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Research Paper

Arthroscopic double-bundle anterior cruciate ligament reconstruction using hamstring tendon autografts: does the graft size correlate to the height and weight of the patient

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Abstract

Introduction: Recently, many studies have shown that double-bundle ACL (Anterior Cruciate Ligament) reconstructions have restored better natural ACL-fitting kinematics.

Objective: Assessing the correlation between the Hamstring autografts to the height and weight of the patient in the study and evaluating the outcomes of the arthroscopic double-bundle anterior cruciate ligament reconstruction surgery using Hamstring tendon autografts.

Material and Methods: Between August 2011 and July 2013, 38 ACL-deficient patients underwent double-bundle ACL reconstruction with 4 strand gracilis and 4 strand semitendinosus tendon autograft at Viet-Duc hospital. Clinical assessment at least 2 years postoperative have been documented.

Results: Our results showed that length of 4 strand semitendinosus and 4 strand gracilis tendon grafts were significantly correlated with patient height ($r=0.623$ and $r=0.414$; $p<0.001$). Diameter of 4 strand semitendinosus and 4 strand gracilis tendon graft were significantly correlated with patient weight ($r=0.399$; $p=0.013$ and $r=0.461$; $p=0.004$). The clinical result: Lachman test: 70.3% of patients showed negative of Lachman test. Positive Lachman test results as + were detected in 10 patients (27%), 1 patient was evaluated as ++. Pivot shift test: Positive pivot shift tests were detected in 4 patients that were evaluated as +, and none was evaluated as ++. One leg hop test: The average one leg hop was 92.1 ± 6.8% compared to uninjured. The mean Lysholme score was 92.0 ± 5.90 pts. The mean tibial anterior translation on stress radiograph was 2.42 ± 1.53 mm, respectively.

Conclusion: The length and diameter of ST (Semitendinosus Tendon) and GT (Gracilis Tendon) Agrafts for double-bundle ACL reconstruction were significantly correlated with weight, height. The double-bundle ACL reconstruction is effective in the treatment of the ACL deficient knee.

Keywords: anterior cruciate ligament, knee, autografts, gracilis tendon

INTRODUCTION

Anterior Cruciate Ligament (ACL) injury is one of the knee ligament injury most common. The main reasons cause the ACL injury by accident in activities of sports, entertainment, and traffic. The basic function of the ACL is to prevent the anterior movement of the tibia as well as control the rotational movement of the knee.

ACL reconstruction with standard single-bundle techniques has been restored anteroposterior stability of the knee and gained the satisfaction of the majority of patients. However many studies assessing the results showed single-bundle ACL reconstruction not fully recover rotation stability of the knee [1,2]. The anatomical studies showed ACL mainly consists of two distinct bundles: Antero-medial bundles (AM) and Postero-lateral bundle (PL) [3]. The AM and PL bundles function at different knee flexion angles, working together to provide both anterior and rotational stability of the knee. On that basis, the double-bundle ACL reconstruction technique, which is suggested to more closely resemble normal anatomy of the native knee, was developed in order to restore maximally knee function. The clinical studies comparing outcomes between double-bundle and single-bundle ACL reconstruction have shown double-bundle ACL reconstruction restores knee stability better than single-bundle ACL reconstruction [4-8].

In Vietnam, the double-bundle ACL reconstruction technique is interested in some recent years, with some studies reporting results of double-bundle ACL reconstruction applying the different techniques and materials. In the current conditions of Vietnam, autograft source remains a popular graft, which semitendinosus tendons and gracilis tendon are widely used, particularly in double-bundle ACL reconstruction. However, the size of the semitendinosus and gracilis autograft varies between patients, and short, small graft that will not meet the required surgery. The ability to identify those patients at risk for having hamstring tendons of inadequate length or diameter becomes a necessity.

In order to apply arthroscopic double-bundle ACL reconstruction technique, increase the stability of the knee, improve the efficiency of treatment and use of hamstring autografts, we conducted this study with two objectives:

1. Assessing the correlation between the lengths and diameters of 4-stranded semitendinosus tendon and 4- stranded gracilis tendon autograft to the height and weight of the patient in the study group
2. Evaluating the outcomes of the arthroscopic double-bundle anterior cruciate ligament reconstruction surgery using Hamstring tendon autografts

MATERIALS AND METHOD

Between August 2011 and July 2013, 38 ACL-deficient patients that underwent double-bundle ACL reconstruction with 4 strand gracilis and 4 strand semitendinosus tendon autograft at Viet-Duc Hospital. The average follow-up was 2 years.

