Recovery of Hip Abductor Muscle Strength after Total Hip Arthroplasty in Patients with Leg Length Discrepancy

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Background: *Total hip arthroplasty (THA) is an effective treatment to reduce pain and improve function outcomes for osteoarthritis patients. To our knowledge, there were scant of information about effect of preoperative leg length discrepancy (LLD) on recovery of hip abductor muscle strength and functional outcomes.*
Objective: *To evaluate the recovery of hip abductor muscle strength after THA in osteoarthritis patients with LLD and to study the correlation among LLD, recovery of hip abductor muscle strength and functional outcomes.*
Material and Method: *Between January 2014 and December 2015, 30 osteoarthritis patients who underwent THA at least six months were divided into two groups, Group 1 (LLD less than 2 cm), and Group 2 (LLD greater than 2 cm). Four parameters were measured on anteroposterior both hip radiographs in the supine position before and after operation: LLD, abductor length, abductor lever arm, and femoral offset (FO). Abductor muscle strength was calculated quantitatively by an isokinetic/isometric dynamometer [Con-Trex MJ]. Hip abductor strengths were calculated as the ratio of operated hip to contralateral healthy hip which used as controls. Functional outcomes were evaluated by two-minute walk test (2MWT) and timed up and go test (TUG).*
Results: *The mean of hip abductor muscle strength ratio in all patients was 89.50% (standard deviation (SD) 29.94). Patients showed 83.10% (SD 34.58) of mean abductor muscle strength ratio at 6 to 12 months after operation, 88.50% (SD 25.36) at 12 to 24 months after operation, and 112.20% (SD 25.27) after 24 months after operation. Patients in Group 1 had 94.74% (SD 33.54) of mean hip abductor muscle strength ratio. It was greater than 79.02% (SD 18.18) in Group 2, however, there were no statistically significant differences between the two groups ($p = 0.18$). There were no significant differences of 2MWT and TUG between the two groups either. A weak correlation between preoperative LLD and hip abductor muscle strength ratio ($r_s = 0.163$, $p = 0.39$), and between preoperative LLD and 2MWT ($r_s = 0.030$, $p = 0.874$), TUG ($r_s = -0.067$, $p = 0.73$) were found.*
Conclusion: *The hip abductor muscle strength showed good to excellent recovery after THA. The results from this study showed no correlation among preoperative LLD, the recovery of hip abductor muscle strength, and functional outcomes.*

Keywords: *Osteoarthritis, Muscle strength, Abductor muscle strength, Leg length discrepancy, Total hip arthroplasty*

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Osteoarthritis (OA) is the most common articular disease and symptomatic health problems for middle aged and older patient[1-4]. OA is caused by progressive degeneration of cartilage accompanied by attempted repair of cartilage, sclerosis of subchondral bone, and osteophyte formation[5,6]. It is characterized by joint pain, dysfunction, contractures, muscle atrophy, and leg length discrepancy (LLD) in advanced stages[5-7].

Total hip arthroplasty (THA) is an effective treatment to reduce pain and improve function outcomes. In previous study, OA hip patients had 17% less hip abductor strength[8]. A 2 cm LLD patients have more oxygen consumption and the rating of perceived exertion greater than no LLD patients[9]. The biomechanical environment of the hip abductor muscle was changed after THA that can enable hip abductor muscle strength to be improved. Several studies have reported the recovery course of hip abductor muscle strength after THA in patients with hip OA. Early loss of postoperative abductor muscle strength and decreased functional performance was found after THA, yet the strength deficits may persist during the first year after surgery[10].

To our knowledge, there was less information about effect of preoperative LLD on recovery of hip abductor muscle strength and functional outcomes. This study aimed to evaluate the recovery of hip abductor muscle strength after THA in OA patients with LLD and to study the correlation among LLD, the recovery of hip abductor muscle strength and functional outcomes.

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Objective

The primary outcomes were the recovery of hip abductor muscle strength after THA in patients with LLD. The secondary outcomes were to study about correlation among LLD, the recovery of hip abductor muscle strength and functional outcomes.

