Factors Affecting Hip Rotation Angles in Total Hip Arthroplasty

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Research article

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Abstract

Background

Some patients undergoing total hip arthroplasty (THA) show postoperative changes in hip rotation. We investigated changes in the hip rotation angles of patients in the standing position before and after THA and the factors associated with such changes.

Methods

Participants included 77 patients (82 joints) who underwent primary THA for hip osteoarthritis. There were 17 joints in men and 65 joints in women, and the mean age at the time of surgery was 65.7 years. Standing hip rotation angles and hip internal/external rotation ranges of motion (ROM) were measured before and 2 weeks after THA to compare preoperative and postoperative measurements. For radiographic measurements, acetabular and cup anteversion, neck and stem anteversion, combined anteversion (CA), and leg length discrepancy were measured before and after THA to investigate the factors associated with changes in standing hip rotation angles.

Results

Regarding standing hip rotation angles, external rotation was 6.9° ± 4.1° before THA and 2.0° ± 2.4° after THA, showing a shift in the internal rotation direction ($P = < .0001$). The degree of change in standing hip rotation angles before and after THA was found to be negatively correlated with the degree of change in cup anteversion (- 0.429, $P = < .0001$) and CA (- 0.3012, $P = .0063$).

Conclusion

Postoperative changes in standing hip rotation following THA were considered associated with extra-articular position sense, rather than intra-articular position sense, to maintain the balance between the pelvis and proximal femur affected by the angles of the placed implant components.

Introduction

As the population ages, the number of patients requiring total hip arthroplasty (THA) for hip osteoarthritis has been rising year after year. THA is a surgical procedure that can dramatically improve pain and impaired joint function in the hip and yield high levels of patient satisfaction. On the other hand, the loss of in-vivo joint function has been reported to lower the patient's joint position sense, thus affecting motor control [1, 2]. Increasing age has been associated with impairments in sensory, effector, and central processing factors [3]. Kaplan reported the existence of an age-related change in proprioception and static joint position sensation in women and provides a basis for further investigation of contributory factors of musculoskeletal trauma in the elderly [4]. Studies have also reported that postural stability is associated with joint position sense [10] and that patients with hip osteoarthritis have impaired joint position sense, which affects their posture and body balance [11]. When the joint capsule and joint ligament, which are the sensory receptors of hip joint, are extensively resected in THA, their somatosensory system is impaired causing abnormal joint position sense and obstruction of smooth joint movements. However, there have been very few reports on joint position sense after THA [1, 2].

We have also encountered cases in which changes occurred in hip rotation after THA. In this study, we aimed to investigate changes in hip rotation angles in the standing position before and after THA and the factors associated with such changes.

Methods

Eighty-two joints in 77 patients who underwent primary THA for hip osteoarthritis. Ankylosis hips (preoperative rotation range of motion (ROM) < 5°) were excluded in this study. There were 17 joints in 14 men and 65 joints in 63 women, and mean age at the time of surgery was 65.7 (33–86) years. Surgery was performed via the posterolateral approach. The short external rotator muscles were dissected, and the articular capsule was removed circumferentially. After implant placement, the short external rotator muscles were sutured back. In all cases, the same implants manufactured by Zimmer Biomet were used: RingLoc™ Acetabular System (Mallory-Head™) for the cup, Bi-Metric XR™ for the stem, 28-mm CoCr for the head, and E1™ Acetabular Liner for the liner.

Hip rotation angles in the standing position and hip internal/external rotation ROM in the prone position were measured before THA and 2 weeks after THA. To measure standing hip rotation angles, each participant was placed in a standing position and asked to recognize the rotationally neutral position using a line perpendicular to the frontal plane of the body as the reference line. The participants were then asked to take 10 steps, in place, while looking straight ahead and to subsequently stand in the position which they considered to be neutral. The angle formed by the participant’s position and the reference line was measured 3 times, and the average was used as the standing hip rotation angle (Fig. 1). To investigate the factors associated with postoperative changes in the standing hip rotation angle, radiographic measurements, including acetabular and cup anteversion, neck and stem anteversion (Fig. 2), combined anteversion (CA), and leg length discrepancy (the distance from the teardrop line to the tip of the lesser trochanter), were measured before and after THA.

For statistical analysis, data were compared before and after surgery using the Mann-Whitney U test, and $P < .05$ was considered to indicate a statistically significant difference. Additionally, factors contributing to changes in standing hip rotation angles were evaluated using Spearman's rank correlation coefficient (JMP® 11 [SAS Institute Inc., Cary, NC, USA]).

