Function and Disability Journal ISSN: 2588-6304
Original Article

Musculoskeletal Complication Following Arthroscopy Anterior Cruciate Ligament Reconstruction 6 Months Post-operatively

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Article Info

Received: 2017/03/28
Accepted: 2017/06/05
Published Online: 2017/10/29

DOI:
10.30699/fdisj.01.1.11

How to Cite This Article

Kalhor A, Sohani S, Amiri A, Jamshidi Khorneh A. Musculoskeletal Complication Following Arthroscopy Anterior Cruciate Ligament Reconstruction 6 Months Post-operatively. Func Disabil J. 2018; 1 (1) :11-20

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ABSTRACT

Background and Objective: Muscle strength deficits have usually been found after ACL reconstruction. Some studies have demonstrated a relationship

between lower extremity muscle strength and the single-leg hop test in the ACL reconstructed knees.

The aim of this study is to evaluate possible differences in lower limbs including function, muscle strength length and anterior knee pain, 6 months after anterior cruciate ligament (ACL) reconstruction between involved and uninvolved side.

Methods: Sixty patients who underwent anatomic double bundle ACL reconstruction were examined 6 - 36 months post-operatively. All subjects had undergone the same rehabilitation protocol after ACL reconstruction.

Lower extremity isometric strength, muscle length and Triple Single-leg hop test were assessed. Measurements were performed 3 times within a 2-minute interval. The normal limb was tested before the operated limb. The peak strength value was normalized by the body weight.

Results: In the Single-leg hop test there was statistically significant difference in the lower limbs comparing the involved with the uninvolved knee ($P < 0.001$). In the Tensor Fascia Lata-Ilio Tibial Band (ITB/TFL) length, there was statistically significant difference in the lower limbs ($P < 0.001$). In the isometric knee flexion strength there was statistically significant difference in the lower limbs at 90° ($P < 0.001$) and 105° ($P < 0.001$) knee flexion. In the isometric knee extension strength there was statistically significant difference in the lower limbs at 5° ($P < 0.001$), 45° ($P = 0.025$) and 90° (P = 0.003) knee flexion. In the isometric hip abduction, internal rotation and plantar flexion strengths there were statistically significant difference in the lower limbs ($P < 0.001$).

There was statistically significant correlation between isometric muscle strength ratio (involved vs. uninvolved) and Single-leg hop test in hip abduction ($r = 0.345$, $P < 0.001$) , knee extension at 45° ($r = 0.245$, $P = 0.05$) and at 90° ($r = 0.379$, $P = 0.002$) knee flexion and between isometric muscle strength ratio and anterior knee pain in hip abduction ($r = 0.345$, $P = 0.03$) , knee extension at 90° ($r = 0.311$, $P = 0.009$) and at 5° ($r = 0.272$, $P = 0.023$) knee flexion.

Conclusion: Our study shows that after ACL reconstruction, lower limb function and strength deficit remained despite the completion of rehabilitation. These deficits were found at knee, hip and ankle joints. The present results can be used for re-planning rehabilitation protocol.

Keywords: Muscle length, Isometric strength, Anterior cruciate, Ligament reconstruction

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Introduction

ACL acts primarily to check extension of the knee, forward movement of the tibia on the femur, and internal rotation of the tibia on the femur (Hertling & Kessler, 2006). ACL rupture is a common injury to the knee joint in sports and recreational activities (Kartus et al., 1999). ACL reconstruction is currently one of the most common surgical procedures in sports medicine and has yielded promising clinical results for patients with ACL injuries (Lewis et al. 2008). However, a substantial number of postoperative complications may occur after ACL reconstruction, including a range of motion (ROM) deficits, quadriceps weakness; hamstring weakness and lower knee function (Kartus et al., 2001; Tsuda et al., 2001; Lautamies et al., 2008; Niki, Matsumoto et al. 2011; Niki, Hakozaki et al., 2012; Nomura, Kuramochi et al., 2015).

