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Four-strand hamstring tendon autograft versus LARS artificial ligament for anterior cruciate ligament reconstruction

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Abstract This retrospective study compared the results after anterior cruciate ligament (ACL) reconstruction using a four-strand hamstring tendon graft (4SHG) versus Ligament Advanced Reinforcement System (LARS) artificial ligament in 60 patients between January 2003 and July 2004 with a minimum four-year follow-up. The KT-1000 examination, the International Knee Documentation Committee (IKDC) scoring systems and Lysholm knee scoring scale were used to evaluate the clinical results. The mean side-to-side difference was 2.4±0.5 mm and 1.2±0.3 mm in the 4SHG group and LARS group, respectively (P=0.013). Although other results of ACL reconstruction, measured by IKDC evaluation, Lysholm scores and Tegner scores, showed using a LARS graft clinically tended to be superior to using a 4SHG, there were no significant differences calculated. Our results suggest that four 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.

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Introduction

Arthroscopically assisted anterior cruciate ligament (ACL) reconstruction has been widely used for patients with anterior knee laxity, and good clinical results have been obtained following the advances in arthroscopic surgery. However, the best choice of tissue graft for use in ACL reconstruction has remained the subject of controversy. For the past two decades, the bone-patellar tendon-bone (BPTB) autograft has been considered the gold standard in ACL reconstruction because of its osseous fixation mode, but increasingly the hamstring tendon (HT) graft has been used as an alternative to the BPTB graft due to the reduced donor site morbidity and significantly improved fixation techniques [1, 2]. Nevertheless, 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, to avoid those morbidities associated with autograft harvest, use of artificial ligaments may offer an alternative form of treatment.

The use of synthetic material for ligament reconstruction was recommended in the 1980s. After a preliminary period of enthusiasm for these implants, their popularity declined because of the high device failure rate and reactive synovitis caused by 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 satisfactory clinical results have been obtained following its use in ACL reconstruction [4–8]. However, there have been few studies focusing specifically on comparing the autografts and the LARS artificial ligaments in ACL reconstruction. The aim of this study was to compare the outcome after ACL reconstruction using either a four-strand hamstring tendon graft (4SHG) or a LARS ligament and assess the effectiveness of the two grafts. To our knowledge it is the longest follow-up after ACL reconstruction with the LARS ligament in the literature.

Materials and methods

This retrospective study evaluated 60 patients who underwent ACL reconstruction for isolated ACL rupture between January 2003 and July 2004. The diagnosis of ligament rupture was identified by anterior drawer test, positive posterior sag sign and magnetic resonance imaging (MRI) [9]. The exclusion criteria were a combined ligament injury, radiographically visible degenerative changes, previous knee surgery history and contralateral knee ligament injury. Furthermore, patients with a follow-up period of less than four years were excluded. Sixty patients fulfilled these criteria and were included in this study. In the first half of the study period, the ACL was reconstructed with a 4SHG in 32 patients, and in the second half of the study period, the ACL was reconstructed with a LARS ligament in 28 patients. The groups were comparable in terms of gender, age, cause of injury, time from injury to operation and preoperative Lysholm and Tegner scores ($P > 0.05$) (Table 1). Each patient was fully informed of the disease details and the surgical procedures.

Surgical technique

One senior surgeon performed all of the procedures. 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 structures was evaluated and the extent of the ligament tear and any associated injuries of meniscus or cartilage was identified. The meniscal lesions found were treated by partial menisectomy and the cartilage lesions by débridement.

In the LARS group, the partial ACL stump was débrided with a shaver. If there was no effect on the field of view or manipulation, the ACL stump with synovial covering was preserved as much as possible. The bone tunnels were prepared in a standard transtibial fashion. The tibial tunnel was placed just anterior to the normal posterior cruciate ligament between the medial and lateral tibial eminences and the femoral tunnel was placed at approximately 10:30 in the right knee (or 1:30 in the left knee) [10]. The bone tunnels were created with a cannulated drill to a size that matched the diameter of the graft. From the tibial portal, a wire loop was passed through the tibial tunnel into the joint, then through the femoral tunnel and the lateral thigh. The sutures at the end of the 4SHGLARS were passed in the loop and the graft was pulled through the joint and osseous tunnels filled with both end segments of the graft when the wire loop was pulled out of the femoral and tibial tunnels. A cannulated interference screw was driven along a guide pin inserted through the gap between the graft and the osseous tunnel wall to secure the graft at the femoral side. A maximal manual tension was applied to the distal sutures of the graft and the knee was cycled through full flexion to extension several times for graft pretensioning and settling. The knee was then placed at 70° flexion and firm traction was applied to the graft. Then the tendon end of the graft was fixed to the anteromedial tibia by using an interference screw in a similar way to the femoral side.

