Difference in Hip Prosthesis Femoral Offset Affects Hip Abductor Strength and Gait Characteristics During Obstacle Crossing

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KEYWORDS

• Total hip replacement • Femoral offset • Abductor strength • Obstacle clearance

KEY POINTS

- Failure to restore femoral offset in total hip replacement may compromise the safety of patients with total hip replacement performing the normal activities of daily living.
- To significantly improve patients' ability to safely negotiate obstacles of heights commonly encountered, it may be helpful to increase femoral offset somewhat above the native state.

INTRODUCTION

Pain relief following total hip arthroplasty (THA) allows patients with arthritis of the hip to perform more of their daily and recreational activities.[1] Consequently, the increased physical activity should promote the restoration of muscle function. However, a meta-analysis of recovery of physical function 6 to 8 months after THA revealed that THA patients perceived their physical function to be 80% that of equivalent controls,[2] and increases in levels of daily activity were meager.

Stability and efficiency of gait represents an important measure of post-THA hip function. Several investigators have reported that residual gait impairments still persist several years after the surgery.[3–5] Weakness of the hip abductor muscles in individuals with THA has been found to be associated with poor gait patterns, with patients

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demonstrating abnormalities such as a decreased single-limb stance time, decreased hip extension motion and hip abduction moment, and a positive Trendelenburg sign.[4,6–8] Atypical muscle activation patterns of the hip abductor muscles of THA individuals may also affect locomotor ability.[9]

It has been demonstrated that one of the most effective methods to improve the mechanical leverage of the hip abductor muscles is to increase the femoral offset (FO) of the hip prosthesis.[10–13] FO is defined as the perpendicular distance from the long axis of the femur to the center of rotation of the femoral head.[14,15] The FO of the THA limb is said to be restored, high, or low, respectively, if it is the same, longer, or shorter than that of the natural state.[14] Several investigators have revealed the advantages of restored or high FO compared with low FO, including improved hip stability,[16,17] range of motion,[17–19] and hip abductor strength.[11–14,20,21] However, whether these advantages improve physical function during a demanding lower extremity gait task remains unknown.

For gait, use of the THA hip abductor muscles during ipsilateral single-limb support is essential in controlling pelvic obliquity and maintaining upright balance of the trunk.[10] During the THA single-support phase, the weight of the body (minus that of the THA limb) creates a torque on the pelvis that attempts to laterally tilt the pelvis downward on the non–THA-limb side. To keep the pelvis upright, the hip abductors must create an equivalent countermoment on the trunk. Simplistically assuming that all other factors remain constant, THA patients with a high FO should be able to generate sufficient hip abductor muscle torque to maintain appropriate pelvic obliquity and an upright trunk posture, in comparison with patients with a low FO. However, it is unclear whether this supposition is true.[22]

For this study, to assess whether FO affects hip abductor strength, and consequently whether strength differences make a functional difference to THA patients, the authors used a gait task that requires higher levels of balance and pelvic obliquity control than level walking; specifically, stepping over an obstacle. It was anticipated that during the THA single-support phase, THA patients with a high FO (HI-FO) would be able to produce more adaptations to higher obstacle heights kinematically than would those with a low FO (LO-FO). Simultaneously, LO-FO patients were expected to display greater electrical activation and poorer trunk and limb control as the height of the obstacle increased.

Therefore, the purposes of this study were to determine: (a) if HI-FO in comparison with LO-FO would display increased hip abductor muscle strength and, consequently, differences in gait kinematics and level of muscle activation during the crossing of an obstacle; and (b) whether these FO-group differences would be greater as obstacle height increased.

METHODS

Participants

The study included 20 participants who had previously undergone a unilateral, primary THA resulting from hip osteoarthritis, performed by one surgeon (O.M.M.). Potential participants were excluded if they had leg length discrepancy of greater than 20 mm, or any functional, neurologic, or morphologic disorders affecting gait. All participants had a reconstructed hip joint with well-fixed, uncemented acetabular and femoral components; all contralateral hips were disease-free with normal radiologic findings. Postoperative time ranged from 18 to 80 months (mean, 43 months).

To classify the participants into the LO-FO or HI-FO groups, standard hip and pelvic radiographs of each participant were used to measure the FO of both hips (**Fig. 1**).[15] Based on pilot testing and practical ranges of FO used in the surgeon's practice, the current study focused on participants for whom FO of the reconstructed hip differed in magnitude from that of the normal contralateral hip by more than $\pm$ 5%. Participants were classified into the HI-FO group if the FO of the THA hip was greater than 105% the FO of the non-THA hip (range, 106%–139%; median, 118%), and the LO-FO group if the FO of the THA hip was less than 95% the FO of the non-THA hip (range, 73%–95%; median, 87%). The characteristics of the 9 LO-FO and 11 HI-FO participants are shown in **Table 1**.

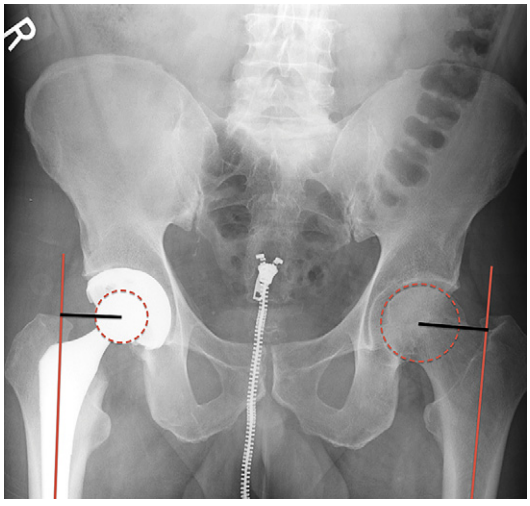

Fig. 1. Pelvic radiograph showing measurement of femoral offset.