Using the transverse acetabular ligament as a landmark for acetabular anteversion: an intra-operative measurement

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ABSTRACT

Purpose. To measure the transverse acetabular ligament (TAL) anteversion in hips with severe deformity, using fluoroscopy–computed tomographic navigation.

Methods. 31 hips in 10 men and 19 women aged 40 to 78 (mean, 58.7) years who underwent total hip arthroplasty for primary osteoarthritis (n=6) or osteoarthritis secondary to developmental hip dysplasia (n=19) or congenital hip dislocation (n=6) were included. The severity of hip dislocation was classified according to the Crowe classification; 15 hips were grade 1, 7 were grade 2, 3 were grade 3, and 6 were grade 4. The TAL anteversion was measured using fluoroscopy–computed tomographic navigation. The difference in TAL anteversion between non-dislocated hips (Crowe grade 1, n=15) and dislocated hips (Crowe grades 2–4, n=16) was compared.

Results. In all 31 hips, the TAL could be visualised intra-operatively. No patient reported severe pain, early wear, loosening, or dislocation after 2 years. The mean TAL anteversion and inclination angles measured by the navigation system were 26.5º (SD, 8.9º; range, 8º–42º) and 41.5º (SD, 4.6º; range, 32º–49º), respectively. 22 of the 31 hips were in the safe zone. TAL anteversion in non-dislocated and dislocated hips was not significantly different. Inter- and intra-observer mean absolute differences in TAL anteversion were 0.3º and 0.4º, respectively.

Conclusion. The TAL is a useful anatomic landmark for total hip arthroplasty in dislocated hips.

Key words: anatomic landmarks; arthroplasty, replacement, hip; bone anteversion

INTRODUCTION

Acetabular cup malalignment during total hip arthroplasty (THA) can cause dislocation, impingement, and accelerated wear, all of which can lead to revision surgery.1,2 In THA, a fixed angle referenced to the body axis is used for orientation of the acetabular component. The number of dislocations...
markedly decreases when the acetabular anteversion is set at $15^\circ \pm 10^\circ$ and inclination at $40^\circ \pm 10^\circ$. This safe zone is the standard placement for the acetabular cup, but is not defined in terms of anatomy and biomechanics of the hip joint. There are studies on optimal angles for acetabular cup orientation. Individualised orientation based on bony or soft-tissue landmarks is emphasised. However, none of the landmarks tested is universally applicable as an ideal orientation, because most are difficult to visualise intra-operatively.

The transverse acetabular ligament (TAL) forms a bridge across the inferior acetabular notch continuing the outer edge of the acetabulum, and is a landmark for acetabular anteversion with a low dislocation rate of $\leq 1\%$. However, it has only been used in normal or primary osteoarthritic hips. It may not be applicable to hips with severe deformity secondary to developmental dysplasia or congenital dislocation. In addition, the TAL is difficult to visualise intra-operatively. This study measured TAL anteversion in hips with severe deformity using fluoroscopy–computed tomographic navigation.

**MATERIALS AND METHODS**

This study was approved by the institutional review board of our hospital. 10 men and 19 women (31 hips) aged 40 to 78 (mean, 58.7; standard deviation [SD], 15.1) years underwent THA between April 2009 and October 2009 for primary osteoarthritis (n=6) or osteoarthritis secondary to developmental hip dysplasia (n=19) or congenital hip dislocation (n=6). The severity of hip dislocation was classified according to the Crowe classification; 15 hips were grade 1, 7 were grade 2, 3 were grade 3, and 6 were grade 4 (Figs. 1 and 2).

THAs were performed by 2 senior consultants through a posterolateral approach. A cementless press-fit acetabular component, a modular head with a diameter of 28 mm with metal-on-polyethylene bearings, and a femoral component were used.