Muscle strength deficits have usually been found after ACL reconstruction (Osteras et al., 1998; Anderson et al., 2001; Feller et al., 2001; Ejerhed et al. 2003). Mikkelsen et al. (Mikkelsen et al., 2000) showed that the subjects with good quadriceps strength after ACL reconstruction were able to return to their previous activity earlier and at the same activity level as before injury. Using the semitendinosus (ST) tendon as a graft material is the mainstream method for ACL reconstruction. The advantages of the surgical procedure are that it is less likely to cause anterior knee pain and that it ensures good recovery of thigh muscle strength (Rosenberg & Deffner 1997). Despite tendon harvest, most studies have shown almost full recovery of knee flexion strength compared with the uninjured limb during isokinetic strength testing; however, deficits at high knee flexion angle strength have been confirmed during isometric strength testing (Ohkoshi, Inoue et al., 1998; Tashiro et al., 2003). Because of the differences in morphological structure, the component muscles in the hamstring muscle group have diverse functions; i.e., the semimembranosus (SM) and the long head of the biceps femoris (BF) are mainly responsible for the muscle strength exerted during lower degrees of knee flexion, and the ST is mainly responsible for the muscle strength exerted during high knee flexion angle (Herzog & Read 1993). Naturally, if the ST is subjected to invasive surgery, deficits in high knee flexion angle may occur.

A triple single-leg hop test, International Knee Documentation Committee (IKDC) and Kujala scores are methods used to test knee function (Negahban, 2012; Rahimi, 2013). A single-leg hop test is considered to test dynamic muscle co-activation (Sekiya et al., 1998). Some authors have demonstrated a relationship between lower extremity muscle strength and the single-leg hop test in the ACL reconstructed knees (Sachs et al., 1989; Wilk et al., 1994; Sekiya et al., 1998).

A limitation of Isokinetic dynamometry is that they are expensive and cumbersome, which precludes their use as a clinically-feasible device for routine patient assessment. Commonly used devices that measure isometric lower muscle strength include hand-held dynamometers (Mentiplay et al., 2015).

Knee muscles length and isometric force evaluation with Hand-Held Dynamometry after anterior cruciate ligament reconstruction is carried out less.

Our hypothesis was that knee function and muscle strength and length 6-60 months after ACL reconstruction differ between involved and uninvolved side.

Material and Methods

Subjects

This study was approved by the Ethical Committee of Iran Medical University (process number IR.IUMS.REC1395.9413340002).

Seventy patients (mean age, 33 ± 8.13 years) underwent anatomic double-looped semitendinosus with double looped gracilis (ST-G). ACL reconstruction was examined 6-36 months post-operatively. Post-operatively, all patients underwent the same rehabilitation protocol. Briefly, the knee was immobilized with a brace for 2 weeks, partial weight bearing was allowed at 3 weeks, and full weight bearing was permitted at 4 weeks. Jogging and running were allowed at 3–4 months, followed by a return to previous sports activities at 6 months (Brukner and Khan 2012). The mean post-operative time was 15.70 ± 9.28 months (range 6-36 months). Exclusion criteria comprised were as follows: previous ligament reconstruction; multiple ligament injuries; bilateral ACL injuries; and anatomic defects and fracture of lower limbs.

Clinical Assessments

Isometric lower limb muscles strength (knee extensors, knee flexors, ankle plantar flexors, hip abductors, hip external rotators, hip internal rotators) was measured using a Hand-Held Dynamometer Jteach Power-Track II HHD (J Tech Medical, Salt Lake City, UT) with Kendall approach (Kendall et al., 2005) and was also used to evaluate muscles length(knee extensors, hamstring, ankle plantar flexors, ITB/TFL band) using a inclinometer (ACCUD723 Austria) with Kendall approach (Kendall et al., 2005). Before testing, the subjects performed a 5-min warm-up riding on a stationary bicycle. After the subject warmed up and became familiarized with the procedure, measurements were performed 3 times within a 2-min interval. The normal limb was tested before the operated limb. The peak strength value was normalized to the body weight. Quadriceps (knee extension) isometric contraction was performed at 45°, 90°, and 5° of knee flexion(Knezevic et al., 2014) and hamstring (knee flexion) isometric strength was assessed at 45°, 90°, and 105° of knee flexion(Nomura et al., 2015).

A stabilization board similar to that used by Meftahi et al. (Meftahi, 2011) was constructed. This apparatus was designed to ensure that the hip position would be fixed during the measurement and that it returned to the same point for each measurement.

