RESEARCH ARTICLE

Anterior Cruciate Ligament Reconstruction with Hamstring Tendons Has no Deleterious Effect on Hip Extension Strength

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Abstract

Background: Hamstring tendons are secondary hip extensors. Their harvest for graft in anterior cruciate ligament (ACL) reconstruction may create deleterious effect on hip extension strength. This is of particular importance in sports that need powerful hip extension force like climbing and sprinting. Due to scarcity of a comprehensive study in this area, we designed this prospective study to evaluate hip extension strength following ACL reconstruction using different types of grafts.

Methods: Fifty eight patients were enrolled in this prospective non-randomized case control study to compare isokinetic hip extension strength following ACL reconstruction with different graft types. Twenty patients in group A (both Semitendinosus and Gracilis tendons autograft (ST-G)), 14 patients in group B (Tibialis Posterior tendon allograft (Allograft)), 12 patients in group C (bone-patellar tendon-bone autograft (BPTB)) and 12 patients in group D (only semitendinosus autograft (ST)) were studied. Hip extension strength was tested post-operatively at three- and six-month periods using a Biodex isokinetic testing machine at a speed of 30 degree per second in operated (cases) and non-operated (controls) limbs.

Results: There was a significant increase in hip extension force between three and six month intervals in all four groups and in both operated (case) and non-operated (control) limbs ($P<0.05$, 95% CI). However, there was more increase in case limbs in comparison to control limbs. There was no significant difference in hip extension strength among all four groups (both in case and control limbs) in the third- and the sixth-month post-operative tests.

Conclusion: Graft type had no effect on hip extension strength following ACL reconstruction, and the harvest of one or both hamstrings had no deleterious effect on hip extension force.

Level of evidence: III

Keywords: Anterior cruciate ligament, Hip extension, Isokinetic testing

Introduction

Anterior cruciate ligament (ACL) injury is highly common in athletes (1, 2). Its prevalence in the United States is reported to be 80,000 to 250,000 cases per year that is associated with short- and long-term disabilities (3, 4). The primary goal of ACL reconstruction is to obtain a stable knee and return to

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previous activities at the same level of performance or at least at a reduced level (5). Various types of grafts are used for ACL reconstruction. The most common ones are hamstring autograft and bone patellar tendon bone autograft (BPTB). Due to high raw power and good potential for bone on bone repair, BPTB autograft is known as a gold standard for ACL reconstruction, especially among workers and professional athletes (6-8). However, it has also some disadvantages including anterior knee pain, patellofemoral arthritis, knee extension weakness, and kneeling pain (9-16). This has led to a higher prevalence of hamstring tendon autograft use within the recent years (17). Harvesting the hamstring tendons reduces power of deep knee flexion (18-28). In addition, the created dysfunction affects the skill and athletic performance in some sports such as gymnastics, wrestling and judo (17). Some scholars believe that removing gracilis and semitendinosus together causes more power loss than removing semitendinosus alone (29-30). Apart from primary knee flexors, hamstrings act as secondary hip extensors as well. Their harvest to reconstruct ACL could have an impact on the ability of hip extension. This has higher importance for the athletes who need to run at high speeds such as soccer, sprinting, and rugby and/or need full extension and strong hips in rock climbing and mountaineering (17). According to our literature review only one study evaluated hip extension strength after ACL reconstruction using hamstring tendons without comparing it with other graft types. Given the importance of hip extension power in athletes of certain sports and the popularity of using hamstrings in ACL reconstruction among orthopedic specialists, the main purpose of this study is to examine the changes in the power of hip extension after ACL reconstruction using hamstring tendons, and to compare the results with other graft choices in ACL reconstruction. The novelty of this study mainly revolves around the comparison of the hip extension strength among patients with different grafting, not simply measuring hip extension strength following the hamstring graft. This study addresses the stated gaps in the literature.

Materials and Methods

This is a prospective non-randomized case-control study. The participants of the study consisted of all patients in need of ACL reconstruction that were operated in our center from September 2015 to April 2016. Graft selection was carried out based on surgeon decision.

Patient's weight, the presence of ligamentous laxity, athleticism, and the athleticism type influence the decision. The exclusion criteria included associated ligamentous, chondral or meniscus pathology that interfere with rehabilitation process of the patients cause alterations in final results and non-participation of the patients in the third- and the sixth- month follow-ups after surgery.

