A simple method to minimize limb-length discrepancy after hip arthroplasty

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Background **Limb-length discrepancy is not uncommon after total hip arthroplasty. To minimize such discrepancies, we introduced a simple method to select an appropriate modular head during surgery.**

Patients and methods **We used this method in 45 hips, and compared the outcome with that of a historical control group of 47 hips. Both groups received cementless femoral components with modular heads of 4 different neck lengths. In the study group, we calculated the ideal distance between the center of the modular head and lesser trochanter on a preoperative AP radiograph. During surgery, we measured the actual distance between the center of trial heads and the lesser trochanter with a ruler, and selected the head in which the measured distance was closest to this distance. In the control group, we had selected a modular head based on preoperative planning.**

Results **The study group had a smaller mean postoperative limb-length discrepancy (2 (SD 2) mm) than the controls (7 (SD 4) mm).**

Interpretation **This simple technique reduces limb-length discrepancy after cementless total hip arthroplasty.**

To minimize limb-length discrepancy after THA, preoperative planning using templates and radiographs is commonly used. However, in cementless THA, it is difficult to predict the position in which a femoral component can be fixed rigidly by press-fit. In modular femoral components, surgeons can adjust limb-length during surgery by selecting a modular head having appropriate neck length among several modular heads. However, a standard method for appropriate modular head selection has not been established. We introduced a simple method to select a modular head by measuring the distance between the center of a modular head and the proximal end of the lesser trochanter during surgery. We evaluated the limb-length discrepancy after cementless THA using this method.

Patients and methods

We performed 139 primary THAs without cement between February 2002 and December 2004. We excluded 43 hips in 38 patients who had hip deformities with lower limb shortening requiring future arthroplasty on the contra-lateral side, and 4 severely dysplastic hips in which a simultaneous shortening osteotomy of the femur was performed. This left 92 hips for the study. We introduced our measuring method in August 2003, and used it for all 45 hips operated thereafter. The 47 hips operated before formed the control group. One surgeon (SN) operated all hips (Table).

In both groups, all acetabular components were Trilogy (Zimmer, Warsaw, IN). In the control group, the femoral components were Anatomic (Zimmer) in 38 hips and Versys (Zimmer) in 9 hips. In the study group, they were Anatomic in 1 hip and Versys in 44 hips. Both Anatomic and Versys femoral components have a common modular head system with 4 variations of neck length (0, 3.5, 7.0, and 10.5 mm).

Limb-length discrepancy was assessed using anteroposterior radiographs of the pelvis with a magnification marker before and after surgery, as

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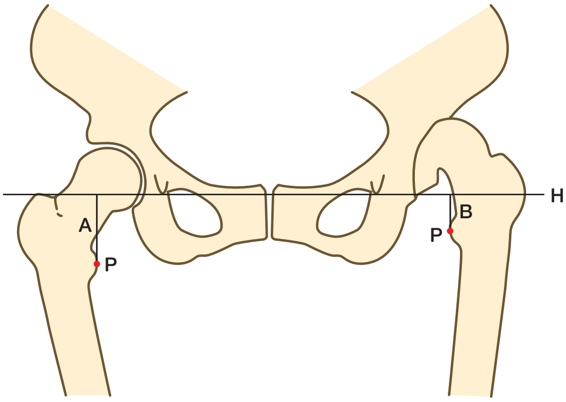

Figure 1. Measurement of limb-length discrepancy before and after surgery on an anteroposterior radiograph of the pelvis. A horizontal reference line (H) was drawn through the inferior aspect of the teardrops (inter-teardrop line). The perpendicular distance between H and the prominent point of the lesser trochanter (P) was measured on both sides. The measured value was defined as A for the contralateral side, and as B for the operative side. The value C was calculated by subtracting B from A: i.e. C = A – B. The value C was defined as the amount of leg lengthening required. It was positive when the indicated side for surgery was shorter than the contralateral side. The absolute value of C was defined as limb-length discrepancy before and after surgery.

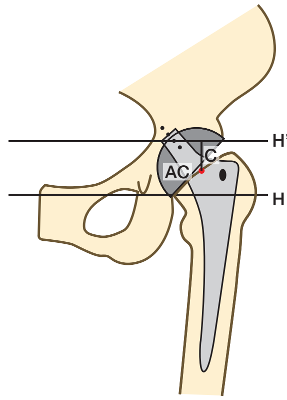

Figure 2. Planning in the control group. An acetabular component and its center (AC) were drawn using a template on the indicated hip in an anteroposterior radiograph. The inclination angle of the acetabular component was set at 45º. Next, the femoral components and 4 points indicating the centers of 4 modular heads (0, 3.5, 7.0, 10.5 mm) were drawn on the femur of the same radiograph. We drew a new horizontal line, H', C mm above the center of the acetabular component. In the few cases in which C had a negative value, this line was C mm below the center of the cup. The line was parallel to the inter-teardrop line (H). After comparing the four centers of the modular heads, the one which came closest to this line was selected as the planned modular head for the appropriate neck length.

described by Ranawat et al. (2001) (Figure 1). The details of preoperative planning in the control and the study group are shown in Figures 2 and 3.