STUDY DESIGN

Graft size and the correlations

We pre-operatively reported the height and weight of the patient at the time of diagnosis was confirmed. The length and diameter of the grafts were measured intraoperatively. Correlation coefficients (Pearson r) and simple linear regression were used to determine the relationship between the outcome variables (diameter and length graft) and the predictor variables (patient height and weight).

Clinical outcomes

Each patient underwent a clinical assessment with the Lachman test, anterior drawer test, and a lateral pivot- shift test. The anterior tibial translation was measured on stress radiograph radiographs at 200 of knee flexion under an anterior drawer force of 120 N. Knee function was evaluated by Lysholm score and IKDC (International Knee Documentation Committee) evaluation. All statistical analysis was done using SPSS (Statistical Package for the Social Sciences) program version 16.0.

SURGICAL TECHNIQUE

After the knee was examined under spinal or general anesthesia, a routine diagnostic arthroscopy was carried out through the anterolateral and anteromedial portal. According to the arthroscopic diagnosis, meniscus tears were partially resected. No treatments were administered for softening or fissuring of the articular cartilage. An approximately 2-3 cm long longitudinal incision was made in the anteromedial portion of the proximal tibia. The semitendinosus and gracilis tendons were harvested. Each tendon was cleaned and quadruped. The length and diameter of the grafts were measured. The semitendinosus tendon graft was used for the anteromedial bundle and gracilis tendon graft for posterolateral bundle reconstruction. We created a femoral tunnel and tibial tunnels using the Anatomic ACL guide system.

The length of femoral tunnels was measured to choose the appropriate loop of EndoButton so that at least a 15 mm long autogenous tendon portion would be placed within each bone tunnel (Fig. 1). EndoButtons were attached to the proximal grafts with the appropriate length of the loop. The graft for the posterolateral bundle was introduced through the tibial tunnel to the femoral tunnel using a passing pin (Fig. 2).

The EndoButton was flipped on the femoral cortical surface. Then the graft for the anteromedial bundle was placed in the same manner. For graft fixation, the thigh was manually fixed the knee at 20° flexed. We used interference screw for graft fixation and tied the sutures at the end of grafts to the postscrew at the tibia. An assistant surgeon simultaneously applied tension of 60 N to the grafts using the tensiometer during fixing. After the Lachman test was performed, the incisions were sutured. Identical postoperative management was followed according to our original rehabilitation protocol (Fig. 3).

RESULTS

GRAFT SIZE AND THE CORRELATIONS

The mean measurements included weight: 64.32 ± 7.67 kg (Min-max: 48-82 kg). Height 170.05 ± 5.49 cm (Min-Max: 160-182 cm)

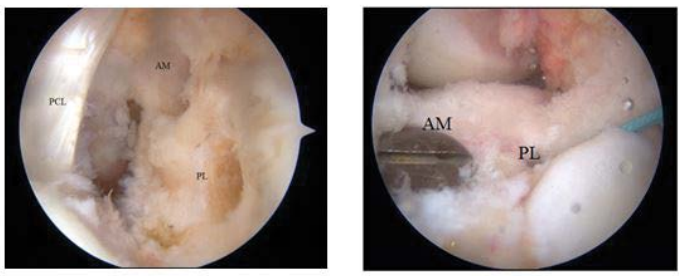

Fig. 1. The femoral tunnels (A) and tibial tunnels (B)

Fig. 2. The Hamstring autografts

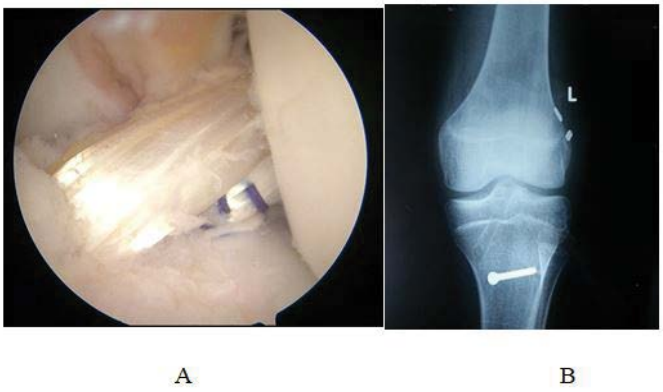

Fig. 3. Double bundle ACL reconstructed. Intraoperative arthroscopy photograph (A) and postoperative radiograph (B)

Hamstring tendon graft length

The average length of 4 strand semitendinosus tendon graft was 70.16 ± 4.52 mm, minimum 60mm and maximum 80 mm. The average length of 4 strand gracilis tendon graft was: 66.55 ± 4.68 mm, minimum 60 mm and maximum 75 mm.

