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Basic Science

The Assessment of Limb Length Discrepancy Before Total Hip Arthroplasty

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ABSTRACT

Introduction: The clinical relevance of limb length discrepancy (LLD) after total hip arthroplasty gains attention as the number of total hip arthroplasties increases. Although several techniques are commonly used to assess LLD using a pelvic radiograph, their accuracy is not well established. This study measures LLD using different techniques viewing the pelvis and compares the measurements with the true LLD.
Method: Pelvic landmarks used included the femoral head, lesser trochanter, acetabular teardrop, ischial tuberosity, and tibial plafond. The true LLD was determined by finding the difference in distance between the lowest point of the ischial tuberosity and the tibial plafond as well as the top of the femoral head to the center of the tibial plafond for each lower limb.
Results: Using pelvic landmarks to assess LLD is significantly different ($P < .001$) from the true LLD. The difference in distance from the center of the tibial plafond to the ischial tuberosity was not significantly different from the measurement from the top of the femoral head to the center of the tibial plafond ($P = .08$). Also, using the acetabular teardrop as a landmark has less reliability when compared to the ischial tuberosity.
Discussion: Owing to the extensive variety of pathologies that are associated with LLD, preoperative planning should include an assessment of any preexisting LLD. Although it may be reasonable to compare pelvic measurements preoperatively and postoperatively to assess for changes, the data from this study do not support the estimation of the true LLD using a pelvic radiograph.

Leg length discrepancy (LLD) describes a condition in which the lower limbs are unequal in length. It has been stated that LLD is found in the majority (90%) of people, and when the difference exceeds 20mm, it is much more likely to become clinically significant [1,2]. It has also been suggested that LLD is common after both total hip and total knee arthroplasties [3-5]. The clinical importance of LLD, after total joint surgery, is due to its association with increased incidence of back pain, sciatica, gait disorders, and general postoperative dissatisfaction [6]. The magnitude of LLD that generates these pathologies and that warrants treatment continues to be debated, but it is agreed that effort should go into minimizing total hip arthroplasty (THA) postoperative LLD.

Owing to the known risk of LLD after THA, it is essential that a preoperative radiographic assessment of the lower extremities be complete to template and plan for the THA procedure. Although limb lengthening may be required to stabilize the hip, LLD is a common reason for litigation after THA [7-9]. By considering any preexisting LLD, and understanding the state of the preoperative hip, a surgeon can predict a suitable planned prosthetic position and develop an operative strategy to achieve appropriate offset and postoperative limb-length equality.

Owing to the increasing awareness of the clinical importance of LLD, many techniques have been developed to plan for leg length equality in the preoperative setting before a THA. Full-length radiography is considered the gold standard for measuring LLD, and until recently, a scanogram, which involves three radiation exposures from the hips to the ankles, was the modality used most frequently [10]. Sabharwal and Kumar [11] concluded that full-length standing anteroposterior (AP) radiographs might be

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superior to the scanogram for measuring LLD because of the increased radiation and the potential for some inaccuracies with the scanogram. On each, the LLD can be calculated as the difference in the limb length of each limb measured by the distance from the top of the femoral head to the base of the tibial plafond [3]. Computed tomography (CT) scanogram has been demonstrated by others to be the most effective, especially in instances of flexion deformities of the knee [11,12]. CT scanogram however is not readily available in all centers, has a higher cost, and requires appropriate scheduling [13]. Clinical measurements during physical examination have also been attempted with varying results and should be considered when screening or when precision is not required [14].

In an attempt to minimize the amount of radiation required, different landmarks have been used on a pelvic radiograph to predict the LLD. On an AP view of the pelvis and proximal femur, LLD has been predicted as the difference in perpendicular distance between a line passing through the lower edge of the acetabular teardrops of the hip to the corresponding lesser trochanter on each limb, as was demonstrated by Kjellberg et al [12,13]. Others have attempted using the perpendicular distance of the most inferior portion of the ischium to the lesser trochanter [15]. These are the two most commonly used techniques that have been reported in the literature. Interestingly though, few reports exist that attempt to demonstrate the accuracy and error associated with each of these techniques [13,16].

This study will attempt to validate pelvic measurement techniques as a prediction of the true LLD. True LLD will be measured with a full-length standing AP radiograph. This will be compared with LLD measurements using a radiographic view of the pelvis and proximal femur. It will be determined if there is a significant difference in the measurement of LLD between measurements taken from the full-length image and those using only a view of the pelvis. We hypothesize that the measurements taken using the hip landmarks to estimate LLD will serve as adequate predictions of the true LLD and will not be significantly different from those of the full-length measurement.

