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ORIGINAL RESEARCH

Medicine Science 2017;6(2):310-3

Medicine Science International Medical Journal

Effects on knee kinematics following anterior cruciate ligament repair using semitendinosus and gracilis tendon grafts

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Received 24 October 2016; Accepted 29 November 2016
Available online 21.12.2016 with doi: 10.5455/medscience.2016.05.8563

Abstract
Semitendinosus and gracilis tendons are the most commonly used autografts in anterior cruciate ligament (ACL) reconstruction. In this study, we researched the effects of these grafts on knee kinematics. Seventeen patients who had ACL surgery at the GATA Orthopaedics Clinic between 2010 and 2011 were included in this study. The flexion, extension, internal and external rotation of the operated knee and the contralateral healthy knee peak moments were measured and evaluated with Cybex Dynamometer device. Results were evaluated using the paired t-test in SPSS 15.0 and $p \leq 0.05$ was considered to be significant. The flexion, extension, internal and external rotation peak moments were decreased in ACL reconstructed knees compared with contralateral healthy knees. Decrease in knee flexion and extension at 60° and 180°/second was found statistically significant compared with the contralateral healthy knee ($p < 0.05$) in the postoperative first year. Also internal and external rotation of the reconstructed knee declined compared to healthy knee it was found statistically significant. After the use of STG autograft in ACL reconstruction, the knee flexion, extension, internal and external rotation moments decreases. In the postoperative period, rehabilitation programs should be redesigned using this knowledge. Especially in athletes postoperative physical therapy should be applied in meticulously.

Keywords: Hamstring, anterior cruciate ligament, repair, peak moment

Objective

The importance of healthy living, in addition to the increasing number of "synthetic" sport fields, has brought about an increase in sports-related injuries. Sports injuries (non-contact) are responsible for 54% of all anterior cruciate ligament (ACL) injuries [1]. The incidence of ACL injury is 1/3000 and approximately 250,000 new events emerge annually [2]. Therefore, ACL surgery is still common. The most preferred method to reconstruct the ACL is the autogen graft which the semitendinosus and gracilis (STG) and bone-patellar tendon-bone autografts (PTB) are mostly preferred.

The STG autograft is preferred because the cross-sectional area is close to the natural ACL. The tendon is also folded four times making it twice as strong as the ACL, and the donor site morbidity is either of a non- or very limited existence makes this choice preferrable. There are some disadvantages, such as longer recovery time because graft contact is not between the bones, a lack of stability because the fixation is on the external side of the knee, the risk of missing the graft during the taking phase and the graft not being of the planned length [3].

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Hamstring muscles enhance knee stability by reducing the stress on the ACL and prevent the forward tendency of the knee [4]. In ACL reconstruction, the effect of using medial hamstring muscles as an autograft on knee kinematics has always been a topic for discussion. In this study, after the repair of the ACL using STG autografts, we examined changes in the knee kinematics by comparing the movement indexes of a healthy knee and an ACL reconstructed knee by Cybex Dynamometer.

Material and Method

Patients who had undergone STG autografts between January 2010 and December 2011 were invited as volunteer study participants. The average age of the patients was 31 ± 7 (range 18 to 44) years and all were male. The standards for inclusion in the study were as follows:

1) Patients who had undergone ACL reconstruction with STG graft at least 1 year back.
2) Patients whose other leg was healthy.
3) Patients who had no postoperative trauma to their knee following ACL repair.
4) Patients who had no problems with their knee stability after ACL repair (no instability in physical examination).
5) Patients who had normal bilateral knee physical findings in examination.

6) Patients who did not have central or peripheral nerve injuries.

In all patients, the Endobutton system was used for femoral fixation, a post-fixation screw was used for tibia fixation, and the patients had been subjected to a standard physical therapy protocol postoperatively. Patients who participated in the study were informed about the "patient procedures," and each of them signed a confirmation form. Before the isokinetic evaluation, the age, weight, and height of each patient were recorded (Table 1). Because the optimal curve of strength-speed and height-strain is between 60° and 180°/second; the flexion, extension, internal and external rotation moment indexes were examined according to these degrees with Cybex Dynamometer. The examinations were performed by two doctors at the GATA Medical Science and Sport Clinic, both having knowledge of this study. Before the examinations, the patients were informed and prepped about the Cybex Dynamometer device.

