THE ALL-INSIDE ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION WITH FIBER-LOOP AUGMENTATION

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Abstract

Objectives: To evaluate the functional outcomes in patients who underwent anterior cruciate ligament (ACL) reconstruction with fiber-loop augmented to reinforce the ligament, acting as a secondary stabilizer. ***Methods:*** A retrospective study was conducted on 25 patients who underwent the all-inside ACL reconstruction with the addition of fiber-loop inside the ACL graft in the Department of Joint Surgery, Military Hospital 103, from August 2022 to August 2023. Patients were evaluated pre-operatively and finally post-operatively via the Lachman test, Pivot shift test, and Lysholm score. ***Results:*** The mean follow-up was 9.84 months; the mean age was 33.04 ± 9.95 years. 24 patients (96%) were post-operatively Lachman negative. The pivot-shift test showed 96% of patients absent or glide after surgery. The Lysholm knee score at the last visit was good and very good in 96% of the patients; the mean score was 92.56 ± 4,53. ***Conclusion:*** This study showed good functional outcomes of arthroscopic ACL reconstruction with fiber-loop augmentation to reinforce the ligamental graft. There is a need for more comparative studies with longer follow-ups and large sample sizes.

Keywords: Anterior cruciate ligament reconstruction; All-inside; Fiber-loop augmentation.

INTRODUCTION

An ACL injury is the most common knee injury worldwide, especially in athletes. The primary structure of the ACL is maintaining the stability of the knee joint. The arthroscopic ACL reconstruction is considered the gold treatment to restore normal knee kinematics. In 2014, over 200,000 ACL reconstruction procedures were

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performed in the USA [1]. For many years, ACL reconstruction failure still remains a challenge by laxity and rupture. The re-rupture ACL rate was noted to be 8.7%, with 94.7% of these patients requiring revision reconstruction [2]. Besides graft fixation and tunnel incorporation, the maintenance of graft tension during maturation and integration during rehabilitation is the factor contributing to avoiding future ACL failure [3]. In the early post-operative phase, the ACL graft strength decreases in the process of ligamentization due to apoptosis, a gradual increase in strength related to extra-cellular matrix synthesis and remodeling of collagen fibers [4] afterward. In this vulnerable period, excessive graft-loading can lead to graft elongation or rupture, which causes knee instability [5]. As a result, the instability of the knee can significantly increase the risk factor for meniscal and cartilage injury, later osteoarthritis in joints [6].

Several recent biomechanical studies have shown that tying fiber-loop augmentation (between two adjustable loops of fixation device) to ACL graft construct increases both strength and loading. This addition uses ultra-high molecular weight polyethylene fiber to serve as an internal brace in order to provide stress protection for the newly reconstructed ligament in the course of the ligamentization process and accelerated rehabilitation [4].

The objective of this study was: *To demonstrate clinical results of ACL reconstruction with the addition of fiber-loop tied distally and proximally over the loop of the fixation device in terms of various clinical scores and laxity measurements.*

MATERIALS AND METHODS

1. Subjects

25 patients who underwent arthroscopic ACL reconstruction in the Department of Joint Surgery, Military Hospital 103, from August 2022 to August 2023.

* *Inclusion criteria:* Primary ACL reconstruction using hamstring tendon autograft with an ACL tear or concomitant ACL and meniscal tear confirmed clinical symptoms and on MRI; in the age group of 18 - 60 years; with no history of ligament injury or surgery in the affected knee.

* *Exclusion criteria:* Revision ACL reconstruction; multi-ligament knee injuries; using other than hamstring tendon autograft; evidence of osteoarthritis over grade 2; limited range of motion; malformation impacted to clinical assessments; and inadequate follow-up.

2. Methods

* *Research design:* A retrospective study was conducted.

* *Study protocols:* This technique focuses on the fiber-loop used to assist tendon grafts as an internal decompression device. We used HS fiber (HS 112) considered substantially equivalent to ultra-high molecular weight polyethylene 10x stronger than steel on a weighted basis, which is cleared by the FDA (the U.S Food & Drug Administration) for use in general soft tissue, including the use of tissue of orthopedic procedures. This fiber was manufactured in Portland by Riverpoint Medical Company, USA. The HS fiber provides for greater surface area fixation compared to the traditional suture, while the colored warp strand enhances visibility.

An experienced team of orthopedic surgeons performed all the surgeries. A tourniquet was applied in all cases, and antibiotic prophylaxis was pre-operatively used. All patients post-operatively underwent a rehabilitation period according to the institutional protocol. Patients were encouraged to perform early progressive range-of-motion exercises and bear full weight on the second post-operative day with an assistant device and knee brace locked extension. For six weeks after the surgery, a knee brace was recommended and removed according to the patient's comfort afterward. In addition, full knee flexion was advised.

* *Surgical technique:*

Under anesthesia, the examination was first performed, and then diagnostic arthroscopy was done through standard anterolateral (AL) and anteromedial (AM) portals. The AL portal is a diagnostic portal, and the AM portal is set for working.

