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Review Article

Recovery of Hip Muscle Strength after Rotational Acetabular Osteotomy Using the Combined Approach

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Abstract

Background: Either a combined approach or a transtrochanteric approach, performed with the patient in the lateral decubitus position, is used in Rotational Acetabular Osteotomy (RAO) to treat symptomatic hip dysplasia. Muscle strength after RAO using the transtrochanteric approach has been reported, but muscle strength after RAO using the combined approach has not been well studied. We aimed to investigate muscle strength and gait speed over a one-year follow-up period after RAO using the combined approach.

Methods: Data from 124 patients who underwent RAO (129 hips) were analyzed retrospectively. Patients' mean age was 44 years (14-64) and mean Body Mass Index (BMI) was 23 kg/m2 (16-36). Isometric hip flexion, abduction, and extension strengths and gait speed were measured before surgery and three months, six months, and one year after surgery. We assessed whether age and BMI were correlated with one-year post- to pre-operative strength ratio.

Results: Muscle strength had not changed significantly three months after surgery but had significantly improved at six months, exceeding pre-operative strength. One year after surgery, muscle strength of the treated hip exceeded that of the contralateral hip. Gait speed was significantly lower than pre-operative speed three months after surgery, recovered to pre-

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operative levels at six months, and exceeded pre-operative gait speed one year after surgery. Age and BMI were not correlated with muscle strength recovery ratio.

Conclusions: Six months after having undergone RAO using the combined approach, patients exhibited hip flexion, abduction, and extension strengths that exceeded preoperative strengths. Gait speed exceeded pre-operative gait speed one year after surgery.

Keywords

Rotational Acetabular Osteotomy; Combined Approach; Muscle Strength; Gait Speed

Introduction

Acetabular reorientation osteotomies, including Periacetabular Osteotomy (PAO) and Rotational Acetabular steotomy (RAO), are surgical procedures used to treat hip dysplasia in symptomatic patients. PAO is performed with the patient lying supine [1]. Studies have found outcomes after PAO were positive, one year after surgery, flexion and abduction strengths had improved [2-5].

RAO is performed, using either a combined approach or a transtrochanteric approach, with the patient in a lateral decubitus position [6,7]. The combined approach allows RAO to be performed with a single skin incision, by using a combined anterior iliofemoral and posterior approach, this approach has been used by many surgeons in Japan, with good outcomes in hip function and radiographic evaluations reported for patients with early or advanced hip osteoarthritis [8-10]. Recovery of muscle strength after RAO using a transtrochanteric approach has been investigated but strength recovery after RAO using the combined approach has not been well studied [11,12].

Winther, et al., reported that different surgical approaches for total hip arthroplasty have different effects on post-operative muscular strength and influence early post-operative mobilization and recovery [13]. Therefore, it is reasonable to assume that, when the combined approach is used, the effects of RAO on post-operative muscular strength and gait speed may differ from those when the transtrochanteric approach is used. In this study, we aimed to investigate changes in gait speed and hip strength, relative to those before surgery, during a one-year follow-up period after RAO using the combined approach.

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Materials and Methods

Patients

Between April 2016 and December 2018, 155 patients (162 hips) with hip dysplasia underwent RAO in our regional hospital. In our hospital, indications for RAO in adolescent or adult patients with hip dysplasia are pain that has lasted longer than six months, Center-Edge (CE) angle 25° or less in an Anteroposterior (AP) radiograph, flexion range of motion 100° or greater, and acceptable hip joint congruency in an AP radiograph with hip abduction [14]. 31 patients (33 hips) were excluded. We excluded two patients (two hips) who had undergone RAO for the contralateral hip within the year prior, and 29 patients (31 hips) for whom follow-up evaluation data (within one year of surgery) were missing. Retrospective data from 129 hips in 124 patients (117 female and seven male) were included. Five patients had undergone RAO for both hips with an interval greater than one year. After good functional recovery of the first hip had been confirmed by physical examinations, the second RAO had been performed. Patients' mean age was 44 years (14-64), and patients' mean Body Mass Index (BMI) was 23 kg/m^2 (16-36). This study was approved by the local ethics committee and has therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Surgical Procedure

RAO using the combined approach, with the patient in a lateral decubitus position, was performed by the same surgeon for all patients. The surgical techniques were principally the same as those described by Yasunaga, et al., except we did not incise the origin of the rectus femoris [14].

