Assessment of restoration of leg length and femoral offset after total hip arthroplasty

Hatem Bakr, Mohamed Mahran

Department of Orthopedics and Traumatology, Assiut University School of Medicine, Assiut, Egypt

Correspondence to Hatem Bakr, MD, Department of Orthopedics, Assiut University Hospitals and School of Medicine, Assiut 71526, Egypt.
E-mail: hatem_bakr@hotmail.com

Received: 12 April 2018
Revised: 12 May 2018
Accepted: 25 May 2018
Published: 17 November 2021

The Egyptian Orthopaedic Journal 2021, 56:148–152

Background

Total hip arthroplasty has proven to be one of the most successful operations done in orthopedic surgery. Preoperative planning, including meticulous history, examination, and preoperative templating, is quite important and must be done to all cases as a routine. Numerous studies used surrogates for clinical success rates that included satisfaction of the patient, reduced pain, improvement of function, and the absence of the need for further surgery. Minimizing leg-length discrepancy and restoring offset to normal is very important for good functional outcome, patient satisfaction, and quality of life.

Aim of the study

Radiological and functional assessment of restoring the leg length and hip offset after total hip replacement. Also, to compare different methods used to decrease leg-length discrepancy with the method used in this study.

Patients and methods

A prospective study of 50 patients (31 males and 19 females) with arthritic hips for various reasons undergoing either cemented or uncemented total hip arthroplasty. The mean age was 47 years old. Preoperative history and examination for all patients was done, preoperative and postoperative evaluation of offset and limb length was done for all patients, and preoperative and postoperative evaluation of hip function using Harris hip score (HHS) was done in addition to evaluation of abductor muscles' power. Variable intraoperative methods were used to minimize the limb-length discrepancy (LLD) after the operation.

Results

There was a statistical significance between hip offset pre- and postoperative and between LLD preoperative and postoperative. HHS was improved postoperative.

Conclusion

Limb-length restoration is very important for improvement of HHS. The intraoperative clinical method is much effective to minimize LLD as other methods, although it is much easier to apply.

Keywords:
Limb-length discrepancy, restoration of limb length, total hip arthroplasty

Egypt Orthop J 56:148–152

1110-1148

Introduction

Total hip arthroplasty (THA) appears to be one of the most successful procedures performed nowadays. The clinical success rates were more than 90% after a minimum of 10-years' follow-up in numerous long-term studies. The statistics used in these studies included patient satisfaction, reduced pain, functional improvement, and the absence of the need for further surgery [1].

THA is also one of the most common elective surgeries performed in older adults. It is estimated that ∼1–3% of the older-adult population (those 65 years and older) will undergo THA at some point, with the average age being 66 [2].

Minimizing leg-length discrepancy and restoring offset to normal is very important for good functional outcome, patient satisfaction, and quality of life.

Preoperative planning, including meticulous history, examination, and preoperative templating, is quite important and must be done to all cases as a routine.

There are different methods used to restore offset and minimize leg-length inequality, these includes:

(1) Preoperative templating.
(2) Intraoperative assessment using a large unicortical fragment screw.
(3) Steinmann pin method.
(4) In-situ leg-length measurement technique.
(5) Straight and L-shaped calipers.
(6) Digital templating method.

(7) Computer-assisted methods and navigation.
(8) Manual measurement using a ruler.
(9) Patient control anesthesia (PCA) limb-lengthening gauge.
(10) Clinical method used in this study.

Patients and methods

A prospective study of 50 patients (31 males and 19 females) with arthritic hips for various reasons undergoing either cemented or uncemented THA. The study was approved by the institutional ethics committee in the Orthopedic Department of Orthopaedic Surgery, Assiut University, Egypt. The mean age was 47 years old.

Inclusion criteria: patients with ipsilateral and contralateral normal knee, leg and foot length and direction, and patients without spine deformity (causing apparent length discrepancy).

Exclusion criteria: ipsilateral or contralateral abnormal knee, leg, foot affecting length or rotation of the hip, spine deformity causing pelvic tilt, and fixed pelvic obliquity.

