INTRODUCTION: Dislocation continues to be a common complication of total hip arthroplasty (THA), affecting 2% to 11% of primary cases. Many factors affect the prevalence of dislocation after THA, including soft tissue laxity, surgical approach, component position, patient factors, and component designs [1,2]. Many in vitro studies have reported the range of motion (ROM) of the hip, impingement, and dislocation mechanisms, and several studies have reported the ROM and dislocation mechanisms in vivo [3,4]. Recently, we investigated the dislocation mechanism in vivo using shape matching technique [3], and also measured intraoperative passive hip force using sensor-instrumented femoral head for analyzing the dislocation mechanisms [5,6]. Sultan et al. reported increased intraoperative ROM using elevated-rim acetabular liner and large diameter femoral head [4]. However, to the best of our knowledge, it has not been reported the relationship between the component positions and in vivo ROM and stability.

MATERIALS AND METHODS: 102 hips (100 patients) undergoing primary THA between May 2009 and July 2011 were enrolled in this study. The project was approved by IRB. All of the procedures were performed in a lateral decubitus position, using a posterolateral approach without trochanteric osteotomy. All components were determined intraoperatively using a standard fashion, then fixed in position. The acetabular component was inserted with a line-to-line fit or 0.5mm under reaming, and was intended to be placed at 45° of abduction and 20° of anteversion. Femoral neck length and offset were determined based on preoperative templating, then minor adjustments were made intraoperatively when necessary to optimize abductor tension to achieve optimal stability. Total capsulectomy was performed, and an effort was made to remove any osteophytes that were deemed to be potential causes of postoperative impingement.

After all components were placed into position, the femoral head was observed independently by the assistant surgeon while the hips were ranged by the senior surgeon. The point of instability was determined by direct visual inspection and was predefined as the position at which the femoral head began riding out of the liner. With a 90° flexion of the hip joint, the range of internal rotation with 0° abduction/adduction was measured using a goniometer (IR angle), similar to Sultan et al. [4]. Hips also were tested for anterior dislocation in the position of maximum external rotation of 0° extension.

During this time, senior surgeon operated 139 THAs at one hospital. To be included in the analysis, the following was required: primary THA, single surgeon, ROM data available, and Computed tomography (CT) data available. During this time, CT scanning was routinely performed 1 to 2 weeks after the surgery. 37 hips were excluded, so 102 hips were included and analyzed in this study. The average age at the time of operation was 63 years (39 to 87). Their average weight and height were 57.8 kg (37.8 to 88.6) and 154 cm (133 to 180). Twenty three patients were men and 77 were women. There were 52 right hips and 50 left hips. The diagnosis was osteoarthritis in 83 (81.2%), osteonecrosis of the femoral head in 9 (8.8%), rheumatoid arthritis in 5, and femoral neck fracture in 4, and rapidly destructive coxopathy in 1. Eighty four (82%) femoral components were cemented (4-U: Nakashima Medical Co., Japan) [7,8] and 18 uncemented (S-ROM; Depuy, IN). All acetabular components were uncemented. There were 70 4-U cup (Nakashima Medical Co.), 25 Trilogy cup (Zimmer, IN), and 7 ZTT-2 cup (Depuy). The diameter of the prosthetic femoral head was 22 mm in 1 hip, 26 mm in 73 hips, 28mm in 12 hips, and 32mm in 15 hips. The average outer diameter of the acetabular component was 55mm (42-60). The standard flat liner was used in 49 hips and the elevated liner was used in 52.

The following variables were measured and investigated: (a)cup abduction; (b)cup anteversion; (c)stem anteversion; (d)female head diameter; (e)liner type (flat vs elevated). Cup anteversion and stem anteversion were measured from CT data, according to the method of Mian et al. [9] and the method of Pierchon et al. [10]. The abduction angle of the cup was measured according to the method of Lewinnek et al. [11], respectively.

Component positions affect in vivo stability of Total Hip Arthroplasty

Statistical analysis. The Pearson correlation coefficient was used to assess correlation between variables and ROM (IR angle). Then, multivariate analysis (stepwise linear regression) was used to determine which variables influenced ROM (IR angle). Variables that were nonsignificant predictors of the ROM outcome were eliminated in a stepwise fashion until only those that were significant remained. Thus, variables included in the final linear regression model were all significant copredictors of the ROM. Statistical analyses were performed with SPSS version 19 (SPSS Inc., IL).

RESULTS: Mean IR angle was 57° (15-91). None of the hips could be dislocated anteriorly during ROM testing. The mean cup abduction was 42.1° (24 to 60). Mean cup anteversion was 16.6° (-20 to 57), retroversion of the cup was found in 10. The mean stem anteversion was 39.1° (1 to 67). Cup abduction, cup anteversion, and stem anteversion were significantly and positively related to IR angle (p=0.011; r=0.228) (p=0.018; r=0.207) (p=0.000; r=0.532). We could demonstrate no significant correlation between head size and IR angle, liner type and IR angle. Multiple regression was used to determine the relative importance of each of the variables. Cup abduction, cup anteversion, and stem anteversion predicted the IR angle. Increasing cup abduction, cup anteversion, and stem anteversion correlated with increased IR angle. Interpretation of the standardized coefficients in the regression model, where a measure of each variable’s effect on the dependent variable, revealed stem anteversion had the strongest effect on the IR angle, followed by cup abduction, and cup anteversion (Table 1).

Table 1. Variables significant to IR angle

<table>
<thead>
<tr>
<th>Variables</th>
<th>β Coefficient</th>
<th>Lower</th>
<th>Upper</th>
<th>Standardized Coefficient</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>cup abduction</td>
<td>0.580</td>
<td>0.241</td>
<td>0.919</td>
<td>0.268</td>
<td>0.001</td>
</tr>
<tr>
<td>cup anteversion</td>
<td>0.191</td>
<td>0.031</td>
<td>0.352</td>
<td>0.186</td>
<td>0.020</td>
</tr>
<tr>
<td>stem anteversion</td>
<td>0.603</td>
<td>0.432</td>
<td>0.774</td>
<td>0.554</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

DISCUSSION: This study investigated the relationship between the component positions and in vivo ROM and stability, and the results showed cup abduction, cup anteversion, and stem anteversion were significantly related to in vivo ROM and stability. Nishii et al. investigated component positions using CT, and reported cup anteversion, not cup abduction and stem anteversion, was related with dislocation after THA [12]. Pierchon et al. did not find statistical difference between the dislocated hips and the control group with respect to cup abduction, cup anteversion, and stem anteversion analyzing CT [10]. These studies analyzed the component positions using CT, and the relationship between the component positions and the incidence of dislocation. This study analyzed the relationship between the component positions and in vivo ROM and stability. ROM should be more affected by component positions compared with the incidence of dislocation, because many factors, not only component positions, affect the incidence of dislocation. From the results of this study, component positions affect the range of internal rotation with a 90° flexion of the hip joint, and stem anteversion had the strongest effect on ROM. For increasing IR angle to prevent posterior dislocation, increasing stem anteversion can be a choice for surgeons, especially when posterolateral approach is used.


Significance: Cup abduction, cup anteversion, and stem anteversion affect in vivo ROM and stability of THA. Stem anteversion had the strongest effect on the internal rotation angle with a 90° flexion of the hip joint.