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A Simple Method Using a PACS to Minimize Leg Length Discrepancy in Primary THA A Method to Minimize Leg Length Discrepancy

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ABSTRACT

We determined whether a PACS-based method (head-lesser trochanter distance [HLD]) better equalized leg length discrepancy (LLD) after primary THA than a conventional method. We retrospectively reviewed 312 patients (379 hips) with osteonecrosis or primary osteoarthritis who underwent primary cementless THA: 198 patients (240 hips) underwent THA using the HLD method, while the conventional group consisted of 114 patients (139 hips) in whom we measured with the method of McGee and Scott. We then compared the LLDs in the two groups. We observed no difference in the mean postoperative LLD. A higher percentage of patients in the HLD group had an LLD less than 6 mm: 81% vs 68% hips, respectively. HLD method decreases the possibility of an LLD over 6 mm after THA.

Substantial leg length discrepancy (LLD) after THA can be associated with complications, including sciatic, femoral, and peroneal nerve palsies [1,2], lower back pain [3,4], abnormal gait [5,6], and dislocation [7]. In addition, patient dissatisfaction with the LLD has been the most common reason for litigation after THA [1]. LLD has been perceived in between 6% and 32% of patients, and was perceived when shortening exceeds 10 mm and lengthening 6 mm [8]. Even for highly skilled surgeons it is challenging to obtain equal leg length during surgery.

A variety of methods have been described for minimizing LLD, including preoperative templating [9–11] and intraoperative techniques, such as the shuck test [12], comparing the dimensions of the resected bone with the dimensions replaced by the prosthesis [10,13], use of mechanical jigs and measuring calipers [14–16], and use of reference pins driven into the pelvis [17–19]. None of these studies discussed the accuracy of the measurement technique or reported the correlation between the predicted and actual lengths.

The use of a picture archiving communication system (PACS) has led some institutions to abandon conventional plain film radiography. Fowler et al reported that the mean measured values were very accurate (within 0.1 mm for a known distance of 3.2 mm) when using PACS measuring tools, the standard deviation of measurements (0.5 mm) could affect the interpretation of data [20]. Because a 1-mm difference in measuring the leg-length discrepancy is unlikely to be clinically significant, we reasoned that a PACS could be used to measure LLD [20].

We examined (1) whether the head-lesser trochanter distance (HLD) method reduced LLD after primary THA, based on the postoperative LLD and (2) whether the distribution of the LLD was comparable with the results of preoperative templating and use of the conventional method of McGee and Scott [18].

Patients and Methods

We retrospectively reviewed 363 patients (438 hips) who underwent primary THA between March 2002 and March 2009. Of these, we excluded 39 patients (44 hips) for one of the following reasons: previous trochanteric osteotomy (14 patients, 14 hips), previous pelvic osteotomy (12 patients, 16 hips), severely dysplastic hips with a simultaneous shortening osteotomy of the femur (eight patients, eight hips), and prior septic arthritis (five patients, five hips). Of the remaining 324 patients (394 hips), 12 patients (15 hips) did not have the appropriate radiographs for analysis (no AP pelvis radiograph at index arthroplasty). This left 312 patients (379 hips) who had a minimum 2-year followup (mean, 67 months; range, 27–108 months) and radiographs available for review at both the index THA and latest clinical followup. These were divided into two groups based on which procedures were used preoperatively and intraoperatively to equalize the leg length during THA. In the THAs performed between March 2002 and September 2007 (114 patients, 139 hips), the leg length was equalized using preoperative templating and intraoperative distance measurement with a u-shaped reference pin, as described by McGee and Scott [18] (conventional group). Our study

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was a comparative cohort study with patients undergoing the McGee and Scott method serving as a control group.

In the THAs performed between October 2007 and March 2009 (198 patients, 240 hips), the leg length was equalized using the PACS (HLD). All of the data used for this study were retrieved from our institution's database; we did not see or contact patients specifically for this study. We received institutional review board approval for the study.

A power analysis (alpha = 0.05; n = 312; differences, 5 mm; SD, 5.42) was performed to determine whether the sample size was appropriate for the analysis (Student's t-test) of the LLD of each group, resulting in a *P* value of 1.0.

We compared the two groups with respect to age, BMI, and the preoperative Harris hip score (HHS) [21] using a student t-test and gender and diagnosis using chi-square test (Table 1). There were no differences in age, gender, or diagnosis characteristics between the HLD and conventional groups.

For all surgeries, we made a preoperative plan and performed templating on standardized plain radiographs on a PACS. The radiographs consisted of an AP view of the pelvis centered over the pubic symphysis, with the contralateral nonarthritic hips in 10º to 15° of internal rotation, and lateral views of both hips. We presumed that if the actual distance from the center of the femoral head to the superior end of the lesser trochanter (the HLD) were about the same for both hips, the leg length after THA would be equal. The prevalence of anatomic inequality was found to be 90%, the mean magnitude of anatomic inequality was 5.2 mm (SD 4.1) [22]. We selected 200 people, who do not complain of leg length discrepancy and LLD was less than 5 mm measured by slit scanogram. The difference was calculated between HLD of both hips. Two investigators (YWL, YJC) independently evaluated the results to assess the interobserver variation and reliability. The average difference was 1.01 mm (SD, 0.89) with a range of 0 mm to 4.2 mm. The ICC for interobserver reliability was 0.897.