Preoperative clinical assessment

(1) History:
  (a) Patient-perceived leg-length discrepancy.
  (b) Any shoe lift used.
  (c) Muscle contracture.
  (d) Scoliosis, polio, developmental dysplasia of hip, spine diseases, and pelvic obliquity.
  (e) Previous surgery..
(2) Examination:
  (a) Abduction range and power.
  (b) Flexion contracture.
  (c) Measure the true leg length (from the level of the anterior–superior iliac spine to the level of the medial malleolus).
  (d) Spine and pelvic examination to exclude scoliosis and pelvic obliquity.
(3) Preoperative functional evaluation:
  (a) Harris hip score (HHS).
  (b) Abductor power.

Preoperative planning: making a standard radiographic film with internal rotation 15° for the patient and then measuring leg length and offset before surgery.

Hip offset measurement: femoral offset was calculated by measuring the perpendicular distance from the center point of the head of femur to a line bisecting the length of the femur [3]. The center of rotation of the femoral head was identified by using Moses' concentric circles method [4].

A straight line across the inferior point of each acetabular teardrop was used to measure the leg length. Two perpendicular lines are drawn from the most medial part of each lesser trochanter superiorly to meet the first line drawn. This is the standard method of measuring leg length as described by Ranawat *et al.* [5].

Preoperative templating: acetabular templating is performed to achieve these goals. First, bone contact between the subchondral plate and the acetabular shell. The lateral opening should approximate 40±5°. Finally, in most cases, the inferomedial corner of the acetabular component should coincide with the teardrop. This helps to establish the new center of rotation of the THA. Placement of the acetabular component as the templated position accurately is important because doing so defines the hip center and directly influences leg length [6,7]. When templating the femoral side of the acetabular socket, there are three main goals: optimally size the femoral component, maintain offset, and optimize limb lengths.

Intraoperative method to minimize leg-length inequality

(1) Chuck test: by traction of the leg, there is a space between the head of the implant and the acetabulum usually about 5 mm.
(2) Muller test: the center of the femoral head is usually at the level of the greater trochanter and we always relate it to the normal contralateral hip for assessment.
(3) Electrode method: the electrode of ECG placed on patella of both legs. We then compare the length of the diseased leg to that of the healthy side after placing the implant by palpating the prominence of the ECG electrodes (they should be at equal level at the end of the operation).

Postoperative evaluation

(1) Radiological: measure offset and leg length in postoperative x-ray and compare them to the preoperative values.
(2) Functional: improvement in HHS at 6 and 12 months postoperative and improvement of abductor power.

Results

According to the results of this study, the difference between the hip offset was statistically significant ($P<0.05$) preoperative and postoperative (Table 1), also the difference between the limb length between the healthy and the operated side in a statistically significant way ($P<0.05$) (Table 2).

Table 1 Difference in offset between healthy hip and operated hip

	Mean±SD (cm)	Range	*P* value
Preoperative difference in offset between healthy hip and operated hip	1.26±0.65	1.0–2.3	0.019*
Postoperative difference in offset between healthy hip and operated hip	0.24±0.85	1.1–1.8	

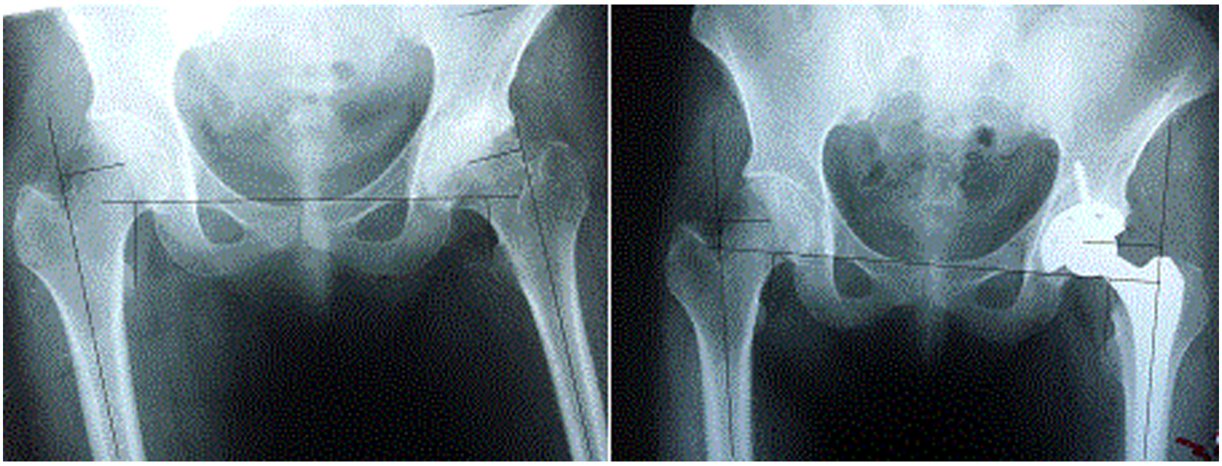
Wilcoxon signed-rank test. *Statistical significant difference ($P<0.05$).

