Comparison of Kinematic Analysis between 28, 32, 36 mm Femoral Heads during Squatting after Total Hip Arthroplasty

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INTRODUCTION:

The influences of the femoral head size on in vivo kinematics during deep flexing motion as squatting after total hip arthroplasty (THA) is unclear. The purpose of the present study was to determine the difference of the range of motion and to affect the prosthetic impingement between 28, 32, 36 mm femoral heads during squatting after THA using the two-dimensional to three-dimensional (2D/3D) registration technique.

METHODS:

33 hips in 29 patients, 28 females and 1 male, who underwent primary cementless THA using the CT-based navigation system (CT-THA, Striker, Germany) were investigated using a flat panel detector. The mean age of the patients was 58 years (43-78 years). On the acetabular side, a socket with concavities around the rim (TriAD HA PSL, Stryker, NJ) and a highly cross-linked polyethylene flat insert (Crossfire, Stryker) were used (Fig. 1a). On the femoral side, an anatomical stem with reduced neck geometry (CentPillar GB, CentPillar TMZF, Stryker) and a 28 mm, 32 mm, or 36 mm diameter head were used. In the preoperative planning using the navigation system, cup orientation was targeted at 40° for radiographic inclination, 15° for radiographic anteverision and adjusted depending on the femoral neck anteverision. The present study was performed with the approval of our institutional review board. Informed consent was obtained from all patients.

After we confirmed that the patients could squat, the patients were instructed to squat down to the maximal attainable depth and to return to the standing position with maintaining of heels down throughout the movements (Fig. 2). Successive hip motion was recorded as serial digital X-ray images. The motion of the acetabular component and femoral component based on the neutral standing position were analyzed using the 2D/3D registration technique (Fig. 1b). Changes of angle of the acetabular and femoral components estimated by employing Carden/Euler angle system.

The root-mean-square-errors (RMSE) of rotation or translation of the 2D/3D registration technique for the THA component was less than 0.3° or 0.7 mm in-plane direction, and less than 1.7° or 2.4 mm out-of-plane direction.

We estimated changes hip flexion angles (HFA), the pelvic posterior tilting angle (PA), and the femoral flexion angle (FA) during squatting. In addition, we estimated the minimum angle (MA) up to the prosthetic impingement theoretically when both components were positioned most closely during squatting. Kruskal-Wallis test was performed between 28, 32, 36mm femoral heads. Differences with p-values less than 0.05 were considered significant.

RESULTS:

No impingement occurred during squatting in any hips megascopically. The maximum HFA was mean 89.1±13.0° (55.1°-117.4°) and 20 hips showed from 80° to 100°. The maximum PA was mean 28.7±11.5° (5.6°-98.5°), less than 15° in 4 hips and more than 40° in 6 hips. The maximum FA was mean 117.8±11.7° (86.4°-136.7°), more than 110° in 27 hips. MA was mean 24.8±7.5° (10.0°-37.9°), and 2 hips showed less than 15°.

In 28 mm heads (N = 9 hips), the mean maximum HFA was 88.4±13.0° (55.1°-117.4°) and the mean MA was 18.5±7.3° (10.0°-34.6°). In 32 mm heads (N = 10 hips), the mean maximum HFA was 88.5±4.7° (78.9°-106.0°) and the mean MA was 25.2±7.3° (15.6°-36.5°). In 36 mm heads (N = 14 hips), the mean maximum HFA was 91.8±29.7° (78.7°-109.8°) and the mean MA was 28.8±4.6° (24.0°-37.9°). There were statistical significant differences in MA (P<0.01) though there was no significant difference in maximum HFA between 28, 32, and 36mm heads (Fig. 3).

DISCUSSION:

Numerous studies including computer simulation models and experimental models have reported that the effects of femoral head size on impingement-free range of motion after THA. However, to our knowledge, the comparison of in vivo kinematics during squatting after THA between 28, 32, 36 mm femoral heads has not been reported. In the present study, the maximum HFAs were not related with the femoral head diameter. Our results of MA agreed with these previous reports the effectiveness of using larger femoral heads.

SIGNIFICANCE:

Concerning in vivo kinematics of squatting after THA, there was no difference of the maximum hip flexion angles between 28, 32, 36 mm heads, whereas the minimum angle up to theoretical prosthetic impingement increased significantly as the femoral head diameter was larger.

Fig. 1 (a) A hydroxyapatite-coated socket with concavities around the rim (arrows), a highly cross-linked polyethylene insert, and an anatomical stem with reduced neck geometry. (b) The 2D/3D registration technique

Fig. 2 Squatting motion after THA. The forth picture from the left showed the maximum squatting. X-ray images (lower stand) were matched by the CAD models using the 2D/3D registration technique.

Fig. 3 Maximum hip flexion ROM and MA between 28, 32, 36mm femoral heads during squatting after THA

*Kruskal-Wallis test between 28, 32, 36mm femoral heads. P<0.05 indicates significant difference.