A triple single-leg hop test, IKDC and Kujala scores were used to assess knee function. The single-leg hop test was performed hopping forward, hands behind the back, as far as possible landing on the same leg. After one practice hop, subjects started with the uninjured extremity. Three trials were recorded and averaged. Then the same procedure was repeated with the injured extremity. The distance hopped was recorded.

Assessment of Anterior Knee Pain

The criteria used for the diagnosis of anterior knee pain were based on a level of at least 2cm on a visual analog scale (VAS) and a positive answer of at least 2 items of the Kujala questionnaire.

Data Analyses

The differences between the means of isometric muscle strength on the injured versus uninjured extremities were determined using paired samples t test. Relationships between categorical variables were determined by the Pearson Chi square-test and between continuous-type variables by the Pearson product moment correlation coefficient. Statistical significance was set at the $P=0.05$ level (two-sided). The statistical analyses were performed with SPSS statistical software package (SPSS, Version 16.0, SPSS Inc., USA).

Results

Average IKDC&Kujala subjective scores and Patient characteristics are shown in detail in Table 1.

Patient incidences of anterior knee pain, 41.4 % showed symptoms (fig.1)

8.6% patients showed flexion & extension ROM limitation (fig.2)

Single-Leg Hop

In the single-leg hop test there was a statistical difference ($P < 0.01$) between the involved vs. uninvolved extremity (Table 2).

Muscle Length Testing

The lower limb muscle length in the operated limb was not significantly lower than that in the normal limb; however, the difference was significant at ITB/TFL ($P = 0.001$) (Table 3).

Table 1. Demographic characteristics of the study

Variable	Min	MAX	N	Mean ± SD
Involved limb IKDC score	44.82	100	60	71.09 ± 15.1
Involved limb Kujala score	38	100	60	79.23 ± 11.88
Age(years)	19	50	60	33 ± 8.13
BMI ($^{kg}/_{m^2}$)	18.33	29.98	60	25.75±3.04
The time between the injury and the reconstruction (month)	6	36	60	15.70 ± 9.28

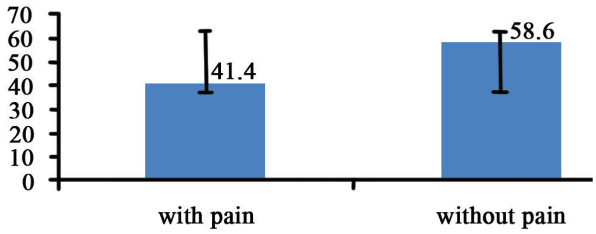

Fig1. incidences of anterior knee pain

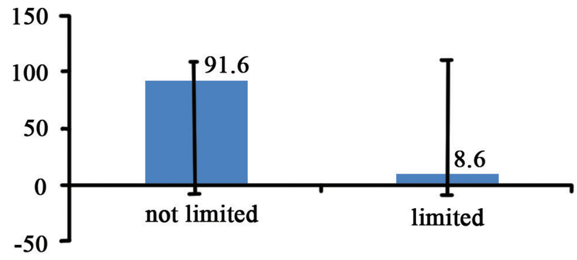

Fig 2. incidences of flexion & extension ROM limitation

Table 2. involved limb versus uninvolved limb single-leg hop test

single-leg hop test (CM)	Mean ± SD	T	P- value
Involved limb	79.92 ± 29.83	9.026	0.000*
Uninvolved limb	100.90 ± 23.096		

** Statistical difference between involved and uninvolved knee*

Table 3. involved limb versus uninvolved limb muscle length

Muscle	Limb	Mean ± SD	T	P-value
Hamstring	Uninvolved limb	77.33 ± 12.48	0.707	0.48
	Involved limb	76.77 ± 13.97		
Quadriceps	Uninvolved limb	134.698 ± 11.59	0.511	0.61
	Involved limb	134.176 ± 11.40		
Ankle plantar flexor	Uninvolved limb	24.748 ± 7.18	1.853	0.71
	Involved limb	23.573 ± 7.11		
ITB/TFL band	Uninvolved limb	13.67 ± 6.955	3.568	0.001*
	Involved limb	9.893 ± 4.32		

** Statistical difference between involved and uninvolved knee*

Muscle Strength Testing

The isometric lower limb muscle strength in the operated limb was significantly lower than that in the normal limb Hip abductor ($P < 0.001$), Hip internal rotator ($P = 0.001$), Ankle plantar flexor ($P < 0.001$), respectively; however, the difference was not significant at hip external rotator (Table 4).