We utilized adjustable-length loop devices for both femoral and tibial side-graft fixation. The tying fiber-loop was inserted through two suspensory loops of the femoral and tibial adjustable fixation device at a constant distance (about 60mm) *(Figure 3)*. The tied fiber-loop was inside and crossed along the length of the ACL graft to conduct as a loading-share device.

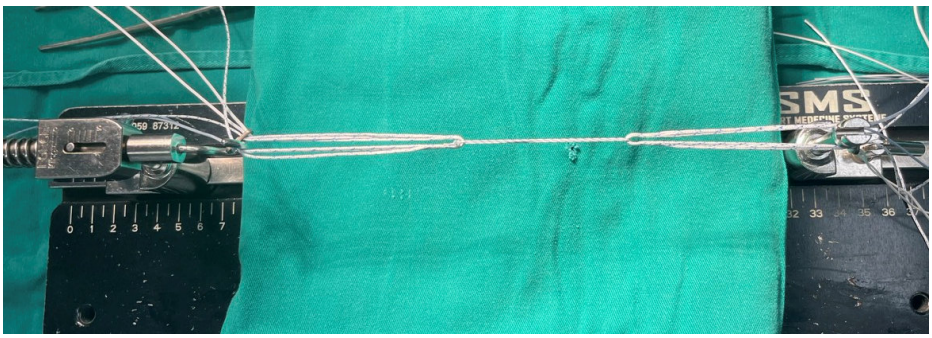

Figure 1. Fiber-loop as a graft augmentation.

The semitendinosus tendon is harvested, quadrupled, and pre-tensioned. The length of collagen within the femoral and tibial socket may be measured (typical distance is 15mm) and marked to ensure that the ACL graft is not bottomed out when the graft is tensioned so the surgeons can identify graft tensioning. At both the femoral and tibial sides, the marked parts of the ACL graft were sutured *(Figure 4).*

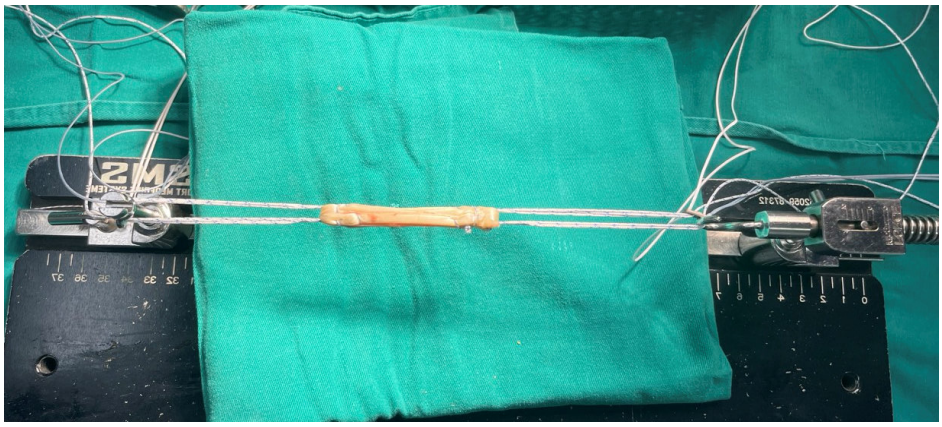

Figure 2. The ACL graft with fiber-loop inside.

According to the size of the quadrupled semitendinosus graft, the femoral and tibial socket were drilled by FlipCutter. Subsequently, the 4-strand looped autohamstring tendon graft was first passaged into the femoral tunnel and later into the tibial tunnel so that the distance-marked two ends of the graft were completely seated within the socket. The graft is fixed with adjustable-length loop devices at both the femoral and tibial tunnel.

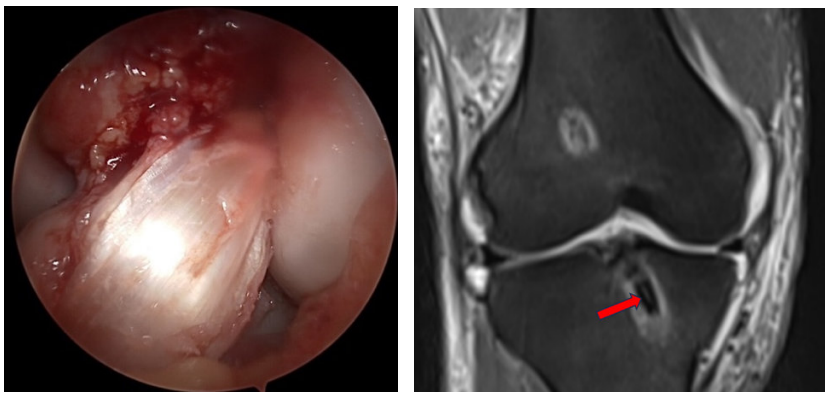

Figure 3. The ACL graft was pulled through the tibial to the femoral tunnel, and the new ACL graft was in MRI with an augmented fiber-loop.

The study was approved by the Ethics Committee of the Hospital. Patients' data were kept confidential throughout the study to protect the anonymity of their patients. To participate in the trial, every patient provided written, fully informed consent.