Material and Method

This investigation was a cross sectional study. This study was approved by the Ethics Committee for Research in Human of Faculty of Medicine Siriraj Hospital, Mahidol University and all patients gave informed consent to participate in this study. Thirty subjects (11 males, 19 females) with unilateral symptomatic severe OA hip who had undergone unilateral THA in Siriraj Hospital between January 2014 and December 2015 were enrolled. Thirty patients underwent THA at least six months by posterior approach. Participants were eligible if they were between 40 and 80 years of age. Patients who had unstable medical condition, any functional, or neurologic disorders affecting gait function were excluded from this study. Patients who developed infection, fracture, nerve palsy, or dislocation were not included in this study. Patients with LLD <2 cm were assigned to Group 1, whereas patients with LLD equal or greater than 2 cm were assigned to Group 2. Patient characteristic are summarized in Table 1.

Radiographic assessment

Standard preoperative and postoperative plain film anteroposterior both hips in supine position were obtained. Four parameters were measured (Fig. 1): 1) abductor length was measured by the distance between the anterior superior iliac spine and tip of the greater trochanter[11], 2) abductor lever arm was the length of a straight line from the center of femoral head perpendicular to the line of action of the abductor muscles[11], 3) LLD was evaluated as the difference in length between the tip of the lesser trochanter and the reference line (inter-teardrop line)[12-14], 4) femoral offset (FO) was the distance from the center of the femoral head or prosthesis to a line bisecting the long axis of the femoral shaft.

Outcome measures

Hip abductor muscle strength

Isometric hip abductor muscle strength was measured in patients postoperative THA at least six months. All measurements were performed for all patients by the same physiotherapist using an isokinetic/isometric the dynamometer [Con-Trex MJ]. The contralateral healthy hips served as within-subject controls. During the test, the patients were placed with side lying on a padded table with the study hip up and the resistance arm was secured to the lateral thigh just proximal to the lateral femoral condyle. The study hip was placed in straight neutral position whereas the contralateral hip was placed in approximately 30 degree of hip flexion and 30 degree of knee flexion on the padded table. The normal hip was tested first. The patients were asked to perform two times of maximal isometric exertions for five seconds with one minute of rest between the repetitions. The peak force was normalized to each patient's body weight (Nm/Kg). The hip abductor muscle strength ratio was calculated by the ratio of body weight-normalized hip abductor muscle strength on the operated hip to the contralateral healthy hip. The ratio of abductor muscles length, abductor lever arm, FO, and abductor muscle strength on the operated hip versus the contralateral healthy hip were calculated to allow comparison of participants with different heights and builds[15,16].

Functional outcomes

The two-minute walk test (2MWT) and the timed up and go test (TUG) were used as the tools for evaluate functional performance and ability of patients

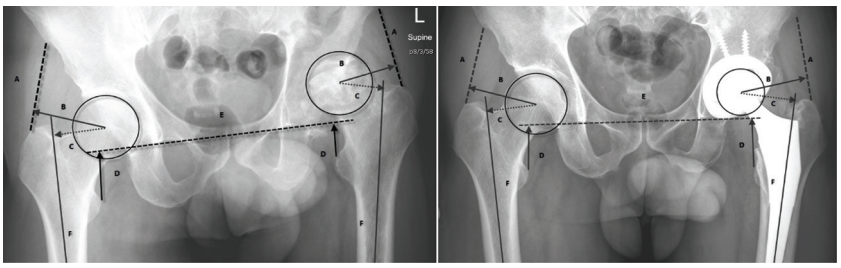

Fig. 1 Preoperative and postoperative THA radiographs showing measurement of following parameters, (A) abductor length, (B) abductor lever arm, (C) femoral offset (FO), (D) distance between tip of lesser trochanter and reference line, (E) interteardrop line, and (F) long axis of femur.

Table 1. Patient characteristic

Characteristic	Group 1 (LLD <2 cm)	Group 2 (LLD ≥2 cm)	Total
Gender, n (%)			
Male	5 (16.7)	6 (20.0)	11 (36.7)
Female	15 (50.0)	4 (13.3)	19 (63.3)
Age at surgery (years), mean (SD)	59.2 (10.8)	56.9 (8.8)	58.4 (10.1)
BMI (kg/m^2), mean (SD)	24.2 (3.7)	28.2 (4.7)	25.5 (4.5)
Postoperative duration (month), mean (SD)	22.7 (26.9)	23.0 (23.7)	22.8 (25.43)
Affected leg, n (%)			
Right side	7 (23.3)	3 (10.0)	10 (33.3)
Left side	13 (43.3)	7 (23.3)	20 (66.7)
Dominant leg, n (%)			
Right side	17 (56.7)	8 (26.6)	25 (83.3)
Left side	3 (10.0)	2 (6.7)	5 (16.7)

LLD = leg length discrepancy; BMI = body mass index

in standard environment[17]. Functional endurance was evaluated by the 2MWT, in which the distances as possible over two minutes was documented. This test had excellent reliability (ICC = 0.95)[18]. The TUG, which assesses basic mobility skill, walking, balance and fall risk, measures the time in seconds to rise from sitting in a chair, walk three meters, turn around, walk back to the chair, and sit down[19]. This test had a reliable (ICC = 0.75)[20]. These two tests were easy to assess and monitor function performance in the clinical setting[21].

