RESULTS OF FOLLOWING SELECTIVE BUNDLE RECONSTRUCTION IN PARTIAL ANTERIOR CRUCIATE LIGAMENT TEARS BY ALL-INSIDE TECHNIQUE

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Summary

Objectives: To evaluate the outcome of selective reconstructive anterior cruciate ligament (ACL) surgery using the All-inside technique with a four-strand semitendinosus or gracilis autograft tendon. Subject and methods: 34 patients were diagnosed with a partial tear of the ACL and underwent selective reconstructive surgery at the Orthopedic Center, Military Hospital 103 from November 2018 to September 2020. Lysholm knee scale and IKDC class were used to access post-operatively clinical outcomes. Stability was evaluated using the anterior drawer test, the Lachman test, the Pivot shift test, and the Rolimeter measure at 20° of knee flexion. Results: The pre-operative and post-operative Lysholm scores were 49.5 ± 18.4 and 94.47 ± 6.81, respectively (p < 0.001). Pre-operatively, most patients were classified as C and on the IKDC score. At the final follow-up, IKDC scores included 22 class A, 10 class B, 2 class C (p < 0.001). The pre- and post-operative laxity measured by Rolimeter were 5.15 ± 1.5 mm and 1.74 ± 1.34 mm, respectively (p < 0.001). Pre-operatively and post-operatively, the Pivot-shift was absent in all cases. Conclusion: Selective reconstruction of the injured ACL bundle restores knee stability and function. All-inside technique can be used to reconstruct the rupture ACL bundle with many advantages. Longer follow-up is needed to fully evaluate clinical outcomes after selective reconstruction in partial ACL tears.

* Keywords: All-inside; Partial tear; Selective reconstruction.

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Date received: 29/6/2022
Date accepted: 21/7/2022

http://doi.org/10.56535/jrpm.v47i6.64
INTRODUCTION

The anterior cruciate ligament is made up of two bundles, the posterolateral bundle is mostly tight in extension, limiting tibial rotation, while the anteromedial bundle is rather tight in flexion, limiting anteroposterior translation of the knee. Partial ACL tears now make up 10 - 28% of all ACL tears [7]. However, a standard definition of a partial ACL tear does not exist, and its diagnosis remains clinically challenging. Preserving the uninjured bundle at least has some theoretical advantages. First, ACL remnants may add biomechanical strength and stability to the reconstruction in the immediate post-operative period, while graft strength primarily depends on the fixation device. Moreover, the residual portion of the ACL may maintain its blood supply and thus provide support to the healing process of the graft. In addition, maintaining some of its proprioceptive innervations might allow for a faster return to sport. Finally, the intact bundle might help to optimize the accuracy of bone tunnel placement by serving as a landmark. Currently, the All-inside technique is a modern technique in arthroscopic ACL reconstruction. This technique minimizes soft tissue damage and decreases bone removal during surgery, and at the same time, reduces pain for patients after surgery, allowing patients to practice rehabilitation earlier. This study aims: To evaluate the outcome of selective reconstructive ACL surgery by All-inside technique with four-strand semitendinosus tendon or gracilis tendon autograft.

SUBJECTS AND METHODS

1. Subjects

34 patients were diagnosed with a partial ACL tear and underwent selective reconstructive surgical treatment using semitendinosus or gracilis tendon, fixed at the femoral tunnel with Button and the tibial tunnel with Tightrope (Arthrex, USA) during the period from November 2018 to September 2020.

* Inclusion criteria:

All patients are definitively diagnosed with a partial tear of the ACL by arthroscopy, aged from 18 - 60 years old, the grafts were semitendinosus tendon or gracilis tendon, fixed in the femoral tunnel with the Button and in the tibial tunnel with the Tightrope.