* *Clinical and functional evaluation:* The characteristics of eligible patients and functional outcomes, involving the Lachman test, Pivot-shift test, Lysholm score, and IKDC score, were recorded. No further testing was performed at that time. All patients were also contacted by telephone at the time of the analysis to collect data about any complications.

* *Statistical analysis:* The collected data were entered and processed according to medical statistical methods using SPSS 26.0 software and Microsoft Excel. Analysis of variance was used to compare the pre- and post-operative patient-reported outcomes. The descriptive statistics were calculated to summarise the clinical characteristics and described with means and standard deviations with ranges.

3. Ethics

The study was approved by the Ethics Committee at Military Hospital 103 (ref number 192/HĐĐĐ) on June 15th, 2022. Patient's data were kept confidential throughout the study to protect the anonymity of their patients. All participants gave written informed consent at the time of participation.

RESULTS

The study demonstrated the properties of the participants as well as the pre-operative and post-operative functional scores.

The clinical records of 25 consecutive patients, 21 males and 4 females, with a total of 15 right and 15 left knees, were assessed for inclusion. The patient's average age was 33.04 ± 9.95 years (ranging from 19 - 54 years). The mean follow-up period was 9.84 months (ranging from 5 - 17 months). The concomitant injury was a meniscus injury in 7 cases. Baseline patient characteristics are mentioned in table 1.

Table 1. Baseline patient characteristics (n = 25).

Variables		Data
Age (years)		33.04 ± 9.95
Gender (Male/female)		21/4
Side (Right/left)		15/15
Time from trauma to surgery (weeks)		32.32
Mechanism of injury (cases)	Sport	18
	Road traffic accident	7
Follow-up period (months)		9.84
Combined meniscus-injury (cases)		7

All patients pre-operatively practiced physical activities to ensure full range of motion. 64% of the patients had chronic injuries (more than three months of trauma), and 9 patients presented acute injuries (less than three months).

Table 2. Description of personal properties involved in the study (n = 25).

Variables		Pre-operative (cases)	Post-operative (cases)
Lachman test	Grade 0	0	24
	Grade 1	0	1
	Grade 2	9	0
	Grade 3	16	0
Pivot shift test	Grade 0	0	24
	Grade 1	0	0
	Grade 2	6	2
	Grade 3	19	0
Lysholm score		63.36 ± 4.64	92.56 ± 4.53

There has been a significant improvement in the scoring and laxity assessment compared to the pre-operative values. All patients showed good and excellent functional outcomes at the final evaluation. The pre-operative mean Lysholm scores were 63.36 ± 4.64 (52 - 70). Regarding the post-operative evaluation, the Lysholm score was 92.56 ± 4.53 (82 - 98). The Lachman and Pivot-shift tests were performed on each patient pre- and post-operatively *(Table 2)*.

There were no infection or graft failures, and the range of motion was full (0 - 140º) in all patients.

DISCUSSION

The results of this study confirmed the high ACL injury rates in young patients who often participate in vigorous physical activities like playing sports and manual labour, with a mean age of 33.04 ± 9.95 years. Darren et al. also showed that the mean age of 526 participants who underwent the all-inside ACL reconstruction with semitendinosus tendon was 31.9 ± 5.9 years [7]. In regard to gender distribution, the male-female ratio was 21/4. The study conducted by Mark d Santi et al. (1994) revealed a male:female ratio of 75:25% [8]. The main reason might be that males often spend more time in risky bodily activities, which exposes them to high risks of knee injuries.

During the early post-operative period, ligamentous graft protection is essential to avoid post-operative failure from excessive stress. The most important findings have shown a trend toward greater improvement in post-operative clinical outcomes. There were differences in improvement in post-operative Lysholm score, which changed from pre-to-post operation and were significantly superior.

The mean Lysholm score changed between 63.36 ± 4.64 and 92.56 ± 4.53 points, a promising result. When the primary ACL reconstruction was performed with Internal Brace (Arthrex Inc) augmentation in 31 patients, Vu Trung Hieu et al. (2021) reported that the mean Lysholm score of 91,2 ± 11,7 in 87.1% of the patients, which was excellent and good results after six post-operative months [9]. Sana Ullah et al. showed the clinical outcomes of the all-inside arthroscopic ACL reconstruction using semitendious tendon in 40 patients during a 3-year period starting from 2018, with a mean Lysholm score of 92 after at least 12 months [10].

In our study, an improvement in grades on the Lachman test and Pivot-shift test was found. When analyzing

the Lachman test and Pivot-shift test as the rotational stability, 24 patients were negative, respectively. Similar outcomes have been described in a study performed by Williams et al. who found that the Lachman and Pivot-shift tests were negative for 89% of patients [11].

Because of the added mechanical strength, Fiber-loop is currently used to support ACL graft, especially during the early recovery phase of ligamentization (probably up to 12 months post-operatively) [12], working as a load-sharing device.

CONCLUSION

Our study demonstrates that the ACL reconstruction with fiber-loop augmentation inside the graft demonstrated a promising technique to increase the strength of auto tendon grafts through post-operative functional outcomes. On that basis, this technique facilitates rehabilitation and prevents re-rupture of failure. The technique needs further clinical assessment with long-term outcomes and large sample sizes.

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