Skin incision: A single anteriorly convex incision from the apex of the ilium to the base of the greater trochanter was used. The skin flap was elevated posteriorly for posterior approach.

The anterior iliofemoral approach: The tensor fascia latae and gluteus medius were subperiosteally detached from the iliac crest between anterior superior iliac spine and the tubercle of crest, and were elevated from periacetabular area of the ilium. The origin of the rectus femoris was identified, and the iliac muscle and psoas tendon were retracted anteriorly to expose the ilio-pubic eminence.

The posterior approach: The short external rotator muscles were divided to expose the posterior wall of the acetabulum. The ischial tuberosity was palpated, and the innominate sulcus of the ischium was exposed. The gluteus minumus was subperiosteally detached to exposure the posterior periacetabular area of ilium.

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Osteotomy: A circumferential osteotomy was performed 2 cm from the joint, using a special curved chisel. The acetabular fragment was rotated laterally, and an autogenous bone graft from the external wall of the iliac crest was placed into the gap between the ilium and rotated acetabulum. The acetabular fragment was temporarily transfixed to the pelvis using a Kirschner wire. After radiographic confirmation, the acetabular fragment was transfixed to the pelvis using two or three polylactide screws.

Rehabilitation

Each patient was permitted to use a wheelchair two days after surgery. Patients began non-weightbearing walking, by using parallel bars, one week after surgery. Active straight-leg raising exercises were initiated three weeks after surgery, and active hip abduction exercises were initiated four weeks after surgery. Partial weightbearing walking (up to 10 kg) with the assistance of crutches was permitted four weeks after surgery; weightbearing was gradually increased. Patients were permitted to start walking with a single crutch six weeks after surgery, at which time patients were discharged from the hospital. Walking without crutches was permitted between five and six months after surgery when the Trendelenburg sign was no longer positive.

Muscle Strength and Gait Speed Measurement

Isometric hip flexion, abduction, and extension strengths were evaluated with a handheld dynamometer (μTas F-1; Anima Corp., Tokyo, Japan) before surgery and three months, six months, and one year after surgery. Isometric strengths of the contralateral hip were evaluated before surgery. For the five patients who had undergone RAO for both hips with an interval greater than one year, the first hip had been evaluated just prior to the second RAO, and these data were used as contralateral data for the second hip. Measurements were conducted by one of 26 physiotherapists, which included the third author. At each assessment visit, patients were evaluated by the same physiotherapist who was in charge of their rehabilitation. Hip flexion strength was assessed with the patient seated, and hip abduction and extension strengths were evaluated with the patient lying prone. Three measurements were taken at 30-second intervals in each visit, the mean of the three measurements was calculated, and mean data were normalized by weight for analysis. The Recovery Ratio for Strength (RRS) was defined as the ratio of post-operative to pre-operative strength.

Gait speed was measured using a digital stopwatch before surgery and three months, six months and one year after surgery. Patients walked along a 12-meter walkway and the maximum gait speed during the middle ten meters was recorded.

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Evaluation of Radiographs

AP radiographs of the pelvis taken before surgery and one year after surgery were used by the second author to evaluate osteoarthritis severity, CE angle and acetabular roof obliquity. Osteoarthritis severity was classified into four stages using the system defined by the Investigation Group into Coxarthrosis and Acetabular Dysplasia in Japan [15]: pre-arthrosis (no arthrotic changes); initial (one or more arthrotic changes, possible narrowing of the joint space but joint space ≥2 mm throughout the weight-bearing area); advanced (joint space <two mm at the narrowest point, localized loss of joint space with length <15 mm); or terminal (gross loss of joint space for length ≥15 mm).

Functional Evaluation

Before surgery and at the one-year follow-up visit, patients had completed the self-administered Japanese Orthopaedic Association Hip Disease Evaluation Questionnaire (JHEQ). The questionnaire is used to investigate pain, movement, and mental health status and has a maximum score of 84 points (28 points for each part); its assessment criteria have been found to be valid and reliable [16,17].

