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Difference in Stem Alignment Between the Direct Anterior Approach and the Posterolateral Approach in Total Hip Arthroplasty

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ABSTRACT

The purpose of this study was to investigate the effects of different surgical approaches, the posterolateral approach (PLA) and the direct anterior approach (DAA), on postoperative femoral anteversion and stem coronal and sagittal alignment in total hip arthroplasty (THA), and to identify the factors related to postoperative femoral anteversion and stem alignment. A total of 209 hips of 181 patients were evaluated. THA was performed through the PLA in 80 hips and through the DAA in 129 hips. Femoral anteversion and stem alignment were measured on postoperative computed tomography images. The factor related to postoperative anteversion change was preoperative femoral anteversion, and the surgical approaches did not affect the postoperative anteversion change, while surgical approach did have an effect on stem sagittal alignment.

Malalignment of the cup and the stem has been reported to cause impingement-related complications including dislocation, accelerated wear or breakage of the bearing, and component loosening in total hip arthroplasty (THA) [1–3]. Better implant placement may allow for less restriction of daily activities related to range of motion (ROM) [4], followed by producing a greater quality of daily life. The combined cup and stem anteversion theory is better than the sole cup safe zone concept to avoid implant impingement [5–7]. Therefore, to achieve ideal implant positioning, not only cup anteversion, but also stem anteversion should be considered. In addition, sagittal stem alignment, which might affect stem anteversion, should be appreciated [8].

When the combined cup and stem anteversion is considered in preoperative planning, the native femoral anteversion can be used to predict postoperative stem anteversion. However, some studies have reported that stem anteversion often increased from the native femoral anteversion [9,10]. The stem alignment and anteversion in the femur may change in the same femur through different surgical approaches. It has been reported to be more difficult to implant the femoral component in the neutral position on the sagittal plane through the anterolateral approach than posterolateral approach (PLA) due to the difficulty of elevation of the proximal femur [11]. The same tendency might be shown through direct anterior approach (DAA). In addition, stem anteversion may be controlled more accurately through the PLA. However, no study has reported whether different approaches affect postoperative stem alignment and stem anteversion.

Our hypothesis is that surgical approaches affect postoperative anteversion and femoral component sagittal and coronal alignment. The purposes of this study were: (1) to elucidate the effects of surgical approaches, the DAA and the PLA, on the differences between preoperative femoral native anteversion and postoperative cementless anatomical femoral stem anteversion, as well as postoperative stem sagittal and coronal alignment; (2) to investigate whether stem alignment affects postoperative stem anteversion; and (3) to investigate the factors related to stem anteversion and stem alignment using computed tomography (CT) images.

Materials and Methods

This was a retrospective study using preoperative and postoperative CT images. A total of 267 hips in 228 patients who underwent primary THA by a single surgeon (NS) using an anatomical stem (CentPillar; Stryker Orthopaedics, Cork, Ireland) between January 2005 and December 2012 at our institution were included in the present study. Patients with a history of femoral osteotomies or femoral fractures (8 hips), hips with metal on metal (1 hip) or ceramic on ceramic bearings (5 hips), Perthes-like deformity (2 hips), and lack of postoperative CT data (42 hips) were excluded because the changes of femoral anatomy, metal artifacts on CT images, and the boundary obscureness of ceramic on ceramic bearings disrupted accurate

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measurement. The remaining 209 hips in 181 patients (13 males, 168 females) were included. The mean age at operation was 60 years (range 24 to 85 years), and the BMI was 22.8 (range 15.6 to 35.5 kg/m^2). The preoperative diagnosis was osteoarthritis in 180 hips, osteonecrosis of the femoral head in 20 hips, rapidly destructive coxopathy in 7 hips, rheumatoid arthritis in one hip, and chondrodysplasia in one hip. A metal on polyethylene bearing was used for 43 hips, and a ceramic on polyethylene bearing was used for 166 hips. Concerning the preoperative Dorr type [12], 61 hips were Dorr type A, 123 hips were Dorr type B, and 25 hips were Dorr type C. The mean preoperative canal flare index (CFI) [13] was 4.1 (range 2.4 to 5.9), and the mean preoperative cortical index (CI) [14] was 0.6 (range 0.3 to 0.7). The mean implanted stem size was 6 (range 3 to 8). A total of 129 hips were implanted through a DAA (DAA group), and the remaining 80 hips were implanted through a PLA (PLA group). Preoperative 3-dimensional (3D) planning of the femoral component was performed to achieve the maximum fit and fill for the femoral canal, to achieve no leg length discrepancies postoperatively, and to perform the actual surgery. High accuracy of 3D planning has been reported [15]. For the surgical approach, patients with restriction of range of motion under 60 degrees flexion or with need for more than 2 cm leg lengthening were selected for PLA. Either approach was selected for other patients by a surgeon.

Preoperative and postoperative CT images of the femur were used for this study. Anteversion and alignment of the stems were measured on CT images with 3D template software (Kyocera Medical Material, Osaka, Japan).