Hamstring tendon graft diameter

The average diameter of the semi-tendinosus tendon graft was 7.67 ± 0.62 mm, minimum 6,0 mm and maximum 9,0 mm. The average diameter of gracilis tendon graft was 5.67 ± 0.59 mm, minimum 4.5 mm and maximum 7.0 mm.

Correlation between patient height and graft lengths (n=38) (Fig. 4)

Correlation between patient height and gracilis tendon graft length (n=38) (Fig. 5)

Correlation between patient weight and semitendinosus tendon graft diameter (n=38) (Fig. 6)

Correlation between patient weight and gracilis tendon (GT) graft diameter (n=38) (Fig. 7)

CLINICAL OUTCOMES

Surgery-related results

Operation time: The mean operation time was 85.7 ± 7.97 minutes, minimum 70 minutes and maximum 100 minutes. Most cases were less than 90 minutes.

Lengths of femoral tunnels: The mean length of AMB (Antero-medial Bundle) femoral tunnel was 39.26 ± 4.38 mm, minimum 30 mm and maximum 55 mm. The mean length of the PLB femoral tunnel was 35.13 ± 3.76 mm, in which 2 shortest cases was 28 mm.

Length of the intra-articular portion graft: The mean length of the intra-articular portion of AMB was 24.03 ± 1.31 mm, minimum 20 mm and maximum 26 mm. The mean length of the intra-articular portion of PLB (Postero-lateral Bundle) was: 15.66 ± 1.53 mm, minimum 14 mm and maximum 19 mm.

AMB tunnels position: The center of AMB femoral tunnel projected on Blumensaat' line at a mean of 25.68 ± 1.55%, minimum 23% and maximum 28.5%. The center of AMB tibial tunnel lay at a mean of 34.77 ± 1.29% of Amis-Jacob' line, minimum 32% and maximum 37%.

Postoperative range of motion: Range of motion improved quicky post-operative, most cases obtained a normal range of motion at 10-week post-operation. In our study, two patients had an extension deficit of approximately 50 and two had a flexion deficit of approximately 50.

KNEE FUNCTION POSTOPERATIVE RESULTS

In our study, there was a patient who had graft failure at 2 months postoperative due to a motor accident so he was excluded. The remaining 37 patients were evaluated.

Results of Lysholm score (n=37) (Table 1)

Results of IKDC evaluation (n=37) (Table 2)

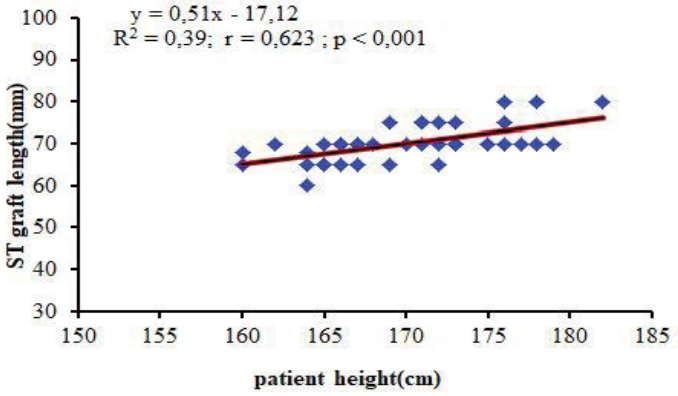

Fig. 4. Scatterplots showing the correlation between patient height and Semitendinosus Tendon (ST) graft length

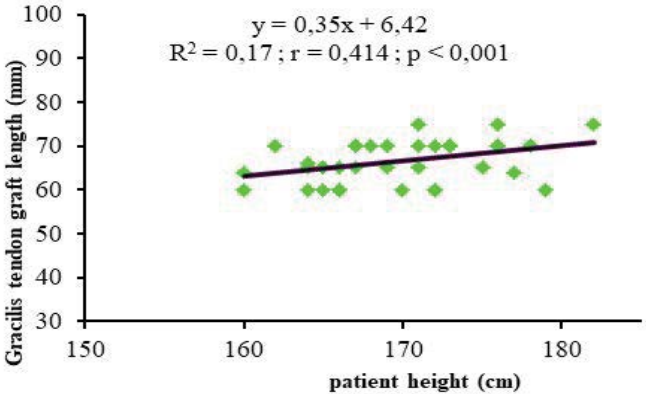

Fig. 5. Scatterplots showing the correlation between patient height and gracilis tendon graft length