Statistical analysis

The data were presented as mean (standard deviation, SD) or median (minimum, maximum) for continuous data, number and percentage for categorical data. We used independent t-test to compare clinical characteristic between the two groups and to examine group differences in hip abductor muscle strength ratio, result of the 2MWT, and the TUG. One-way ANOVA used to compare recovery of hip abductor muscle strength after postoperative THA in different period. Preoperative and postoperative differences in radiographic parameters (LLD, abductor length ratio, abductor lever arm ratio, and FO) were compared with paired t-test. The relationship between variables with a scatterplot was examined. Spearman correlation coefficient (r_s) analyses were performed to investigate the relationships among abductor muscle strength ratio, result of performance-based tests, and preoperative LLD. Statistical significance was accepted at $p<0.05$. All statistical analyses were performed with PASW (SPSS) Statistics version 18 (SPSS Inc., Chicago, IL).

Results

Thirty patients with end stage OA hip participated in the study (Table 1). Most of OA patients were female (63.30%). Mean age at surgery was 58.4 (SD 10.1) years. Most of affected legs were left side (66.70%) but most of patient's dominant leg was right side (83.30%). Median duration after operation was 14.5 (6,105) months. There were no differences in mean age at surgery or mean post-operative duration between Group 1 and Group 2. But there were significant differences in BMI between both groups ($p = 0.02$).

The recovery courses of abductor muscle strength, by duration after operation, were reported in Fig. 2. Mean hip abductor muscle strength ratio in all patients were 89.50% (SD 29.94). Patients showed 83.10% (SD 34.58) in mean hip abductor muscle strength at 6 to 12 months after operation, 88.50% (SD 25.36) at 12 to 24 months after operation and 112.20% (SD 25.27) after 24 months post operation. Postoperative hip abductor muscle strength ratio

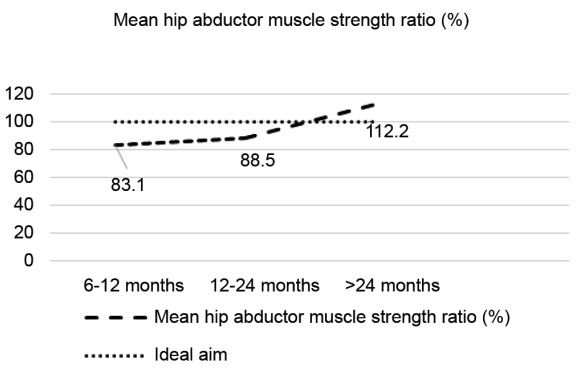

Fig. 2 Changes in mean hip abductor muscle strength ratio.

Table 2. Radiographic parameters between preoperative and postoperative

Parameter	Preoperative	Postoperative	*p*-value
LLD (cm), mean (SD)	-1.77 (1.23)	0.17 (0.90)	<0.001
Abductor length ratio, mean (SD)	78.62 (18.89)	103.49 (15.94)	<0.001
Abductor lever arm ratio, mean (SD)	91.75 (13.19)	102.72 (14.92)	<0.001
Femoral offset ratio, mean (SD)	84.43 (20.52)	99.66 (21.48)	0.002

Table 3. Mean hip abductor muscle strength ratio and functional outcomes between both groups

Outcomes	Group 1 (LLD <2 cm)	Group 2 (LLD ≥2 cm)	*p*-value
Abductor muscle strength ratio (%), mean (SD)	94.74 (33.54)	79.02 (18.18)	0.18
2MWT (meter), mean (SD)	288.20 (85.29)	298.70 (94.82)	0.76
TUG (second), mean (SD)	12.79 (3.67)	12.97 (4.72)	0.91

2MWT = two-minute walk test; TUG = timed up and go test

Table 4. Correlation of preoperative LLD, hip abductor muscle strength ratio, and functional outcomes

Outcomes	Preoperative LLD	
	Correlation coefficient (r_s)	*p*-value
Abductor muscle strength ratio	0.163	0.390
2MWT	0.030	0.874
TUG	-0.067	0.727

showed no significant differences between each groups ($p = 0.25$).