* Exclusion criteria:

- Patients with either a concomitant injury or previous surgery of any other major ligament in the knee.
- Patients with any surgical treatment of associated chondral injuries.
2. Methods

* Definition of variables:

Data on age, gender, the time period between initial injury and surgery, type of trauma, a bundle of ACL injury, anterior knee laxity before and after surgery (Rolimeter), knee function Lysholm, IKDC class before and after surgery, and complications were recorded for each patient.

* MRI evaluation:

Magnetic resonance images with standard axial, coronal, and sagittal images were obtained for every patient. All studies were performed with a 1.5-T superconducting magnet. A diagnosis of a partial ACL rupture was suspected when any of the following signs were observed in the magnetic resonance images: Hyperintense signal within the ACL substance; distortion of fibers without obvious discontinuity; and attenuation and/or abnormal orientation of the ACL concerning Blumensaat's line. When either complete discontinuity or a complete absence of the ACL fibers was observed, the diagnosis of a total ACL tear was made. The same radiologist, experienced in the musculoskeletal diagnosis, evaluated the images for every patient.

* Surgical procedures and rehabilitation:

The patient is placed supine with a standard leg holder allowing the full range of motion under spinal anesthesia. An initial arthroscopy was systematically performed at the beginning of surgery to evaluate the type of tear. Once the isolated bundle rupture of the ACL was confirmed, the graft was harvested. The semitendinosus or gracilis tendons were harvested using the tendon open stripper (Arthrex). The tendon was quadrupled bands and looped with TightRope and Button. The graft ligament was 7 - 10 mm in diameter and 55 - 70 mm in length. Each end of the graft was stitched with No.1 nonabsorbable sutures approximately 2 cm in length. Each stitch must pass through each strand of graft.

- Anteromedial bundle reconstruction:

The femoral tunnel was performed by All-inside technique, the center of the femoral AMB bone tunnel was located at the AM footprint as identified during the removal of the AM bundle remnants, with the help of a femoral off-set guide (Arthrex). For the tibial AMB bone tunnel, the tibial drill guide (Arthrex) was set at 55º, and placed 2 cm medial to the tibial tuberosity on the distal tibial cortex. The intra-articular tip was positioned close to the medial tibial spine and anterior to the PL bundle tibial insertion and should also be contained by the anatomical footprint of the AM bundle. The tibial tunnel was drilled by A Flipcutter (Arthrex) with the same diameter as the graft. The length of the
tibial tunnel is about 20 - 30 mm, depending on the length of the graft. Fixation of the graft was done at 30° of knee flexion.

- Posterolateral bundle reconstruction:
The intact AMB was used as a landmark for orientation. Special care was taken to preserve these intact ACL fibers. The knee was at hyperflexion, the femoral tunnel was made by All-inside technique, the center of the femoral PLB bone tunnel was located at PL footprint as identified during the removal of the PL bundle remnants, and the femoral tunnel was drilled with a femoral off-set guide (Arthrex). The diameter of the femoral tunnel is as same as the graft, the length of tunnel is about 20 - 25 mm, depending on the length of the graft and the length of the total femoral tunnel. The tibial tunnel was performed with the ACL tibial drill guide set at between 55°. It was placed 2 cm medial to the tibial tuberosity on the distal tibial cortex. The intra-articular tip of the guide was positioned in the posterolateral aspect of the tibial ACL insertion. The intact AMBs were protected during the tibial tunnel drilling. A tibial tunnel was carefully drilled with the same technique as that described for the AMB tibial tunnel. Fixation of the graft was also performed at 30° of knee flexion.

- Rehabilitation protocol:
The program of rehabilitation exercises after selective reconstruction of a bundle of the ACL with semitendinosus tendon or gracilis is similar to the program for conventional ACL reconstruction. We instructed patients to exercise based on the Fowler Kennedy Sports Medicine Clinic ACL Rehab Guidelines. Full activities and a return to contact sport were only allowed at least 6 months after surgery, depending on the physical examination, strength, and the MRI aspect of the graft.

