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Satisfactory Clinical Outcomes of Revision Anterior Cruciate Ligament Reconstruction Using Quadriceps Tendon-Patellar Bone Allograft

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Background: Allografts are preferred in certain cases of revision anterior cruciate ligament reconstructions to avoid additional graft harvesting and to fill in enlarged tunnels. The clinical outcomes of quadriceps tendon-patellar bone allograft in revision anterior cruciate ligament reconstruction are not well-known. This study was performed to evaluate the clinical outcomes of revision anterior cruciate ligament reconstructions using quadriceps tendon-patellar bone allografts.

Methods: Patients who underwent revision anterior cruciate ligament reconstructions with quadriceps tendon-patellar bone allografts with a minimum follow-up of 2 years were retrospectively reviewed. Their mean follow-up length was 33.5 ± 19.5 months. Outcomes including clinical scores (Lysholm, International Knee Documentation Committee [IKDC], Tegner scale, and Knee injury and Osteoarthritis Outcome Score [KOOS]), knee stability (physical examinations and knee arthrometer), return to sports, and any associated complications were assessed. Degrees of graft synovialization were also evaluated using arthroscopy.

Results: A total of 38 patients were reviewed and their age at the time of surgery and follow-up length were 37.2 ± 12.5 years (range, 17–66 years) and 2.8 ± 1.6 years, respectively. All clinical scores including KOOS, IKDC, Lysholm, and Tegner scale significantly improved at 2 years after surgery and 92.1% of the patients returned to sports. The mean preoperative side-to-side difference in knee arthrometer decreased from 4.5 ± 2.3 mm before surgery to 2.6 ± 1.5 mm after surgery ($p < 0.001$). Graft synovialization was observed in 13 of 16 patients (81.3%) who underwent second-look arthroscopy. Complication rate was 10.5% (n = 4). All complications were graft re-rupture and occurred at an average of 18 months after revision surgery.

Conclusions: Quadriceps tendon-patellar bone allograft showed satisfactory clinical outcomes in revision anterior cruciate ligament reconstruction and thus could be a good alternative when autograft harvesting is not optimal.

Keywords: *Anterior cruciate ligament, Anterior cruciate ligament reconstruction, Quadriceps muscle*

Anterior cruciate ligament (ACL) rupture is the most common sports knee injury in young adults.[1] Gold standard treatment for complete ACL rupture is ACL reconstruction (ACLR) with promising clinical outcome. However, sometimes graft failure can occur after ACLR in up to 25% of cases within 10 years.[2] In these re-ruptured cases, revision ACLR is the gold standard procedure for patients to return to sports. Though not as commonly used as other graft choices such as bone-patellar tendon-bone (BPTB) or hamstring tendon, quadriceps tendon-patellar bone (QTPB) autograft was first introduced for revision ACLR for those who already used BPTB or hamstring graft in their primary ACLR.[3,4] However, QT and QTPB grafts are recently gaining some popularity with good mechanical

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properties and satisfactory clinical outcomes also in primary ACLR.[5]

Although autograft is more commonly used than allograft for primary and revision ACLRs, allograft is preferred in certain cases for several reasons, especially in revision ACLR.[6] First, in cases in which primary ACLR were already performed with an autograft, additional graft harvesting with the same type of graft is usually unsuitable. Secondly, allograft is useful when femoral and tibial tunnels are too wide to adequately fill in with autografts. For these reasons, allografts are more commonly used in revision ACLRs than in primary ACLRs. However, there are some concerns about using allografts in revision ACLR due to its poorer clinical outcome and higher re-rupture rate than using autografts according to a multicenter study.[7]

Bone-tendon allografts such as Achilles tendon and BPTB allograft are especially advantageous in revision ACLRs because the attached bone block can be used to fill in the widened tunnels. Similarly, QTPB allograft could be a useful alternative with comparable biomechanical properties to Achilles tendon allograft.[8] However, to the best of our knowledge, the clinical outcomes of revision ACLR using QTPB allograft have not been reported yet. Thus, the objective of this study was to evaluate knee stability, patient-reported outcome measures (PROMs), and complications after revision ACLR using QTPB allograft. Graft integrity and synovialization were also evaluated in second-look arthroscopy after revision ACLR. The authors hypothesized that QTPB allograft would show comparable clinical outcomes in comparison to other previously well-described graft choices in the literature on revision ACLR.

METHODS

This study was approved by the Institutional Review Board of Seoul National University Hospital (IRB No. 2301-058-1393). The study was exempted from the requirement for informed consent due to its retrospective design and the use of anonymized data under approval of institutional review board.

