

Anterior Cruciate Ligament Reconstruction: Results of LARS Artificial Ligament Versus Four-Strand Hamstring Tendon Autograft

Mostafa Shahrezaee¹, Mohammad Sobhan Sheikh Andalibi², Seyyed Reza Sharifzadeh^{3*}

¹Department of Orthopedic Surgery, School of Medicine, AJA University of Medical Sciences, Tehran, Iran.

²International UNESCO Center for Health Related Basic Sciences and Human Nutrition, Mashhad University of Medical Sciences, Mashhad, Iran.

³Department of Orthopedic Surgery, School of Medicine, AJA University of Medical Sciences, Tehran, Iran. E-mail: reza.sharifzadeh@gmail.com
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Abstract

Background: This study compares the four-strand hamstring tendon (HT) autograft and the ligament advanced reinforcement system (LARS) artificial ligament for functional outcomes after anterior cruciate ligament (ACL) reconstruction.

Material and Methods: This retrospective study included 101 patients (89 males and 12 females) with isolated anterior cruciate ligament injury who underwent arthroscopic ACL reconstruction using a four-strand HT autograft (50 patients), or LARS ligament (51 patients), between 2017 and 2020. Eligible participants were followed for the mean of 32.5 months (range 12 to 48 months) and assessed functionally using the Knee Injury and Osteoarthritis Outcome Score (KOOS), Lysholm knee score, and International Knee Documentation Committee (IKDC) score.

Results: The mean age of patients was 29.9 ± 6.0 years (range 19-47 years). Sports injuries were the most common mechanism of injury in both groups. According to the Lysholm knee score classification, 86% (n: 43) of patients in the HT group had excellent and good knee function, while 78.5% (n: 40) reported excellent and good knee function in the LARS group ($p=0.02$). The mean of the Lysholm knee score, IKDC score, and KOOS subscales in the LARS group was higher than the HT group. However, this difference was not statistically significant.

Conclusion: This study showed that the short-term functional outcomes of ACLR surgery were slightly better with four strand HT grafts than LARS ligaments. However, patients' characteristics and the surgeon's experience should be considered in evaluating the best surgical option for patients with ACL injury.

Keywords: Anterior Cruciate Ligament, Autograft, Four Strand Hamstring Tendon, Ligament Advanced Reinforcement System, Anterior Cruciate Ligament.

INTRODUCTION

Anterior cruciate ligament (ACL) injury is one of the most common knee injuries in young people with rigorous physical activity, especially athletes and military personnel (1,2). The incidence of ACL injury is 0.6 and 2.41 per 1000 persons annually in the general population and high-risk patients, respectively (3). Although some recent alternative approaches with promising results such as tissue engineering and bone/graft regeneration have been introduced (4), surgical treatment seems to be the best choice for most patients.

Various types of grafts have been introduced for arthroscopic ACL reconstruction, including autografts, allografts, and artificial grafts. Biological tissue graft has been used for ACL reconstruction (ACLR) with comparatively satisfying results (5-7). Each of these grafts has its advantages and disadvantages. Although BPTB grafts seem to have a higher success rate than HT in ACLR surgery (8-10), postoperative complications, including patellar tendon rupture, anterior knee pain, kneeling difficulty, and decreased range of motion, in BPTB grafts are relatively remarkable (5,7,11).

Artificial ligaments have been developed in order to minimize the postoperative morbidities of biological grafts and the time to return to sports activities (12). The early generations of artificial ligaments had a high rate of graft failure and long-term complications, such as foreign body synovitis, ligament laxity, and tearing of the prosthetic ligament. Therefore, shortly after the introduction, most surgeons decided not to use artificial grafts for the ACLR (13). In light of recent innovations in graft design and biocompatible materials, the willingness to implement artificial ligaments in ACLR has become popular again (14,15).

Based on previous studies, Ligament Advanced Reinforcement System artificial grafts would provide favorable ACL function, especially for patients who are engaged in professional or rigorous physical activities (16,17). In addition, patients who were treated with LARS ligament were able to start their rehabilitation courses earlier (18-20). However, some studies reported a high rate of long-term complications of using LARS ligaments, such as graft failure and synovitis (21,22). Keep in mind that the appropriate choice for tissue graft in ACLR is still controversial.