The surgical approach and implant fixation techniques were generally the same in both groups. The patients were placed in the lateral position. A straight skin incision was made slightly oblique from posterior-superior to anterior-inferior. The fascia was exposed and incised in line with the skin incision. The gluteus maximus muscle fibers were split. The capsule and rotators were incised together at the attachment to the femur. The femoral head was dislocated posteriorly and the femoral neck cut with a reciprocating bone saw. The acetabulum was reamed to 1 or 2 mm less than the size of the planned acetabular component. The spherical acetabular component was impacted by free-hand technique. Screws were used for additional fixation and an acetabular liner was inserted. After the femoral canal was prepared with rasps, the femoral component was inserted into the femur until press-fit fixation was achieved.

A modular head was selected for each group as follows. In the control group, we first inserted the

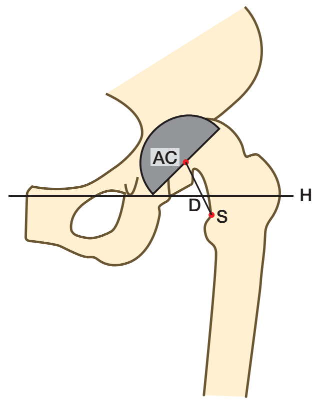

Figure 3. Planning in the study group. For the study group, we measured the distance (D) between the center of the acetabular component (AC) and the superior edge of the lesser trochanter (S). We calculated the planned neck length (E) by adding C (the amount of leg lengthening required) to the distance D. No modular head was selected before surgery.

trial modular head having the pre-planned neck length. We then checked the position of the head, comparing to the tip of the greater trochanter by eye measurement, and changed the modular head only if the position of the head differed appre-

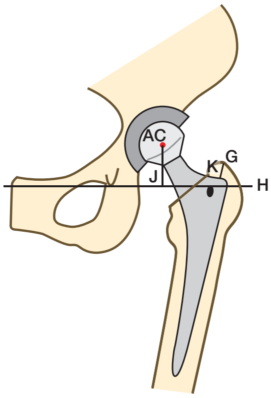

Figure 4. Measurement of component positions on radiographs. The perpendicular distance (J) from the center of the acetabular component (AC) to the inter-teardrop line (H) was measured for evaluation of the acetabular component. The perpendicular distance (K) from the tip of the greater trochanter (G) to the superolateral corner of the femoral component was measured for evaluation of the femoral component.

Patient characteristics and operative records

	Study group	Control group	P-value
Age (years) [a]	60 (12)	62 (11)	0.4
Female/male	35/10	40/7	0.3
OA/AN [b]	34/11	41/6	0.3
Right/Left	28/17	25/22	0.3
Required leg lengthening (mm) [a]	9 (6)	10 (5)	0.2
LLD before surgery (mm) [a]	10 (7)	10 (8)	0.8
LLD after surgery (mm) [a]	2 (2)	7 (4)	< 0.001
DFC [c] (mm) [a]	5 (3)	5 (3)	0.4
DAC [d] (mm) [a]	2 (3)	3 (2)	0.7
Operation time (min) [a]	85 (18)	98 (26)	0.008
Blood loss (g) [a]	354 (222)	336 (217)	0.5

[a] Values are mean (SD).
[b] OA: osteoarthritis; AN: avascular necrosis.
[c] DFC: difference in femoral component position between the planning and the final radiographs.
[d] DAC: difference in acetabular component position between the planning and the final radiographs.

ciably from the preoperative plan. In the study group, we inserted a trial modular head with a 7-mm neck length at first, and then measured the distance between the center of the trial head and the superior edge of the lesser trochanter with a ruler. Based on this distance, we then selected the modular head in which the distance came nearest to the planned neck length. For both groups, after the final modular head was inserted, the hip joint was reduced and the posterior capsule and short rotators were re-attached together to the posterior femur through two drill holes. A wound drainage system was inserted and the wound was closed.

We measured the positions of components in the planning and final radiographs (Figure 4), and calculated the difference of each value. The difference in the position of the femoral or acetabular components was compared between the two groups. The difference in the position of the femoral components was also compared between the two types of femoral components. One of the authors (KM) performed all the radiographic measurements. Operation time and blood loss during surgery were recorded. All patients were followed for at least 3 months.