Results

Regarding the standing hip rotation angle, external rotation was 6.9°± 4.1° (mean ± SD) before THA and 2.0° ± 2.4° after THA, showing a shift in the internal rotation direction (P = < .0001). Internal rotation ROM changed from 12.5° ± 8.8° before THA to 23.6° ± 10.4° after THA (P = < .0001), external rotation ROM changed from 21.8° ± 10.9° before THA to 27.2° ± 10.1° after THA (P = .0016), cup anteversion changed from 12.8° ± 9.8° before THA to 22.8° ± 10.7° after THA (P = < .0001), stem anteversion changed from 22.4° ± 11.6° before THA to 29.0° ± 10.3° after THA (P = .0002), and leg length discrepancy changed from − 7.3 mm ± 8.3 mm before THA to 3.2 mm ± 6.2 mm after THA (P = < .0001) (Table 1).

Table 1
Changes before and after THA

	Pre-THA (mean ± SD)	**2 weeks post-THA (mean ± SD)**	***p*-value**
Standing rotation angle	6.9°±4.1°	2.0°±2.4°	< .0001
Internal rotation ROM	12.5°±8.8°	23.6°±10.4°	< .0001
External rotation ROM	21.8°±10.9°	27.2°±10.1°	.0016
Cup anteversion	12.8°±9.8°	22.8°±10.7°	< .0001
Stem anteversion	22.4°±11.6°	29.0°±10.3°	.0002
Combined Anteversion	35.2°±14.1°	51.8°±14.2°	< .0001
Leg length discrepancy	-7.3 mm ± 8.3 mm	3.2 mm ± 6.2 mm	< .0001

Regarding analysis of the correlation between the degree of change in standing hip rotation angles before and after THA, Spearman's rank correlation coefficient was calculated as − 0.0454 (P = .6875) for cup anteversion, − 0.429 (P = < .0001) for stem anteversion, − 0.3012 (P = .0063) for CA, and − 0.106 (P = .3463) for leg length, thus showing that the degree of change in standing hip rotation angles was negatively correlated with the amount of change in stem anteversion and CA (Table 2).

Table 2
Factors associated with postoperative rotation angle and the degree of change in rotation angle

		Spearman Rank correlation coefficient	*p*-value
Postoperative rotation angle	Postoperative cup anteversion	− 0.2708	0.0145
	Postoperative stem anteversion	− 0.1520	0.1754
	Postoperative CA	− 0.2978	0.0069
	Postoperative leg length discrepancy	0.0339	0.7639
	Postoperative internal rotation ROM	0.0036	0.9749
	Postoperative external rotation ROM	0.0867	0.4416
Change in rotation angle	Change in cup anteversion	− 0.0454	0.6875
	Change in stem anteversion	− 0.429	< .0001
	Change in CA	− 0.3012	0.0063
	Change in leg length	− 0.106	0.3463

Discussion

Postoperative changes in hip rotation when standing or walking sometimes occur in patients undergoing THA. Although researchers have suggested that such changes may be associated with joint position sense, only a few reports have focused on this association [1, 2]. Previously studies reported that the sensory receptors were existed in articular capsule, labrum, transverse acetabular ligament, and ligament of the head of femur of the hip joint [5–9]. Among structures surrounding the hip joint, sensory receptors are most commonly located in the articular capsule [9]. Lord reported in a sample of 95 elderly individuals that postural stability is significantly associated with decline in proprioception and vibration sense of the lower extremity [10]. Slomka reported that the generalized sensomotor deficit, a lack of proprioceptive information, and loss of neuromuscular control due to the degenerative process may lead to balance problems in osteoarthritis patients [11].

Nakagawa reported that a position sense test conducted at an angular velocity of 2°/sec 1–4 weeks after surgery found a significant difference in the perceived angles, claiming that broad excision of the articular capsule by THA leads to a postoperative decrease in the accuracy of sensory receptors, which manifests as an abnormal joint position sense, hindering smooth joint movements and the avoidance of unsafe body positions [1]. Karanjia also reported that reduced joint position sense was observed in a position sense test at an angular velocity of 0.6°/sec, suggesting that the influence of intra-articular structures cannot be completely ruled out [2]. On the other hand, Ishii and Grigg stated that the control of joint position sense also largely involves mechanoreceptors in extra-articular structures, such as tendons and muscles, in addition to those in intra-articular structures. They reported no reduction in joint position sense after THA [12, 13]. Nallegowda also reported that removing the articular capsule by THA did not affect position sense in patients [14].