Statistics

Descriptive data are reported as means with ranges (minimum to maximum). Paired sample t-tests were used to compare post-operative evaluations of the treated hip with pre-operative evaluations of the treated or contralateral hip; mean differences with 95% Confidence Intervals (CI) are reported. Spearman rank was used to determine whether RRS was correlated with either age or BMI. Statistical significance was set as $p < 0.05$ for all evaluations. All statistical analyses were performed using JMP software (version 12.0.1, SAS Institute, Cary, NC).

Results

Muscle Strength

Three months after surgery, flexion, abduction and extension strengths had shown no significant changes (p=0.2, 0.06, 0.3, respectively) compared with preoperative strengths (Table 1, Fig. 1). At six months, flexion, abduction, and extension strengths had significantly increased and were greater than preoperative strengths (p=0.01, 0.02, <0.0001, respectively), and one year after surgery, flexion, abduction, and extension strengths had further increased and were greater than those of the contralateral hip (p=0.01, 0.0001, <0.001, respectively).

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Gait Speed

Three months after surgery, gait speed had decreased significantly ($p<0.0001$), but gait speed at six months was similar to that before surgery ($p=0.06$) (Fig. 2). At one year, gait was significantly faster than that before surgery ($p=0.0007$) (Table 2).

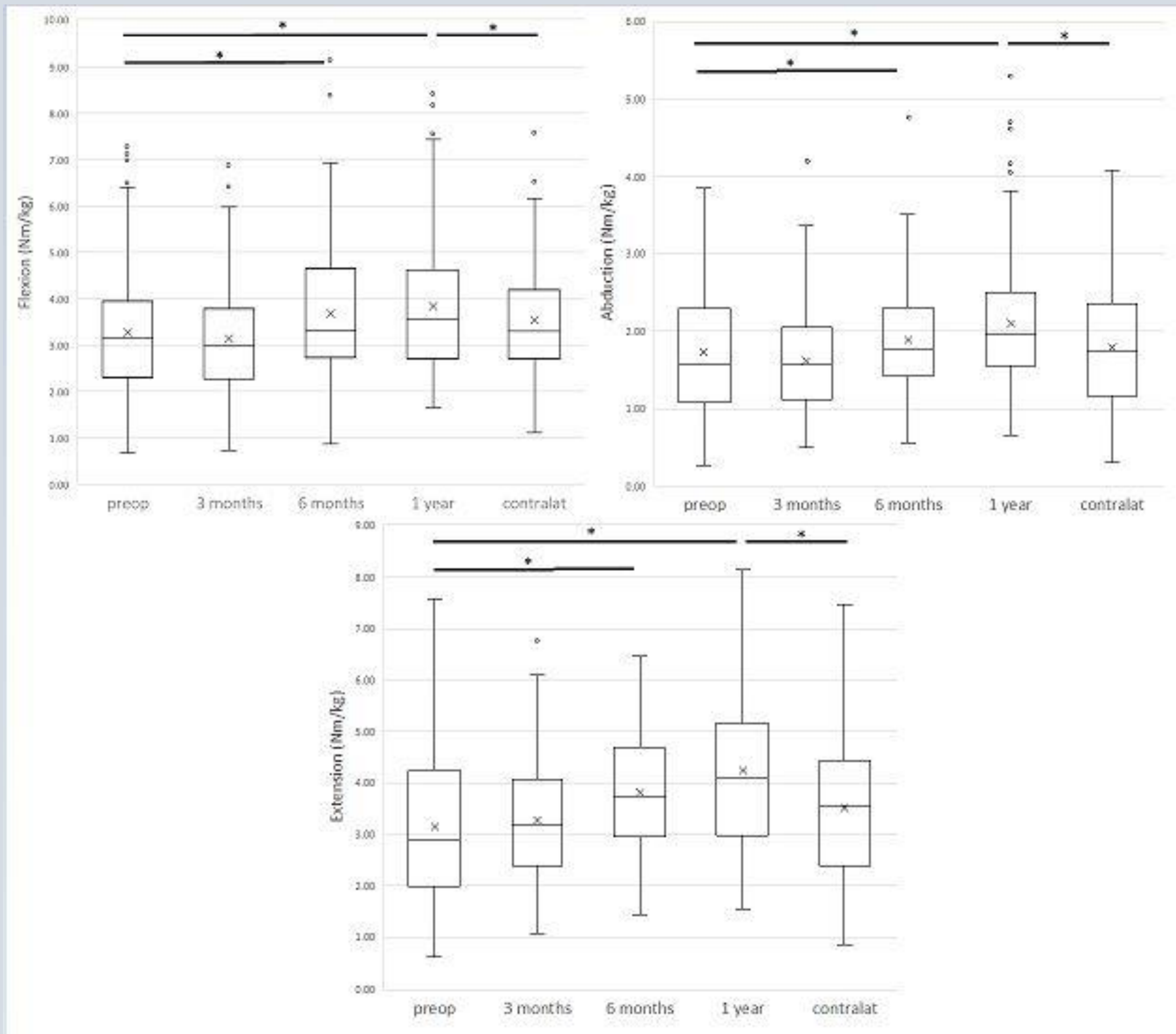

Figure 1: Changes in isometric muscle strength for a) flexion, b) abduction, and c) extension. Box and whisker plots show means (cross marks), medians (transverse lines), interquartile ranges (boxes), minimum and maximum (bars), and outliers (dots). *Statistically significant ($p<0.05$). preop, pre-operative timepoint; contralat, the contralateral hip before surgery.

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		Mean diff.	95%CI
Three months compared with pre-operative	Flexion	-0.14	-0.36 to 0.074
	Abduction	-0.12	-0.24 to 0.072
	Extension	0.12	-0.11 to 0.33
Six months compared with pre-operative	Flexion	0.39	0.15 to 0.62
	Abduction	0.17	0.03 to 0.30
	Extension	0.65	0.42 to 0.88
One year compared with pre-operative	Flexion	0.55	0.32 to 0.79
	Abduction	0.38	0.22 to 0.54
	Extension	1.08	0.85 to 1.31
One year compared with contralateral	Flexion	0.31	0.07 to 0.55
	Abduction	0.31	0.16 to 0.47
	Extension	0.71	0.48 to 0.95
diff, differences; contralateral, the contralateral hip before surgery			

Table 1: Differences between post- and pre-operative muscle strengths (Nm/kg).

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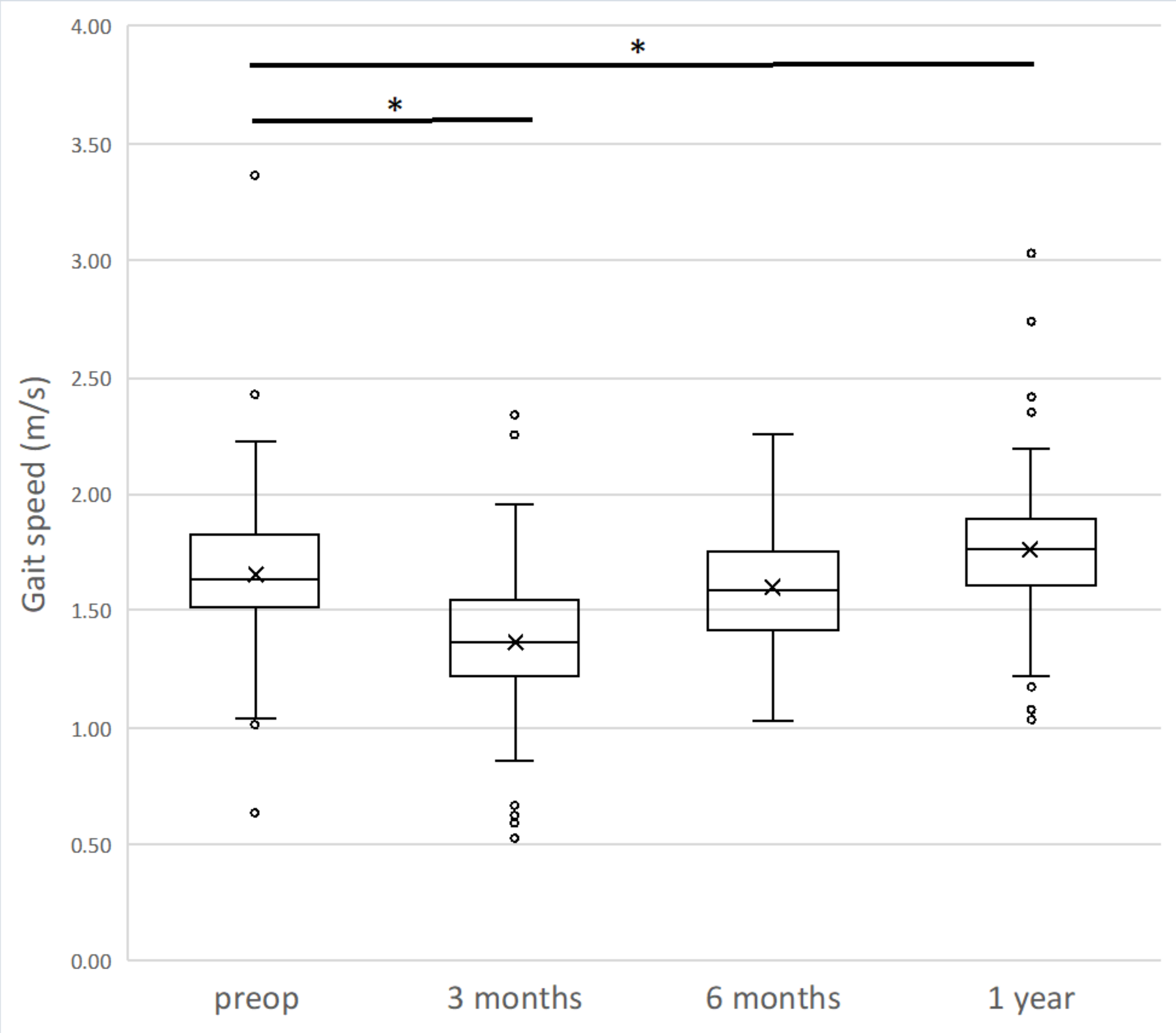

