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Intraoperative limb length measurement in total hip arthroplasty

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Abstract In order to evaluate the efficacy of intraoperative measurement of limb length inequality (LLI), we performed a prospective study on 64 patients who underwent unilateral total hip arthroplasty. The patients were divided into 2 groups. In Group I, the LLI was evaluated by the Shuck test, and in Group II by intraoperative measurement using a Steinman pin and an adjustable caliper. Preoperative LLIs assessed on radiographs averaged 1.18 cm in Group I and 0.37 cm in Group II.

Résumé Pour évaluer l'efficacité de la mesure intra-opératoire de l'inégalité de la longueur d'un membre (ILM), nous avons effectué une étude prospective sur 42 patients qui ont subi une arthroplastie totale de la hanche unilatérale. Les patients furent divisés en 2 groupes selon la méthode particulière d'estimation intra-opératoire de ILM. ILM fut évalué par un essai de réduction dans le Groupe I et par une mesure intra-opératoire en utilisant une broche de Steinmann et un compas de calibrage ajustable dans le Groupe II. Sur les radiographies ILM intra-opératoires du Groupe I, la moyenne établie fut de 0,34 cm et pour le Groupe II de 0,41 cm. La moyenne établie de 1,15 cm dans le Groupe I et de 0,4 cm sur des radiographies ILM postopératoires a montré une différence significative entre les deux groupes.

Introduction

While a number of authors have described objective techniques using pins, rulers, and callipers for intraoperative LLI measurement [3, 4, 6], a comparison has not been made between the results obtained using such techniques and those obtained without them. In this study, we prospectively evaluated the efficacy of intraoperative

LLI measurement using a Steinmann pin and an adjustable calliper compared to that using the Shuck test [2, 3, 6].

Patients and methods

We studied a total of 64 hips in 64 patients who underwent unilateral THA between 1993 and 1995. This investigation was restricted to persons who had a preoperative LLI of less than 2.5 cm. We used the Impact Modular Total Hip System in every instance (Biomet, Inc., Warsaw, Indiana, USA). All operations were performed by the senior author using the same posterolateral approach. Two patients died at 8 and 17 months after arthroplasty. The average period of follow-up for the remaining patients was 2.9 (2–5) years. The investigation subjects were assigned alternatively to Group I or II as they entered the study. Their mean ages at the time of arthroplasty was 63 (52–81) years in Group I and 62 (51–80) years in Group II. The preoperative diagnoses in Group I were primary or secondary osteoarthritis in 27 patients, rheumatoid arthritis in 4 patients, and osteonecrosis in one. Those in Group II were primary or secondary osteoarthritis in 25 patients, rheumatoid arthritis in 4, and osteonecrosis in 3. None had unilateral pelvic shortening or LLI distal to the lesser trochanter.

In Group I the trial components were inserted in accordance with the preoperative plan and the hip was reduced. The stability and mobility of the joint was assessed and limb length evaluated by the Shuck test [2, 3, 6]. If the prosthetic femoral head distracted more than 0.5 cm from the socket, the limb was assessed as being too short and a head with a longer neck was then tried. If distraction was not possible, the limb was assessed as being too long and the femur was reamed further in the distal direction. Alternatively, a prosthetic head with a shorter neck was used, and the hip biomechanics were assessed again at this stage.

In Group II, Steinmann pins and wires, bent at 90 degrees as adjustable limb length callipers (Fig. 1), were used. The calliper had a moveable length indicator attached to the Steinmann pin. Before dislocating the hip, a reference point on the pelvis was established below the iliac crest close to the antero-superior iliac spine. This was accomplished by inserting a Steinmann pin percutaneously through both cortices of the lateral ilium. A second reference point was made on the femur by making a small transverse mark over the greater trochanter with an electrocautery. The distance between the iliac and femoral reference points was then measured with the limb in its reference position (Fig. 2). This was carried out using the leg length calliper which was attached to the iliac Steinmann Pin. The calliper was calibrated in millimeters by a movable length indicator that was locked into place for later reference. The caliper was detached from the Steinmann pin, and the

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Fig. 1 A set of devices for intraoperative measurement showing a Steinmann pin, a wire bent at 90 degrees, and a movable length-indicator (connector)

Fig. 2 The leg length calliper is used to measure the distance between the pelvic and the femoral reference point to determine change in limb length