Postoperative LLD was significantly decreased compare with preoperative length ($p<0.001$). The postoperative abductor muscle length ratio, abductor level arm ratio, and FO ratio significantly increased from preoperative values ($p<0.001$) (Table 2).

Comparison between groups of postoperative mean hip abductor muscle strength ratio and functional outcomes were reported in Table 3. Patients in Group 1 had 94.74% (SD 33.54) of mean hip abductor muscle strength ratio which greater than 79.02% (SD 18.18) in Group 2, however, no statistical significant between both groups ($p = 0.18$). There were no significant difference in the results of 2MWT and TUG between both groups.

Spearman correlation coefficient analysis demonstrated a weak correlation between preoperative LLD and hip abductor muscle strength ratio ($r_s = 0.163$, $p = 0.39$), and between preoperative LLD and 2MWT ($r_s = 0.030$, $p = 0.874$), TUG ($r_s = -0.067$, $p = 0.727$) (Table 4).

Discussion

The severe degenerative process of hip OA was progressive loss of articular cartilage and upward migration of the femoral head, which result in LLD. The challenge of intra-operative THA was fixing a LLD without compromising stability of hip[22,23].

Most of recent study reported result of postoperative LLD to functional outcome. Some authors recommended the leg length should be within 10 mm of the contralateral side because this did not affect the functional performances of gait[24] and produces a satisfactory result in most patients[22,25]. One study reported a LLD had no effect on the functional outcomes of THA[26]. However, there were less information about effect of preoperative LLD to recovery of hip abductor muscle strength and functional outcomes.

In our study, we found that mean hip abductor muscle strength ratio after six months were 89.50% (SD 29.94). Hip abductor muscle strength deficits persist two years after THA and it could be improved. Previous studies reported that deficits of strength and functional outcome persist several years after surgery[27-30]. Radiographic parameters were improved. Lecerf et al[31] reported similar results that an increase in the FO correspond to improve the abductor muscles strength.

Contrary to expectation, there were no statistically significant differences in result of hip abductor muscle strength ratio, 2MWT, and TUG between both different LLD groups. There were a weak relationship among preoperative LLD, hip abductor muscle strength ratio, and functional outcomes. Ruiyu et al[32] reported different results that the range of preoperative LLD were associated with postoperative abductor strength recovery. This may be due to small sample size. However, restoration of leg length equality is an important goal of the THA

operation. Preoperative LLD should be evaluated and corrected during THA[33].

We acknowledge the limitations to our study. Firstly, our sample size was relatively small. It may not be sufficiently statistical powered to detect differences in all outcomes. Secondly, postoperative rehabilitation was not standardized, including various patterns of rehabilitation protocols use after surgery from several practices.

Conclusion

In summary, the postoperative recovery of hip abductor muscle strength showed good to excellent recovery after six months from THA. The results from this study showed no statistically significant correlation among preoperative LLD, the recovery of hip abductor muscle strength, and functional outcomes.

What is already known on this topic?

The literature reported postoperative LLD had no effect on the functional outcomes of THA. However, there were less information about effect of preoperative LLD to recovery of hip abductor muscle strength and functional outcomes.

What this study adds?

This study showed no statistically significant correlation among preoperative LLD, the recovery of hip abductor muscle strength, and functional outcomes.

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Potential conflicts of interest

None.

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การฟื้นตัวของความแข็งแรงของกล้ามเนื้อกางข้อสะโพก (hip abductor muscle) ภายหลังการผ่าตัดเปลี่ยนข้อสะโพกเทียมในผู้ป่วยที่มีภาวะขาสั้นยาวไม่เท่ากัน

ศุภวัทน์ ตันติถาวรวัฒน์, ระพีพัฒน์ นาคบุญนำ

ภูมิหลัง: *การผ่าตัดเปลี่ยนข้อสะโพกเทียมเป็นที่ยอมรับว่าสามารถแก้ปัญหาความผิดปกติของข้อสะโพก ลดอาการปวด และเพิ่มคุณภาพชีวิตของผู้ป่วย*

