



LARS versus hamstring tendon autograft in anterior cruciate ligament reconstruction: a single-centre, single surgeon retrospective study with 8 years of follow-up

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Abstract

Purpose The choice of graft type in the anterior cruciate ligament (ACL) reconstruction remains a subject of controversy. The aim of this study was to assess the outcomes in ACL reconstructions performed using a four-strand hamstring tendon graft (4SHG) or a LARS ligament comparing the effectiveness of the two grafts at a medium follow-up of 8 years.

Methods This retrospective, single-centre, single surgeon study evaluated the clinical, functional and radiographic outcomes in 50 patients who underwent ACL reconstruction (25 4SHG and 25 LARS). Patients who underwent surgery after more than 6 months from injury and showed radiographically visible degenerative changes at time of surgery were excluded from the study.

Results None of the patients underwent re-surgery in the same knee. The range of motion of the operated knee, compared to the contralateral, was good for both groups. The anterior drawer test resulted negative in 21 patients (84%) in the LARS group and eight patients (32%) in the 4SHG group ($P=0.039$). The Lachman test was negative in 19 patients (76%) in the LARS group and in 11 patients (44%) in the 4SHG group ($P=0.045$). Although other results of ACL reconstruction measured by Lysholm scores, IKDC evaluation, Tegner scores and radiographic images showed using a LARS graft tended to be superior to using a 4SHG, there were no statistically significant differences calculated.

Conclusion Our results suggest that 4 years after ACL reconstruction using a LARS ligament or 4SHG dramatically improves the function outcome, while the patients in the LARS group displayed a higher knee stability than those in the 4SHG group.

Keywords ACL · Reconstructions · Knee · Sport · LARS · Artificial

Introduction

Anterior cruciate ligament (ACL) reconstruction has been widely used for patients suffering from anterior knee laxity. Current reconstruction techniques usually lead to good clinical outcomes thanks to the developments in arthroscopic

surgery. However, the choice of graft type remains a subject of controversy.

In the past 2 decades, the bone–patellar tendon–bone (BPTB) autograft has been considered the gold standard graft in relation to its osseous fixation mode. Recently, the hamstring tendons have been used alternatively as a result of the reduced donor site morbidity and of an improved fixation technique. It is currently the most commonly used graft [1].

Regardless of the graft type, there can be a degree of morbidity following autograft harvest, which may negatively affect recovery after ACL reconstruction [1–3].

Therefore, the use of artificial ligaments may offer an alternative form of treatment that does not take place in donor site morbidity. The use of synthetic material for ligament reconstruction was widely recommended in the 1980s. After a preliminary period of enthusiasm, the popularity of artificial implants declined because of the high

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device failure rate and reactive synovitis from wear particles. The ligament advanced reinforcement system (LARS) artificial ligament (surgical implants and devices, Arc-sur-Tille, France) has recently been reported to be a suitable device due to its special design and biomechanical–biological characteristics. Satisfactory clinical results have been obtained following its use in ACL reconstruction [4–8].

However, few studies focused specifically on the comparison between autografts and LARS use in ACL reconstruction.

The aim of this study was to assess the outcomes in ACL reconstructions performed using a four-strand hamstring tendon graft (4SHG) or a LARS ligament comparing the effectiveness of the two grafts at a medium follow-up of 8 years.

Materials and methods

In this retrospective, single-centre, single surgeon study, we evaluated 50 patients who underwent ACL reconstruction for isolated ACL rupture between January 2006 and December 2009.

The diagnosis of ligament rupture was posed following anterior drawer, Lachman tests positivity and magnetic resonance imaging support (MRI), it was also the only inclusion criterion.

All the patients who underwent surgery after more than 6 months from the injury, who had combined ligament injury, previous knee surgery history, chondral lesions in the same knee, who showed radiographically visible degenerative changes at time of surgery were excluded from the study [9, 10].

Fifty patients fulfilled our criteria and were included in the study; the ACL was reconstructed with a 4SHG in 25 patients and with a LARS ligament in the others. The groups were comparable in terms of gender and follow-up, not in relation to age (Table 1). Treatment choice for each patient was not randomised; we generally used to implant a LARS ligament in patients older than 40 years old and a 4SHG in the younger ones.

The patients gave the informed consent prior to being included into the study.

Table 1 Demographics in LARS® and 4-SHG groups

Group	Male/female	Mean age at surgery (years) (range)	Mean follow-up (months) (range)
4SHG	21/4	24 (18–36)	95.4 (85–112)
LARS	20/5	37 (35–41)	95.7 (86–110)

Surgical technique

The reconstruction was carried out under arthroscopic control. One senior surgeon performed all the procedures. All the patients were treated using an inside-out transtibial tunnel technique.