* Clinical and functional evaluation:
The evaluation included the Lachman test, the anterior drawer test at 90° of knee flexion, and the Pivot-shift test to assess the rotational stability. All these three parameters were qualified using the International Knee Document Committee criteria as grades 0, 1+, 2+ and 3+. A quantitative assessment of anterior tibial translation was performed at the office with the Rolimeter at 20° of knee flexion to find side-to-side differences. Clinical and functional follow-up also included the objective IKDC ligament evaluation form and the Lysholm questionnaire. The physical examination and the functional evaluation of every patient were performed pre-operatively and at final follow-up by a single sports medicine surgeon who was independent of the study and blinded to the type of ACL.
surgery (AMB, PLB reconstructions) that had been performed.

* Statistical analysis:

Continuous variables (age, time from injury to surgery, the length and the diameter of the graft, the Lysholm score, anterior knee displacement with the Rolimeter) were presented as mean, standard deviation (SD), maximum and minimum. Categorical variables (gender, trauma, the injury bundle of ACL, Lachman test, anterior drawer test, Pivot-shift test, IKDC class) were presented as percentages and frequencies. The inference in continuous variables was calculated with the paired-samples T-test. A marginal homogeneity test was used to compare the pre-operative and post-operative Lachman test, anterior drawer test, Pivot-shift test, and IKDC evaluation. The level of significance was set at 5% (α = 0.05). All the analyses were performed with SPSS 22.0 (SPSS Inc., Chicago, Illinois).

* Ethics in the study:

The clinical research ethics committee of our institution approved the study. All the patients signed informed consent to participate in the study as well as for evaluation and publication of their results. The diagnosis of partial tear was suspected from the physical examination and MRI assessment. However, tears of a single bundle were only confirmed arthroscopically.

RESULTS

1. Age and gender

Age ranged from 19 to 56 years old, average age: 31.65 ± 9.14 years. The age group accounting for the highest proportion is from 21 - 30 years old, with 16 patients accounting for 47.06%. The patients in the study group were mainly men, with 31 patients accounting for 91%, the number of women was much less with only 3 patients, equivalent to 9%.

2. Etiology of partial ACL injuries

The main cause of partial ACL tear was due to sports accidents encountered in 25/34 patients, accounting for 73.53%.

3. Time from injury to surgical intervention, timely follow-up

The mean time from the initial injury to reconstruction surgery was 9.24 ± 12.68 months, the earliest was 3 days, and the latest was 4 years. Most patients come to the hospital sooner than 3 months after injury (16 patients accounting for 47.05%). The mean follow-up time was 12.14 ± 5.14 months (range, 6 - 23 months).

4. The sign injuries ACL on MRI

The radiologist found at least one sign [10] of a partial ACL rupture in only 23 patients (67.65%) of the pre-operative MRI analyzed, 9 patients
(26.47%) with total tear ACL. The radiologist described a normal ACL in the remaining 2 patients (5.88%).

5. The bundle ACL reconstruction
31 patients (91.2%) were AMB reconstructions, and the remaining 3 patients (8.8%) were PLB augmentation procedures.

* The graft:
Only 10 patients (29.4%) used semitendinosus graft. In the remaining 24 cases (70.6%), it was necessary to use both semitendinosus and gracilis tendon grafts to ensure the size of the graft. The mean diameter of the grafts was $8.58 \pm 0.71$ mm (range 7-10 mm). Grafted pieces with a diameter of 7.0 to 9.0 mm accounted for the majority (30 cases accounting for 88.2%). The average length of the graft folded by 4 was $60.53 \pm 2.29$ mm (the longest was 70 mm and the shortest was 55 mm).

* Clinical and functional evaluation:
The clinical results were presented in table 1:
The pre-operative and post-operative Lysholm scores were $49.5 \pm 18.4$ (range: 12 - 79) and $94.47 \pm 6.81$ (range: 79 - 100), respectively, at the final follow-up ($p < 0.001$). Pre-operatively, most patients were classified as C and on the IKDC score ($n = 34$). At the final follow-up, IKDC scores included 22 class A patients, 10 class B, 2 class C ($p < 0.001$).