Figure 2: Changes in gait speed. Box and whisker plots show means (cross marks), medians (transverse lines), interquartile ranges (boxes), minimum and maximum (bars), and outliers (dots). *Statistically significant (p<0.05). preop, pre-operative timepoint; contralat, the contralateral hip before surgery.

	Mean diff.	95%CI
Three months compared with pre-operative	-0.29	-0.35 to -0.23
Six months compared with pre-operative	0.06	-0.11 to 0.002
One year compared with pre-operative	0.1	0.04 to 0.16
diff, differences		

Table 2: Differences between post- and pre-operative gait speed (m/s).

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Radiographic Evaluations and Hip Function

Mean CE angle and acetabular roof obliquity were 13° (-30 to 25) and 18° (0 to 39), respectively, before surgery and 31° (0 to 53) and 3° (-13 to 22), respectively, one year after surgery. The osteoarthritis stage before surgery was classified as pre-arthrosis for 88 hips, initial for 19 hips, and advanced for 22 hips; the osteoarthritis stage at the one-year follow-up was classified as pre-arthrosis for 87 hips, initial for 20 hips, and advanced for 22 hips (Table 3). Progression was observed in two hips (one from pre-arthrosis to initial stages and one from initial to advanced stages), and improvement was observed in one hip (from advanced to initial stages). JHEQ scores before surgery and one year after surgery were available for 104 hips. Mean JHEQ scores had improved from 38 (1-79) before surgery to 62 (21-84) one year after surgery.

Osteoarthritis Severity	Before Surgery (Hips)	After Surgery (Hips)
Pre-arthrosis	88	87
Initial stage	19	20
Advanced stage	22	22

Table 3: Osteoarthritis severity on radiographs.

Correlations between Preoperative Factors and RRS

Median RRS was 1.3 (0.4-6.8) for flexion, 1.5 (0.32-6.5) for abduction, and 1.6 (0.73-4.8) for extension one year after RAO. No correlation was found between age or BMI and flexion, abduction, or extension RRS (Table 4).

Factors	Flexion RRS		Abduction RRS		Extension RRS	
	r	p-value	r	p-value	r	p-value
Age	-0.09	0.31	-0.06	0.49	-0.04	0.63
BMI	-0.01	0.9	-0.09	0.33	0.07	0.46

Table 4: Correlations between one-year post- to pre-operative recovery ratio for strength and pre-operative factors.

Discussion

In patients with symptomatic hip dysplasia, hip strength is impaired [5]. Acetabular reorientation osteotomies, including PAO and RAO, are more invasive (with respect to muscles) and require longer rehabilitation than total hip arthroplasty. Data on recovery of

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muscle strength and gait speed would be useful for surgeons to inform patients about their expected level of function.