From September 2015 to April 2016, eighty patients underwent ACL reconstruction surgery from which 12 patients were excluded because of associated lesions and 10 others because of non-participation in the sixth-month follow-up. Fifty eight patients (58 knees) were enrolled in four groups based on graft choice. Twenty patients were in group A in whom both semitendinosus and gracilis tendons were harvested for grafting. In group B that tibialis posterior tendon allograft was used for grafting, 14 patients enrolled. Group C consisted of 12 patients and bone patellar tendon bone autograft was used while in group D that 12 patients participated, only semitendinosus was harvested for grafting.

Arthroscopic ACL reconstruction was performed with trans portal technique and graft was fixed with bioscrew (Smith & Nephew, Memphis, Tennessee) in tibial tunnel for all patients. Femoral side fixation was achieved with endobutton closed loop (Smith & Nephew, Memphis, Tennessee) except in group B that bioscrew (Smith & Nephew, Memphis, Tennessee) was used. Rehabilitation protocol was the same in all groups.

Isokinetic testing

The data on hip extension strength were measured and recorded for the operated limb (as the case) and the healthy side (as the control) by a Biodex isokinetic testing machine (Biodex Medical Systems, Ramsey Road Shirley, NY, USA) in the third- and the sixth- month follow-ups after surgery. Prior to start the measurements, the patient spent time on different stages such as warm up, familiarity with the equipment, and necessary training to perform the movements. Then, the testing procedure started. Mean eccentric and concentric powers and maximum power (at a rate of 30 degrees per second) were measured. The reason for choosing this speed was that muscle weakness is less clear at higher speeds of isokinetic machine (31). Peak torque of hip extension with extended knee (PTEK) and peak torque of hip extension with flexed knee (PTFK) were measured. In addition, average torque of hip extension with extended knee (ATEK) and average torque of hip extension with flexed knee (ATFK) were measured for each operated and non-operated side.

Data Analysis

Our hypothesis was that hip extension strength in patients using bone patellar tendon bone graft or allograft would be more than the power of hip extension in patients using both or single hamstrings graft. Data were analyzed with SSPS20. Values obtained from isokinetic testing were investigated and compared using independent t-test, paired t-test and ANOVA. *P value* less than 0.05 was considered significant (CI 95%).

Results

58 patients, divided in four groups based on graft selection, were enrolled in this prospective non-randomized case control study. Group A (Semitendinosus-gracilis group) consisted of 20 male patients with the mean age of 26.7 (18-45) years that in whom both hamstrings were harvested for graft. Eight left knees and 12 right knees had undergone surgery. No complications were observed in the post-surgical period.

Group B (Allograft group) included 14 patients with the mean age of 26.7 (18-45) years. Five patients were female, and tibialis posterior tendon allograft was used in this group as a graft. Seven left knees and seven right knees received surgery. No complication was observed in the post-surgical period.

In group C (Bone patellar tendon bone group) there were 12 male patients with the mean age of 26.5 (18-34) years and selected graft was bone patellar tendon bone autograft. Six left knees and 6 right knees had undergone surgery. One patient was complicated with DVT in this group.

Group D (Semitendinosus alone group) included 12 male patients with the mean age of 26.9 (18-45) years. In this group, only semitendinosus tendon was harvested for graft. Four left knees and 8 right knees had undergone surgery. No complication was observed in the post-surgical period.

Isokinetic results: In all four groups and for both operated and non-operated limbs, the peak torque of hip extension with extended knee (PTEK), average torque of hip extension with extended knee (ATEK), peak torque of hip extension with flexed knee (PTFK) and average torque of hip extension with flexed knee (ATFK) in the isokinetic test showed a significant increase from third month to sixth month postoperatively ($P<0.05$, CI 95%). However, the amount of this increase was higher in the operated limbs.

The results of PTEK and ATEK in the isokinetic test performed on operated limbs (case group) and non-operated limbs (control group) in the third month revealed no significant difference between either sides in all four different graft types ($P>0.05$, CI 95%) [Table-1].

The results of PTFK and ATFK in the isokinetic test performed on operated limbs (case group) and non-operated limbs (control group) in the third month revealed no significant difference between either sides in all four different graft types ($P>0.05$, CI 95%) [Table-2]

The results of PTEK and ATEK in the isokinetic test, performed on operated side (case group) and non-operated side (control group) in the sixth month also showed no significant difference between two limbs in all four groups ($P>0.05$, CI 95%) [Table-3].