Regarding the conflicting results which were presented in previous studies, we aimed to compare the functional outcomes of LARS and four-strand HT autografts in Iranian patients who underwent ACLR.

MATERIALS AND METHODS

Study Design and Subjects

From 2016 to 2019, 168 patients underwent arthroscopic reconstruction for an isolated ACL tear. Approval was acquired from the Iran National Committee for Ethics in Biomedical Research (no: IR.AJAUMS.REC.1398.221). Written informed consent was obtained from all patients before the study began. Inclusion criteria were patients older than 18 years with isolated ACL tear based on the Pivot-Shift test, the Lachman test, and magnetic resonance imaging. We excluded patients with bilateral ACL tears, concomitant ligament or bone injuries in the involved or contralateral knee, revision surgery due to graft failure, and prior history of knee surgery or infection (septic arthritis). All the surgeries were performed by two surgeons no later than 6 months after the ACL injury. The first surgeon (RS) performed the surgery for both groups, and the second surgeon (MS) merely performed the HT graft surgery. Among all participants, 101 patients were followed-up for the minimum of 12 months with the mean follow-up of 32.5 months (range 12 to 48 months). In these 101 patients, ACL reconstruction was performed using the LARS artificial graft for 51 patients and HT autograft for 50 patients. The Knee Injury and Osteoarthritis Outcome Score (KOOS) (23), Lysholm knee score (24), and International Knee Documentation Committee (IKDC) score (25) were obtained at the final follow-up. The grading scales in Lysholm knee score are: (>90), good (84–90), fair (65–83), and poor (<65). In addition to functional outcome scores, post-operative complications, including surgical site infection, reactive synovitis, and graft failure were assessed.

Surgical Technique

Surgical procedures were performed with patients in the supine position and under general or spinal anesthesia. Routine diagnostic knee arthroscopy was performed through standard anterior portals for trans-portal ACL reconstruction. Evaluation of every related structure and the extension of the ACL tear were done. For both four-strand HT and LARS (Surgical Implants, and Devices, Arc-sur-Tille, France) graft groups, we used a trans-portal technique via a medial accessory portal. We tried to position the femoral tunnel posterior and inferior enough to resemble an anatomic foot print and to have better rotational stability. The tibial foot print was contemplated anteroposteriorly at the anterior root of the lateral meniscus and close to the medial eminence in the coronal plan. The tibial tunnel was created using a cannulated reamer in accordance with the diameter of the graft. The angle between the tibial tunnel and the horizontal arm of the guide device was set at 55 degrees with slight medial inclination.

The femoral reamer was introduced through the tibial tunnel with the knee flexed at 90 degrees, and the femoral half tunnel was reamed under arthroscopic control, reaching a depth of 45 mm. The tibial tunnel guide pin was anatomically positioned within the ACL footprint. The graft was passed and fixed on the femoral side with Endobutton and on the tibial side with a bioabsorbable interference screw 2 mm larger than the tunnel diameter. For the four-strand HT graft group, semitendinosus and gracilis grafts were harvested with a small medial incision of 2-3cm in the anteromedial of the knee. They were prepared in a quadruple strand manner. Grafts underwent 20 minutes of 50-pound tension using a tension device. As long as it did not affect the visual field or manipulation, the ACL stump with synovial coverage was preserved as much as possible.

Rehabilitation

The rehabilitation protocol was similar between the groups. From the first day following surgery, straight leg raises and Quadriceps isometric exercises were initiated as soon as possible. For the first two weeks, knee flexion was allowed from 45 degrees to 90 degrees and increased gradually to complete flexion and extension within 4-6 weeks. After four weeks, full weight-bearing was allowed without a brace. Patients were allowed to return to normal daily activity in three months.