Several studies have investigated muscle strength recovery after PAO. In a study that included 22 patients (24 hips), Ezoe, et al., found that, 12 months after abductor-sparing PAO, flexion, abduction, adduction, and extension strengths had exceeded preoperative strengths [2]. Sucato, et al., investigated post-PAO mean muscle strength in 21 patients (24 hips) and found that, at 12 months, abduction strength was 103% and flexion strength was 75% relative to preoperative mean values [3]. Mechlenburg, et al., measured leg extension power after PAO in 41 patients and found the treated leg and contralateral leg were equal at 12 months [4]. Jacobsen, et al., prospectively conducted a study to assess isometric hip strength in 82 patients (82 hips) before and one year after PAO, as well as assessing hip strength once in 50 healthy volunteers and found that patients' flexion and abduction strengths improved significantly, but extension and adduction strengths were unchanged [5]. Patients' strengths one year after surgery did not reach those of the healthy volunteers.

RAO is performed with the patient in a lateral position using either a combined approach or a transtrochanteric approach. The tensor fascia latae and gluteus medius are subperiosteally detached from the iliac wing in the combined approach and osteotomy of the greater trochanter is performed in the transtrochanteric approach [14]. Regardless of which approach is used, after surgery, active abductor exercise is not permitted until the structures have had sufficient time to heal. Ueda, et al., evaluated abductor strength of 30 patients (32 hips) before surgery and eight weeks, 12 weeks, 16 weeks, 20 weeks and at the final follow-up (mean, 28 months) after RAO using the transtrochanteric approach and found that mean abductor strength had reached preoperative levels 16 weeks after surgery [11]. Although they stated that mean abductor strength of these patients was compared to that of 24 patients (24 hips) after RAO using the combined approach, they measured strength only before surgery and at the final follow-up (mean, 52.5 weeks) in the combined approach group.

Enishi, et al., retrospectively studied isometric muscle strength and gait speed after RAO using the transtrochanteric approach in a study that included 57 patients (57 hips) [12]. They found that flexion and abduction strengths had recovered to preoperative strength levels six months after surgery but at the 1-year follow-up, only abduction strength had further improved, to be equivalent to that of the contralateral hip. Also they found that gait speed recovered to the preoperative levels six months, and exceeded the preoperative levels one year after surgery. We found that flexion, abduction, and extension strengths exceeded preoperative strengths 6 months, and were greater than those of the contralateral hip one year after RAO using the combined approach. Recovery patterns of gait speed in our study were similar to those of the study of Ezoe, et al., [12]. Further study is needed to directly compare recovery speeds for both RAO approaches.

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Whereas Enishi, et al., found that BMI was negatively correlated with both hip flexion and abduction strengths one year after RAO, we found no such correlations; however, Enishi, et al., used absolute muscle strength values, whereas we used post-operative to pre-operative strength ratio [12]. We decided to use post-operative to pre-operative strength ratio instead of absolute strength because we had found negative correlations between BMI and pre-operative strength for flexion and extension (p=0.0002, 0.0002) in preliminary analyses.

Limitations

- Muscle strength was not measured in healthy volunteers. Instead, we compared post-operative hip strengths with those of the treated hip and contralateral hip measured before surgery
- Muscle strength and gait speed measurements were completed by 26 physiotherapists. Although inter-observer errors must be considered, these measurements took place up to 30 months before the study period, and all physiotherapists had experience in conducting evaluations
- 20% of hips were excluded because there was insufficient data. However, a sample size of 129 is the largest among previous studies, including those on PAO
- Follow-up time of one year was short, and further follow-up is needed for evaluations of clinical outcomes

Conclusion

Flexion, abduction, and extension strengths exceeded preoperative strengths six months after RAO using the combined approach. Gait speed exceeded pre-operative speed one year after surgery. Since this procedure needs a long post-operative rehabilitation, our findings represent useful information that can be shared with patients who are deciding whether to undergo RAO and reference data for future studies on muscle recovery after RAO.

