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Preoperative Evaluation of Transverse Acetabular Ligament Orientation using CT for Total Hip Arthroplasty

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Abstract

Background: Orientation of the acetabular component with the transverse acetabular ligament (TAL) to provide optimal anteversion has been reported to reduce dislocation rates. The usefulness of TAL as a landmark is controversial because there are large variations in TAL orientation. We examined anteversion of TAL preoperatively to improve its usefulness.

Methods: Three-dimensional computed tomography (3D-CT) and successive roentgenography were used to analyze 42 hips that suffered idiopathic necrosis of the femoral head.

Findings: The mean operative TAL anteversion in the supine position was 14.9° ± 8.4° (range -6.5 to 30.5). There are large individual variations of TAL orientation in supine position. When the acetabular component was placed in accordance with the operative anteversion of the TAL angle in the supine position and at 40° inclination, the radiographic acetabular component anteversion was 11.3° ± 6.5° (range -5.0° to 22.9°). Six of 42 (14.3%) acetabular component was outside the safe zones of Lewinnek. The mean operative TAL anteversion in the standing position was 18.0° ± 10.8° (range-15.8 to 35.8). There was statistical difference between operative TAL anteversion in the supine and standing positions. In addition, the individual variations of TAL orientation were greater in standing position.

Conclusions: When acetabular component was placed in accordance with the operative anteversion of the TAL, more than 10% of component was outside the safe zone. Although anteversion of TAL have substantial variation, preoperative evaluation of TAL using 3D-CT increases the intraoperative reference and the accuracy of determining acetabular component orientation.

Keywords: Transverse acetabular ligament; Total hip arthroplasty; Anteversion; Total hip Arthroplasty

Abbreviations:

TAL: Transverse Acetabular Ligament; 3D-CT: Three-dimensional Computed Tomography; THA: Total Hip Arthroplasty; CI: Confidence Intervals

Introduction

The most common causes of revision total hip arthroplasty (THA) in the United States were dislocation (22.5%), aseptic loosening (19.7%), and infection (14.8%) [1]. Dislocation occurs in 0.3% to 10% of primary THA cases [2]. Malalignment of the acetabular component is common, increasing the rates of dislocation and revision [3,4]. Many factors cause malalignment of the acetabular component, including poor visualization of the acetabulum, high body mass index, and the inability to maintain precise patient positioning during the operation [3]. Improving the orientation of the acetabular component can minimize the risk of dislocation. Several systems have been reported to improve the orientation of the acetabular component, including computer-assisted systems [5,6]. Archbold et al. reported that the transverse acetabular ligament (TAL) and acetabular labrum were useful for determining the anteversion of the acetabular component [7]. TAL has been evaluated as an anatomic landmark for acetabular component orientation [7-17]. The usefulness of TAL as a landmark is still controversial. We tried preoperative evaluation of TAL anteversion to improve its usefulness. Our findings showed that there are greater variations in the orientation of the TAL.

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Materials and Methods

Patients

We examined 42 hips of 42 patients with osteonecrosis of the femoral head who had undergone preoperative computed tomography (CT) and roentgenography examinations between June 2006 and July 2013. There were 21 males and 21 females in each group. All patients gave informed written consent to the study. The Ethics Committee on Clinical Research at Kagoshima University Hospital approved the research protocol for this study.

Measurements

Two observers (T.S., Y.Y.) performed all measurements after intraobserver and interobserver reliability was established. All patients underwent lateral radiography of the whole lumbar spine, including the hip joints, in the standing position with their hands gently clasped in front of their trunk. Pelvic CT was performed using a Toshiba Aquilion CX (Toshiba, Tokyo, Japan). Images were obtained at 1-mm intervals. Scans were viewed and measured in a multiplanar reconstruction. Patients were placed in the supine and central position in the gantry. Images were rotated to align with the anterior pelvic plane [18]. The line of the superior TAL was established between the posteroinferior and anteroinferior edges of the acetabular rim, as previously reported [11]. The first angle of the TAL for three-dimensional (3D-CT) was measured between the line of the superior edge of the lowest visible vertebra and that of the TAL. The lowest visible vertebra that was not covered by the iliac crest was selected from the first sacral, fifth lumbar, and fourth lumbar vertebrae. The line of the superior TAL was established between the posteroinferior and anteroinferior edges of the acetabular rim on 3D-CT. A line of the lowest visible vertebra (blue) was drawn across the cranial border of the lowest visible vertebra in the 3D-CT (Figure 1A) and sagittal plane CT image (Figure 1B). Operative anteversion of the TAL in the supine position was calculated between the line of the TAL and a line perpendicular to the horizon following adaptation of the line of the lowest visible vertebra line between 3D-CT and sagittal plane CT image (Figure 1C).