After exposure of the acetabulum, the appearance of the TAL was graded according to the system described by Archbold et al. Grade 1 (n=1) indicated a normal-quality TAL visible on exposure of the acetabulum; grade 2 (n=14) indicated a TAL covered by soft tissue, which had to be cleared to expose the ligament; grade 3 (n=16) indicated a TAL covered by osteophytes, which had to be removed to expose the ligament; and grade 4 (n=0) indicated no ligament identified, even after adequate clearance of soft tissue or osteophytes. Chisels and small-diameter reamers were used to carefully remove osteophytes and overlying bone.

Once the TAL was identified, the acetabulum was reamed, and TAL anteversion was measured using fluoroscopy–computed tomographic navigation, which yields excellent translational ($\leq 1\, \text{mm}$) and rotational ($\leq 1^\circ$) accuracy. Guide pins were inserted into the iliac crest, and reference bases were attached to the pins. The anterior superior iliac spine and pubic tubercles were registered using a reference pointer, and fluoroscopic pelvic images captured from 2 different angles were used for registration.

![Figure 1](image-url) A hip with primary osteoarthritis and Crowe grade-1 deformity: the transverse acetabular ligament (TAL) is covered by osteophyte, which is removed by a chisel, and an acetabular cup is placed parallel to the TAL.
The trial cup was installed on the holder and then placed parallel to the TAL. The inclination angle of 45° was defined by placing the cup holder guide parallel to the floor, whereas anteversion was defined by placing the cup parallel to the TAL. All surgeons were blinded during this process by turning the screen away. Each surgeon made 2 measurements to evaluate intra- and inter-observer reliability. The acetabular cup was then implanted parallel to the TAL for anteversion reference, whereas the inclination angle was simultaneously set at 35° to 45°. If acetabular bone coverage was poor in patients with severe dysplasia or congenital dislocation of the hip, bone grafting was performed (Fig. 3). The femoral stem was implanted with respect to the original anatomy.

Anteversion and inclination measured by the navigation system were converted to those commonly used in radiographic studies of the conventional safe zone using the Murray method. Patients were followed up for 24 months; any pain, dislocation, early wear, and loosening were noted.

The mean and difference of inter- and intra-observer measurements of TAL anteversion were shown using a Bland-Altman plot. The difference in TAL anteversion between non-dislocated hips (Crowe grade 1, n=15) and dislocated hips (Crowe grades 2–4, n=16) was compared using the unpaired t-test. A p value of <0.05 was considered statistically significant.

**RESULTS**

In all 31 hips, the TAL could be visualised intra-operatively. No patient reported severe pain, early wear, loosening, or dislocation after 2 years. The mean TAL anteversion and inclination angles measured by the navigation system were 26.5° (SD, 8.9°; range, 8°–42°) and 41.5° (SD, 4.60°; range, 32°–49°), respectively. These values were converted to those used in radiographic studies of the conventional safe zone. The corresponding values were 19.8° (SD,
Inoue et al.  

**Figure 4** 22 of the 31 hips are within the safe zone, defined as transverse acetabular ligament (TAL) anteversion of 15±10° and inclination of 40±10°.

**Table**  
Crowe classification of transverse acetabular ligament (TAL) anteversion

<table>
<thead>
<tr>
<th>Crowe grade</th>
<th>Mean±SD (range) TAL anteversion (degree)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (n=15)</td>
<td>18.7±6.6 (6.8–28.1)</td>
</tr>
<tr>
<td>2 (n=7)</td>
<td>20.0±5.2 (12.1–27.5)</td>
</tr>
<tr>
<td>3 (n=3)</td>
<td>17.7±11.1 (5.3–26.5)</td>
</tr>
<tr>
<td>4 (n=6)</td>
<td>23.3±12.6 (16.1–28.6)</td>
</tr>
<tr>
<td>Total (n=31)</td>
<td>19.8±6.5 (5.3–28.6)</td>
</tr>
</tbody>
</table>

* No significant difference between Crowe grade 1 and grades 2 to 4 hips (p=0.249)

6.5°; range, 5.3°–28.6°) and 44.0° (SD, 5.5°; range, 33.5°–57.1°). 22 of the 31 hips were in the safe zone (Fig. 4).

