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Does Patients' Perception of Leg Length After Total Hip Arthroplasty Correlate With Anatomical Leg Length?

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ABSTRACT

Background: This study assessed the correlation among the patients' perception of the leg length discrepancy (LLD) after total hip arthroplasty (THA) and the anatomical and functional leg length, pelvic and knee alignments, and foot height.
Methods: Patients without significant spinal pathology or previous spine or lower extremity surgery who underwent primary THA (101 patients) were evaluated using EOS images obtained in standing position. All 3-dimensional measures were evaluated and compared for the repeatability and reproducibility and correlation with patients' perception of leg length.
Results: In our study, the anatomical femoral length (odds ratio [OR] 0.9, $P = .732$) did not correlate with patients' perception of the LLD, but other variables like the distance from the middle of the tibial plafond to ground (OR 14.3, $P = .003$), sagittal knee alignment (OR 1.07, $P = .021$), and pelvic obliquity (OR 1.05, $P = .021$) were correlated with the patients' perception of LLD.
Conclusion: The LLD is a multifactorial complication. We found that the anatomical femoral length as the factor that can be modified with THA technique or choice of prosthesis is not the only important factor. We recommend comprehensive physical examination to investigate spinal deformities, pelvic obliquity, abductor muscle weakness, sagittal and coronal knee alignment, and foot deformity in patients who complain of LLD after THA.

Leg length discrepancy (LLD) is a common postoperative complication after total hip arthroplasty (THA) [1–3]. It can result in patient dissatisfaction, limping, need for shoe lift, low back pain, hip instability, and revision surgery [4–10]. According to a survey study of the members of the American Association of Hip and Knee Surgeons by Upadhyay et al [11], LLD was the second most common reason for litigation, and 8% of surgeons had been a defendant in a legal case secondary to this complication.

Among the factors important in the LLD, femoral length and offset are the 2 main factors that a surgeon can modify with surgery. The femoral length can be affected by the choice of the stem design and fixation technique and the length of the prosthetic femoral head. The increased offset due to the use of high offset stems or prosthetic head with longer neck might also result in patients' perception of tightness in the abductor muscles, pelvic obliquity, and as a result a perception of LLD [12]. Regular anteroposterior radiographs of the pelvis are 2 dimensional only and they cannot accurately measure the leg length. Despite its better accuracy, computed tomography measures the anatomical length in the supine position instead of the standing position. The standing position is the position in which LLD is perceived by patients. Unlike the anatomical length, the functional length integrates the lengths of the femur and tibia, hip flexion contracture, and the coronal and sagittal knee alignments. Pelvic obliquity and axial

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Ethical review: Study approval was obtained from La Pitié-Salpêtrière Hospital review board.

Location of Study: La Pitié-Salpêtrière Hospital.

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pelvic rotation which affect the patients' perception of leg length will also be taken into account in this position.

In this study, these questions were asked: (1) Does the perception of LLD correlate better with the anatomical or functional length? and (2) Does the perception of LLD correlate with other variables including the femoral offset, pelvic obliquity, sacral slope, axial pelvic rotation, and coronal or sagittal knee alignment and foot and ankle height?

Our hypotheses were that the functional length would correlate with the perception of LLD better than the anatomical length. We also hypothesized that the perception of LLD correlates with coronal and sagittal knee alignment, axial pelvic rotation, and obliquity.

Methods

After obtaining Institutional Review Board approval, 101 consecutive patients (aged 18-80 years) who presented to our clinic between January 2014 and December 2016 were reviewed in this retrospective study. Patients had primary THA for degenerative hip arthritis. All the patients with symptomatic spinal pathology, previous spinal surgery, lower extremity open reduction and internal fixation, osteotomy, or arthroplasty (knee, ankle) were excluded. Thirty-eight hips were performed through an anterolateral approach, 37 through a posterior approach, and 26 through a direct anterior approach. All procedures utilized cementless implants. The bearing surface was ceramic-on-ceramic in 56 patients and metal or ceramic-on-polyethylene in 45 patients. All patients were evaluated using standing 3-dimensional (3D) imaging system for spine-related pain and lower extremity—related pain (EOS; EOS Imaging SA, Paris, France). They were asked about their perception of the leg lengths.