A 3-dimensional surface model was constructed with CT scan images of the femur in the supine position, obtained with a helical scanner (HiSpeed Dx/i, GE Medical Systems, Milwaukee, WI, USA) preoperatively and postoperatively. The coordinate systems were built on the surface models according to the following definitions. The coordinate system of the femur consisted of the retrocondylar plane and the femoral axis projected on the retrocondylar plane based on the discrete points on the surface model. The retrocondylar plane included the most posterior points of the medial femoral condyles (MFC) and the lateral femoral condyle (LFC) [16], and the most posterior points of the greater trochanter of the femur (Fig. 1). The femoral axis was the line between the knee center and the trochanteric fossa. The unit vectors of the femoral coordinate system were defined as follows: the X axis was perpendicular to the retrocondylar plane; the Y axis was the line on which the femoral axis was projected on the retrocondylar plane; and the Z axis was perpendicular to the X and Y axes. The axial plane was defined as the plane containing the X axis and the Z axis. The coronal plane was defined as the plane containing the X axis and the Y axis. The sagittal plane was defined as the plane containing the Y axis and the Z axis.

The proximal femoral bone axis was defined as the line between the center of the canal at the lesser trochanter and the center of the canal at the isthmus. Center of the canal was detected by fitting the circle to the canal. The femoral stem axis was defined as the axis of the distal portion of the stem as set by the manufacturer.

Preoperative anteversion was measured at the head–neck junction on the axial plane. At the head–neck junction plane, we fit the two circles to the cortex, and draw the line between the centers of the two circles. The angle between the Z axis and the line was defined as the naïve preoperative anteversion. Postoperative anteversion was measured at the head–neck junction on the axial plane. We fit a circle to the neck, and we draw the line between the center of the circle and the femoral head center. The angle between the Z axis and the line was defined as the postoperative artificial neck anteversion. The change of anteversion was calculated as follows: the change of anteversion (°) = postoperative anteversion (°) − preoperative anteversion (°) (Fig. 2).

The femoral tilt was measured as the angle between the Y axis and the proximal femoral bone axis on the sagittal plane. The stem sagittal tilt was measured as the angle between the Y axis and the femoral stem axis on the sagittal plane (Fig. 3). The sagittal alignment of the femoral stem was defined as the difference between femoral tilt and the stem sagittal tilt, using the following formula: stem sagittal alignment (°) = stem sagittal tilt (°) − femoral tilt (°). A negative value less than −3° was defined as flexed implantation, and a positive value more than 3° was defined as extended implantation (Fig. 4).

Femoral lateral bowing was measured as the angle between the Y axis and the proximal femoral bone axis reflected on the coronal plane. Positive value means lateral bowing, and negative value means medial bowing. The stem coronal angle was measured as the angle between the Y axis and the femoral component axis on the coronal plane (Fig. 3). The coronal alignment of the femoral stem was defined as the difference between femoral lateral bowing and the stem coronal angle, using the following formula: stem coronal alignment (°) = stem coronal angle (°) − femoral lateral bowing (°). A negative value less than −3° was defined as valgus implantation, and a positive value more than 3° was defined as varus implantation.

We investigated the intraobserver reliability and the interobserver reliability by two observers (HA and TS) of these measuring method

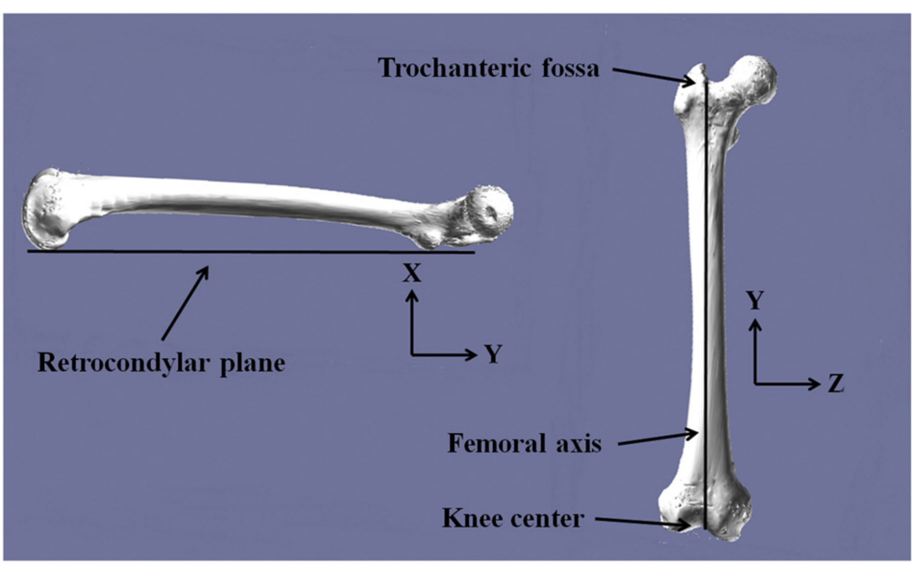

Fig. 1. Definition of the femoral coordinate system. The coordinate system of the femur consists of the retrocondylar plane and the femoral axis projected on the retrocondylar plane based on the discrete points on the surface model. The retrocondylar plane includes most posterior points of both femoral condyles and most posterior points of the greater trochanter of the femur. The femoral axis is the line between the knee center and the trochanteric fossa. The unit vectors of the femoral coordinate system are defined as follows: the X axis is perpendicular to the retrocondylar plane; the Y axis is parallel to the line that is the femoral axis projected on the retrocondylar plane; and the Z axis is perpendicular to the X and Y axes.