The pre-operative and post-operative differential laxity measured by Rolimeter was $5.15 \pm 1.5$ mm (range: 3 - 7 mm) and $1.74 \pm 1.34$ mm (range: 0 - 4 mm) at the final follow-up ($p < 0.001$). Pre-operatively and post-operatively, the Pivot-shift was absent in all cases. Before surgery, the clinical examination showed a positive grade 1 Lachman test in 14/34 cases and grade 2 in 20/34 cases. After surgery, a negative Lachman test was found in 22 cases (64.71%), positive grade 1 in 12 cases (33.29%). Pre-operatively, a negative anterior drawer test encountered in 2 cases (5.88%), a positive grade 1 in 17 cases (50%), positive grade in 15 cases (44.12%). After surgery, a negative anterior drawer test in 33 cases (97.06%), and positive grade 1 in 1 case (3.94%).

* Complications:
One case developed knee synovitis two weeks after reconstructive surgery. This patient had surgical debridement and placed negative pressure drainage for 72 hours. The patient's condition was then stabilized, and the rehabilitation program was continued. Three patients complained that they had pain in front of the knee, snapping sounds when flexing and extending the knee.
Table 1: Clinical results.

<table>
<thead>
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<th></th>
<th>Before surgery</th>
<th>Final follow-up</th>
<th>p</th>
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<tr>
<td></td>
<td>B: 0</td>
<td>B: 10</td>
<td></td>
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<tr>
<td></td>
<td>C: 20</td>
<td>C: 2</td>
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<tr>
<td></td>
<td>D: 14</td>
<td>D: 0</td>
<td></td>
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<tr>
<td>Lysholm score (X, SD) (range)</td>
<td>49.5 ± 18.4 (12 - 79)</td>
<td>94.47 ± 6.81 (79 - 100)</td>
<td>&lt; 0.001</td>
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<tr>
<td>Lachman test (Grade)</td>
<td>0: 0</td>
<td>0: 22</td>
<td>&lt; 0.001</td>
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<tr>
<td></td>
<td>1: 14</td>
<td>1: 12</td>
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<td></td>
<td>2: 20</td>
<td>2: 0</td>
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<td></td>
<td>3: 0</td>
<td>3: 0</td>
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<tr>
<td>Anterior drawer test (Grade)</td>
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<td>0: 33</td>
<td>&lt; 0.001</td>
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<tr>
<td></td>
<td>1: 17</td>
<td>1: 1</td>
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<td></td>
<td>2: 15</td>
<td>2: 0</td>
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<td>3: 0</td>
<td>3: 0</td>
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<td>Pivot shift test (Grade)</td>
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<td></td>
<td>2: 0</td>
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<td>3: 0</td>
<td>3: 0</td>
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<tr>
<td>Rolimeter, mm (range) 20° of knee flexion</td>
<td>5.15 ± 1.5 (3 - 7 mm)</td>
<td>1.74 ± 1.34 (0 - 4 mm)</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>
DISCUSSION

We conducted a study on 34 patients, we performed ACL augmentation on partial tears from November 2018 to September 2020. We checked the anterior drawer test, Pivot shift test, Lachman test, Lysholm score, IKDC class, and Rolimeter measurement before and after surgery more than six months. The mean Lysholm subjective score and IKDC class improved significantly after surgery (p < 0.001), and the anterior drawer test, Pivot shift test, and Lachman tests showed good results after surgery. Average anterior tibial translation from neutral, measured with a Rolimeter decreased significantly (p < 0.001). These results, as well as the post-operative laxity assessment, were good and similar to those reported in other studies [4, 6]. Recently, Sonnery-Cottet and Colombet [3] published a review article analyzing outcomes after partial ACL reconstruction. They found significant improvements in the subjective and objective scores in all examined studies, therefore justifying selective reconstruction in case of a partial ACL tear.