In this study, standing hip rotation angles changed from a mean external rotation of 6.9° before THA to a mean external rotation of 2.0° 2 weeks after THA, shifting internal rotationally by 4.9° on average. In addition, the degree of change in standing hip rotation angles was negatively correlated with the degree of change in stem anteversion and CA. Therefore, as factors contributing to internal rotation direction shift from preoperative baseline to 2 weeks after THA, postoperative increases in femoral neck anteversion and CA were considered. Extra-articular position sense in the proximal femur (around the hip joint) was retained by excessive anteversion of the cup and stem placed in the implant, which presumably caused the body to acquire the posture that can maintain a correct tissue balance between the pelvis and proximal femur, thus resulting in internal rotation of the distal femur (Fig. 3). Therefore, extra-articular position sense may have a greater influence on joint proprioception than intra-articular position sense such as articular capsule, labrum, transverse acetabular ligament, and ligament of the head of femur.

Limitations

In this study, the articular capsule was removed circumferentially in all patients, and no comparative investigation was conducted in patients whose articular capsule was preserved. It is thus necessary to examine standing hip rotation angles in patients in whom the articular capsule is preserved.

Conclusion

We investigated postoperative changes in standing hip rotation angles following THA and the factors associated with such changes. After THA, standing hip rotation shifted internal rotationally by 4.9 degrees on average. Changes in hip rotation angles were considered to be associated with the body's reaction to the positioning of the implant components to maintain the positional relationship between the pelvis and proximal femur. Based on these findings, it is considered that postoperative changes in hip rotation following THA were affected by changes in extra-articular position sense, rather than intra-articular position sense.

Declarations

Conflict of Interest Statement

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest: Each author certifies that he or she has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.