In the 4SHG group, the semitendinosus tendon (ST) and gracilis tendon (GT) were harvested and transected at 20 cm. The tendons were prepared to form a quadruple stranded graft. The four-strand tendon was then sutured together at a point 3 cm from the distal end and the proximal end in a running baseball whipstitch mode using no. 2 absorbable suture; meanwhile, the suture ends were retained long enough as pulling suture. Both the femoral and the tibial tunnels were placed at the same locations as in the LARS group. Meanwhile, the four-strand tendon graft was passed through the bone tunnels and fixed by the same method as in the LARS group.

Postoperative rehabilitation

Postoperatively the patients in the two groups used a different rehabilitation protocol due to the time necessary

Table 1 Preoperative demographics in the 4SHG and LARS groups

Group	Male/female	Mean age at surgery (range) (years)	Cause of injury			Mean time to surgery (range) (months)	Lysholm score (mean ± SD)	Tegner score (mean ± SD)
			Traffic	Sports	Fall			
4SHG	24/8	32 (20–56)	16	11	5	9 (5–33)	43.8±6.4	3.2±0.4
LARS	21/7	36 (18–54)	15	7	6	8 (4–34)	44.9±7.6	3.7±0.6

for the 4SHG to fulfil 'ligamentisation'. In the LARS group, quadriceps isometric exercises, straight leg raises and knee flexion exercises were initiated from the first day following surgery. Knee flexion began from 45° and increased gradually to the complete flexion and extension within one week. Patients usually walked with the help of crutch from three days following surgery. The crutch was discarded after three weeks. The patients were allowed to participate in non-competitive sports after the second month and then were given full freedom in their activities between three and four months following reconstruction.

In the 4SHG group, a hinged brace locked between −10° and +90° was used to prevent hyperextension and prevent inadvertent flexion while walking for the first two months. Quadriceps isometric exercises and straight leg raises were initiated as early as possible. For the first three weeks only static stepping for balance was allowed, and then the flexion exercises were started. Full weight-bearing was allowed after ten weeks without use of a brace. Flexion beyond 120° was allowed after the third month. Patients usually returned to normal daily activity in three months and returned to non-competitive activity after the sixth month. Resumption of full pre-injury sports activities could be undertaken after the ninth month.

Evaluation

The minimum follow-up was 48 months, and the mean follow-up was 49 months (range: 48–52 months). All examinations and results were evaluated at follow-up by a single orthopaedic surgeon who was not involved in the patients' care. All patients were evaluated using the KT-1000 arthrometer test, International Knee Documentation Committee (IKDC) scoring systems, Lysholm knee scoring scale and Tegner activity level. The evaluation data at the latest follow-up were gathered and statistically analysed with SPSS 11.0 software. The results were compared between the two groups using the unpaired Student's *t* test for continuous measurements, chi-square test for the nominal data and Wilcoxon signed rank test for ordered categorical variables, respectively. A P value of <0.05 was considered statistically significant.

Results

At arthroscopic examination, in the 4SHG group there were eight medial meniscal tears, four lateral meniscal tears and nine catilage lesions and in the LARS group nine medial meniscal tears, three lateral meniscal tears and ten cartilage lesions. As shown in Table 2, knee stability assessed by KT-1000 arthrometer (30° flexion and 134 N) showed that the mean side-to-side difference was 2.4±0.5 mm and 1.2±0.3 mm in the 4SHG group and LARS group, respectively (P=0.013). The side-to-side difference was less than 3 mm in 22 patients (73.9%) in the 4SHG group and 26 patients (95.8%) in the LARS group, 3–5 mm in 7 patients in the 4SHG group and two patients in the LARS group and more than 5 mm in three patients in the 4SHG group but no patient in the LARS group, respectively (P=0.029). The stability results showed that the LARS group had significantly less anterior displacement than the 4SHG group.

Postoperative assessments of knee function are summarised in Table 3. In terms of IKDC evaluation system, 28 patients (87.5%) in the 4SHG group were graded as normal or nearly normal and 26 patients (92.9%) in the LARS group (P=0.523). The mean Lysholm scores were 92.1±7.9 and 94.6±9.2 (P=0.259), and the mean Tegner scores were 6.2±1.6 and 6.6±1.8 (P=0.387) in the 4SHG group and the LARS group, respectively. There was no significant difference between the two groups with respect to the three types of assessment results.

The one-leg hop test was normal in 25 cases and 25 cases, nearly normal in five cases and three cases and abnormal in two cases and no case in the 4SHG group and the LARS group, respectively, which did not reveal significant differences between the two groups (P=0.382). All of the patients in both groups achieved full knee extension. Apart from three patients in the 4SHG group, two of whom had a loss of 5° of full flexion and one developed arthrofibrosis, all of the patients in both groups had normal flexion. In both groups, there were no immediate postoperative complications that required reoperation or readmission. One patient in the LARS group required removal of the tibial screw because it was painful.