The isometric knee flexion strength in the operated limb was significantly lower than that in the normal limb at 90° ($P < 0.001$), and 105° ($P < 0.001$), respectively; however, the difference was not significant at 45° (Table 5).

The isometric knee extension strength in the operated limb was significantly lower than that in the normal limb at 90° ($P = 0.003$), 45° ($P = 0.025$), and 5° ($P < 0.001$) respectively (Table 6).

We found a significant correlation between anterior knee pain and the single-leg hop test (r = 0.429, $P < 0.001$), hip abductor strength (r = 0.345, P = 0.03), knee extensor at 5° knee flexion knee (r = 0.272, $P = 0.023$), extensor at 90° knee flexion (r = 0.311, $P = 0.009$).

There was a significant correlation between the single-leg hop test and hip abductor strength (r = 0.474,

$P < 0.001$), knee extensor at 45° knee flexion (r = 0.245, $P = 0.05$), knee extensor at 90° knee flexion (r = 0.379, $P = 0.002$), knee flexor at 45° knee flexion (r = 0.298, $P = 0.016$).

There was a significant correlation between IKDC questionnaire and hip abductor strength (r = 0.327, $P = 0.006$), hip internal rotator (r = 0.235, $P = 0.05$), knee extensor at 90° knee flexion (r = 0.307, $P = 0.01$).

There was a significant correlation between Kujala questionnaire and hip abductor strength (r = 0.438, $P < 0.001$), ITB/TFL length (r = 0.259, $P = 0.03$), knee extensor at 5° knee flexion (r = 0.285, $P = 0.017$), knee extensor at 90° knee flexion (r = 0.237, $P = 0.048$).

Table 4. Involved limb versus uninvolved limb muscle strength

Muscle	limb	Mean ± SD	T	P- value
Hip abductor	Uninvolved limb	0.207 ± 0.04	40.024	0.000*
	Involved limb	0.0698 ± 0.01		
Hip internal rotator	Uninvolved limb	0.175 ± 0.05	3.448	0.001*
	Involved limb	0.156 ± 0.05		
Hip external rotator	Uninvolved limb	0.119 ± 0.03	1.83	0.07
	Involved limb	0.111 ± 0.03		
Ankle plantar flexor	Uninvolved limb	0.43 ± 0.1	3.906	0.000*
	Involved limb	0.402 ± 0.09		

** Statistical difference between involved and uninvolved knee*

Table 5. Involved limb versus uninvolved limb flexor muscle strength at 45°, 90° and 105°

Angle	limb	Mean ± SD	T	P- value
45°	Uninvolved limb	0.20 ± 0.068	1.954	0.055
	Involved limb	0.17 ± 0.135		
90°	Uninvolved limb	0.14 ± 0.049	10.430	0.000*
	Involved limb	0.09 ± 0.040		
105°	Uninvolved limb	0.07 ± 0.038	9.445	0.000*
	Involved limb	0.04 ± 0.027		

** Statistical difference between involved and uninvolved knee*

Table 6. involved limb versus uninvolved limb extensor muscle strength at 45°, 90° and 5°

Angle	limb	Mean ± SD	T	P- value
5°	Uninvolved limb	0.179 ± 0.045	3.741	0.000*
	Involved limb	0.167 ± 0.044		
45°	Uninvolved limb	0.31 ± 0.063	2.293	0.025*
	Involved limb	0.29 ± 0.079		
90°	Uninvolved limb	0.44 ± 0.091	3.028	0.003*
	Involved limb	0.41 ± 0.112		