Fig. 3 Radiograph of the hip of a woman, 59 years of age, with protrusio deformity and rheumatoid arthritis. We constructed a line connecting the bottom of the ischial tuberosities for LLI evaluation. Another line parallel with the first line was placed through the most medial projection of the lesser trochanter, and the perpendicular distance between the 2 lines was measured to the nearest 0.5 mm

Table 1 LLI distribution in Group I and II patients before and after THA

LLI (cm)	No. of patients			
	Before THA		After THA	
	Group I	Group II	Group I	Group II
-3 - -2	0	1	0	0
-2 - -1	3	1	2	1
-1 - 0	29	30	4	11
0 - 1	0	0	16	17
1 - 2	0	0	8	3
2 - 3	0	0	2	0

hip was dislocated. After the hip was reduced with the trial components in place, the limb was placed as before, and the amount of lengthening or shortening was measured with the calliper using the reference points on the pelvis and the femur. Adjustment of the limb length and assessment of hip biomechanics were performed in the same manner as in Group I.

We used a simple method to evaluate LLI from a single standard AP view of the pelvis. Using a line connecting the bottom of the ischial tuberosities on the anteroposterior radiograph, the intersection of that line on both femurs was gauged from the top of the lesser trochanter and was measured to the nearest 0.5 mm (Fig. 3). These measurements were made on preoperative radiographs, postoperative radiographs obtained at an average of 11 days after arthroplasty, and radiographs taken during the most recent follow-up. The measurements were made on both hips to test the validity of our method. Statistical analysis was performed using the Student *t* test.

Results

As a control for the technique, measurements were made on the normal hip not undergoing surgery. The difference in the vertical lesser trochanter-ischial tuberosity distance in the pre- and postoperative radiographs averaged 0.5 mm (range, 0–2 mm) with a standard deviation of 0.5 mm. Because the difference of the distance was not significantly different from zero at the 5% level ($P>0.19$), we believe that this radiographic measurement method is valid.

Preoperative LLI averaged 0.4 cm in both groups. The involved limb was equal in length to or shorter than the contralateral limb in all members of both groups (Table 1). In all Group I patients and in 30 Group II patients, component sizes were determined by limb length evaluation; after assessment of the hip joint mechanics, no significant differences were found among the trial limb lengths. A discrepancy between the appropriate component size determined by LLI measurement and that determined by hip joint mechanics assessment was present in the remaining 2 Group II patients. We intentionally over-lengthened the involved limb to improve joint stability in both patients. The overlengthening measured during surgery was 1.40 cm and 1.50 cm and the LLIs measured on the postoperative radiographs were 1.15 cm and 1.60 cm, respectively.

The LLI on the radiographs obtained at an average of 11 days after arthroplasty averaged 1.18 cm (0–3 cm) in

Group I and 0.37 cm (0–1.6) in Group II ($P<0.01$). No significant change was found in either group between LLIs on postoperative radiographs taken at an average of 11 days after arthroplasty and those taken at the most recent follow-up (mean, 2.9 years).

Discussion

The Shuck test for the intraoperative evaluation for LLI is based on soft tissue tension [2, 3, 6]. This, in turn is influenced by the amount of surgical release, muscle relaxation at that point in the operation and the force applied to distract the joint [3, 6]. Intraoperative evaluation of hip joint mechanics is also affected by soft tissue tension. In all 32 Group I patients, there was no discrepancy between the limb lengths determined by the Shuck test and those by assessment of hip joint mechanics. Nevertheless, their LLIs averaged 1.18 cm on postoperative radiographs.

In contrast, the postoperative LLIs averaged only 0.37 cm in the same number of patients in Group II, who had undergone intraoperative measurement of the LLI. For 2 patients, we intentionally overlengthened the involved limb to improve hip joint mechanics, and their postoperative LLIs of more than 1 cm were predicted during the operation. These results indicate that the Shuck test assesses the soft tissue balance rather than LLI, and that a more precise LLI is estimated by the intraoperative measurement method.

A similar technique using a threaded Steinmann pin and a limb length calliper, was reported by Jasty et al.

[3]. They reviewed 85 patients who underwent primary THA in which their technique was used. Although they described good results, in that only 14 (16%) patients had LLI after surgery, postoperative limb length was measured between the anterosuperior iliac spine and the medial malleolus with a tape ruler. It is well-known that clinical measurement using a tape ruler is inexact and at times misleading [1, 5]. Our prospective study was based on the radiographic method for measuring LLI and included a control group. Our technique is relatively accurate and only requires a Steinmann pin, a right-angled wire, and a connector.

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