The sacral line (yellow) was defined as a line drawn across the cranial border of the first sacral vertebra in the standing position roentgenogram (Figure 1D) and sagittal plane CT image (Figure 1E). A line of the lowest visible vertebra (blue) was drawn across the cranial border of the lowest visible vertebra in the sagittal plane CT image (Figure 1E) and 3D-CT (Figure 1F). The operative anteversion of the TAL in the standing position was calculated between the line of the TAL and a line to the horizon following adaptation of the sacral line (yellow) between roentgenograms in standing position and sagittal CT image, and adaptation of the line of the lowest visible vertebra (blue) between sagittal plane CT image and 3D-CT (Figure 1G). We calculated radiographic cup anteversion to determine that the cup is placed at operative anteversion in accordance with the operative anteversion of the TAL angle in the supine position and 40° inclination [19] (Figure 1).

Figure 1

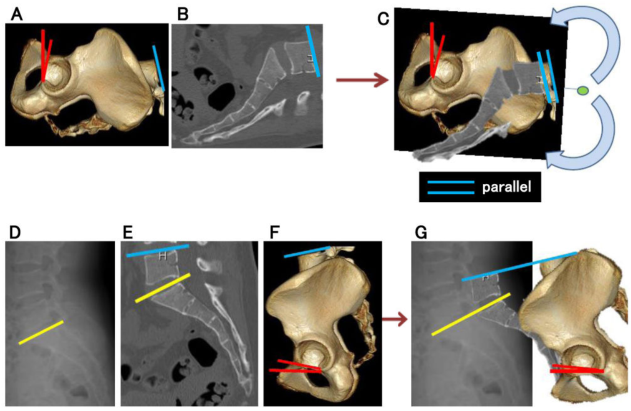

Figure 1: The line of the superior TAL was established between the posteroinferior and anteroinferior edges of the acetabular rim on 3D-CT. A line of the lowest visible vertebra (blue) was drawn across the cranial border of the lowest visible vertebra in the 3D-CT (A) and sagittal plane CT image (B). Operative anteversion of the TAL in the supine position was calculated between the line of the TAL and a line perpendicular to the horizon following adaptation of the line of the lowest visible vertebra line between 3D-CT and sagittal plane CT image (C).

The sacral line (yellow) was defined as a line drawn across the cranial border of the first sacral vertebra in the standing position roentgenogram (D) and sagittal plane CT image (E). A line of the lowest visible vertebra (blue) was drawn across the cranial border of the lowest visible vertebra in the sagittal plane CT image (E) and 3D-CT (F). The operative anteversion of the TAL in the standing position was calculated between the line of the TAL and a line to the horizon following adaptation of the sacral line (yellow) between roentgenograms in standing position and sagittal CT image, and adaptation of the line of the lowest visible vertebra (blue) between sagittal plane CT image and 3D-CT (G).

Statistical analysis

Interclass and intraclass correlation coefficients were determined to examine the accuracy of the measurement of the TAL angle and the SA. Distribution of the variables of each group was assessed using histogram with normal curve as well as Kolmogorov-Smirnov test. Student's t-test was performed to examine whether there were significant differences in the TAL anteversion between males and females and differences in TAL anteversion in the supine and standing positions. All statistical analyses were performed using Microsoft Office Excel (Microsoft, Edmond, WA, USA) and Statcel (OMS Publishing, Tokorozawa, Japan), and Excel Statics 2012 (SSRI, Osaka, Japan).