Statistical Analysis

All statistical analyses were done using SPSS, version 22.0 software package (SPSS Inc., Chicago, IL, USA). The Kolmogorov Smirnov test was performed to identify the pattern of data distribution. Data were expressed as mean \pm SD for quantitative variables and n (%) for qualitative variables. Categorical variables were compared with the χ^2 test. Independent sample t-test was used for comparison between two groups. A p-value of < 0.05 was considered statistically significant.

RESULTS

Demographic and Clinical Characteristics

This study included 101 patients with ACL tear, of whom 89 patients (88.1%) were male. The mean age of patients was 29.8 ± 6.0 years (range 19-47 years), while patients in the LARS group were younger (28.6 vs. 30.3 years, $p=0.02$). In 55 (54.5%) patients, the left knee was injured. As Table-1 summarizes, the mechanism of injury was mostly due to sport injuries and martial arts in both groups. The frequency of sociodemographic and clinical characteristics, including involved knee (left/right), time from injury to surgery, follow-up period, post-surgical complication rate, and marital status, did not appear to differ between groups (Table 1).

Table 1: Demographic and clinical characteristics of the study participants (n: 101)

Variable	HT graft group n: 50 n (%)	LARS group n: 51 n (%)	p-value
Age (years)*	31.3 ± 6.2	28.3 ± 5.6	0.01
Sex (male)	41 (82.0)	48 (94.1)	0.06
Marital Status			0.12
Married	17 (34.0)	25 (49.0)	
Single	33 (66.0)	26 (51.0)	
Involved Knee (Left)	28 (56.0)	27 (52.9)	0.76
Mechanism of Injury			0.18
Sport Injuries/Martial Arts	31 (62.0)	38 (74.5)	
Motor Accident/Falling	19 (38.0)	13 (25.5)	
Follow-up Period (months)*	21.0 ± 7.5	22.6 ± 6.7	0.22
Post-surgical Complication**	7 (16.0)	6 (11.8)	0.54

*Data were expressed as mean \pm SD. ** Post-surgical complication was defined as the presence of surgical-site infection, reactive synovitis, and graft failure.

HT: Hamstring tendon, LARS: Ligament Advanced Reinforcement System.

Clinical Outcomes

The comparison of functional outcome scales, including Lysholm, IKDC, and KOOS scores in two groups, is shown in Table 2 and Figure 1. According to the Lysholm score classification, 34 (68.0%), 9 (18.0%), and 6 (12.0%) patients had a result graded excellent, good and fair. Only one case had a poor outcome in the HT graft group. Whereas, in the LARS group, 41.2% (n: 21) of patients had excellent results, 37.3% (n: 19) had good results, and 21.6% (n: 11) had fair results ($p=0.02$, Table 2). No cases reported poor functional outcomes in the LARS group. There was no significant difference in the mean Lysholm score between the two groups ($p=0.08$).

The mean IKDC score was higher in the HT graft group than in the LARS group; however, this difference did not reach statistical significance (87.2 ± 11.4 vs. 86.1 ± 11.6 , $p=0.65$). Although the HT graft group showed better outcome results in the pain, symptoms, ADL, quality of life, and function in sport and recreation subscales, no significant difference was found in the KOOS subscales between the LARS and HT graft groups (Figure 1).

Table 2: Comparison of functional outcome scales, including Lysholm score, and IKDC score between the HT graft group and LARS group (n: 101)

Variable	HT graft group n: 50 mean \pm SD	LARS group n: 51 mean \pm SD	p-value
IKDC Score	83.0 ± 11.2	86.2 ± 11.6	0.16
Lysholm Score	85.4 ± 9.8	87.7 ± 7.6	0.17
Lysholm Score Classification*			0.75
Excellent (>90)	22 (44.0)	25 (49.0)	
Good (84-90)	16 (32.0)	15 (29.4)	
Fair (65-83)	11 (22.0)	11 (21.6)	
Poor (<65)	1 (2.0)	0 (0.0)	

*Data were expressed as n (%). HT: Hamstring tendon, IKDC: International Knee Documentation Committee, LARS: Ligament Advanced Reinforcement System.