Table 2 Preoperative and postoperative leg-length discrepancy

	Mean±SD (cm)	Range	*P* value
Preoperative leg-length discrepancy	1.46±0.38	−1.0 to 3.0	0.009*
Postoperative leg-length discrepancy	0.38±0.92	−1.8 to 2.2	

Wilcoxon signed-rank test. *Statistical significant difference ($P<0.05$).

Figure 1



Female patient, 32 years old, history of long-term corticosteroid therapy for 3 years, now-developed osteoarthritis hip, and cementless total hip replacement was done.

Table 3 The scoring system (Harris hip score, HHS)

HHS	Preoperative	Postoperative	*P* value difference
Mean±SD	60.5±14.0	93.3±3.0	0.001*

Wilcoxon signed-ranked test. *Statistical significant difference ($P<0.05$).

HHS improved from 60.5 to 93.3 at 6 and 12 months postoperative, which shows the improvement of hip function as limb-length discrepancy (LLD) decreases (Table 3).

Radiological outcome

The radiographic evaluation was done according to the standardized protocol of pelvis and both hips with upper-femora anterioposterior view. The hip offset and LLD were compared in preoperative and postoperative radiographs (Figs 1 and 2).

Preoperative radiographic measurements

Offset of a healthy hip=3.8 cm, leg length of a healthy hip=4.4 cm, offset of a diseased hip=3.0 cm, leg length of a diseased hip=3.5 cm, preoperative difference in offset=0.8 cm, and preoperative leg-length discrepancy=0.9 cm.

Postoperative radiographic measurements

Offset of the operated hip=4.0 cm, leg length of the operated hip=4.1 cm, postoperative difference in offset=0.2 cm, and postoperative leg-length discrepancy=0.3 cm.

Preoperative radiographic measurements

Offset of a healthy hip=5.4 cm, leg length of a healthy hip=5.5 cm, offset of a diseased hip=4.0 cm, leg length of a diseased hip=4.5 cm, preoperative difference in offset=1.4 cm, and preoperative leg-length discrepancy=1.0 cm