From March 2013 to February 2020, patients who underwent revision ACLR with QTPB allograft and were followed up for more than 2 years after surgery were reviewed. Exclusion criteria were as follows: previous knee surgery other than primary ACLR, previous ligament injury other than ACL rupture, and concomitant ligament injury of the affected knee (other than grade I or II medial collateral ligament injury). Patients who had definite knee laxity (at least grade 1 instability in terms of Lachmann or pivot shift test in physical examination) and confirmed ACL re-rupture in magnetic resonance image (MRI) scans underwent revision ACLRs.

Surgical Technique

Standard anteromedial and anterolateral portals were utilized as viewing and working portals, respectively. Femoral and tibial tunnels were drilled using the previous tunnel apertures if anatomical placements were expected. Medial portal technique was used for femoral tunnel drilling and separate drilling was performed if previous apertures were non-anatomic. QTPB allografts were the non-gamma irradiated fresh frozen type. Serological and microbiological tests were performed on the donors in accordance with American Association of Tissue Bank standards. The graft was prepared to fit the size of femoral tunnel, which was measured using arthroscopic probes during arthroscopy (a 10-mm bone block was used in the cases of separate drilling). A bone plug was trimmed to a bullet shape with a saw and a rongeur. With the bone block heading to the proximal femoral side, passed grafts were fixed with a metal interference screw (CONMED) on the femoral side. The tendinous portion was fixed on the tibial side with a bioabsorbable screw (BIORCI-HA SCREW; Smith & Nephew Inc.) augmented by tying sutures over a cortical screw with the knee extended. The prepared QTPB allograft and an example postoperative x-ray of a study patient are shown in Fig. 1. With the aid of preoperative computed tomography (CT)-scans, cases in which anatomical tunnel placement was not possible due to tunnel overlapping with previously mispositioned tunnels and cases in which tibial or femoral tunnels were more than 16 mm in size underwent a 2-stage revision. The tunnel diameter was measured at the tunnel mid-point in all 3 image planes (axial, sagittal, and coronal) using a straight line drawing tool.[9] The mean value of the measurements from the 3 image planes was used. Otherwise, a 1-stage surgery was performed. In 2-stage revisions, bone graft was performed with cancellous chip bones from the femoral head allograft in the first stage surgery. Intervals between staged surgeries were 6 months and CT scans were performed to ensure adequate bone fill before performing the second-stage surgery. Anterolateral ligament reconstruction was not performed in all cases.

Rehabilitation Protocol

Immediately after surgeries, patients were put on a motion-control brace set at 0° to 90°. The brace was applied for a month. Full flexion was obtained within additional 2 weeks. The motion-control brace set at 0° to full flexion

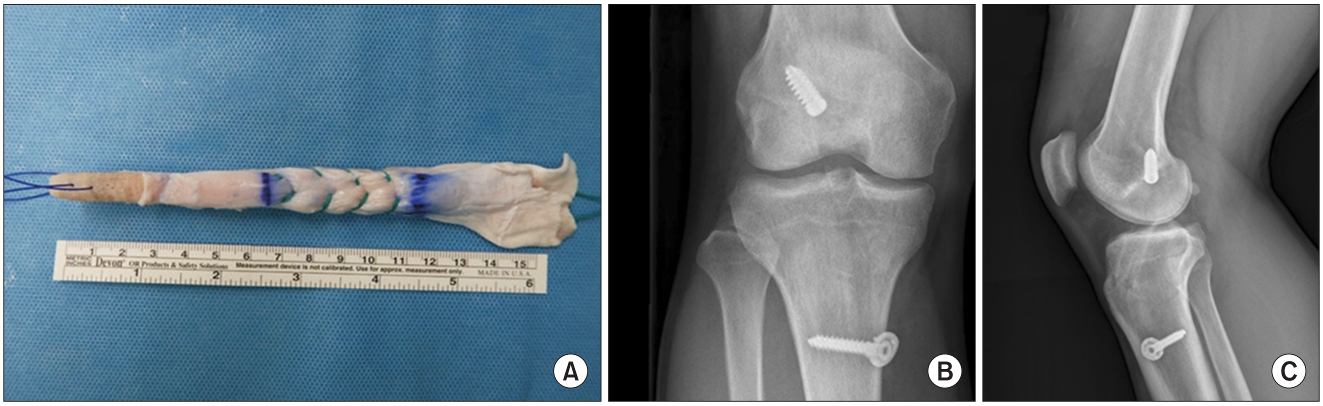

Fig. 1. Intraoperative gross photo of a quadriceps tendon-patellar bone allograft (A) and postoperative anteroposterior (B) and lateral (C) simple radiograps of a study patient.

