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Review article

Lower limb length and offset in total hip arthroplasty

X. Flecher*, M. Ollivier , J.N. Argenson

Service d'Orthopédie-Traumatologie, CHU Sud, 270, boulevard Sainte-Marguerite, 13009 Marseille, France

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ABSTRACT

Restoration of normal hip biomechanics is a key goal of total hip arthroplasty (THA) and favorably affects functional recovery. Furthermore, a major concern for both the surgeon and the patient is preservation or restoration of limb length equality, which must be achieved without compromising the stability of the prosthesis. Here, definitions are given for anatomic and functional limb length discrepancies and for femoral and hip offset, determined taking anteversion into account. Data on the influence of operated-limb length and offset on patient satisfaction, hip function, and prosthesis survival after THA are reviewed. Errors may adversely impact function, quality of life, and prosthetic survival and may also generate conflicts between the surgeon and patient. Surgeons rely on two- or three-dimensional preoperative templating and on intraoperative landmarks to manage offset and length. Accuracy can be improved by using computer-assisted planning or surgery and the more recently introduced EOS imaging system. The prosthetic's armamentarium now includes varus-aligned and lateralized implants, as well as implants with modular or custom-made necks, which allow restoration of the normal hip geometry, most notably in patients with coxa vara or coxa valga. Femoral anteversion must also receive careful attention. The most common errors are limb lengthening and a decrease in hip offset. When symptoms are caused by an error in length and/or offset, revision arthroplasty may deserve consideration.

1. Introduction

Restoring normal hip biomechanics is a key goal of total hip arthroplasty (THA) and benefits functional recovery [1]. Another major concern is preservation or restoration of limb length equality, which must be achieved without compromising the stability of the prosthesis [2]. Lower limb length discrepancy (LLLD) is a common source of patient dissatisfaction and litigation [3–10]. The discrepancy may be either anatomical (structural) or functional, and a clear understanding of all the factors that create a sensation of length discrepancy is essential.

Offset became a focus of interest more recently, when cementless stems were introduced. We will discuss the measurement of offset, which is highly controversial, and the impact of offset on function. Anteversion influences offset and must be taken into account.

2. Definitions

2.1. Length

2.1.1. Anatomical (structural) lower limb length discrepancy (LLLD)

LLLD can be measured by determining the difference between the two sides in the distance from the antero-superior iliac spine and the medial malleolus. Another method consists in placing increasingly thick boards under the foot on the shorter side until the two iliac crests are on the same horizontal line.

2.1.1.1. Preoperative measurement. A full-length antero-posterior standing radiograph should be obtained, given the limited reliability of clinical measurement techniques [1]. The preoperative LLLD is measured as the difference in length of the line segments extending from the top of the femoral head to the center of the ankle on each side. This length is modified in patients with flexion contracture of the hip and/or knee. Another relevant parameter is the height of the center of rotation of the femoral heads, as a difference in this value can induce LLLD despite identical lower limb lengths.

* Corresponding author. Tel.: +33 491 745 012; fax: +33 491 745 625.
E-mail address: xavier.flecher@ap-hm.fr (X. Flecher).

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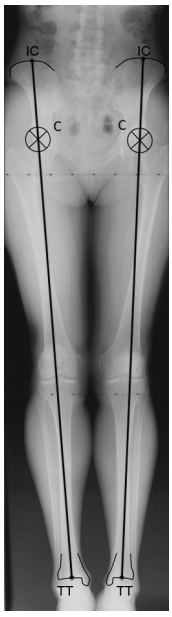

Fig. 1. Measurement of lower limb length on a full-length radiograph of both legs: length of the line segment connecting the top of the iliac crest (IC) to the middle of the tibio-tarsal joint line (TT) and running through the center of rotation of the femoral head (C).

Lower limb length should therefore be measured as the length of the line starting at the top of the iliac crest (or, if this structure is not visible on the radiographs, the sacro-iliac joint), running through the center of rotation of the femoral head, and ending at the middle of the tibio-tarsal joint space (Fig. 1). The two lower limbs must be aligned perpendicularly to the pelvis, with no flexion.

2.1.1.2. Postoperative measurement. The following landmarks are identified on a pelvic radiograph taken under the above-described conditions: the bi-ischial line [10] or radiological teardrops [11] at the pelvis and the centers of the lesser trochanters at the femurs (Fig. 2).

Measuring the distance separating these two landmarks before and after THA reflects the lower limb length change induced by the procedure. The change in length may be due to the femur and/or acetabulum.