Each patient stood comfortably in the EOS machine and the position was specifically checked to avoid superimposition of anatomical structures on the lateral view because this would make 3D reconstruction impossible. The simultaneous biplanar acquisition was used to perform stereoradiographic 3D modeling of each lower extremity using specialized software (sterEOS 3D; EOS Imaging SA) according to a previously described method [13]. The software used the bony landmarks to determine the femoral and tibial torsions in 3D images. After 3D modeling, the software automatically measured all the variables used in this study (Table 1). The femoral offset is the distance between the center of the femoral head and the greater trochanter. Axial pelvic rotation is the angle between the line passing through the centers of both hips and the X-ray beam, with negative rotation being rotation toward the operative hip and positive rotation being rotation toward the nonoperative hip. If the pelvis rotates toward one side, one hip will be in more flexion (the side that the pelvis turns toward) which can give a perception of shorter leg. The opposite hip will be in more extension (the side that the pelvis rotates away from) which can give a perception of longer leg [14]. The pelvic obliquity was measured as the distance between the horizontal line and acetabular roof that was lower in a coronally tilted pelvis. Other variables included the hip-knee-ankle angle and the femoral and tibial mechanical axes (FMA, TMA). The FMA is the line connecting the center of the femoral head to the center of the femoral notch, and the TMA is the line from the center of the tibial plateau (interspinous intercruciate midpoint) extending distally to the center of the tibial plafond. Hip-knee-ankle angle is the angle between the FMA and TMA with neutral angle being zero. Tibial and femoral rotation and knee flexion/hyperextension angle were also derived from the 3D reconstruction [15].

We used the following definitions for measuring the length (Fig. 1):

- Anatomical femoral length: distance between the center of the femoral head (A) and the center of the trochlea (B).
- Anatomical tibial length: distance between the center of the tibial spine (intercondylar eminence) (C) and the center of the ankle joint (D).
- Functional length: distance between the center of the femoral head to the center of the ankle joint (AD).
- Anatomical length: sum of the anatomical femoral and tibial lengths (AB + CD).

Foot deformities cannot be assessed in the EOS images thoroughly. For this study, the distance between the middle of the tibial plafond and the ground was considered the height of the foot as a possible factor affecting the LLD. The patients were divided into 2 groups for simple comparison of the means for all the measured variables. The first group (case group) included the patients with a

Table 1
Measurements of Study Variables in Operative and Nonoperative Sides in the Cohort.

Variable	Operative			Nonoperative			*P* Value
	Mean	Minimum	Maximum	Mean	Minimum	Maximum	
No perception of LLD							
Femoral offset (cm)	4.4	3.3	5.6	4.3	3.4	5.1	.667
Femoral neck-shaft angle (°)	132.4	126.3	139.3	124.2	111.9	140.6	<.001
Anatomical femoral length (cm)	41.9	37.7	47.3	41.5	37.4	46.3	.005
Anatomical tibial length (cm)	35.1	31.8	40	35.4	31.8	40.3	<.001
Anatomical leg length (cm)	77	69.7	86.1	77	69.8	85.8	.976
Functional leg length (cm)	77.6	69.9	87.2	77.4	70.2	86.4	.008
Knee varus/valgus angle (°)	−0.1	−6.7	12.1	−1.6	−10	4.52	.008
Hip-knee-ankle angle (°)	4.5	0.6	7.9	5	2.3	7.8	.09
Knee flexum/recurvatum (°)	6.6	−7.88	30.2	5.9	−6.4	27.3	.554
With perception of LLD							
Femoral offset (cm)	4	2.4	5.6	4.1	3.2	5.7	.06
Femoral neck-shaft angle (°)	133.8	121.2	149.5	125.9	109.9	135.9	<.001
Anatomical femoral length (cm)	41.3	34.5	47.3	41	33.9	47.6	.011
Anatomical tibial length (cm)	34.8	29.8	40.6	35.1	23	42.1	<.001
Anatomical leg length (cm)	76.1	65.6	87.9	76.1	65.7	89.6	.687
Functional leg length (cm)	76.7	66.3	88.5	76.5	65.5	90.3	.036
Knee varus/valgus angle (°)	−0.3	−7.7	15.3	−0.5	−12.8	8.5	.825
Hip-knee-ankle angle (°)	4.6	0.8	10.2	4.9	1.7	11.2	.269
Knee flexum/recurvatum (°)	6.3	−11.2	26.9	1.8	−11.4	28.9	<.001