** Statistical difference between involved and uninvolved knee*

Discussion

According to our results, even 6 months after ACL reconstruction, lower limb function and strength deficit remained despite the completion of rehabilitation. These deficits were found at knee, hip and ankle joints. After the ACL reconstruction, the subjects had weaker quadriceps muscle strength at a 5°, 45°, and 90° knee flexion in the involved extremity compared with the uninvolved one. These results were similar to the studies of Feller et al. (Feller et al., 2001). An isometric knee flexion torque allowed for a recovery at 45° knee joint flexion but showed a significant decrease at a 90°, or 105° in knee joint flexion. Like the findings reported by Tashiro et al. (Tashiro et al. , 2003), Tashiro et al. suggest that deficits at higher degrees of knee flexion torque occurred after ST tendon resection. They argued that this was due to muscle atrophy in type II fast fibers after disuse of the knee. Snyder- Mackler et al. (Snyder-Mackler et al., 1994) demonstrated that a subject with an ACL reconstructed knee may regain full capacity of the quadriceps only if the reconstruction is performed before irreversible atrophy occurs.

This study shows the isometric strength of all evaluated muscles except hip external rotator and knee flexor at 105° knee flexion, in a comparison between involved extremities and the uninvolved ones; which demonstrated statistically significant difference. There was also significant correlation between lower limb function and hip abductor, knee extensor, hip internal rotator, and then knee flexor muscles.

The results indicate that the ITB/TFL band was significantly shorter in involved extremity compared with the uninvolved one; this difference was classed as large and indicated markedly lower flexibility. It has been argued that reduced flexibility in the ITB/TFL band is clinically relevant, as it can elicit knee flexion as more than normal during activities, which can produce increased patellofemoral joint reaction forces.

In this study, there was a statistically significant difference between the involved extremity compared with the uninvolved one regarding the single-leg hop ratio. Sachs et al. (Sachs et al., 1989), Sekiya et al. (Sekiya et al., 1998) and Wilk et al. (Wilk et al., 1994) demonstrated a relationship between lower extremity muscle strength and the single-leg hop test in patients with an ACL reconstruction. These studies support the results of this paper. Also in this study, the subjects with the best single-leg hop ratio had the highest isometric hip abduction strength ratio.

The current study also indicated that the incidence of anterior knee symptoms was 41.4 %, and statistically, it had a relationship with lower limb function and then isometric hip abduction strength ratio. In previous reports, incidences of anterior knee symptoms after ACL reconstruction with HT grafts were 2.5–32.2 % (Mohtadi et al., 2011). A possible explanation for this discrepancy is evident owing to different assessment methods. With no agreement on exact diagnostic criteria, investigators have diagnosed anterior knee symptoms with their own methods (Tsuda et al., 2001; Niki et al., 2011) or systems such as the IKDC score (Aglietti et al., 1993), patellofemoral pain score (Eriksson et al., 2001) or Kujala patellofemoral score (the Anterior Knee Pain Scale) (Ibrahim et al., 2005). Among these, we selected the Anterior Knee Pain Scale and VAS. We also assessed symptoms at 6 months post-operatively, while most other studies were performed at least 2 years after the ACL reconstruction (Mohtadi et al., 2011). Niki et al. (Niki Hakozaki et al., 2012) recently reported that the prevalence of anterior knee pain was 42.0 % 3 months post-operatively, falling to 11.1 %after 2 years. These issues make it difficult to compare our incidence of anterior knee pain.

Limitations

The present study has some limitations. First, the relatively small sample size and short duration of follow-up might obscure precise long-term clinical outcomes. Second, not all of the study subjects were randomized. However, the groups in this test were comparable with respect to age, gender, preinjury and preoperative activity level and time from injury to operation. Third, the lack of data on tibia rotator muscle strength was one of the drawbacks of this study.

Conclusion

It is recommended to consider functional training, strengthening lower limb muscles especially hip abductor muscle and ITB/TFL band stretching in rehabilitation protocol of these patients.

Acknowledgments

We are grateful to all participants for their co-operation throughout this study. This study was supported IUMS fund.

Conflict of Interest

Authors declared no conflict of interest.

