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A Validation Study for Estimation of Femoral Anteversion Using the Posterior Lesser Trochanter Line
An Analysis of Computed Tomography Measurement

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ABSTRACT

The aim of this study was to introduce a simple and reliable intraoperative reference guide to reproduce the normal femoral anteversion during total hip arthroplasty (THA). We hypothesized that the posterior lesser trochanter line (PLTL) could be a useful guide for estimating femoral anteversion during THA. We conducted a study of 56 men (112 hips) to evaluate the relationship between the PLTL and the femoral anteversion using computed tomography scans. The mean femoral anteversion was 9.0° ± 8.1° (range, −16.2° to 32.9°). The PLTL angle correlated ($r^2 = 0.12$, $P < 0.05$) with the femoral anteversion. We found a constant relationship between the PLTL and femoral anteversion, and the PLTL may be used as a guide for estimating the femoral stem anteversion during femoral stem fixation.

Accurate reproduction of the center of rotation of the hip joint is one of the most important factors influencing the outcome of total hip arthroplasty (THA) [1]. Femoral reconstruction during THA should ideally reproduce the center of rotation of the femoral head. The center of rotation of the femoral head is determined by the vertical length, medial offset, and femoral anteversion [2]. The placement of the femoral stem in excessive anteversion or retroversion can result in a significant increase in the incidence of a dislocation because of an impingement of the neck of the stem onto the rim of the acetabular component [3]. Moreover, component impingement has been cited as a factor contributing to the accelerated wear, cracking, and noise production [4].

Femoral anteversion is defined as the angle in the transverse plane determined on the femur between the femoral neck axis (FNA) and the distal femoral condylar axis (DFCA). Often the posterior femoral condylar axis (PFCA) is used as a DFCA [5–8]. Femoral anteversion has been measured by fluoroscopy, radiography, radiography, ultrasound, MRI, or computed tomography (CT) [9–14]. Of these methods, cross-sectional CTs provide the most accurate measurements of femoral anteversion [7].

The posterior lesser trochanter line (PLTL) [15] has been devised as a new method, which precisely estimates the FNA with reasonable reliability. We hypothesized that the PLTL might provide a useful means of estimating the femoral anteversion, and thus the femoral stem anteversion during THA. We asked 2 questions: (1) Is there a pattern in the FNA, PLTL and DFCA, and if so, how do they show? (2) Is there a relationship between the PLTL and femoral anteversion, and if so, how well do they correlate? To answer these questions, we investigated the relationship between the FNA, PLTL, and DFCA using CT scans. The aim of this study was to introduce a simple and reliable intraoperative reference guide to reproduce the proper femoral anteversion during THA when the posterolateral approach is used.

Materials and Methods

Between March 2008 and December 2011, 137 Vietnam War veterans underwent 3-dimensional computed tomographic angiogram (3D-CTA) (Sensation 64; Siemens Medical Solutions, Erlangen, Germany), which was part of national inspection for Agent Orange sequelae involving a blood vessel (atherosclerosis). Agent Orange exposure has caused cancers and other serious illness [16]. Agent Orange exposure has also induced bone toxicity in the animal and developing human [17–20]. However, there has been no report on the direct harmful effect of Agent Orange exposure to the adult hip joint. All the subjects were males. The study exclusion criteria were (1) evidence of femoral fractures, (2) metal implant or deformity in the proximal or distal femurs, and (3) more than grade 2 osteoarthritic changes [21] in the hip or knee joint. The exclusions were based from