After adequate anaesthesia, standard anterolateral and anteromedial portals were fashioned. Preliminary diagnostic arthroscopy was performed, and ACL rupture was confirmed visually. Meanwhile, the condition of all of the relevant anatomical knee structures and the extent of the ligament tear and any associated injuries of meniscus or cartilage were evaluated.

The ACL stump with synovial covering was preserved as much as possible.

In the 4-SHG group, the semitendinosus and gracilis tendons were harvested through 2–3 cm incision medial to the tibial tuberosity and were prepared to form a quadruple strand graft.

The tibial tunnel guide pin was anatomically positioned within the ACL footprint. The tibial tunnel was created using a cannulated reamer matching the diameter of the graft (Fig. 1). The angle between the tibial tunnel and the horizontal arm of the guide device was set at 55° with slight medial inclination. The femoral reamer was introduced through the tibial tunnel with the knee flexed at 90°, and the femoral half tunnel was reamed under arthroscopic control reaching a depth of 45 mm. The ligament was then introduced with a single-bundle technique (Fig. 2) and fixed to the femur using Arthrex Titanium TransFix® cross-pin fixation technique (femoral corticocancellous pin). Once the right tension was achieved (Fig. 3), the tibial end of the graft was fixed with a bioabsorbable cannulated interference screw for 4-SHG group or metal cannulated interference screw for LARS group.

Postoperative rehabilitation

Postoperatively the patients in the two groups underwent two different rehabilitation protocols due to the time necessary for the 4SHG to fulfil ‘ligamentisation’. In the LARS group, quadriceps isometric exercises, straight leg raises and knee flexion exercises started from the first day following surgery. Knee flexion began from 45° and increased gradually to the complete flexion and extension within 1 week. Patients usually walked with the help of crutches from 3 days following surgery. Crutches were discarded after 2 weeks. The patients were allowed to return to sport activities between 4 and 5 months following reconstruction.

In the 4SHG group, a hinged brace locked was used to prevent hyperextension and inadvertent flexions while

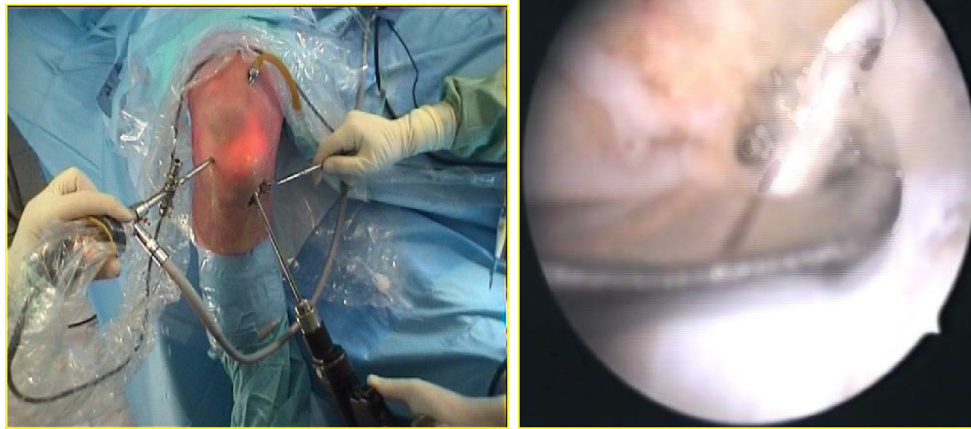


Fig. 1 Tibial tunnel guide pin position



Fig. 2 Ligament introduction

walking for the first month. Quadriceps isometric exercises and straight leg raises were initiated as early as possible. Knee flexion was allowed from 45° to 90° for the first 2 weeks and increased gradually to the complete flexion and extension within 1 month. Full weight-bearing was allowed after 4 weeks without a brace. Patients usually returned to sport after the sixth month.