Table 1. Comparison of mean isokinetic test results in non-operated and operated limbs 3 months after the surgery

	Side	Group A (S.D.)	Group B (S.D.)	Group C (S.D.)	Group D (S.D.)	All (S.D.)	*P value*
PTEK N/(m/s)	Non-operated	101.4 (20.2)	86.75 (29.0)	103.68 (23.1)	108.5 (29.8)	99.8 (25.7)	0.63
	Operated	102.37 (17.9)	82.64 (29.5)	104.84 (21.1)	99.33 (30.4)	97.49 (25.4)	
ATEK N/(m/s)	Non-operated	92.53 (18.1)	77.65 (27.2)	93.48 (22.8)	99.64 (29.1)	90.6 (24.1)	0.58
	Operated	92.93 (18.3)	74.97 (27.0)	95 (22.4)	88.36 (28.8)	88 (24.4)	

PTEK: Peak torque of hip extension with extended knee, ATEK: Average torque of hip extension with extended knee, N: Newton, m/s: meter/second, S.D.: standard deviation

Table 2. Comparison of mean isokinetic test results in non-operated and operated limbs 3 months after the surgery

	Side	Group A (S.D.)	Group B (S.D.)	Group C (S.D.)	Group D (S.D.)	All (S.D.)	*P value*
PTFK N/(m/s)	Non-operated	99.54 (16.8)	82.5 (28.1)	100.89 (22.4)	103.99 (22.4)	96.6 (21.2)	0.48
	Operated	99.55 (18.0)	77.82 (23.0)	102.45 (19.4)	93.93 (16.8)	93.74 (21.1)	
ATFK N/(m/s)	Non-operated	91.42 (15.3)	74.98 (25.9)	91.4 (24.0)	94.55 (21.3)	88.09 (21.4)	0.48
	Operated	90.68 (17.4)	71.04 (22.2)	92.81 (22.9)	85.3 (16.8)	85.27 (21.0)	

PTFK: Peak torque of hip extension with flexed knee, ATFK: Average torque of hip extension with flexed knee, N: Newton, m/s: meter/second, S.D.: standard deviation

Table 3. Comparison of mean isokinetic test results in non-operated and operated limbs 6 months after the surgery

	Side	Group A (S.D.)	Group B (S.D.)	Group C (S.D.)	Group D (S.D.)	All (S.D.)	*P Value*
PTFK N/(m/s)	Non-operated	116.25 (27.4)	97.85 (36.0)	124.15 (35.3)	129.14 (39.2)	116.11 (37.7)	0.34
	Operated	119.72 (27.8)	98.8 (41.2)	136.72 (31.4)	140.6 (39.6)	122.51 (37.3)	
ATEK N/(m/s)	Non-operated	105.6 (28.4)	87.23 (29.1)	113.17 (31.2)	116.94 (35.2)	105.08 (35.8)	0.24
	Operated	108.52 (28.1)	90.08 (36.4)	127.74 (31.4)	129.33 (37.2)	112.35 (35.5)	

PTEK: Peak torque of hip extension with extended knee, ATEK: Average torque of hip extension with extended knee, N: Newton, m/s: meter/second, S.D.: standard deviation

Table 4. Comparison of mean isokinetic test results in non-operated and operated limbs 6 months after the surgery

	Side	Group A (S.D.)	Group B (S.D.)	Group C (S.D.)	Group D (S.D.)	All (S.D.)	*P Value*
PTFK N/(m/s)	Non-operated	108.94 (20.1)	88.06 (29.0)	117.05 (24.8)	119.26 (36.2)	107.71 (33.9)	0.52
	Operated	114.19 (23.0)	87.97 (37.2)	126.96 (27.4)	118.82 (39.1)	111.46 (33.7)	
ATEK N/(m/s)	Non-operated	100.09 (19.7)	80.68 (25.2)	106.37 (23.3)	107.2 (32.9)	98.17 (30.3)	0.68
	Operated	102.64 (26.5)	81.34 (31.1)	111.5 (26.8)	107.48 (32.4)	100.33 (30.4)	

PTFK: Peak torque of hip extension with flexed knee, ATFK: Average torque of hip extension with flexed knee, N: Newton, m/s: meter/second, S.D.: standard deviation

The results of PTFK and ATFK in the isokinetic test, performed on operated side (case group) and non-operated side (control group) in the sixth month also showed no significant difference between two limbs in all four groups (*P >0.05*, CI 95%) [Table-4].