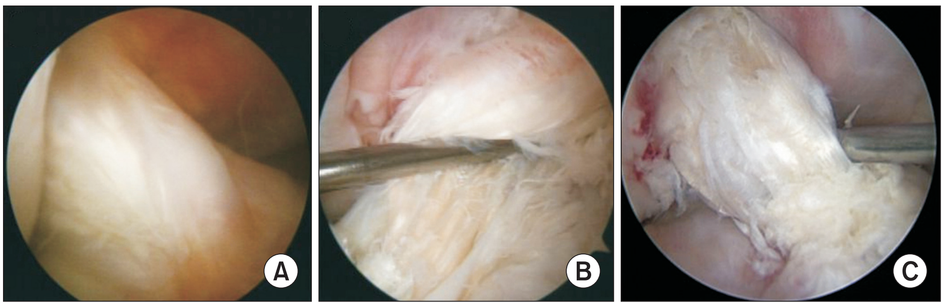

Fig. 2. Evaluation of synovial coverage of grafts in second-look arthroscopy. An evaluation was performed with a 30° arthroscope from a standard anterolateral portal. (A) Right knee. The remnant was fully covered with synovium. It was graded as A. (B) Left knee. Partial synovial coverage was shown. It was graded as B. (C) Right knee. Synovial coverage was rarely observed. It was graded as C.

was applied until postoperative 3 months. Partial weight-bearing was allowed right after surgery with progression to full weight-bearing as tolerated except for those who underwent concomitant meniscal repair or cartilage regeneration, in whom full weight-bearing was restricted until postoperative 6 weeks. Full sports activities were started at 6 months after surgery. Before allowing full activity, recovery of quadriceps muscle strength was checked with physical examination by surgeons in the outpatient clinic and grade 5 in terms of Medical Research Council muscle strength scale[10] was considered appropriate. Gradual return to full sport activities was emphasized for all patients.

Clinical Evaluation

Clinical evaluations were done preoperatively, at 3 months and 1 year postoperatively, and annually thereafter. Clinical outcomes included knee stability, clinical scores, return to sports and any associated complications after surgery. Knee stability was evaluated by physical examinations (anterior drawer test, Lachman test, and pivot shift test) and a KT-2000 arthrometer (MEDmetric). Preoperative and postoperative physical examinations were done in the outpatient clinic by an independent observer and side-to-side difference was measured by arthrometry. For clinical scores, Lysholm, International Knee Documentation Committee (IKDC), Tegner Activity Scales score, and Knee injury and Osteoarthritis Outcome Score (KOOS) were obtained. Any form of complications including graft re-rupture was checked at every visit of the clinic. For those who presented with significant recurrence of knee instability, re-ruptures were suspected and confirmed using MRI scans. Lastly, the results of the QTPB allograft were compared in terms of knee stability, clinical scores, and re-rupture rate with other revision ACLR studies that implemented allografts.

Arthroscopic Postoperative Evaluation

For those who underwent hardware removal at our institute, a second-look arthroscopic exam was done at postoperative 1 year. Graft was evaluated using a 30° arthroscope through the standard anterolateral portal. Synovialization and graft integrity were assessed according to a previously described method.[11,12)] Synovialization was classified in 3 grades: fully synovialized, partially synovialized, and rarely synovialized (Fig. 2). Graft integrity was also classified into 3 grades according to the proportion of intact portion: grade 1, > 80% of total graft volume; grade 2, between 30% and 80% of total graft volume; and grade 3, < 30% of total graft volume.

Statistical Analysis

All of the statistical analyses were performed using the RStudio version 2022.07.01 (RStudio, PBC; http://www.rstudio.com/). The Kolmogorov-Smirnov test and Shapiro-Wilk test were used to assess the normality of the distribution for all data. Continuous variables are presented as mean and standard deviation and categorical variables are presented as frequencies and percentage. Nominal variables such as Tegner scale are presented as median and range. The preoperative and postoperative clinical outcomes at annual follow-up periods were compared with a paired *t*-test and Fisher's exact test for continuous and categorical variables, respectively. In all analyses, $p < 0.05$ was considered to indicate statistical significance.