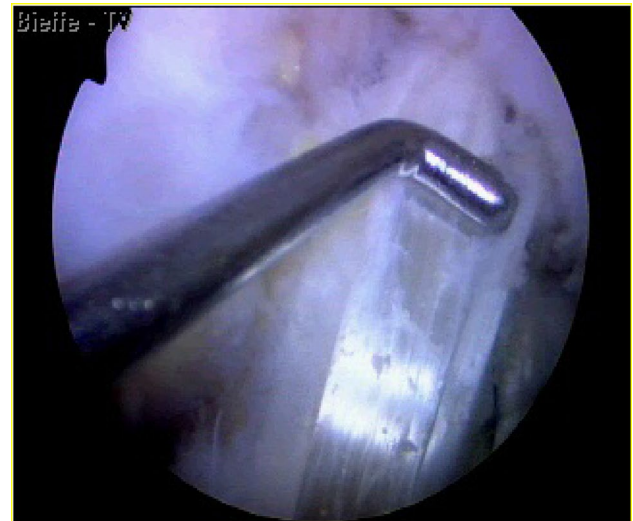


Fig. 3 Arthroscopic right tension of ligament evaluation

Evaluation

All physical examinations and outcomes evaluations were performed at follow-up by a single orthopaedic surgeon who was not involved in the patients' care.

All the patients were submitted to a clinical evaluation at the time of the trauma, in the immediate postoperative period, after ending the rehabilitation protocol and periodically.

Subjective clinical assessment was performed using:

- Lysholm scoring scale [11] (Table 2);
- International Knee Documentation Committee (IKDC);
- Tegner activity level scale.

Table 2 Lysholm knee scoring scale

Limp	None (5 pt)	Slight or periodical (3 pt)	Severe and constant (0 pt)			
Support	None (5 pt)	Stick or crutch (2 pt)	Weight-bearing impossible (0 pt)			
Pain	None (25 pt)	Inconstant and slight during severe exertion (20 pt)	Marked during severe exertion (15 pt)	Marked on or after walking more than 2 km (10 pt)	Marked on or after walking less than 2 km (5 pt)	Constant (0 pt)
Instability	Never giving way (25 pt)	Rarely during athletic or other severe exertion (20 pt)	Frequently during athletics or other severe exertion (or incapable of partici- pation) (15 pt)	Occasionally in daily activities (10 pt)	Often in daily activi- ties (5 pt)	Every step (0 pt)
Locking	No locking and no catching sensa- tions (15 pt)	Catching sensation but no locking (10 pt)	Locking occasionally (6 pt)	Frequently (2 pt)	Locked joint on examination (0 pt)	
Swelling	None (10 pt)	On severe exertion (6 pt)	On ordinary exertion (2 pt)	Constant (0 pt)		
Stair climbing	No problems (10 pt)	Slightly impaired (6 pt)	One step at a time (2 pt)	Impossible (0 pt)		
Squatting	No problems (5 pt)	Slightly impaired (4 pt)	Not beyond 90° (1 pt)	Impossible (0 pt)		

Later on, an objective clinical evaluation comparing with the contralateral knee was made. Swelling of the knee (present or absent), range of motion (complete or incomplete, deficit of flexion or/and extension) and the presence or absence of joint effusion were evaluated.

Specific tests for LCA ruptures were performed: the anterior drawer test (grade 1 for 0–5-mm anterior tibial translation, grade 2 for 5–10 mm and grade 3 for > 10 mm) and the Lachman test (--- if the test was negative; +-- slightly positive; ++- moderately positive; and +++ highly positive test as index of severe ligamentous instability) [12].

All patients were studied with weight-bearing X-ray images in anteroposterior and latero-lateral views in order to detect:

- Degeneration of the joint space using the Ahlbäck classification system in assessing the osteoarthritis of the knee joint: stage 1: joint space narrowing (< 3 mm); stage 2: joint space obliteration; stage 3: minor bone attrition (0–5 mm); stage 4: moderate bone attrition (5–10 mm); and stage 5: severe bone attrition (more than 10 mm) [13];
- Expansion of the bone tunnels;
- Loss of fixation.

The results were compared between the two groups using *t* test (Student) for ordinal data and Chi-square test

for nominal data. *P* value of < 0.05 was considered statistically significant.

According to the Italian law, ethics committee approval for this study was not required because it involved only routine clinical follow-up and radiographic examination. Written informed consent was obtained from each patient. With this consent, the patient authorises the surgical treatment and also collection and publication of clinical data about his case for scientific and educational purposes even outside the institution.

Results

None of the patients underwent a second surgery in the same knee.

Subjective clinical evaluation

We assessed clinical outcomes using Lysholm score, IKDC score and Tegner activity level scale. Concerning the Lysholm score in the LARS group, 13 patients (52%) had a result rated excellent (> 90 points in Lysholm scoring scale), 8 (32%) good (84–90 points) and 4 (16%) fair (65–83 points); no cases with poor outcome were reported (< 65 points). In the 4SHG group, eight patients (32%) had an excellent result, 11 (44%) good, 4 (16%) fair and 2 (8%) poor. The average Lysholm scores were 90.1 (80–99) and

85.8 (63–98) ($P=0.248$) in LARS group and 4SHG group, respectively.