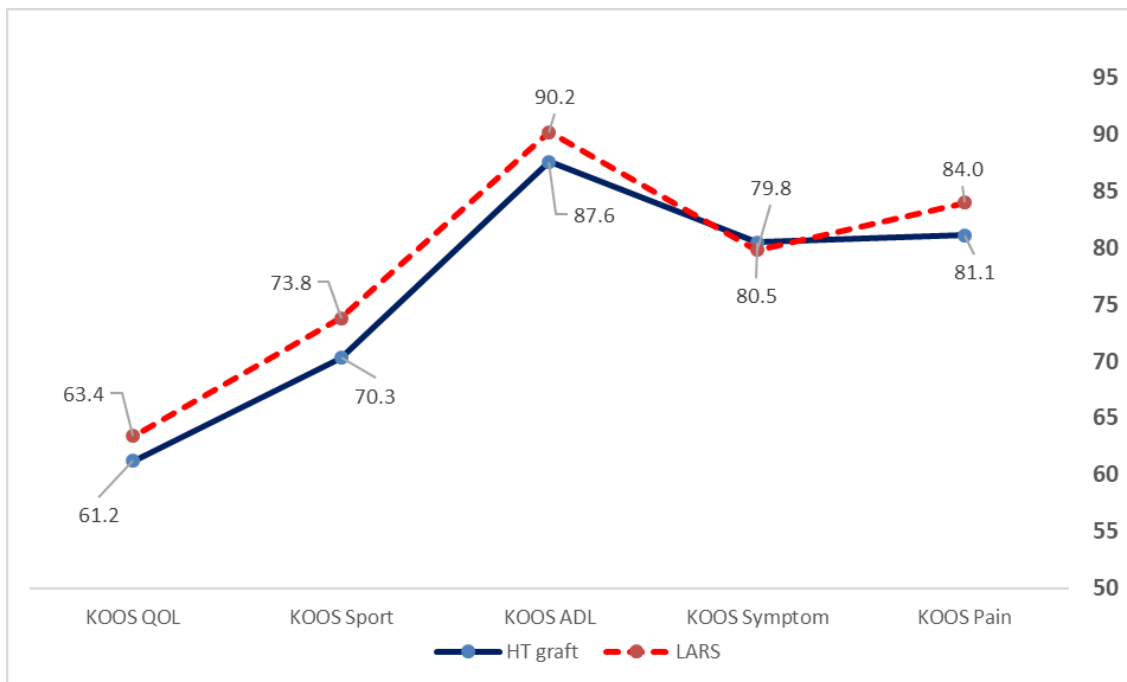


Figure 1: Comparison of KOOS subscales between HT graft group and LARS group. There was no significant difference in the KOOS subscales between groups ($p > 0.05$). ADL: activities of daily living, HT: Hamstring tendon, KOOS: Knee Injury and Osteoarthritis Outcome Score, LARS: Ligament Advanced Reinforcement System, QOL: Quality of life

DISCUSSION

In this study, we sought to investigate the short-term functional and clinical outcomes of patients with isolated ACL injury after ACLR surgery using a four-strand HT autograft and LARS artificial graft. As we found, after 12-48 months of ACLR surgery, both HT grafts and LARS artificial grafts showed favorable clinical and functional outcome measured by KOOS, IKDC, and Lysholm scales. Although patients in the four-strand HT graft showed a better clinical outcome based on Lysholm's knee classification, there were no statistical differences in the other clinical and functional outcomes, such as IKDC and KOOS subscales, between the two study groups. In addition, the rate of post-operative complications was similar between the LARS and HT graft groups.

Due to its structure (longitudinal fibers) and material (polyester fibers), the LARS artificial graft provides favorable strength and resistance to fatigue. In addition, the LARS artificial porous structure facilitates fibroblastic ingrowth (15,26,27). These fibroblasts and other bone cells create a cellular net around the ligament fibers and surround them. This would result in reduced cellular stress on the prosthetic graft and, thus, strengthened ligament, even in the short-term (6-month) after the operation (28,29). It has been suggested that LARS artificial grafts are stronger than autografts at the implemented site, since autografts undergo revascularization, cellular proliferation and remodeling to complete the 'ligamentisation' process. This process takes about one year for the four-strand HT autograft. This phenomenon perhaps causes loosening of the graft (30). However, the long-term outcomes of the artificial grafts need to be comprehensively elucidated.