1. The graft

In our study, the mean diameter of the grafts was 8.58 ± 0.71 mm (range 7 - 10 mm), graft diameter was mainly from 7.0 to 9.0 mm. It is very important to reduce the diameter of the graft compared to classic reconstruction to avoid excess tissue in the intercondylar notch, which can develop a cyclops lesion. Many authors recommend that the graft should be from 7 to 8 mm in diameter. The grafts with a diameter less than 7 mm have been associated with an increased rate of failure and lead to early revision [8]. In our study, one patient had a graft diameter of 10 mm. This patient had a very small residual bundle; therefore, we required an increased-diameter graft. Li, et al. [5] showed the importance of evaluating the residual bundle’s quality. If the residual bundle is small, we should increase the graft diameter or conventional total reconstruction. A large graft can result in a loss of full extension post-operatively and pain due to excess tissue in the intercondylar notch.

At the final follow-up, the rate of complications was 12.9%, and most patients (3/4 patients) had residual pain, especially anterior. Sonnery, et al. [2] reported 13% of the patients had residual pain. This pain was statistically correlated to post-operative flexion (p < 0.016) and the type of graft (p < 0.00018). 9 patients underwent revision surgery for anterior arthrolysis because of cyclops syndrome and one patient due to a secondary lesion of the medial meniscus. 5 patients (3%) presented with a graft failure.
2. Technique

Most authors agree on anatomical reconstruction AMB. However, selective PL bundle augmentation had various opinions. We think that it requires a reproducible technique to place the PL tunnel in the anatomic insertion while preserving the AM remnant. We used the All-inside technique to make a femoral tunnel. Buda et al. [1] thought that an anatomic reconstruction of the PLB is not strictly required because they wanted to keep the PLB remnant, which maintains blood supply and support for the healing process in the graft. If we reconstruct the PLB, an anatomic passage of the graft is not permitted because of the presence of the intact AMB. They used the “over the top” femoral placement technique. On the femoral side, the passage between the residual portion of the ACL and the posterior cruciate ligament is the only one that can be used because of the presence of the intact bundle of the ACL. The tibial tunnel was not on the anatomic footprint of this bundle, but just lateral and posterior to the insertion of the intact AMB. This provides a more vertical graft placement, with the graft passing just in front of the AMB, with tensioning of the native AMB. These selective reconstruction techniques for the AM and PL bundles have to preserve intact ACL bundle. To preserve the non-damaged fibers, when drilling the tunnel, we lift the intact bundle by a probe to protect this bundle.

In our study, the injury ACL bundle was reconstructed by the All-inside technique. All-inside ACL reconstruction has recently gained popularity because it has several advantages over traditional techniques, including creating the femoral socket, accurate measurement of the whole thickness of the femoral condyle before drilling, the possibility of minor changes according to the desired femoral canal length, the ability to achieve no space in the femoral canal between the graft and bony canal, and lower pain levels after surgery.

3. MRI evaluation

Concerning MRI evaluation, the previously performed MRI diagnosed the ACL as partially injured instead of a total ACL tear in only 21.4% of the arthroscopically confirmed partial ACL ruptures. This low accuracy of standard MRI in terms of properly diagnosing a partial ACL tear has already been reported. In our study, the rate of accurate diagnosis of partial ACL rupture was 67.65%, the remaining rate was total ACL rupture and normal ACL. Therefore, we think the diagnosis of partial ACL tear should be based on an arthroscopic evaluation.
CONCLUSION

Our study confirms that selective reconstruction of the injured ACL bundle restores knee stability and function. The All-inside technique can be used to reconstruct the rupture ACL bundle with many advantages. A longer follow-up is needed to fully evaluate clinical outcomes after selective reconstruction in partial ACL tears.

REFERENCES