Flexion and extension examinations were conducted in the sitting position. Examinations were conducted with the Dynamometer device after the patients were tied and stabilized with femoral and calf velcro bands (Figure 1a). Subsequently, flexion and extension movements were examined at 60°/second and 180°/second (Table 2). After each examination, patients were given 3 minutes to rest. Next, in the supine, internal and external rotation examination of patients was conducted under the condition of hip flexed at 60° and the knee and the ankle flexed at 180° (Table 3). The patients' feet and ankles were stabilized by tying them with velcro bands on a foot table (Figure 1b) not to affect the internal and external rotation peak moments during examination. All these measurements were repeated on both the healthy leg and the reconstructed one.

Table 1. Patient demographic data

Demographic Data (N = 17)	Average ± Standard Deviation
Age (years)	31.7 (18-46)
Weight (kg)	79.9 ± 7.3
Height (cm)	177,5 ± 5,4

Table 2. Extension and flexion peak moment data

Test	Operation	Healthy	*P* value
Extension			
60°/s	102.5 ± 38.6	124.6 ± 29.8	0.02
180°/s	45.4 ± 16.0	83.7 ± 22.0	0
Flexion			
60°/s	67.3 ± 29.8	86.2 ± 24.4	0
180°/s	42.9 ± 15.5	54.2 ± 18.1	0
Extension/flexion			
60°/s	58.2 ± 14.0	70.1 ± 17.0	0
180°/s	77.9 ± 13.0	85.7 ± 18.1	0

Table 3. Internal and external rotation peak moment data

Test	Operation	Healthy	*P* value
Internal rotation			
60°/s	16.4 ± 4.8	23.8 ± 6.4 0	
180°/s	14.3 ± 4.5	18.7 ± 7.4	0.001
External rotation			
60°/s	18.3 ± 4.3	23.1 ± 5.5	0
180°/s	15.4 ± 4.3	19.1 ± 6.1	0.001
IR/ER			
60°/s	80.1 ± 11.5	95.4 ± 18.3	0
180°/s	89.1 ± 11.6	99.2 ± 20.1	0.031

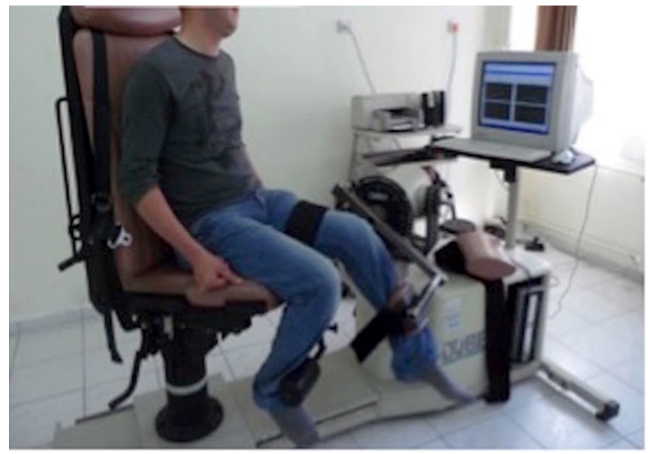

Figure 1. Patients with the Cybex Dynamometer Device
a) Flexion-extension measurements

Figure 1. Patients with the Cybex Dynamometer Device
b) Internal-external rotation measurements

Results

There were 17 male patients with an average height of 177,5 ± 5,4 centimeters and average weight of 79.9 ± 7.3 kilograms. When sitting position, reconstructed knee extension peak moments at 60° and 120° were decreased to 102.5 ± 38.6 and 45.4 ± 16.0 respectively, which were found statistically significant compared with healthy knee. Flexion peak moments at 60° and 120° were decreased to 67.3 ± 29.8 and 42.9 ± 15.5 respectively, which were also found statistically significant compared with healthy knee. Similarly, in supine position, reconstructed knee internal rotation peak moments at 60° and 120° within the condition of hip flexed were measured 16.4 ± 4.8 and 14.3 ± 4.5 respectively, while external rotation peak moments at 60° and 120° were measured 18.3 ± 4.3 and 15.4 ± 4.3, respectively. The results of internal and external rotation peak moments were found decreased and statistically significant when compared to internal and external rotation peak moments of the healthy knee. The results were summarized in Table 1, Table 2 and Table 3. All results were evaluated using the paired *t*-test in SPSS 15.0 and $p \leq 0.05$ was considered to be significant.