Consequently, the HLD of the opposite hip was measured on a PACS preoperatively, and the HLD was equalized by selecting a suitable modular head during surgery (HLD method). Using these plain radiographs, we measured the HLD and determined the implant combination. We recorded the data on the PACS and viewed it on a monitor in the operating theater. We used a magnification marker for all preoperative and postoperative radiographs in the HLD group (Fig. 1). In case of bilateral hips, all surgeries were performed staged. At the first stage, we underwent THA according to pre-operative templating, and at the second stage THA, we measured the preoperative HLD of the opposite hip, assuming that the opposite hip referred normal. In the conventional group, a 20% oversized transparent acetate sheet was used on the radiograph with a fixed focus film distance of 1150 mm, producing a mean magnification of 120%.

The same surgeon (YSK) performed all surgeries through a modified posterolateral approach. The surgical procedures were generally the same in both groups: patients were placed in the lateral decubitus position, and a posterolateral approach was used in all cases. The difference between the procedures was the method used to select the modular head. In the conventional group, the surgeon inserted a u-shaped pin in the anterior superior iliac spine before making the incision and checked the location of the end of the pin on the lateral thigh. After broaching the femur, the surgeon positioned the femoral component determined in the preoperative templating, and selected the modular head based on the checkpoint and tip of the u-shaped pin, as described by McGee and Scott [18]. In the HLD group, the surgeon first inserted a trial modular head with a 7-mm long neck, and then used a ruler to measure the distance between the center of the trial head and the superior edge of the lesser trochanter (Fig. 2). Based on the preoperative HLD of the contralateral hip, the surgeon selected the modular head that gave the distance nearest to the planned neck length. For both groups, after the final modular head was inserted, the hip was reduced. Finally, the surgeon inserted a drain and closed the wound. Thirty-seven patients underwent bilateral THA in the HLD group. Regardless of whether a simultaneous or staged THA was performed, one hip served as the contralateral side to obtain the intraoperative HLD. On the first operation, we underwent THA according to pre-operative templating, and measuring and recording the HLD during operation. And then, at the second operation, modular head was selected according to the previously measured HLD.

To validate the accuracy on PACS measuring method, we first measured the acetabular cup diameter (A) and 10-cm magnification bar (B) using PACS measurement tools. The acetabular cup diameters using PACS (C) were calculated (C = A*100/B). The difference was calculated between C and the real diameter recorded in chart. Two investigators (YWL, YJC) independently evaluated the results to assess the interobserver variation and reliability. One investigator in each group repeated the measurements 2 weeks later to assess the intraobserver variability in the corresponding technique. The average difference was 0.88 mm (SD, 0.69) with a range of 0 mm to 2.8 mm. The ICCs for interobserver reliability intraobserver reliability were 0.855, and 0.965, respectively.

We assessed the LLD 6 months postoperatively using the method described by Ranawat et al [19]. On an AP radiograph of the pelvis, we drew a horizontal reference line through the inferior aspect of the teardrops (the perpendicular distance between the reference line and lesser trochanter; Fig. 3). Two investigators (YWL, YJC) independently evaluated the results with each method to assess the interobserver variation and reliability within each technique. One investigator in each group repeated the measurements 4 weeks later to assess the intraobserver variability in the corresponding technique. They assessed the intermethod variation and reliability of the LLD using all of the measurements made within each technique. The investigators who made the measurements were familiar with digital assessment. As the neck shaft angle and offset of the Bencox (Corentec, Seoul, Korea) and Corail (DePuy Orthopaedics, Inc, Warsaw, IN, USA) stems were the same, there was no variance depending on the type of stem. We evaluated the HHS [21] for pain and function preoperatively and 2 years postoperatively. The average difference of LLD between the observers was 0.97 mm (SD, 0.54) with a range of 0 mm to 1.8 mm. The ICCs for interobserver reliability intraobserver reliability were 0.822, and 0.913, respectively.

We compared the means of all numeric variables (age, BMI, HHS, and LLD) of the two groups using Student's t-test. The gender distribution and dislocation rate among groups were examined using the chi-square test. We subdivided the LLD into two groups (LLD less than 6 mm and LLD greater than 6 mm) and compared them using the Mann–Whitney u-test. We performed statistical analyses using SPSS (Version 11.5; SPSS, Chicago, IL, USA).

Table 1
Patient Data.

Variable	HLD Group	Conventional Group	*P*-Value
Number of patients (hips)	198 (240)	114 (139)	
Mean age (years)	51.4 ± 14.2	52.5 ± 14.4	0.579
Gender (male/female)	124/74	67/47	0.956
Mean BMI (kg/m^2)	24.2 ± 8.1	23.9 ± 7.9	0.648
Diagnosis (AN/OA)	179/61	96/43	0.374
Mean Harris hip score (range)	47.2 (17–78)	46.8 (14–76)	0.784
Mean followup period (months) (range)	36.2 (27–48)	79.6 (47–108)	
Prosthesis (number of hips)	Bencox (240)	Corail stem with Duraloc cup (139)	

HLD = head-lesser trochanter distance ; AN = avascular necrosis; OA = primary osteoarthritis; Bencox total hip system (Corentec, Seoul, Korea); Corail hip system (DePuy Orthopaedics, Inc., WarsawIN, USA); Duraloc acetabular cup system (DePuy).