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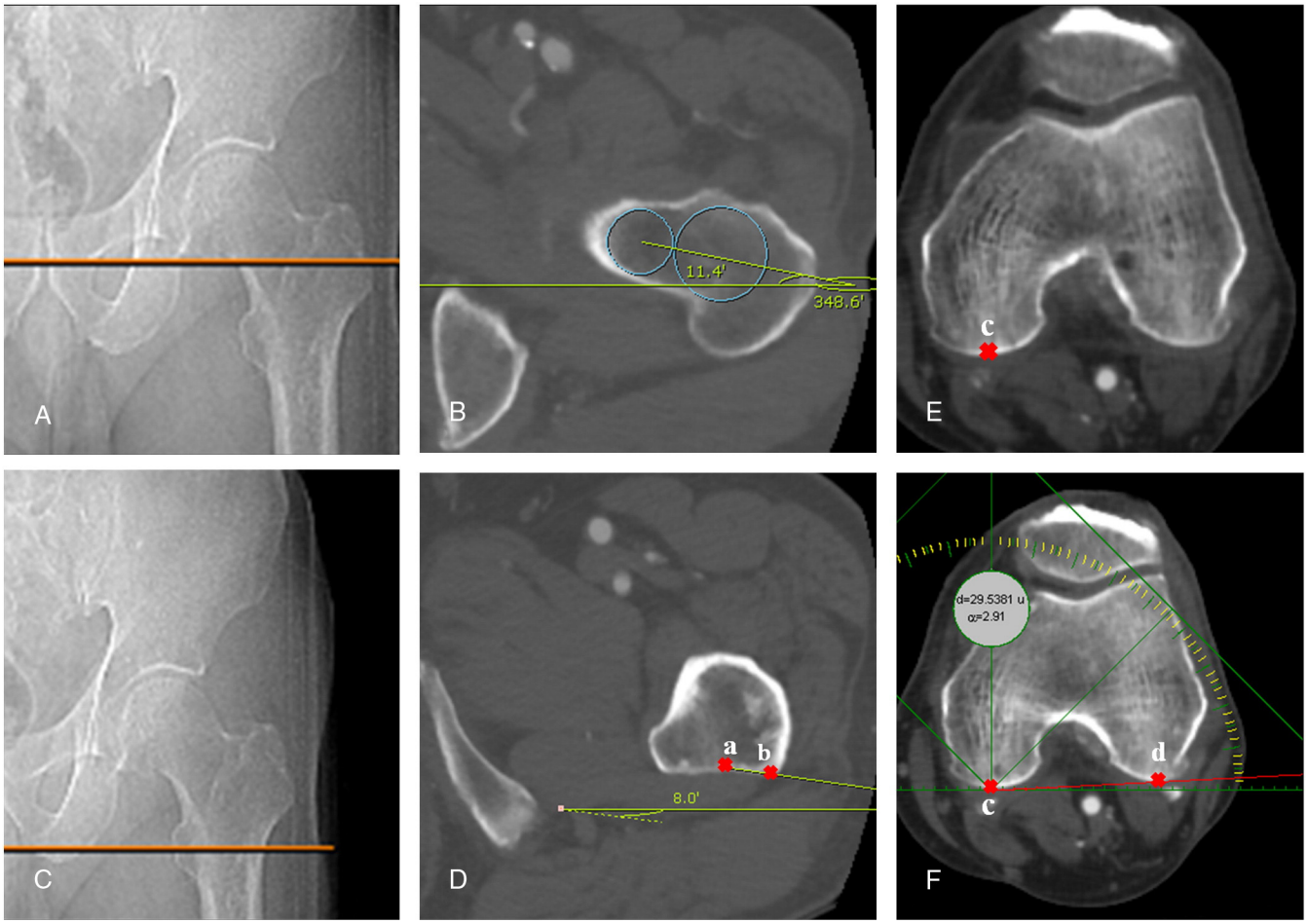

Fig. 1. Measurement of the angles (A–B) between the femoral neck axis and horizontal plane, (C–D) between the posterior lesser trochanter line and the horizontal plane, (E-F) between the posterior femoral condylar axis and the horizontal plane. (a) Base of the posterior lesser trochanter; (b) posterior cortex of the femur, which was adjacent to the lateral cortex of the femur; (c) the lowest point of the medial posterior femoral condyle; *d*, the lowest point of the lateral femoral condyle.

conventional radiographs. After applying these exclusion criteria, we had 56 men (112 hips) with a mean age 60.9 ± 3.9 years (range, 53–73 years) in our retrospective evaluation. All measurements were performed on the both side of the body.

All 3D-CTAs were performed such that every patient was supine and symmetrically positioned in the scanner as shown by the scout views, and in each patient the region from the level of the fourth lumbar vertebra proximally to 5 cm below the level of 1st tarsometatarsal joint was scanned. A support placed beneath the ankles was used to fix the rotational position of the extremity. Each examination was performed using a 2-mm slice thickness, and reconstruction was performed from raw data using 2-mm slices and 1-mm intervals. The images were imported into the Virtuoso software package (Siemens Medical Solutions) in generic DICOM (Digital Imaging and Communications in Medicine) format for measurements. All measurements were made using axial CT images.

CT Measurement

The angles (FNA, PLTL and DFCA) were measured using image-processing software (πViewSTAR, version 5080, Infinitt, Seoul, South Korea). First, CT images stored in a picture-archiving and communication system (PACS; Infinitt) were displayed on a 17-inch (1280×1024 pixels) liquid crystal display monitor (SyncMaster, Samsung, Seoul, South Korea). Second, a proximal slice was obtained

Table 1
Angles Measurement Results With 95% Confidence Interval.

Angle	Right Femur (N = 56)	Left Femur (N = 56)	Total (N = 112)
FNA	3.6° ± 7.8 (1.6° to 5.6°)	4.6° ± 7.1 (2.7° to 6.5°)	4.1° ± 7.4 (2.2° to 6.0°)
PLTL	−12.6° ± 8.1 (−14.7° to −10.5°)	−13.2° ± 8.2 (−15.3° to −11.1°)	−12.9° ± 8.1 (−15.0° to −10.8°)
PFCA	−5.4° ± 7.2 (−7.3° to −3.5°)	−4.4° ± 6.3 (−6.1° to −2.7°)	−4.9° ± 6.7 (−6.7° to −3.1°)
PLFA	16.2° ± 6.3 (14.5° to 17.9°)	17.8° ± 7.9 (15.7° to 19.9°)	17.0° ± 7.2 (15.1° to 18.9°)
PPA	−7.2° ± 10.0 (−9.8° to −4.6°)	−8.8° ± 8.7 (−11.1° to −6.5°)	−8.0° ± 9.4 (−10.4° to −5.6°)
FA	9.0° ± 8.8 (6.7° to 11.3°)	9.0° ± 7.4 (7.1° to 10.9°)	9.0° ± 8.1 (6.9° to 11.1°)

N, number of hips; FNA, angle between the femoral neck axis and horizontal plane; PLTL, angle between the posterior lesser trochanter line and horizontal plane; PFCA, angle between the posterior femoral condylar axis and horizontal plane; PLFA, angle found by subtracting the PLTL angle from the FNA angle; PPA, angle found by subtracting the PFCA angle from the PLTL angle; FA, femoral anteversion.