexion angle, and 10 patients in Group D (37%) showed posterior change in pelvic flexion angle. On the other hand, only 1 in Group A (8%) showed anterior change in pelvic flexion angle, and eight (67%) exhibited posterior change in pelvic flexion angle.

Figure 1-a) Line A and B on AP radiograph
1-b) The pelvis is rotated around horizontal axis using computer software until A/B = B ratio is equal to A/B ratio to match AP radiograph with three-dimensional CT model.
1-c) Pelvic flexion angle is an angle between APP and the vertical plane (*).