INTRODUCTION:
Posterior pelvic tilt (PT) in elderly patients due to the lumbosacral kyphosis, or the patients with ankylosing spondylitis results in the excessive anteversion of the acetabular component and sometimes leads to the anterior instability after total hip arthroplasty (THA) (Fig.1). Large changes of PT in between prone and standing position may mislead surgeons about the implant placement. The purposes in this study was to clarify the effects of (1) PT on ROM quantitatively using a THA model, (2) anteversion of acetabular component on ROM in cases with posterior PT, and (3) the increase of femoral offset on ROM in cases in which sufficient ROM could not be achieved.

RESULTS:

Posterior PT and ER
Posterior PT resulted in an increased acetabular anteversion and led to a decreased ER in a posterior PT-dependent manner (Fig. 3). In the case with 20° acetabular anteversion, the decrease of ER was almost linear and the rate was −0.83° per degree of posterior PT (R² = 0.987). The site of impingement was bony impingement from 0° to −20° PT. It changed to the implant impingement at less than −20° PT. In cases with PT of −20° or less, ER was out of rROM (ER ≥ 30°).

Anteverision of Acetabular Component and ROM
Decreasing acetabular anteversion improved limited ER (Fig. 3). More anterior coverage led to more jumping distance of the femoral head in the case with posterior bony impingement. However, a decrease in acetabular anteversion resulted simultaneously in decreased IR (Fig. 4). In the case with less than 0° acetabular anteversion, IR failed to reach the rROM (IR ≥ 40°).

Femoral Offset and ROM
Use of the +4-mm femoral offset resulted in improved ROM in ER by delaying bony impingement (Fig. 5). This improvement was not accompanied with a decrease in IR (data not shown). In the case with 20° acetabular anteversion, PT that satisfied rROM of ER enlarged from −10° to −20°.

Conclusions:
Excessive posterior PT may lead to anterior dislocation by increasing acetabular anteversion. There is a narrow range for the optimal acetabular placement in cases with posterior PT. Increasing the femoral offset partly improved ER without reducing IR.

Fig. 3 Effects of posterior PT on ER. ER decreased in a posterior PT-dependent manner. A bold line indicates the rROM (ER ≥ 30°). AA, acetabular anteversion.

Fig. 4 Effects of acetabular anteversion on IR. In the case with acetabular anteversion less than 0°, IR failed to reach the rROM. A bold line indicates the rROM. AA, acetabular anteversion.

Fig. 5 Effects of femoral offset on ER. Use of +4-mm offset resulted in improvement of ER by delaying bony impingement. A bold line indicates the rROM. B, bony impingement; I, implant impingement.

METHODS:

THA Model
We developed a THA model as described previously. Cementless THA (Japan Medical Material, Osaka, Japan) was implanted into a model of pelvis and femur (Sawbones, Vashon, WA) with head diameter 28mm and with neck length +3mm. The anteversion of acetabular component can be finely adjusted in accordance to the radiographic definition described by Murray (Fig. 2). This model was further modified in this study; the femoral axis had 7° of freedom of motion when impingement occurred. Therefore dislocation following impingement could be mimicked.

Measurement
The anterior pelvic plane (APP), defined by anterior superior iliac spines and pubic symphysis, was used as the reference for PT. The PT was positive in the case of anterior PT and negative in the case of posterior PT. To reconstruct posterior PT, we configured the APP from 0° to −40° with a 10° increment around the axis connecting femoral head centers. To evaluate ROM, the ranges until impingement and dislocation were measured. We determined two ranges of motion: (i) external rotation with 0° of both extension and abduction (ER), (ii) internal rotation at the ranges of flexion from 50° up to 90° with 0° of abduction (IR). In addition, we recorded the site where impingement occurred. All measurements were performed in triplicate; the average was used as the ROM. The acetabular anteversion was varied from −10° (10° retroversion) to 30° with a 10° increment. Two different femoral offsets were tested: standard (0 mm offset) and 4-mm lateral (+4 mm offset). We defined a required ROM (rROM) as having +30° of ER with 0° of extension, and +40° of IR with 90° of flexion using the range of hip motion required for everyday life.

Fig. 1 A case with severe posterior pelvic tilt. 71 years-old woman. Acetabular component is markedly anteverted in standing position. (A): prone position (B) standing position (C): standing position, lateral view.

Fig. 2. THA model
(A): Sawbone pelvis was installed so that APP was perpendicular to the ground. (B): the built-in goniometer was attached to the femoral axis (B).

Fig. 4 Excessive anteversion of the acetabular component resulted in bony impingement in cases with posterior PT.

Fig. 5 Excessive anteversion of the acetabular component resulted in implant impingement in cases with posterior PT.

References

APP