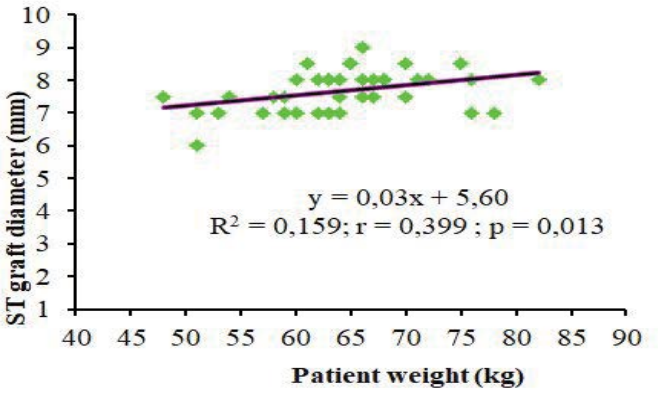

Fig. 6. Scatterplots showing the correlation between patient weight and semitendinosus tendon graft diameter

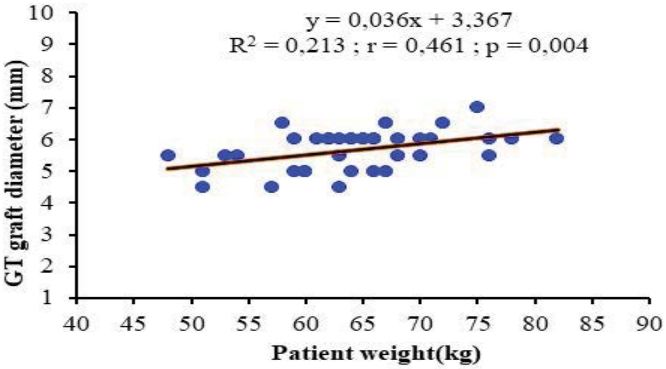

Fig. 7. Scatterplots showing the correlation between patient weight and Gracilis Tendon (GT) graft diameter

Table 1. Results of lysholm scores at 2 years postoperation

Lysholm's grade	Number of patient	%
Excellent (91-100 pts)	21	56.8
good (84-91 pts)	14	37.8
Fair (65-83 pts)	2	5.4
Poor (<65 pts)	0	0
Total	37	100.0
Mean ± SD	92.0 ± 5.90	
Min-Max	76-100	
95% CI	90.0-93.9	

Table 2. Results of IKDC form at 2 years follow-up

Grade	A	B	C	D	Total
N	26	10	1	0	37
%	70.3	27.0	2.7	0	100.0

Table 3. Comparing the graft size of different study

Author	AMB		PLB	
	Length (mm)	Diameter (mm)	Length (mm)	Diameter (mm)
	70.16 ± 4.52	7.67 ± 0.62	66.55 ± 4.68	5.67 ± 0.59
Yasuda et al. [4]	55	7-9	50	6-7
Nakamae et al. [7]	55-70	6.0	55-70	5.0
Sim et al. [8]	80-100	8.0	50-70	7.0

Clinical finding

Lachman test: Most cases were negative of Lachman test with 70.3% of patients in the study group. Positive Lachman test results as + were detected in 10 patients (27%), 1 patient was evaluated as ++.

Pivot shift test: Positive pivot shift test were detected in 4 patients that were evaluated as +, and none was evaluated as ++.

One leg hop test: The average one leg hop were 92.1 ± 6.8% compared to uninjured, most patient hop more than 75%. This significantly increased comparing to preoperation.

Tibial anterior translation measured on stress radiograph: The mean tibial anterior translation was 2.42 ± 1.53 mm, respectively.

DISCUSSION

GRAFT SIZE AND THE CORRELATIONS

In our study, we constructed 4 strand semitendinosus tendon graft for AMB and 4 strand gracilis tendon graft for PLB. Comparing the graft size in our study and other authors who performed double-bundle ACL reconstruction using Hamstring autografts was in Table 3.

The length of the 4 strand semitendinosus and 4 strand gracilis tendon graft is the most important. The short graft might be insufficient to fix securely and heal the graft in the tunnels. In this study, the average length of the intra-articular portion of the AMB graft 24.0 ± 1.3 mm, almost less than 25 mm, and that of PLB was 15.6 ± 1.7 mm, a maximum of 19 mm. For femoral fixation, we used EndoButton with a proper loop to obtain 15 mm of graft in the tunnel. Meanwhile, the average length of AMB and PLB were 70.2 ± 4.5 mm and 66.6 ± 4.7 mm so the portion graft in the tibial tunnels were 30 mm approximately that was sufficient for our combination fixation of interference screw and tying the sutures to the postscrew.