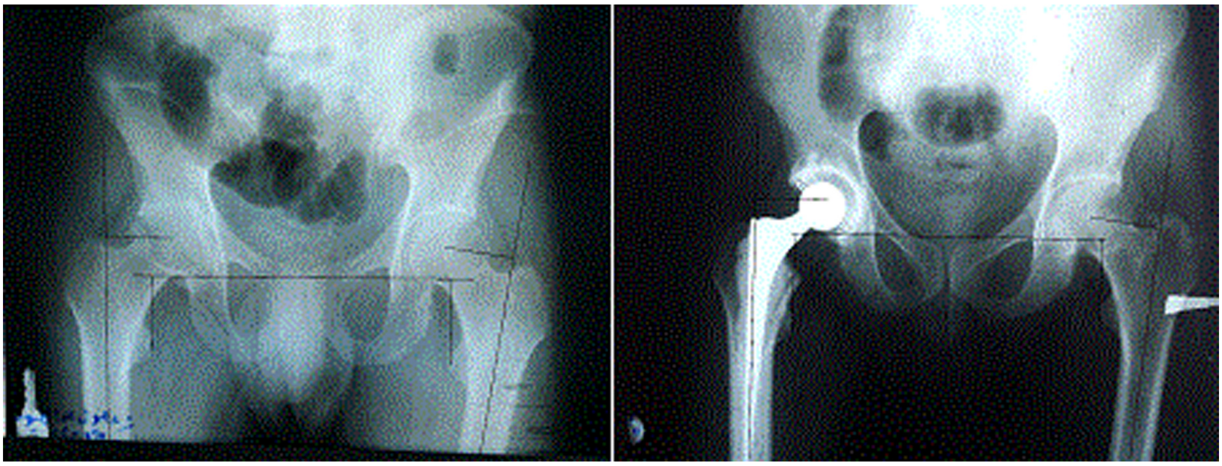
Postoperative radiographic measurements

Offset of the operated hip=5.3 cm, leg length of the operated hip=5.0 cm, postoperative difference in offset=0.1 cm, and postoperative leg-length discrepancy=0.5 cm.

Discussion

Leg-length equality is an important functional parameter that is strongly related to the success in THA. LLD can contribute to hip instability, knee

Figure 2



Male patient, 30 years old, he has ankylosing spondylitis with osteoarthritis hip, cemented total hip replacement was done.

pain, pain at the back muscles, palsy of the sciatic nerve, and aseptic prosthesis loosening. These problems can lead to revision surgeries and may even be the sources of litigation.

Ranawat *et al.* [5,8,9] wrote that the leg-length difference must be 10 mm or less, in order for a patient to have a good quality of life. Despite the careful attention, an unexpected difference of 10–16 mm can sometimes occur. The possible reasons are sunken collarless stem, the excessive reaming of the acetabulum during surgery, flexion deformity of the hip joint before the surgery, several different magnifications of the preoperative radiographs, which might lead to inaccurate templating, and a less-experienced surgeon. The minor discrepancies of up to 1 cm are usually asymptomatic, but in some patients, even a small discrepancy may be a source of dissatisfaction.

Avoiding postoperative LLD remains an important goal for all surgeons performing THA. To this end, many techniques have been proposed to assess leg length intraoperatively, which can produce varying results. For example, the in-situ leg-length measurement technique, L-shaped calipers, digital templating of the healthy hip, PCA limb length measuring gauge, and last manual intraoperative measurement using a ruler.

The clinical method in this study has many advantages that include simplicity as it does not need special intraoperative devices or complex instrumentation, using standard anatomical landmarks; furthermore, it saves much of the intraoperative time needed to attach and detach the calipers and the leg-length-measuring devices.

It provides acceptable and comparable results to other methods. We use a standardized radiograph to make the preoperative and postoperative measurements. It also includes preoperative femoral and acetabular templating that is quite important and significant in predicting the leg length, offset, level of the neck cut, and size of the stem and cup.

Yet, the limitations of our study include the following: postoperative evaluation was based on radiographs and not computed tomography scan that is used in other studies to eliminate the variable of the pelvic tilt. It is not a comparative study and there is no control group. The number of cases is relatively small compared with other studies. It has individual and personal variation because it is dependent on the surgeon clinical skills and judgment to perform the intraoperative double-check using the clinical tests.

The in-situ leg-length measurement used by Kurtz [10] has many advantages, one of them is that it measures the change in the leg length along the femoral axis that is about 3–5 cm from the center of rotation of the hip and returning the leg to the same position for both measurements is confirmed by making the cannulated screw and leg-length-measuring device perpendicular to each other at the final measurement. This will eliminate one source of error for leg-length devices, which is failure to return the leg to the same position for both measurements. Another important point is that the device is attached to a solidly implanted femoral component that does not loosen like the Steinmann pen in the leg-length devices.

Hip calipers were used in some studies. Shiramizu and Naito [11] used a caliper that had the value, which enables measurement parallel to the limb-lengthening axis. However, some surgeons fail to place the femur at the same position relative to the pelvis at the time of both measurements because they are too close to the patient, so in these studies, they depend on the staff around the operating table, which have bias. Furthermore, sometimes the Steinmann pen loosens due to osteoporosis that can lead to errors.