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References

1. Ganz R, Klaue K, Vinh TS, Mast JW. A new periacetabular osteotomy for the treatment of hip dysplasias. Technique and preliminary results. Clin Orthop Relat Res. 1988;232:26-36.
2. Ezoe M, Naito M, Asayama I. Muscle strength improves after abductor-sparing periacetabular osteotomy. Clin Orthop Relat Res. 2006;444:161-8.
3. Sucato DJ, Tulchin K, Shrader MW, DeLaRocha A, Gist T, Sheu G. Gait, hip strength and functional outcomes after a Ganz periacetabular osteotomy for adolescent hip dysplasia. J Pediatr Orthop. 2010;30(4):344-50.
4. Mechlenburg I, Jørgensen PB, Stentz-Olesen K, Tjur M, Grimm B, Soballe K. Leg power, pelvic movement and physical activity after periacetabular osteotomy. A prospective cohort study. Acta Orthop Belg. 2018;84(2):163-71.
5. Jacobsen JS, Jakobsen SS, Søballe K, Hölmich P, Thorborg K. Isometric hip strength impairments in patients with hip dysplasia are improved but not normalized 1 year after periacetabular osteotomy: a cohort study of 82 patients. Acta Orthop. 2021;92:285-91.
6. Ninomiya S, Tagawa H. Rotational acetabular osteotomy for the dysplastic hip. J Bone Joint Surg Am. 1984;66(3):430-6.
7. Hasegawa Y, Iwase T, Kitamura S, Yamauchi Ki K, Sakano S, Iwata H. Eccentric rotational acetabular osteotomy for acetabular dysplasia: follow-up of one hundred and thirty-two hips for five to ten years. J Bone Joint Surg Am. 2002;84(3):404-10.
8. Nakamura S, Ninomiya S, Takatori Y, Morimoto S, Umeyama T. Long-term outcome of rotational acetabular osteotomy: 145 hips followed for 10-23 years. Acta Orthop Scand. 1998;69(3):259-65.
9. Yasunaga Y, Ochi M, Terayama H, Tanaka R, Yamasaki T, Ishii Y. Rotational acetabular osteotomy for advanced osteoarthritis secondary to dysplasia of the hip. J Bone Joint Surg Am. 2006;88(9):1915-9.
10. Kaneuji A, Sugimori T, Ichiseki T, Fukui K, Takahashi E, Matsumoto T. rotational acetabular osteotomy for osteoarthritis with acetabular dysplasia: conversion rate to total hip arthroplasty within twenty years and osteoarthritis progression after a minimum of twenty years. J Bone Joint Surg Am. 2015;97(9):726-32.
11. Ueda T, Tohkura A. Evaluation of isokinetic hip strength after rotational acetabular osteotomy. Nippon Seikeigeka Gakkai Zasshi. 1993;67(12):1105-13.
12. Enishi T, Yagi H, Higuchi T, Takeuchi M, Sato R, Yoshioka S, et al. Changes in muscle strength of the hip after rotational acetabular osteotomy: a retrospective study. Bone Joint J. 2019;101-b(11):1459-63.
13. Winther SB, Husby VS, Foss OA, Wik TS, Svenningsen S, Engdal M, et al. Muscular strength after total hip arthroplasty. A prospective comparison of 3 surgical approaches. Acta Orthop. 2016;87(1):22-8.
14. Yasunaga Y, Ochi M, Terayama H, Tanaka R, Yamasaki T, Ishii Y. Rotational acetabular osteotomy for advanced osteoarthritis secondary to dysplasia of the hip. Surgical technique. J Bone Joint Surg Am. 2007;89(2):246-55.
15. Takatori Y, Ito K, Sofue M, Hirota Y, Itoman M, Matsumoto T, et al. Analysis of interobserver reliability for radiographic staging of coxarthrosis and indexes of acetabular dysplasia: a preliminary study. J Orthop Sci. 2010;15(1):14-9.
16. Matsumoto T, Kaneuji A, Hiejima Y, Sugiyama H, Akiyama H, Atsumi T, et al. Japanese Orthopaedic Association Hip Disease Evaluation Questionnaire (JHEQ): a patient-based evaluation tool for hip-joint disease. the subcommittee on hip disease evaluation of the clinical outcome committee of the Japanese orthopaedic association. J Orthop Sci. 2012;17(1):25-38.
17. Seki T, Hasegawa Y, Ikeuchi K, Ishiguro N, Hiejima Y. Reliability and validity of the Japanese Orthopaedic Association Hip Disease Evaluation Questionnaire (JHEQ) for patients with hip disease. J Orthop Sci. 2013;18(5):782-7.

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