Prediction of the graft size is very useful in double bundle ACL reconstruction with a Hamstring tendon graft. Our results showed that length of 4 strand semitendinosus and 4 strand gracilis tendon grafts were significantly correlated with patient height (r=0.623 and r=0.414; p<0.001). However, there was no significant correlation between graft length and patient weight (r=0.21; p=0.203 và r=0.26; p=0.11). Diameter of 4 strand semitendinosus and 4 strand gracilis tendon graft were significantly correlated with patient weight (r=0.399; p=0.013 and r=0.461; p=0.004), but not correlated with patient height (r=0.23; p=0.16 và r=0.23; p=0.16). Through regression analysis we constructed the following predictive equations for length and diameter of semitendinosus tendon graft (ST) and gracilis tendon graft (GT).

ST length=-17.12 + 0.51 (patient height in cm)

(r=0.623; R^2=39%; p<0.001)

GT length=6.42+0.35 (Patient height in cm)

(r=0.414; R^2=17%; p<0.001)

ST diameter=5.60+0.03 (Patient weight in kg)

(r=0.399; R^2=16%; p=0.013)

GT diameter=3.367+0.036 (Patient weight in kg)

(r=0.461; R^2=21%; p=0.004)

Our equations indicate that patients with a height less than 151.7 cm and 153.1 cm show greater probability of having an ST (Semitendinosus Tendon) and GT (Gracilis Tendon) graft with a length equal to or less than 60 mm, respectively.

Likely, other authors had carried out the study to evaluate the relationship between anthropometric measurements and the size of the hamstring grafts [9-12]. The most studies showed that there was a correlation between hamstring graft size with patient height and weight. Xie G et al. observed in their study that patients with height less than 146.7 cm and 147.3 cm and the female gender show a greater probability of having an ST and GT graft with a length equal to or less than 240 mm and 220 mm, respectively [12].

CLINICAL OUTCOMES

The postoperative knee function result in this study was highly effective, all patients obtained significant improvement that almost they could return to normal and nearly normal activity levels. This outcome was similar to other studies. Biomechanical studies have found that the anatomic double-bundle ACL reconstruction can restore knee stability significantly more closely to the normal level. Intraoperative measurement studies showed that the clinically available anatomic double-bundle procedures can reconstruct knee stability significantly better and improve knee function close to the normal level at the time immediately after surgery compared with the conventional single-bundle procedures [13].

Factors that affect the outcomes

In this study, graft size was not affected by the postoperative results. Actually, there is no consensus in the literature regarding what graft size is too small for ACL reconstruction.

The tunnel position was a significant effect on outcomes. Determine the exact anatomic location of the tunnels, it could mean recreating the ACL similar to native ligaments in both directions of the ligament; the issue depends on the skill of the surgeon. The tunnel position incorrectly can lead to graft lies beyond the insertion area, causing graft impingement, and non-anatomic collagen orientation.

Rehabilitation has an influence on postoperative results. The exercise program should avoid overloading of the graft during graft healing, and promote the process of forming the proprioceptive receptors.

Complication

We had one case of postoperative 2 months of graft failure. This patient was operated easily, and good progress after surgery. Unfortunately, the patient voluntarily drove a motorbike and went down. To avoid this complication, patients should comply with exercise regime rehabilitation as well as daily activities.

Surgical site infections have two cases. Patients were treated as outpatients with dressing changes, cleansing wound daily, using antibiotics regarding antibiograms, After 5 months we operated to remove the screw, clean incision, patients fully recover. In our view, this may be due to complications hematoma at the donor tendons site, or by reaction with materials like interference screws, sutures. To minimize this complication we copiously irrigated the wound before closing.

In our study, there were 3 cases that complained of anterolateral knee paresthesia. Its due to a branch of the infrapatellar branch of the saphenous nerve might be jeopardized when performed tendon harvesting or portal incision. Generally, these disorders rarely affected patient activities.

In summary, we supposed anatomic ACL reconstruction can be defined as the functional restoration of the ACL to its native dimensions, collagen orientation, and insertion sites. Complete restoration of the native ACL may not be possible, because of the complex nature of the ligament. However, as anatomy is the basis of orthopedic surgery, the surgeon should strive toward close approximation.

There are some limitations in this study. The number of patients was not sufficient and the follow-up period was only 2 years. Further clinical studies are needed to examine the effects on rotatory stability, long-term survival of the graft functions, and comparisons with other procedures

CONCLUSION

Our results indicate that double-bundle ACL reconstruction may better improve knee stability. The length and diameter of ST and GT grafts for double-bundle ACL reconstruction were significantly correlated with weight, height. The graft length and diameter can be predicted using simple clinical measurements. These data provide important preoperative information for the surgeon and are useful in planning graft options in clinical practice.

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