Table 2 Postoperative KT-1000 examination results

Group	Side-to-side difference (No. of patients)				Average (mean±SD)
	<3mm	3–5mm	6–10mm	> 10mm	
4SHG (*n*=32)	22	7	3	0	2.4±0.5 mm
LARS (*n*=28)	26	2	0	0	1.2±0.3 mm
P value	*P*=0.029				*P*=0.013

Table 3 Postoperative knee function examination results

Group	Final IKDC rating results				Lysholm score (mean ± SD)	Tegner score (mean ± SD)
	Normal	Nearly normal	Abnormal	Severely abnormal		
4SHG (n=32)	22	6	4	0	92.1±7.9	6.2±1.6
LARS (n=28)	21	5	2	0	94.6±9.2	6.6±1.8
P value	P=0.523	P=0.259				P=0.387

Discussion

This midterm follow-up of ACL reconstruction showed no significant differences between LARS ligament and 4SHG in terms of the knee function examination, including IKDC evaluation, Lysholm scores and Tegner scores. However, the postoperative anterior laxity was significantly less with the LARS ligament for ACL reconstruction than with the 4SHG reconstruction.

Compared with BPTB autograft, the multiple-strand HT graft has become increasing popular in recent years because of lower morbidity, particularly with respect to anterior knee pain and extension deficit [1, 2]. Due to the length limitation of the hamstring tendon, the 4SHG was usually used to reconstruct the injured ACL, of which the initial strength is nearly 2.5 times the normal ACL [11, 12]. There are many reports specially comparing the clinical outcome between BPTB graft and 4SHG which found no significant evidence to indicate that any graft was superior [13–18]. However, several studies evaluated the knee stability with the KT-1000 examination and found that BPTB patients had greater knee stability than 4SHG patients [19–22]. Furthermore, in a prospective study Zhao et al. [23] compared the 4SHG with the 8SHG for ACL reconstruction. At a minimum of two years follow-up, regarding the clinical outcome, either knee stability or knee function, ACL reconstruction with 8SHG yields significantly better results than reconstruction with 4SHG. Yasuda et al. [24, 25] reported that after ACL reconstruction using 6SHG, all of their patients obtained normal or near-normal stability. These results might mean that though the 4SHG has been used as an alternative to the BPTB autograft in recent years for ACL reconstruction, it may not be the best choice due to its insufficient strength.

The ultimate tensile strength of the human femur-ACL-tibia complex has been estimated as 1,725–2,160 N compared to 4,213 N for the 4SHG [11, 12]. This suggests that the initial strength of the 4SHG should be adequate for the ACL reconstruction. However, autografts have to undergo ‘ligamentisation’, which takes nearly one year and is prone to collapse and loosening during this course [26]. Dustmann et al. [27] reconstructed the ACL with a superficial flexor digital muscle tendon in a sheep model. At one year postoperatively they found that neither anteroposterior (AP) laxity nor structural properties of the intact ACL were fully restored. There are no available studies in the current literature that researched the graft strength during and after the course of ‘ligamentisation’ and statistically compared it with the normal ACL. But the outcome demonstrated above that better stability can be obtained when strands of HT are increased may mean that the strength of the 4SHG decreased after reconstruction.

Compared with the 4SHG group in this study, the results of knee laxity examination were better in the LARS group. Differing greatly from the older types of artificial ligament, the LARS ligament is made from an industrial strength polyester fibre and possesses sufficient strength as a graft for ACL reconstruction, 2,500 N or 3,600 N corresponding to 60 gauge or 80 gauge. Meanwhile, its elasticity is very low. Suffering persistent 1,700 N traction and being relaxed in 24 hours, the increased length is less than 1.5%. Furthermore, designed to mimic the normal anatomical ligament fibres, the intra-articular longitudinal fibres of the LARS ligament resist fatigue and allow fibroblastic ingrowth, and the extra-articular woven fibres provide strength and resistance to elongation. There are several studies reporting use of the LARS artificial ligament for ACL reconstruction [4–7]. The outcome was encouraging and patients showed a high degree of satisfaction for the activities of daily living. Furthermore, 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 the one-year follow-up. High device failure rate and reactive synovitis caused by wear particles have been reported as the main contra-indication to synthetic material for ligament reconstruction. In this study we did not find any obvious sign with respect to ligament rupture within the four-year 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 reported here had clinically evident synovitis within the four-year follow-up, which corresponds to the reports of other authors [4–8].

Our study indicates that four years after ACL reconstruction using a LARS ligament or 4SHG the functional outcome of the affected knee has dramatically improved, while the patients in the LARS group displayed a higher knee stability than those in the 4SHG group.

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