Ethical Review Committee Statement

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

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Figures

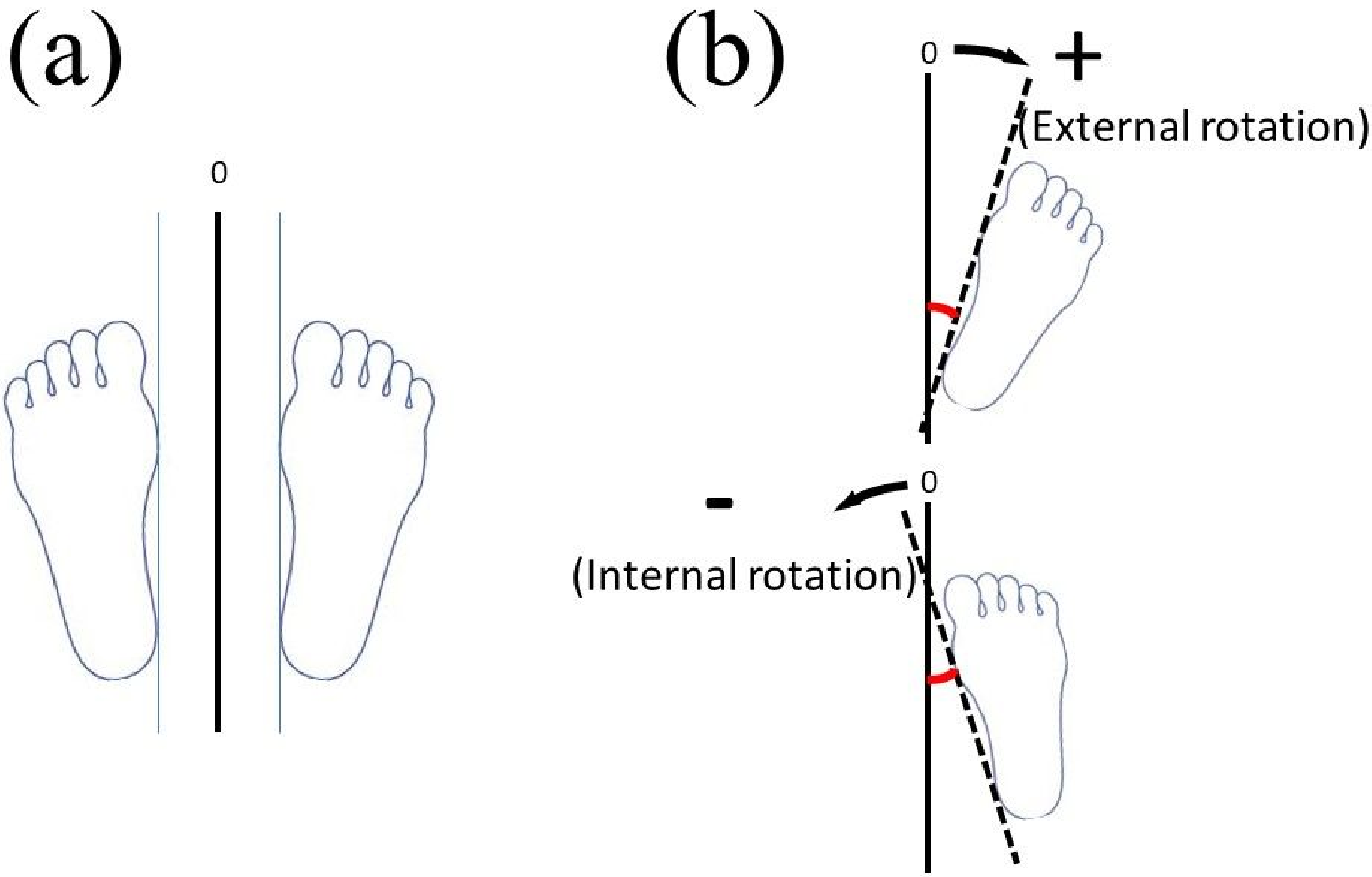

Figure 1

Measurement of standing hip rotation angle a) Participants were asked to recognize the neutral position in standing internal/external rotation. b) Angle in the position which the participant considers to be neutral after taking steps in place while looking straight ahead