Discussion

In surgeries performed for repairing the ACL, an STG autograft is the preferred method because of its anatomic similarity to the ACL. These grafts have other advantages such as a reduced donor area morbidity compared with PTB tendons, absence of immunologic problems such as allografts, and no requirement of extra cost to obtain. An STG autograft remains a reasonable option despite some disadvantages including its fixation point on the external side of the knee, a longer recovery time compared with PTB tendons, and the risk of drawing back and not having the planned graft length [1].

Another disadvantage of STG tendons that is neglected but deserves attention is an emerging change to the knee kinematics once the tendon has been harvested. Hamstring muscles reduce the stress on the ACL by preventing translation of the knee and protect the ACL. It is inevitable that the ACL takes on the extra load when the protecting effects of hamstring muscles disappear or decline. In some reports that evaluated this effect showed %17 flexion strength loss at 60°/s compared healthy leg to determine any loss of strength in the use of STG [5-7], while others have reported no decline in the knee flexion moment [8]. Adachi et al. [9] stated that the use of an STG autograft may cause a loss of strength at deep flexion angles (>70°), but other flexor muscles, such as the gastrocnemius, may compensate for this flexion loss.

Semimembranosus and biceps femoris muscles are responsible for the flexion moments at lower flexion angles. The reason why we used the 60°/s moment speed was that STG muscles begin to show their effect from this angle on. Some studies have stated that the tendon underwent regeneration similar to its natural morphology by 1–3 cm proximal to the tendon adhering area 18–24 months after having and harvesting an STG autograft [10,11]. After this regeneration, it was claimed that the semitendinosus muscle in particular helped with knee flexion and internal rotation. Simonian et al. [12] used magnetic resonance imaging to compare the tendon diameters of both knees (one with(healthy) and one without a graft) over a 3-year period and found no significant differences in the diameter of the grafts to show the increasing functional knee flexion strength scores. To reduce the effects of semitendinosus regeneration in our study, we stipulated that patients were in their first year postoperatively. We found that the patients had ACL reconstruction with STG autograft had decrease in knee flexion and extension at 60° and 180°/s which was found statistically significant compared with their healthy knee ($p < 0.05$) in their first year.

Internal rotation of the tibia is necessary for the endurance of "screw home" mechanism in the continuation of normal knee biomechanics. Although the effect of hamstring autograft use on flexion-extension strength has been studied repeatedly in ACL reconstructions, its effect on internal–external rotation has not been studied as much. One reason about that situation is that the semimembranosus, popliteus, and sartorius muscles are also responsible for knee internal rotation, and it may be speculated that internal rotation loss will not occur.

STG muscles are not only the primary flexors of the knee but also the primary internal rotators of the tibia. In anatomical based studies about these data, Viola et al. [13] and Segawa et al. [14] stated that a decline in the knee internal rotation strength occurred with the use of an STG autograft. In our study, we conclude that in addition to being less at the 180°/s speed, internal and external rotation peak moments at both speeds declined on the knee, which experienced ACL surgery compared with the healthy knee.

Torry et al. [15] stated that the decline in the internal rotation movements was an independent parameter and not affected by gender. In contrast, Segawa et al. [14] stated that the increased valgus and Q angles as in females caused an increase in the loss of internal rotation strength. This may suggest that one drawback of our study was that all of our patients were male and we are unable to elucidate the matter of gender.

In our study, one more drawback could be seen that we did not evaluate the strength of the dominant extremity would be greater. However Perrin [16] stated that there was a slight difference (although not statistically significant) between both extremity kinematics.

In conclusion we can report that knee flexion, extension, internal and external rotation strength will decrease after ACL surgery which is harvested with medial hamstring STG autografts. In the postoperative period, rehabilitation programs need to be revised according to this information. Especially the effect of internal rotation moment loss on athletic performance is a topic that requires additional studies.

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