Bono and Todd *et al.* [12,13] used digital templating of the healthy hip, leading to a more accurate prediction of leg length. This is based on the fact that on the diseased hip, there is often flexion and external rotation deformity and also muscle spasm due to pain, resulting in malpositioning of the joint during radiography and thus distorting the anatomical landmarks as greater and lesser trochanter. This does not occur when using a template on the healthy hip.

PCA leg-length gauge was used by Ogawa *et al.* [14] and it allowed for intraoperative accurate measurement and adjustment of leg length and is quite simple and easy to use. However, the pins may loosen due to osteoporosis, and there is considerable error occurring in abduction/adduction repositioning of the femur with respect to the pelvis. Also, the study used was a retrospective study and the patient was not randomized, and the number of cases was relatively small.The ruler method used by Lakshmanan *et al.* [15] is simple and easy. It also uses fixed reference points on the femur only, which means elimination of the positioning errors between femur and the pelvis during measurement of the different parameters. It also reproduces leg length and femoral offset simultaneously. However, it uses the prominent tubercle as an anatomical landmark.

Conclusion

To conclude, there are many effective methods and tools to restore leg length and offset. These include devices, clinical methods, and templating. Yet, the result of this study proves that the clinical method is simple and easy to apply and has comparable results to the results of using leg-length-measuring devices. However, it can be improved by combining it with other simple methods at the same time, such as the digital templating of the healthy hip to improve the accuracy in the future.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Soderman P, Malchau H, Herberts P. Outcome after total hip arthroplasty: Part I: General health evaluation in relation to definition of failure in the Swedish national total hip arthroplasty register. Acta Orthop Scand 2000; 71:354.

2 Wilcock G. Economic aspects of the demand for total hip replacement in the elderly. Age Ageing 1978; 8:32.

3 Rubin PJ, Leyvraz PF, Aubaniac JM, Argenson JN, Esteve P, De Roguin B. The morphology of the proximal femur. A three-dimensional radiographic analysis J. Bone Joint Surg Br 1992; 74:28–32.

4 Mose K. Methods of measuring in Legg-Calvé-Perthes disease with special regard to the prognosis. Clini Orthop Relat R 1980; 150:103–109.

5 Ranawat CS, Rao RR, Rodriguez JA. Correction of limb-length inequality during total hip arthroplasty. J Arthroplasty 2001; 16: 715–720.

6 Lewinnek GE, Lewis JL, Tarr R, *et al.* Dislocations after total hip replacement arthroplasties. J Bone Joint Surg Am 1978; 60:217–220.

7 Kavanagh BF, Fitzgerald RH. Multiple revisions for failed total hip arthroplasty not associated with infection. J Bone Joint Surg Am 1987; 69:1144–1149.

8 Ranawat CS. The pants too short, the leg too long! Orthopedics 1999; 22:845–846.

9 Ranawat CS, Rodriguez JA. Functional leg-length inequality following total hip arthroplasty. J Arthroplasty 1997; 12:359–364.

10 Kurtz WB. In situ leg length measurement technique in hip arthoplasty. J Arthoplasty 2011;5:66–73.

11 Shiramizu K, Naito M. L-shaped caliper for limb length measurement during total hip arthroplasty. J Bone Joint Surg Br 2004; 86-B:966–969.

12 Bono JV. Digital templating in total hip arthroplasty. J Bone Joint Surg 2004; 80:118.

13 Todd VS, Jonathon M, Siva K. Digital templating of non affected limb as a mean of minimizing leg length discrepancy after primary total hip arthroplasty. Curr Rev Musculoskelet Med 2005; 15:40.

14 Ogawa K, Kabata T, Maeda T, Kajino Y, Tsuchiya H. Accurate leg length measurement in total hip arthroplasty. Clin Orthop Surg 2014; 6:156.

15 Lakshmanan P, Shabhaz M, Richard G. Achieving the required medial offset and limb length in total hip arthroplasty. Acta Orthop Belg 2008; 74:51.