The data collected with IKDC evaluation form in the LARS group showed that 16 patients (64%) achieved an excellent outcome (80–100 points), 9 patients (36%) good (50–80 points) and none had fair (30–50 points) or poor results (0–30 points); in the 4SHG group 15 patients (60%) had an excellent score, 6 patients (24%) good score and 4 (16%) fair score. The average IKDC scores were 83.2 (67–92) and 77.1 (46–91) ($P=0.342$) in LARS group and 4SHG group, respectively.

According to the Tegner activity level scale, in the LARS group, it was estimated that eight patients who belonged to categories 6, 5, 4 (32%) did not change the lifestyle prior to their injury; five patients (20%) who were at level 10/9 decreased daily activities and sports to a more cautious intensity (level 7/6); and the remaining 12 patients (48%) relatively changed their level of activity, from level 6 to 5. In the 4SHG group, five patients levelled in categories 5, 4 and 3 (20%) did not change their lifestyle; three patients (12%) who were at level 10/9 went to daily activities and sports more cautiously (level 7/6); and the remaining 17 patients (68%) deeply changed their level of activity.

There was no statistically significant difference between the two groups with respect to the three types of assessment results.

Objective clinical evaluation

The joint swelling was present in only one patient from both groups, and it was not related with his/her activity.

The range of motion of the operated knee, compared to the contralateral, was good for both groups; in only one patient of 4-SHG group, 15°–20° of flexion and 5° of extension were missing.

The anterior drawer test resulted negative in 21 patients (84%) in the LARS group and eight patients (32%) in the 4SHG group, grade 1 in four patients (16%) in the LARS group and 12 patients (48%) in the 4SHG group, grade 3 in three patients (12%) in the 4SHG group and no patient in the LARS group, grade 4 in two patients (8%) in the 4SHG group and no patient in the LARS group, respectively ($P=0.039$) (Table 3).

Table 3 Postoperative anterior drawer test examination results (P value=0.039)

Group	Grade			
	Negative	Grade 1	Grade 2	Grade 3
4SHG ($n=25$)	8 (32%)	12 (48%)	3 (12%)	2 (8%)
LARS ($n=25$)	21 (84%)	4 (16%)	0	0

The Lachman test was negative in 19 patients (76%) in the LARS group and in 11 patients (44%) in the 4SHG group, slightly positive in six patients (24%) in the LARS group and in seven patients (28%) in the 4SHG group, moderately positive in five patients (20%) in the 4SHG group and in no patient in the LARS group and highly positive in two patients (8%) in the 4SHG group and in no patient in the LARS group, respectively ($P=0.045$) (Table 4).

These results showed that the LARS group had significantly less anterior displacement than the 4SHG group.

Instrumental assessment

In 21 patients (84%) in the LARS group and in 16 patients (64%) in the 4SHG group, X-ray images showed no signs of osteoarthritis, with no changes as to preoperative examinations; in four patients (16%) in the LARS group and in eight patients (32%) in the 4SHG group, we noticed a restriction of the joint space, with a transition from stage 0 to stage 1–2 of the Ahlbäck classification system; in one patient (4%) in the 4SHG group was diagnosed a stage 3 of the Ahlbäck classification system ($P=0.135$) (Table 5).

In no cases, we had mobilisation of the hardware or expansion of the bone tunnels.

Discussion

Compared with BPTB autograft, the multiple-strand HT graft has become increasingly popular in recent years because of lower morbidity, especially regarding anterior knee pain and extension deficits [1, 2]. In the literature, there are many reports comparing clinical outcomes between BPTB and 4SHG grafts which found no significant evidence of superiority [14–19]. However, several studies evaluated knee stability with the KT-1000 examination and found that

Table 4 Postoperative Lachman test examination results (P value=0.045)

Group	---	+-	++	+++
4SHG ($n=25$)	11 (44%)	7 (28%)	5 (20%)	2 (8%)
LARS ($n=25$)	19 (76%)	6 (24%)	0	0

Table 5 Postoperative osteoarthritis of the knee joint examination results (P value=0.135)

Group	Ahlbäck classification		
	Normal	Stages 1–2	Stage 3
4SHG ($n=25$)	16 (64%)	8 (32%)	1 (4%)
LARS ($n=25$)	21 (84%)	4 (16%)	0

BPTB patients had greater knee stability than 4SHG patients [20–22]. These results might mean that although the 4SHG grafts have been used as an alternative to the BPTB autograft in recent years for ACL reconstruction, their utility should be reconsidered due to their insufficient strength.