Radiographic TAL anteversion in non-dislocated hips (Crowe grade 1, n=15) and dislocated hips (Crowe grades 2–4, n=16) was not significantly different (18.7° [SD, 6.6°; range, 6.8°–28.1°] vs. 20.8° [SD, 6.4°; range, 5.3°–28.6°], p=0.249, Table). This indicated that the TAL offered a good means of optimising the anteversion landmark of the original anatomy in hips with severe developmental dysplasia and congenital dislocation of the hip.

Inter- and intra-observer mean absolute differences in TAL anteversion were 0.3° (95% confidence interval [CI], -3.5°–4.1°) and 0.4° (95% CI, -2.7°–3.5°), respectively, indicating good inter- and intra-observer agreement (Fig. 5).

**DISCUSSION**

The TAL is a useful anatomic landmark for THA.7,9–12 Aligning the acetabular component parallel to the TAL enables establishment of patient-specific anteversion and decreases the dislocation rate from 3.7% to 0.6%. In an intra-operative, anatomic study of the TAL,10 the mean TAL anteversion was 18° (range, 10°–36°), and 89.7% of the hips were within the conventional safe zone. Nonetheless, most such hips involved primary osteoarthritis (with no severe acetabular structural abnormality), and this method could not be used in hips with severe dysplasia and dislocation.10 In another study, the TAL could be identified in only 47% of the hips because of acetabular osteophytes.14

In patients with labrum injury, anteversion of the

![Figure 5](image-url)  
Bland-Altman plot showing (a) inter- and (b) intra-observer agreement.
Transverse acetabular ligament as a landmark for acetabular anteversion

An acetabular plane (as defined by the TAL-acetabular labrum) was 23°. In a cadaveric study, all hips that used the TAL as the landmark for cup implantations were within the safe zone. Using the acetabular ridge as a reference, the acetabular anteversion was 19.9°, and the actual acetabular anteversion tended to be greater than the conventional safe zone angles, according to the morphology of the acetabulum. In our study, acetabular anteversion in 71% of the hips were within the conventional safe zone. The mean±SD radiographic TAL anteversion was 23.3°±6.5°, which was slightly greater than the conventional zone angles. None of our patients had dislocations or loosening after 2 years of follow-up. This supported the efficacy of the TAL as a reference for intra-operative anteversion.

Some studies support cup alignment with a fixed angle reference such as the safe zone. However, this gives no consideration to the individual anatomy and biomechanics of the hip joint. Furthermore, if the ideal alignment was achieved, pelvic alignment would change easily depending on patient position (sitting, standing), and the ideal orientation might not be maintained during daily activities. Other studies support a combined anteversion technique. This technique combines anteversion of the acetabulum and the femur as an index. From the perspective of implant impingement (stem and cup impingement), this technique is reasonable. However, the anatomic features of the acetabulum are not reflected, so cup containment (bone coverage) might not be achieved using this approach. Yet other studies support cup implantation closely matching the individual’s original acetabular anatomy. With such an anatomic reconstruction technique, the cup is implanted according to the original position, for which the TAL is a good anatomic landmark.

If no consideration is given to the individual anatomy of the acetabulum, bone coverage could be excessive or insufficient. Bone impingement between the anterior acetabulum and femur may occur in excessive bone coverage, whereas insufficient bone coverage leads to psoas-impingement at the anterior rim of the cup. Reconstruction of the original individual anatomy of the hip joint may provide desirable postoperative outcomes in THA. Using the TAL as the intra-operative landmark for anteversion is simple, straightforward, and reproducible for optimal cup implantation, and enables the cup to closely restore the individual anatomy of the hip joint.

Limitations of this study were the small number of patients, the short duration of follow-up, and no consideration given to the femoral-side anatomy. Future studies should include hips in which TAL anteversion and the femoral anteversion are extremely high or low. Combined anteversion may be needed to avoid implant impingement.

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DISCLOSURE

No conflicts of interest were declared by the authors.

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