2.1.2. Functional lower limb length discrepancy (LLLD)

About 1 in every 3 patients reports a sensation of LLLD after THA [5,12]. In a questionnaire survey, 329 (30%) of 1114 patients reported perceived LLLD after THA, but only 36% of these patients had anatomical LLLD [13]. The remaining 64% had functional LLLD.

Functional LLLD can be related to pelvic obliquity, which may be due to an abnormality in the lower limbs, spine, or both. Pelvic obliquity is common in patients with hip dysplasia or dislocation, particularly when unilateral. In this situation, fixed spinal malalignment develops secondarily, contributing to the pelvic obliquity that was initially due only to a lower limb abnormality.

Another contributor to perceived LLLD is postoperative tension of the gluteus medius and minimus muscles, which is due in some cases to a need for elongation; when the two lower limbs are aligned along the axis of the body, the operated limb seems longer. This distal pelvic obliquity is short-lived, as the muscle tension resolves within the first year. A postoperative limp can also induce a sensation of LLLD: thus, patients with the Trendelenburg gait pattern may perceive the operated limb as shorter than the other limb.

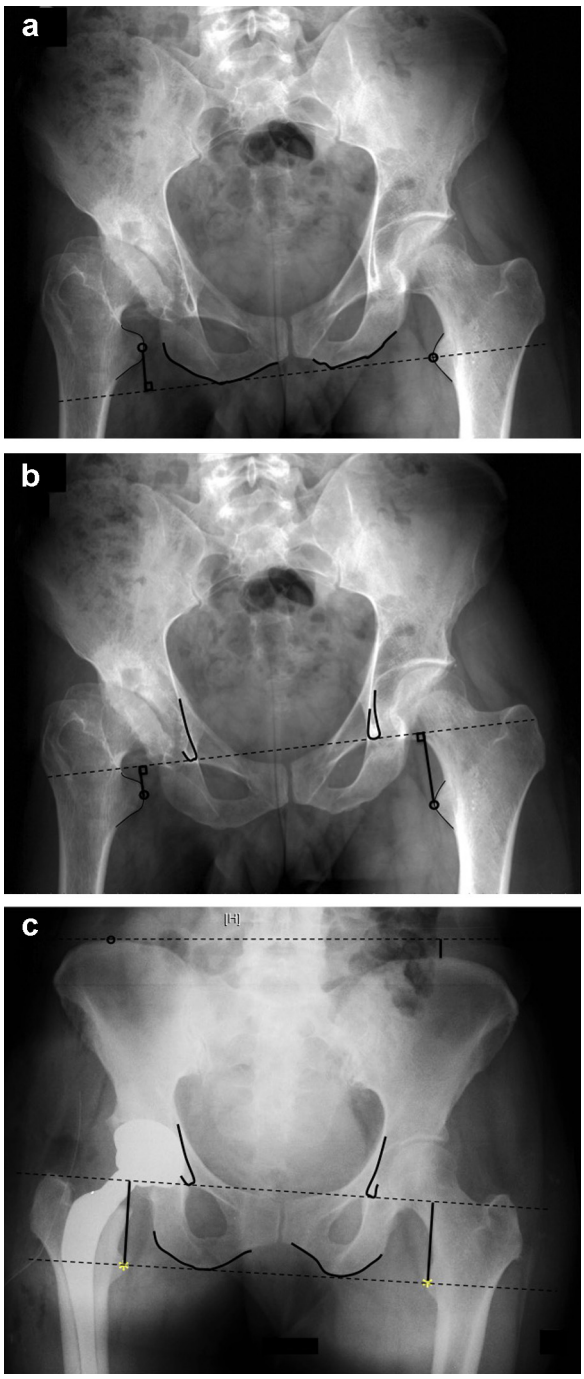

Fig. 2. Estimation of lower limb length discrepancy related to the hip. a: using the bi-ischial line; b: using the radiological teardrop; c: pelvic obliquity is a less reliable criterion: although the hips are at the same level, the pelvis is oblique.

2.2. Offset

Femoral offset is the perpendicular distance from the center of rotation of the femoral head to the line of action of the abductor muscles (Fig. 3a) [14]. Acetabular offset is the perpendicular distance from the center of rotation of the femoral head to the vertical trans-teardrop line (Fig. 3b). Global hip offset is the sum of femoral and acetabular offsets.

Femoral offset is challenging to measure. In practice, the perpendicular distance from the center of rotation of the femoral head to the long axis of the femoral metaphysis or canal is used (Fig. 3). Mean femoral offset is 41 to 44 mm [15,16]. Femoral offset