There is a large body of evidence for using LARS artificial grafts and autologous grafts. Although autografts were thought to be the gold standard due to ease of harvesting, allowable donor site morbidity, and favorable clinical outcome results (31,32), there are conflicting findings regarding the best choice for the ACLR. Bianchi et al. (29) compared the long-term functional outcomes (IKDC, Lysholm, and Tegner scores) between the four-strand HT graft with the LARS artificial ligament. No significant difference was reported between the groups after the eight-year follow-up. Likewise, Liu et al. (33) found similar results between the two groups after four years of follow-up with respect to the IKDC, Lysholm, and Tegner scores. In the current study, we observed similar KOOS, and IKDC scores between the LARS and HT groups.

Recently, Mengdi et al. (34) compared the subjective and objective knee function and time to return to sport activities among 185 young adult patients who underwent ACLR surgery using four strand HT, allograft, and LARS ligaments for the median follow-up of 86.4 months. In accordance with the results of this study, they found no significant differences regarding post-operation complications, graft failure, subjective/objective clinical and functional outcome (Lysholm, Tegner, IKDC, and KOOS scores). In the current study, we observed graft failure in only four patients in the LARS group, which is lower than some previous studies that have reported the long-term outcome of using LARS ligament (21,35). The difference might be due to the shorter follow-up period in our study, which would be explained by the slow, and progressive bone abrasion and mechanical failures in the isometric position in LARS ligaments (21).

KOOS is one of the most validated, responsive, and available self-reported tools for measuring the functional outcome in

patients with knee injuries and osteoarthritis. It also predicts the risk of upcoming knee osteoarthritis in at-risk populations, such as patients who have undergone ACLR surgery (36). However, recently some accurate modalities have been introduced and developed for predicting osteoarthritis which can be applied in future studies (37).

None of the patients in our study had clinically evident synovitis. Studies with longer follow-up periods reported the higher rate of synovitis. Perhaps it might be due to the fact that we only assessed the short-term clinical outcome of LARS ligaments (21,22). With surgical technique advancements and developing new material designs, synthetic ligaments have become more popular among young active patients, such as athletes, because of some advantages such as early rehabilitation, and shorter time of operation (12,35). It is to be noted that sports injuries and martial arts together were the main causes of ACL injuries in our study.

This study should be considered in light of its shortcomings. First, this study was designed retrospectively. Second, because preoperative assessments were unavailable, it was impossible to compare pre- and post-operative functional scores. Finally, because of the lack of randomization in the treatment options, the study groups were not comparable with regard to age. In order to minimize this bias, we excluded patients with preoperative visible degenerative changes in their knees.

CONCLUSION

In summary, our study suggests that the short-term complications and functional outcomes of ACLR surgery were slightly superior with four-strand HT grafts than LARS ligaments. LARS could be implemented as an alternative choice in ACLR surgery in patients with prior multiple revision surgeries, and those with the shortened HT ligament or the other anatomical defects. Of note, successful ACLR is influenced by several factors, including patient autonomy, surgeon experience, and patient's characteristics, such as age, financial status, concurrent injuries, and physical activity level (athletes, military personnel). Further studies are required to compare the long-term clinical outcome and complications of HT/BPTB autografts and LARS artificial ligaments, and to elucidate the best graft choice in ACLR surgery as a result.

ETHICS APPROVAL AND INFORMED CONSENT

All patients signed written informed consent to participate in the study. In addition, this study was done according to the guidelines of the Declaration of Helsinki, Approval was acquired from the Iran National Committee for Ethics in Biomedical Research (no: IR.AJAUMS.REC.1398.221).

DATA AVAILABILITY

Data may be shared after the approval of the ethics board.

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COMPETING INTERESTS

None of the authors have potential conflicts of interest to be disclosed.

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