Statistics

We used Mann-Whitney U-test to compare continuous variables, and Fisher's exact test to compare categorical data between groups. Statistical significance was set at $p < 0.05$.

Results

There were no statistically significant differences in age, sex distribution, and diagnosis characteristics between the study group and the control group. In addition, there were no significant differences in limb-length discrepancy before surgery between the two groups. On the other hand, the study group had significantly less postoperative limb-length discrepancy than the control group (Table 1). The limb-length discrepancy after surgery was less than 5 mm for 40/45 hips in the study group and in 14/47 hips in the control group ($p < 0.001$).

There were no significant differences in the difference of the position of the femoral or acetabular components between the two groups (Table). The mean differences in vertical femoral component position were 5 (range 0–16, SD 3.5) mm for the Anatomic stem and 5 (range 0–15, SD 3.4) mm for the Versys stem, and was no significant difference between the two types of femoral components ($p = 0.7$). There was no significant difference in blood loss, but the LT group had significantly less operation time than the controls (Table 1). During the 3-month follow-up, there was no symptomatic pulmonary embolism or infection in either group.

Discussion

In previous reports in which no intraoperative measurements were performed, the mean limb-length discrepancy after THA was more than 5 mm (Turula et al. 1986, Mizuta et al. 2002). Mean limb-length discrepancy after surgery using intraoperative measurements with pin insertion has ranged from 2.6 mm to 9 mm (Jasty et al. 1996, Ranawat et al. 2001). Several methods of intraoperative measurement without pin insertion have been reported. Eggli et al. (1998) planned surgical procedures on digitized preoperative radiographs and measured the distance between the center of rotation and two landmarks (greater trochanter and neck resection level) during surgery. The mean postoperative leg-length discrepancy reported was 2 mm. However, their planning procedure appears to have been complicated. Woolson et al. (1999) determined the amount of femoral bone needing resection to equalize leg-length in preoperative planning, and chose the modular femoral head before surgery. In their results, the mean leg-length discrepancy was 2.9 mm before surgery and 1 mm after surgery. These authors stated that their technique is ideal for the routine patient who has a minimal preoperative leg-length discrepancy and normal bone anatomy. In their study, a cemented femoral component was used in three-quarters of the cases. Recently, Gonzalez et al. (2005) have reported outcomes after cemented and hybrid THA using intraoperative measurements between the proximal edge of the lesser trochanter and the center of rotation of the femoral head. The postoperative leg-length discrepancy was within 5 mm in 90/103 (87%) of hips. Although the measurement method was similar to ours, cemented femoral components were used for all cases in their study. There has been no report concerning outcome of cementless THA using this type of measurement method.

Our method has some advantages for cementless THA. In the preoperative planning, the position of the femoral component has no influence on the planning of neck length. It is simple and easy to measure the distance between the center of the modular head and the lesser trochanter during surgery. As an anatomical landmark the lesser trochanter seems to be better than the greater trochanter because direct measurement using a simple ruler can be made.

Theoretically, the calculation methods for the planned neck length need some modification as follows. The perpendicular distance (D’) between AC and S should be measured instead of the angled distance D between AC and S (Figure 3). The sum of C and D’ gives the planned perpendicular neck length, and this sum should be adjusted again to the real planned neck length with respect to the angle between the perpendicular line and the line passing through the center of the modular head and the proximal edge of the lesser trochanter. The differences between the values calculated according to these complicated methods and the ones calculated according to our simple methods were less than 2 mm in all of the first 10 hips of the study group. Thus, we decided to use the simple calculation methods for all the hips that followed in the study group. In practice, our simple method is sufficient for most cases except highly dislocated hips in which the complicated calculations shown above are necessary. The line passing through the center of the acetabular component and the proximal edge of the lesser trochanter on anteroposterior radiographs may become excessively slanted or almost horizontal in these hips.

We used two types of femoral components. However, they have an identical modular head system, and there were no significant differences in the position of the femoral component between the two types. Our study was not a randomized trial, but we used a historical control. We believe that the reduction in operating time in the study group was due to increasing experience. However, there were no improvements in the positioning of the femoral or acetabular components. Thus, we believe that the improvements in limb-length discrepancy after surgery can be attributed to our new measuring method.

Our method has some limitations. We could not evaluate the position of the acetabular component during surgery. Theoretically, errors arising from the position of the acetabular component cannot be avoided with this study method. The mean difference in the vertical position of the acetabular component between the planning and the final position was 2 mm in the study group. Although the difference of position was less in the acetabular component than in the femoral component, further modification is required.

Contributions of authors

KM performed the radiographic measurements and statistical analysis. SN operated all cases and performed intraoperative measurements. TM supervised the study design.

No competing interests declared.

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