Materials and Methods

This study received institutional review board approval and was compliant with the Health Insurance Portability and Accountability Act. A cross-sectional prospective study was conducted using a joint replacement database from 147 consecutive patients in an orthopedic surgery clinic at a university medical center. Inclusion criteria included patients with complete preoperative AP standing full-length radiographs. These were required to measure the leg lengths of each limb. One hundred twelve patients had adequate imaging and were included. Patients were excluded if significant bony deformity existed that prevented visualization of the anatomic landmarks for measurement (7 patients) or if they previously had a THA or any other lower limb surgery or deformity (10 patients). Ninety-five patients met the inclusion criteria.

Standing preoperative AP full-length digital images of the lower extremities were obtained using a Fujifilm computed radiography system (Fujifilm USA, Valhalla, NY) using a standard protocol. Images were processed using Fujifilm automatic image stitching software. The digital images were viewed on AGFA Impax PACS software (AGFA, Mortsel, Belgium), and measurements were obtained using a digital cursor.

The leg length of each limb was measured using the full-length radiograph by measuring the distance from the top of the femoral head to the center of the tibial plafond as was outlined by Lang et al [3]. The LLD was determined by finding the difference between the two limbs. This is considered the evaluated LLD. To determine if significant leg length measurement changes occur owing to hip joint degeneration, an additional measurement was taken from the most inferior portion of the ischial tuberosity to the ipsilateral tibial plafond. Each of these measurements is seen in Figure 1.

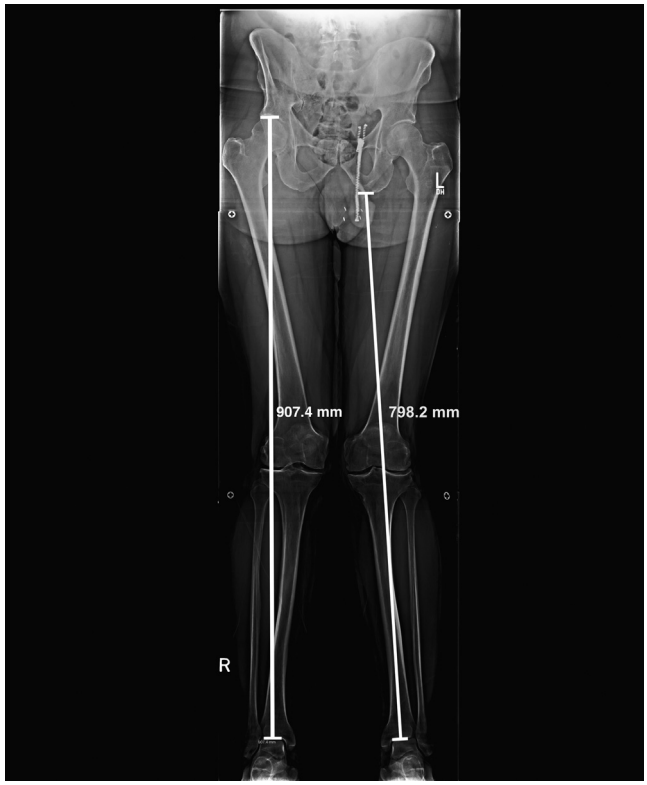

Fig. 1. The image demonstrates the measurement of the limb length. Left side of image: A line is extended from the top of the femoral head to the base of the tibial plafond. This is done on each side, and the true limb length discrepancy is the difference in limb length between each side. Right side of image: Measurement from the ischial tuberosity to the tibial plafond.

LLD was also measured using the same images after using the zoom tool to view only the pelvis. As was done by Meermans et al [13], the landmarks used include the center of the femoral head (CH), the most medial aspect of the lesser trochanter (LT), a line drawn through the most inferior portion of the ischial tuberosities (BI), and a line drawn through the most inferior portion of the acetabular teardrops (IT). A circle was drawn around the femoral head to ensure the center was appropriately identified. A line was drawn from IT-LT, IT-CH, BI-LT, and BI-CH on each side. The difference between the two sides was used as the pelvic LLD. An example of the measurements is seen in Figure 2.

Statistical Analysis

To assess the accuracy and reproducibility of the different measurements, a second individual measured each of the major end points independently, and both individuals performed the measurements on two separate occasions. Neither of the two individuals who measured the radiographs was the primary surgeon. Interobserver and intraobserver variations were determined for all the measurements using the intraclass correlation coefficient. The interpretation was performed as follows: >0.8 represents almost perfect agreement, 0.7-0.8: strong, 0.5-0.6: moderate, 0.3-0.4: fair, and 0-0.2: poor [13].

Using Microsoft Office 2010 Excel (Microsoft Corp., Redmond, WA) software, calculations of averages and standard deviations were obtained, and a 2-sample paired *t* test was executed giving the