Results

The study group included 21 men and 21 women (Table 1). Two observers performed all measurements after intraobserver and interobserver reliability was established. The interclass

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correlation was 0.92 (confidence intervals (CI): 0.85-0.92) (p<0.01). The intraclass correlation coefficient was 0.93 (CI: 0.92-0.95) (p<0.01). TAL anteversion in supine position and standing position were calculated (Figure 1). The mean age of the patients was 45.8 years (range 20-78 years) (Table 1).

Table 1: Demographic data.

	(n = 42)
Mean age	45.8 ± 15.7 (20-78)
Sex (M/F)	21/21

The mean operative anteversion of TAL in the supine position was 14.9° ± 8.4° (range -6.5° to 30.5°) (Table 2). There are large individual variations in TAL orientation in the supine position. When the cup was placed at operative anteversion in accordance with the operative anteversion of the TAL angle in the supine position and at 40° inclination, the radiographic cup anteversion was 11.3° ± 6.5° (range -5.0° to 22.9°) (Table 2). Six of 42 (14.3%) acetabular component was outside the safe zones of Lewinnek et al [18]. The mean operative anteversion of the TAL in the standing position was 18.0° ± 10.8° (range-15.8° to 35.8°) (Table 2).

Table 2: Evaluation of the transverse acetabular ligament.

Operative anteversion of TAL		
Spine position	Mean	14.9 ± 8.4 *
	Range	-6.5 to 30.5
Standing position	Mean	18 ± 10.8 *
	Range	-15.8 to 35.8
Radiographic anteversion (inclination 40°)		
	Mean	11.3 ± 6.5
	Range	-5.0 to 22.9

There were larger individual variations in TAL orientation in the standing than supine position. Student's t-test showed that there was a statistical difference between operative anteversion of the TAL in the supine position and the standing position (p<0.01) (Table 3).

Table 3: Variations in the transverse acetabular ligament angle in the supine and standing positions.

From spine to standing position			
	all (n = 42)		
Mean	6.3° (-10.3 to 17.3)		
	Increase of operative anteversion of TAL (n=24)	Decrease of operative anteversion of TAL (n=17)	No change (n=1)
Mean	7.2° (1.3 to 17.3)	-2.6° (-0.3 to -10.3)	0°

Following postural change from the supine position to the standing position, 24 patients had retroversion of the TAL (average 7.2°, range 1.3° to 17.3°), 17 patients had anteversion of the pelvis (average -2.6°, range -0.3° to -10.3°), and 1 patient had no change. Student's t-test showed that there were no significant differences between men and women regarding operative anteversion of the TAL in either the standing or supine position (data not shown).

Discussion

Archbold et al. reported that the plane between the TAL and the acetabular labrum can be used as a patient-specific reference when determining the correct acetabular component orientation [7]. Epstein et al. reported that the TAL could not be routinely identified at surgery and that using the TAL as a reference guide was no more accurate for acetabular component orientation than the free-hand technique [17]. In addition, Kalteis et al. reported that the plane defined by the TAL and posterior labrum induced no improvement in the range of movement and no significant difference in impingement when compared with the standard navigation system [20]. Our findings showed that TAL angle has large individual variation. Six of 42 (14.3%) acetabular component was outside the safe zones, when the cup was placed at operative anteversion in accordance with the operative anteversion of the TAL angle and at 40° inclination. These findings suggest that TAL angle is not accurate reference for all patients.

Although TAL orientation has large individual variation, preoperative evaluation of TAL must improve the usefulness as an intraoperative reference. We evaluated the operative anteversion of TAL preoperatively using 3D-CT. The average angle of the TAL and variations corresponded to previously reported anatomical, intraoperative, and image evaluation of the TAL [8,9,12,15,20,21]. These findings suggest that our instrumentation using 3D-CT can achieve accurate measured values.

We also evaluated anteversion of the TAL in the standing position. Dislocation occur in dynamic situation including postural change between standing to spine position. Our findings suggest that preoperative image assessment-including TAL orientation and change of pelvic anteversion-helps to achieve accurate orientation of the acetabular component. In conclusion, preoperative evaluation of TAL using 3D-CT increases the intraoperative reference and the accuracy of determining acetabular component orientation.

Acknowledgement

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Informed Consent

All patients gave informed written consent to the study.

Institutional review board statement

The Ethics Committee on Clinical Research at Kagoshima University Hospital approved the research protocol for this study.

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