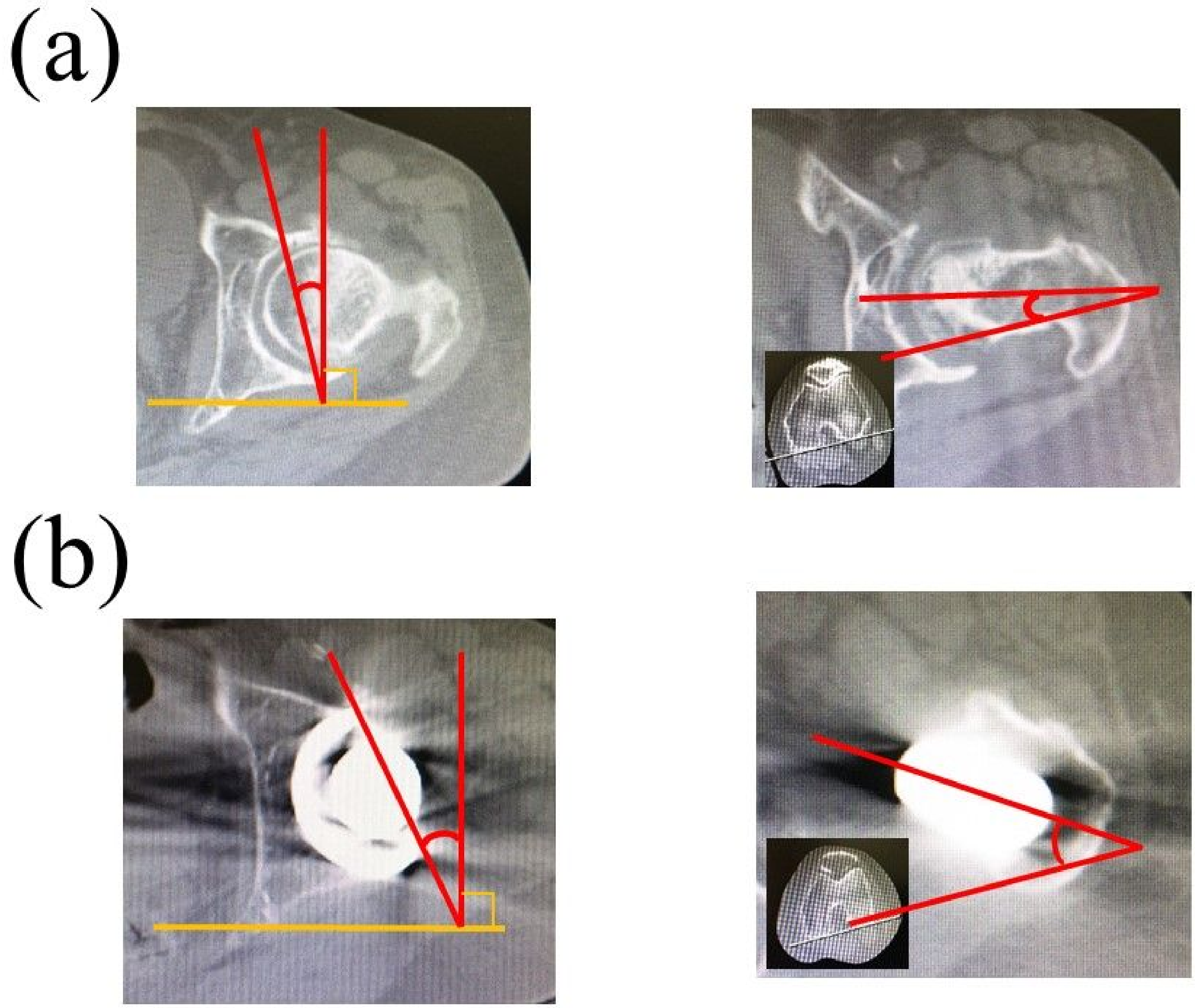

Figure 2

Radiographic measurements a) Pre-THA: With the center of the femoral head at the superior position, the angle formed by the anterior and posterior rims of the acetabulum; the posterior condylar axis of the femur and femoral neck angle b) Post-THA: With the center of the head at the superior position, the angle formed by the anterior and posterior rims of the cup; the posterior condylar axis of the femur and stem neck angle

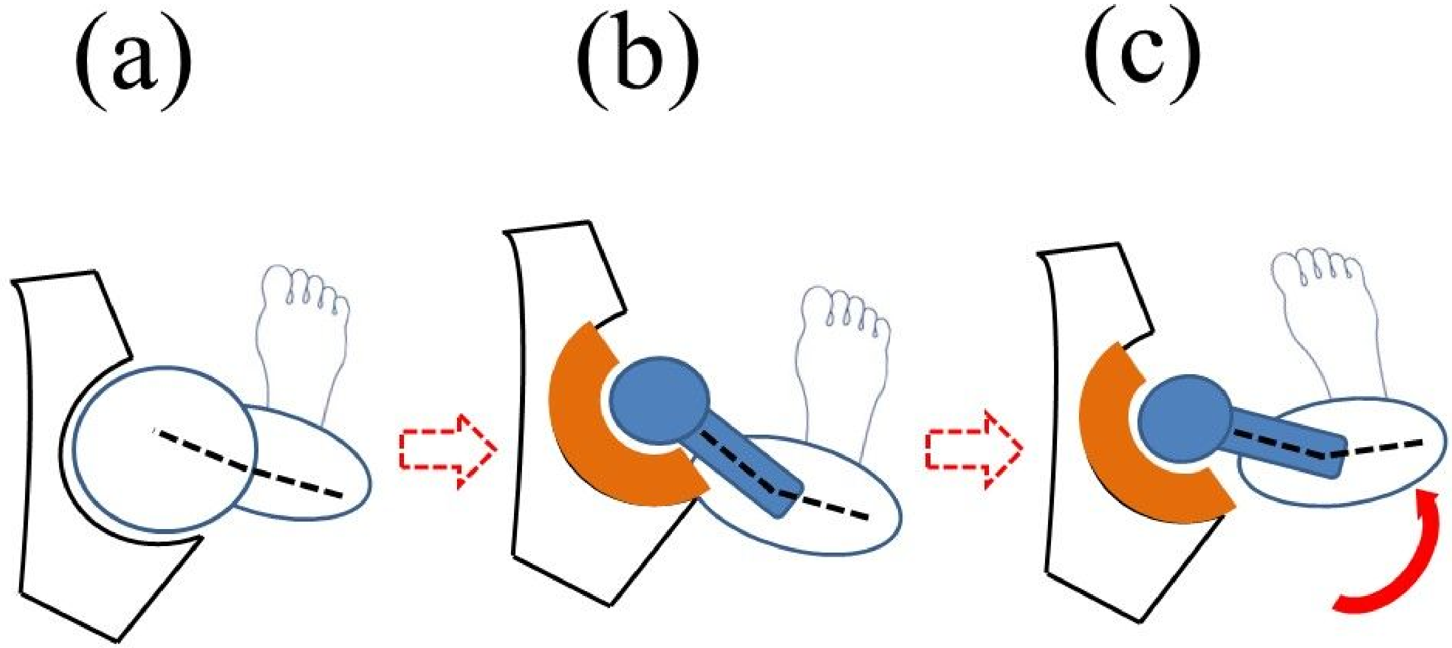

Figure 3

Changes in rotation angles associated with implant component positioning a) Pre-THA b) Excessive cup and stem anteversion in implant c) Rotational response in the medial direction