RESULTS

Thirty-eight patients who met the inclusion criteria were evaluated (Fig. 3). Out of these 38 patients who underwent revision ACLRs with QTPB at our institution, 31 patients had underwent primary ACLRs at other hospitals. The mean age of study patients at the time of revision surgery was 37.2 ± 12.5 years (range, 17–66 years). There was a clear male predominance (33 men and 5 women) and both sides were equally affected. The mean BMI was 26.2 ± 2.9 and the mean follow-up period was 33.5 ± 19.5 months. Two-stage surgeries were performed in 2 cases that showed femoral tunnel enlargements. Average tunnel diameters for tibial and femoral tunnels were 12.9 ± 2.3 mm and 12.3 ± 2.4 mm, respectively.

Different types of grafts were used for primary ACLRs of each patient. Allografts were used in 16 patients (8 Achilles, 4 tibialis anterior, 3 QTPB, and 1 BPTB) while autografts were used in 7 patients (5 QTPB, 1 BPTB, and 1 hamstring). Primary graft choice was unknown for the remaining 15 patients. The mean age at the time of primary ACLR was 31.2 ± 11.2 years, 6 years younger than

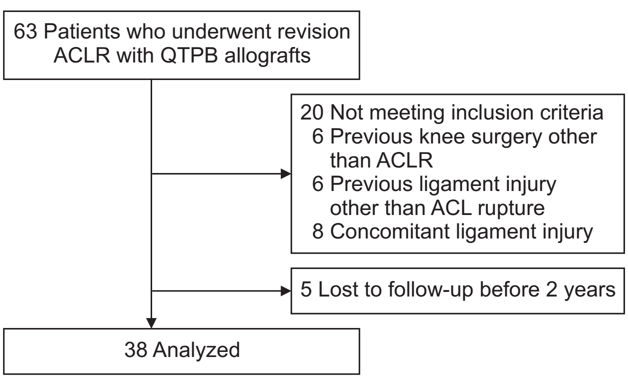

Fig. 3. Flowchart of patients screened and enrolled. ACLR: anterior cruciate ligament reconstruction, QTPB: quadriceps tendon-patellar bone.

Table 1. Evaluation of Knee Instability before Surgery and at the Final Visit

Variable	Preoperative	POD 1 yr	POD 2 yr
Anterior drawer			
Grade 0	0	22 (57.9)	21 (55.3)
Grade 1	12 (31.6)	13 (34.2)	14 (36.8)
Grade 2	20 (52.6)	3 (7.9)	3 (7.9)
Grade 3	6 (15.8)	0	0
p-value		< 0.001*	< 0.001*
Lachmann			
Grade 0	1 (2.6)	26 (68.4)	21 (55.2)
Grade 1	15 (39.5)	10 (26.3)	13 (34.2)
Grade 2	18 (47.4)	2 (5.3)	4 (10.5)
Grade 3	4 (10.5)	0	0
p-value		< 0.001*	< 0.001*
Pivot shift			
Grade 0	1 (2.6)	28 (73.7)	24 (63.2)
Grade 1	17 (44.7)	9 (23.7)	11 (28.9)
Grade 2	14 (36.8)	1(2.6)	3(7.9)
Grade 3	6 (15.8)	0	0
p-value		< 0.001*	< 0.001*
KT-2000			
< 3 mm	10 (26.3)	16 (42.1)	23 (60.5)
3–5 mm	16 (42.1)	22 (57.9)	15 (39.5)
> 5 mm	12 (31.6)	0	0
p-value		< 0.001*	< 0.001*

Values are presented as number (%). Postoperative clinical data were compared with preoperative clinical data at each time period.
POD: postoperative day.
*Statistically significant.

in the revision ACLR. Modes of failure for revision ACLR were as follows: 17 traumatic injuries, 2 postoperative infections, 2 residual instabilities (grade 2 or more in terms of Lachman or pivot shift test), and 17 chronic tears. During revision ACLRs, 13 patients underwent concomitant meniscal surgery (6 partial meniscectomy [4 medial and 2 lateral] and 7 repair [4 medial and 3 lateral]) and 2 patients underwent concomitant microfracture for cartilage lesion at the medial femoral condyle.

There were significant improvements of knee stability after the surgery (Table 1). Along with physical examination results, arthrometry also showed improvements in knee stability after surgery. The mean preoperative side-to-side difference in knee arthrometer decreased from 4.5 ± 2.3 mm before surgery to 2.6 ± 1.5 mm after surgery ($p < 0.001$). The proportion of knees with side-to-side difference less than 3 mm increased from postoperative 1 year to 2 years (42.1%–60.5%) although it was not statistically significant ($p = 0.108$). Likewise, all clinical scores significantly improved after surgery (Table 2). Although Lysholm score slightly decreased at 2 years after surgery from postoperative 1 year, other scores continuously increased at 2 years after surgery. Thirty-five out of 38 (92.1%) returned to sports after postoperative 2 years.