วัตถุประสงค์: *เพื่อศึกษาการฟื้นตัวของความแข็งแรงของกล้ามเนื้อกางข้อสะโพกภายหลังการผ่าตัดเปลี่ยนข้อสะโพกเทียมเปรียบเทียบในผู้ป่วยโรคข้อสะโพกเสื่อมและมีภาวะขาสั้นยาวไม่เท่ากัน และศึกษาความสัมพันธ์ระหว่างภาวะขาสั้นยาวไม่เท่ากัน การฟื้นตัวของความแข็งแรงของกล้ามเนื้อกางข้อสะโพก และ functional outcomes*

วัสดุและวิธีการ: *ศึกษาโดยเก็บข้อมูลผู้ป่วยโรคข้อสะโพกเสื่อมที่ได้รับการผ่าตัดเปลี่ยนข้อสะโพกเทียมแล้วอย่างน้อย 6 เดือน จำนวน 30 ราย ตั้งแต่เดือนมกราคม พ.ศ. 2557 ถึง ธันวาคม พ.ศ. 2558 โดยแบ่งเป็นสองกลุ่ม กลุ่มที่ 1 มีขาสั้นยาวไม่เท่ากันน้อยกว่า 2 เซนติเมตร และกลุ่มที่ 2 มีขาสั้นยาวไม่เท่ากันมากกว่าหรือเท่ากับ 2 เซนติเมตร วัดค่า abductor muscle length, abductor lever arm, LLD และ femoral offset (FO) จากฟิล์มในท่า standardized anteroposterior hip วัดความแข็งแรงของกล้ามเนื้อกางข้อสะโพกโดยใช้เครื่อง Dynamometer [Con-Trex MJ] นำข้อมูลคำนวณเป็นร้อยละของความแข็งแรง โดยใช้ข้อมูลจากข้อสะโพกด้านตรงข้ามเป็นตัวเทียบ นอกจากนี้ยังเก็บข้อมูล functional outcomes โดยใช้ two-minute walk test (2MWT) และ timed up and go test (TUG)*

ผลการศึกษา: *พบว่าค่าเฉลี่ยการฟื้นตัวของความแข็งแรงของกล้ามเนื้อกางข้อสะโพกของผู้ป่วยทั้งหมดเท่ากับร้อยละ 89.50 (29.94) ในช่วงหลังผ่าตัดตั้งแต่ 6 ถึง 12 เดือน มีค่าเฉลี่ยการฟื้นตัวของความแข็งแรงของกล้ามเนื้อกางข้อสะโพกเท่ากับร้อยละ 83.10 (34.58) ช่วง 12 ถึง 24 เดือน เท่ากับร้อยละ 88.50 (25.36) และมากกว่า 24 เดือนขึ้นไป เท่ากับร้อยละ 112.20 (25.27) ตามลำดับ ผู้ป่วยในกลุ่มที่ 1 มีค่าเฉลี่ยการฟื้นตัวของความแข็งแรงของกล้ามเนื้อกางข้อสะโพกเท่ากับร้อยละ 94.74 (33.54) ซึ่งมากกว่ากลุ่มที่ 2 ซึ่งมีค่าเท่ากับร้อยละ 79.02 (18.18) แต่ไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติระหว่างทั้งสองกลุ่ม ($p = 0.18$) ไม่พบความแตกต่างอย่างมีนัยสำคัญทางสถิติของผล 2MWT และ TUG ระหว่างสองกลุ่ม ค่าสัมประสิทธิ์สหสัมพันธ์ (correlation coefficient) ระหว่างภาวะภาวะขาสั้นยาวไม่เท่ากัน กับการฟื้นตัวของความแข็งแรงของกล้ามเนื้อเท่ากับ 0.163 ($p = 0.39$) กับ 2MWT เท่ากับ 0.030 ($p = 0.874$) และกับ TUG เท่ากับ -0.067 ($p = 0.73$)*

สรุป: *ความแข็งแรงของกล้ามเนื้อกางข้อสะโพกมีการฟื้นตัวที่ดีขึ้นภายหลังการผ่าตัดเปลี่ยนข้อสะโพกเทียม ไม่มีความสัมพันธ์ระหว่างภาวะภาวะขาสั้นยาวไม่เท่ากันก่อนผ่าตัด การฟื้นตัวของความแข็งแรงของกล้ามเนื้อกางข้อสะโพก และ functional outcomes*