When the operated sides (case group) were compared on a two-by-two basis, the PTEK, ATEK, PTFK and the ATFK values showed no significant difference among them.

Discussion

This was a prospective non-randomized case-control study to compare isokinetic hip extension strength following ACL reconstruction using common types of grafts consisting of semitendinosus-gracilis tendons, only semitendinosus tendon, bone-patellar tendon-bone grafts, and allografts. The hypothesis was to investigate the difference between hip extension strength among semitendinosus-gracilis group and other graft type groups.

The results revealed that there was no significant difference between patients (the operated feet) with the control ones (non-operated ones) in hip extension strength for all tests in three and six months after the surgery. However, in all groups, the hip extension strength increased in the sixth-month test in comparison with the third-month one.

Suitable graft selection, proper surgical technique, and proper rehabilitation are among the most important success factors in ACL reconstruction surgery. In the present study, patients with lesions such as meniscus and cartilage lesions requiring treatment (causing changes in rehabilitation protocol) were excluded from the study to eliminate confounding effects (17).

To the best of our knowledge, the only similar prospective study was conducted by Geoghegan et al. (17). They found no significant difference in hip extension strength between bone patellar tendon bone group and both semitendinosus and gracilis tendons after 12 months. Their focus was on the assessment of changes in hip extension strength after ACL reconstruction using patellar tendons as well as semitendinosus and gracilis tendons altogether. Our results were similar to Geoghegan et al. results, although our sample size was larger than their study and we had four subgroups. Another cross-sectional research conducted by Hiemestra et al. concentrated on the evaluation and comparison of 15 patients undergoing ACL reconstruction using semitendinosus and gracilis tendons altogether along with a matched control group including 15 people with no knee injury (32). They found no changes, however, they evaluated only semitendinosus and gracilis tendon group. Froster et al. showed that the use of patellar tendon increased the likelihood of knee extension loss and the resulting patellofemoral pain (33). Dauty et al. in a literature analysis showed that in comparison to bone patellar tendon bone graft, use of hamstring tendon graft results in the reduction of knee flexor power (34). Hiemestra et al. found that hip extension strength increased after using semitendinosus and gracilis tendons together 12 months after surgery (32). Yatsuda et al. showed that it is possible to obtain full recovery of hamstrings three months following semitendinosus harvesting (35). In a research by Simonian et al., it was revealed that semitendinosus and gracilis tendons together make no significant disruption in power and performance (mean follow-up of 3 years) (23).

In line with Geighegan et al., we also used Isokinetic testing to get an exact quantitative measure for the comparison of extension strength in the operated limbs with the intact ones (17). Speed of 30 degrees per second was used for isokinetic testing by a Biodex isokinetic testing machine to obtain a more accurate measurement of hip extension. This was because of higher speeds that result in the coverage of hip extension power failure.

In our study, the results from the maximum power of hip extension and average power of hip extension in the test performed on the operated organs (patients' group) and non-operated organs (control group) in the third month revealed no significant difference with the ones found in the sixth month. However, in all groups, the hip extension strength was found to rise in the sixth-month test in comparison to the one taken in month three (*P<0.05*, CI 95%) and the amount of increase was higher in the operated limbs. In the literature, no prospective studies were found concentrating on the effect of all four types of grafts used in ACL reconstruction surgery on the hip extension strength.

One of the main advantages of the present investigation compared to similar studies is that we included more samples in the study, and examined all kinds of grafts used in ACL reconstruction surgery and their prospective nature. While the removal of patients with meniscus or cartilage lesions from the study reduced the number of our participants, elimination the confounding quality regarding the rehabilitation increased the value of the results.

The main limitation of the present research was its non-randomness that might have caused a biased selection due to indications including the body size, the presence of ligamentous laxity, athleticism, and the athleticism type. Sample size in each group is another limitation of this study. Patients were not divided equally in terms of gender among the groups and all female patients were in the allograft group that might cause some bias. Admission after the initial injury and the time interval between injury and surgery were not considered, and this in turn might affect the results, too.

This prospective study showed that graft types used in ACL reconstruction surgery do not have any significant effect on hip extension strength. Moreover, the findings of this study demonstrate that there are no contraindications to use hamstring tendons for ACL reconstruction in athletes in need of powerful hip extension. Conducting a prospective randomized study is highly warranted for the purpose of a closer examination of the results obtained in this study.

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