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Function and Disability Journal ISSN: 2588-6304

مقالهٔ پژوهشی

عوارض عضلانی ـ اسکلتی اندام تحتانی شش ماه پس از جراحی بازسازی رباط متقاطع قدامی زانو

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اطلاعات مقاله

تاریخ وصول: ۱۳۹۶/۰۱/۰۳
تاریخ پذیرش: ۱۳۹۶/۰۳/۱۵
انتشار آنلاین: ۱۳۹۶/۰۸/۰۷

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چکیده

زمینه و هدف: معمولاً ضعف قدرت عضلانی در پی بازسازی لیگامانهای ACL دیده می‌شود. بعضی مطالعات ارتباط بین قدرت اندام تحتانی و تست پرش روی یک عضو تحتانی را نشان داده است. این پژوهش با هدف مقایسهٔ درد قدامی زانو، قدرت ایزومتریک و طول عضلات اندام تحتانی و همچنین ظرفیت عملکردی اندام تحتانی، شش ماه پس از جراحی بازسازی رباط متقاطع قدامی اندام تحتانی جراحی‌شده، با اندام تحتانی سالم طراحی شده است.

روش کار: هفتاد بیمار که حداقل شش ماه و حداکثر پنج سال از زمان جراحی بازسازی رباط متقاطع قدامی آنها گذشته بود و با برنامهٔ توانبخشی مشابه تحت درمان قرار گرفته بودند، بررسی شدند. آزمون‌های عملکردی سه پرش متوالی با یک پا، قدرت ایزومتریک و طول عضلات اندام تحتانی ارزیابی شد. این ارزیابی‌ها سه بار و با فاصلهٔ دو دقیقه صورت گرفت. هر بار ابتدا پای سالم و سپس پای مبتلا سنجیده شد.

یافته‌ها: در مقایسهٔ اندام‌های تحتانی، چند ماه پس از جراحی بازسازی رباط متقاطع قدامی زانو، آزمون عملکردی سه پرش متوالی با یک پا، در مقالیسه با پای سالم تفاوت معنادار آماری داشت (P<۰/۰۰۱). طول عضلهٔ تنسور فاسیالاتا و نوار ایلیوتیبیال تفاوت معنادار آماری داشت (P<۰/۰۰۱). قدرت ایزومتریک عضلات فلکسور زانو در زوایای ۹۰ (P<۰/۰۰۱) و ۱۰۵ (P<۰/۰۰۱) درجهٔ فلکشن زانو تفاوت معنادار آماری داشت. افزون بر این، تفاوت معناداری در قدرت ایزومتریک عضلات اکستانسور زانو در زوایای ۵ (P<۰/۰۰۱)، ۴۵ (P=۰/۰۲۵) و ۹۰ درجه (P=۰/۰۰۳) فلکشن زانو نیز دیده شد. قدرت ایزومتریک عضلات دورکنندهٔ ران، عضلات چرخانندهٔ داخلی ران، و پلانتار فلکسورهای مچ پا نیز تفاوت معنادار آماری داشتند (P<۰/۰۰۱). عملکرد اندام تحتانی (آزمون‌های عملکردی سه پرش متوالی با یک پا) با قدرت ایزومتریک عضلات دورکنندهٔ ران (P=۰/۰۰۱، r=۰/۴۷۴)، اکستانسور زانو در زوایای ۴۵ (P=۰/۰۵، r=۰/۲۴۵) و ۹۰ درجهٔ (P=۰/۰۰۲، r=۰/۳۷۹) فلکشن زانو رابطهٔ آماری معناداری داشت. رابطهٔ درد قدامی زانو با قدرت ایزومتریک عضلات دورکنندهٔ ران (P<۰/۰۳، r=۰/۳۴۵)، اکستانسور زانو در زوایای ۵ (P=۰/۰۲۳، r=۰/۲۷۲) و ۹۰ درجهٔ (P=۰/۰۰۹، r=۰/۳۱۱) فلکشن زانو نیز معنادار بود.

نتیجه‌گیری: این پژوهش نشان داد چند ماه پس از جراحی بازسازی رباط متقاطع قدامی و تکمیل دورهٔ توانبخشی، کاهش عملکرد اندام تحتانی و دیگر عوارض عضلانی ـ اسکلتی (خصوصاً ضعف عضلات) در این بیماران باقی می‌ماند. این عوارض نه تنها در عضلات مفصل زانو بلکه در عضلات و مفاصل بالا و پایین زانو نیز وجود دارد. این نتایج می‌تواند در بازطراحی و بهبود روش‌های درمان توانبخشی این بیماران استفاده شود.

واژه‌های کلیدی: طول عضله، قدرت انقباض ایزومتریک، جراحی بازسازی رباط متقاطع قدامی زانو