The ultimate tensile strength of the human femur–ACL–tibia complex has been estimated as 1725–2160 N compared to 4213 N for the 4SHG [23, 24]. This suggests that the initial strength of the 4SHG should be adequate for the ACL reconstruction. However, these autografts undergo a process of ‘ligamentisation’, which takes nearly 1 year and may lead to the collapse and loosening of the graft [25]. Autogenous grafts are thought to be weaker than artificial polymers and fibre at implantation site and undergo a period of morphological change with a weakening process that doesn’t occur in artificial devices [26].

Artificial reconstructions of the ACL with various materials were recommended in early 1980s. The following old types of artificial ligaments were analysed biochemically and histologically: GORE-TEX (W.L. Gore and Co., Flagstaff, Ariz.), Dacron Ligament Prosthesis (Stryker), Versigraft carbon, Kennedy LAD (3M company USA), Xenograft, Leeds-Keio by (Xiros, Leeds (UK)). All these ligaments proved to induce synovitis [27–31].

The most important innovation introduced by the LARS ligament is its strong similarity to the normal structure of the anterior cruciate ligament, mainly linked to the orientation of its fibres in the intra-articular portion. The design of the intra-articular portion of the LARS minimises the shear stress to the prosthesis and provides good terrain for the regrowth of surrounding tissues. The LARS ligament is made from an industrial strength polyester fibre and possesses sufficient strength as a graft for ACL reconstruction, 2500 N or 3600 N corresponding to 60 gauge or 80 gauge. Meanwhile, its elastic modulus is very high. Suffering persistent 1700 N traction and being relaxed in 24 h, the increased length is less than 1.5%.

There are several studies reporting use of the LARS artificial ligament for ACL reconstruction [4–7, 32]. The outcome was encouraging and patients showed a high degree of satisfaction concerning the activities of daily living.

Nau et al. [6] compared the BPTB graft with the LARS ligament in ACL reconstruction and demonstrated that the knee and osteoarthritis outcome score (KOOS) evaluation and instrument-tested laxity were better in the LARS group at 1-year follow-up.

There are few studies in the current literature evaluating the strength of LARS graft during and after the course of ligamentisation and comparing it with 4-SHG in terms of restoration of the knee function and stability.

In 2010, Liu et al. compared the results of ACL reconstruction obtained with a four-strand hamstring tendon graft (4SHG) and LARS in 60 patients with a minimum follow-up

of 4 years. After 4 years of rebuilding, both systems have shown a similar functional compensation; indeed, reconstructions with LARS were associated with greater stability [33].

The aim of this study was to compare the outcome after ACL reconstruction using 4SHG or a LARS ligament at a medium follow-up of 8 years.

In this long follow-up our analysis showed no significant differences between the LARS ligament and the 4SHG groups in terms of the knee function examination, including IKDC evaluation, Lysholm scores and Tegner scores. The range of movement was optimal in both group of patients, and pain symptoms were considered mild.

High device failure rate and reactive synovitis caused by wear particles have been reported as the main contraindication to synthetic material for ligament reconstruction. In this study we did not find any obvious evidence of ligament rupture within the follow-up. It is possible that some of the LARS ligament fibres have been worn, which cannot be perceived by physical examination. Furthermore, none of the patients had clinically evident synovitis.

The postoperative anterior laxity was significantly less in the LARS ligament group for ACL reconstruction than with the 4SHG reconstruction (anterior drawer test negative in 84% in the LARS group versus 32% in the 4SHG group, $P = 0.039$); (Lachman test negative in 76% in the LARS group versus 44% in the 4SHG group, $P = 0.045$).

Greater stability of the knee was associated with less progression of osteoarthritis in Ahlbäck classification system, as we found a lot of signs of osteoarthritis in 4SHG group, even if these data were not statistically significant.

This study has some limitations. The patients involved in the study were not so many; our groups were not comparable in terms of age due to the lack of randomisation in treatment choice and to the retrospective design of the study. We had tried to overcome this bias excluding patients that showed preoperative visible degenerative changes of their knees.

Conclusion

Our study suggests that for a long time following an ACL reconstruction using a LARS ligament or a 4SHG graft the functional outcome of the affected knee could dramatically improve, while using an artificial device like LARS could assure a more stable knee joint than the one reconstructed with hamstring graft.

Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

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