The Influence of Limb Position on Leg Length and Offset Measurement during Total Hip Arthroplasty

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Introduction: It has been noticed that restoring the offset and equalization of the leg length during total hip arthroplasty, THA, reduces the risk of the dislocation, limping, and polyethylene wear (1,2). However, ensuring both the leg length and offset according to pre-operative planning during the surgery is a challenging task. One of practical methods to improve the consistency is to measure the leg length and offset directly with a gauge. The leg length/offset measurement instrument, LOMI, is a simple, effective and reasonable device to detect the differences in leg length and offset between pre- and post-implantations of the prostheses during THA. Since the device is two-dimensional measurement, it is essential to reproduce a constant limb position at every measurement in order to obtain precise measurements. However, it is not easy to do so in actual surgical settings. There are few studies on the potential error of the direct measurement relating to the limb position (3,4). Therefore, the aim of this study is to evaluate the influence of the limb position on measuring the leg length and offset.

Materials and Methods: Sawbone models of the hemi-pelvis and femur were used. To simulate the lateral decubitus position as usually adopted in operating room, the hemi-pelvis was rigidly fixed to a pedestal with two bolts. The pedestal was also firmly attached to a metal base board measuring 50 cm wide, 90 cm long, and 2 cm thick. The Synergy Select™ hip prosthesis, Smith & Nephew, Memphis Tennessee, was used. As for the femur, a number 12 femoral broach was properly seated in a usual surgical fashion. A high offset trial neck with a 28 mm-diameter (+0) femoral head was attached to the femoral broach. A 56-millimeter acetalbar shell was firmly fixed to the pelvis. A neutral acetalbar polyethylene liner was impacted tightly to the shell. The distal end of the femur was held with a custom made clamp which enabled to alter the angles of the hip joint three dimensionally as desired. Neutral position in flexion/extension was defined when the coronal axis of the femur was parallel to the longer edge of the metal board. Neutral internal/external rotation was determined so that coronal plane of the trial neck was perpendicular to the base board. Neutral adduction/abduction was determined when the lateral surface of the femur was parallel to the base board. Both rotation and adduction/abduction were confirmed with a level measure. The base board was always assured to be horizontal. A 3.2 mm pin with a stopper was placed into the iliac tubercle to install the LOMI. In clinical setting, the iliac tubercle is chosen as a pin site for LOMI because the tubercle is the thickest part of the ilium. Both leg length and offset can be measured using the LOMI referenced from the pin. The most prominent point at the lateral aspect of the greater trochanter in the extended line with longitudinal axis of the trial neck was chosen as the measuring point. In order to ensure the point, a Synthes™ small cortical screw was placed. Prior to this study, the precision of the gauge was revealed to be 0.7 mm for the leg length, and 0.6 mm for the offset. To analyze the influence of the limb position change in flexion/extension, internal/external rotation, and adduction/abduction on measurements, only one of three positions was changed and two positions were fixed to neutral. The limb position was changed with 2-degree increment from 30 degrees flexion to 30 degrees extension, from 30 degrees internal rotation to 30 degrees external rotation, and from 10 degrees adduction to 18 degrees abduction, respectively. One examiner measured leg length and offset three times per each position, and the mean value was used to compare to that of neutral position.

Results: Position change in adduction/abduction had most profound effects on the leg length and offset measurements.

The difference from neutral position in addition/abduction

A 28-degree change in adduction/abduction resulted in 33 mm and 14.6 mm difference in leg length and offset, respectively. 60-degree changes in flexion/extension and internal/external rotation resulted in 8.7 mm and 16.7 mm differences in leg length, respectively.

The difference from neutral position at the different hip angle

Similarly, 60-degree change in internal/external rotation resulted in 9.6 mm differences in offset. Offset was unchanged in flexion/extension, as expected.

Discussion: This simple experiment has revealed the importance of the limb positioning in detecting the proper change of the offset and leg length during surgery. It has been found that the maximal amount of variation was 33 mm in leg length and 14.6 mm in the offset in this study. Using modular head/neck components (from -5 to +5 mm) and standard/high offset stem variations of the Synergy Select stem, the range of adjustment for the leg length and the offset is 6.6 mm and 15.6 mm, respectively. Large differences in leg length and offset due to changes of limb position might mislead surgeons into selecting inappropriate neck length/offset components. The further investigations are needed to clarify the method to reduce the effect of limb positioning on the measurements.