The Effect of Pelvic Tilt on Functional Anteversion and Inclination

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Introduction: The effect of sagittal pelvic tilt on the functional anteversion of an acetabular component in total hip arthroplasty (THA) has been widely recognized. Proponents of imageless navigation suggest that optimal component position can be attained with tilt adjusted acetabular component positioning to attain a combined anteversion between 25 and 50° (1). However, the impact of anteversion and pelvic tilt on the functional inclination of the cup has not been widely acknowledged, since the change in functional inclination is relatively small when the cup is positioned with 15° anteversion and pelvic tilt changes. Our hypothesis is that the effect of pelvic tilt on functional inclination becomes significant with increased acetabular component anteversion. If a surgeon is unaware of this, then a cup positioned with more anteversion in a patient with pelvic tilt, may have a higher than anticipated functional inclination. We utilized a three-dimensional computer model of the pelvis and an acetabular component to investigate the relationship between cup position and pelvic tilt.

Methods: An anatomically accurate three-dimensional model of the pelvis was obtained from BodyParts3D (Database Center for Life Science, The University Of Tokyo, Tokyo, Japan) and rendered in Matlab 2013a (The MathWorks Inc., Natick, MA) with the center of rotation (COR) of the left acetabulum at the origin of the coordinate system. Sagittal pelvic tilt was measured using the anterior pelvic plane (APP), which is defined by the left and right anterior-superior iliac spines (ASIS) and the pubic symphysis. Neutral or 0° of pelvic tilt was defined when the APP was aligned to the coronal plane or the radiographic view of the pelvis (in a sagittal profile of the pelvic model the ASIS were in line with the pubic symphysis). Radiographic inclination and anteversion measurements of the acetabular component, as defined by Murray et al (2), were used to measure the position of the acetabular component, as defined by Murray et al (2), were used to measure the position of the acetabular component. A 50 millimeter 180° hemispheric acetabular shell was positioned with its COR at origin, 40° radiographic inclination and 0° radiographic anteversion. The pelvis and acetabular shell were rotated through the COR of the hip to create 30° of anterior (positive value) and posterior (negative value) tilt in 1° increments. Functional radiographic anteversion and inclination of the acetabular shell was the radiographic anteversion measurement of the pelvis with varying degrees of anterior and posterior tilt. This sequence was repeated for a range of radiographic anteversion from 0° to 40°.

Results: The impact of pelvic tilt on functional radiographic anteversion was a relatively linear relationship for all values of anteversion with a mean of 0.74° increase in functional anteversion for each degree increase in tilt when the inclination of the cup was 40° (Fig. 1). In contrast, there is a steep increase in functional radiographic inclination when anteversion and pelvic tilt increased in combination. At 0° of anteversion there was a mean of 0.02° change in functional inclination per degree increase in pelvic tilt. This increased to 0.21° per degree, 0.44° per degree and 0.66° per degree at 15°, 30° and 40° of anteversion respectively. At any given radiographic anteversion, there is a nonlinear change in functional inclination as the pelvis tilts posteriorly (Fig 2a). While the impact of pelvic tilt on 40° inclination is limited at 15 degrees of anteversion, there is a 15° increase in functional inclination when anteversion is increased to 30° anteversion with 25° posterior tilt (Fig 2b, 2c).

Discussion: In conclusion, the results of this study demonstrate that increased pelvic tilt and anteversion in combination can significantly impact acetabular component inclination. This has implications, since steep cups have been associated with complications and high wear rates (3). The optimal acetabular component position for a patient avoids postoperative complications such as wear, impingement and dislocation. Correcting for pelvic tilt may improve the reliability of attaining optimal component position in the functional positions.

Significance: Pelvic tilt in certain positions such as standing and sitting directly effects the functional inclination and anteversion of the acetabular component. Positioning a cup with more anteversion in a patient with posterior pelvic tilt, may result in a higher than anticipated functional inclination. Therefore, it is important for surgeons to be aware of this.

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