Table 2. Clinical Scores of the Study Patients at Each Time Point

Variable	Score	*p*-value
Lysholm		
Preoperative	62.6 ± 23.2	-
Postoperative 1 yr	84.6 ± 14.8	0.001*
Postoperative 2 yr	81.1 ± 19.4	0.046*
Subjective IKDC score		
Preoperative	53.6 ± 17.9	-
Postoperative 1 yr	69.6 ± 17.7	0.012*
Postoperative 2 yr	70.4 ± 20.7	0.014*
Tegner activity scale		
Preoperative	2.5 (1–6)	-
Postoperative 1 yr	4 (2–7)	0.006*
Postoperative 2 yr	5 (2–7)	0.005*
KOOS		
Preoperative	73.0 ± 25.8	-
Postoperative 1 yr	94.5 ± 18.8	0.005*
Postoperative 2 yr	95.5 ± 23.8	0.004*

Values are presented as mean ± standard deviation or median (range). Postoperative clinical data were compared with preoperative clinical data at each time period.
IKDC: International Knee Documentation Committee, KOOS: Knee injury and Osteoarthritis Outcome Score.
*Statistically significant.

A total of 16 patients (43%, 15 men and 1 women) underwent second-look arthroscopy at average 21 months after revision surgery. Average age and BMI of these group of patients at revision ACLR were 32.8 years (range, 17–58 years) and 26.3 kg/m^2, respectively. There were no significant differences in the demographics between the patients who underwent second-look arthroscopy and those who did not. Full synovialization was observed in 5 patients (31%), partial synovialization in 8 (50%), and rare synovialization in the remaining 3 (19%). The graft integrity was grade 1 in 8 patients (50%) and grade 2 in 7 (43.8%). There was only 1 patient (6.2%) whose graft integrity was grade 3.

Complication rate was 10.5% (n = 4) and all of these cases were graft re-ruptures, which occurred at an average of 18 months (range, 9.8–25.5 months) after revision surgery. Three of them had a traumatic injury (2 fall downs and 1 sports injury) before the re-rupture while 1 patient had a re-rupture without definite traumatic event. Among them, 1 patient underwent second-look arthroscopy prior to re-rupture and it showed rare synovialization and grade 3 graft integrity. These 4 cases all underwent re-revision ACLRs. There were no complications related to limitation of knee range of motion or infection during the study period.

DISCUSSION

QTPB allograft showed satisfactory clinical outcomes in revision ACLR. Knee laxity and PROMs markedly improved after surgery with 11% re-rupture rate at a minimum 2-year follow-up. Synovialization was found in 81% of patients. Although graft integrity was less than 80% in half of the patients, only 1 case showed poor graft integrity in second-look arthroscopy at postoperative 1 year.

Different types of allografts can be used for ACLR, including hamstring tendon, BPTB, QTPB, Achilles tendon, and anterior/posterior tibialis tendons. There have been only 7 studies[13-19] on revision ACLR using allografts (2 using BPTB, 1 using BPTB & tibialis anterior, 1 using Achilles tendon, 1 using hamstring, 1 using tibialis anterior tendon, and 1 mixed allografts). All these studies were retrospective studies and the results were comparable to the current study on QTPB allograft (Table 3). Firstly, knee stability was comparable to other allograft studies. Some of the studies[13-15,18] including those that utilized hamstring

Table 3. Comparison of the Clinical Outcomes in Revision ACLRs Using Allografts

Study	Allograft type	Number of knees	Follow-up duration (yr)	Knee stability	Clinical score	Re-rupture rate (%)
Fox et al.[14]	BPTB	32	4.8 (2.1–12.1)	Grade 0/1+ Lachman and 0/1+ pivot shift (87%), 1+ pivot shift (25%) KT-1000: ≤ 3 mm (84%), > 5 mm (6%)	Lysholm (75), Tegner (6.3), KOOS sports activity scale (67), SF-12 physical component (48), SF-12 mental component (55), and IKDC (71)	6
Mayr et al.[17]	BPTB	15	5.7 ± 0.6	Lachman: grade 0 (47%), grade 1+ (40%), grade 3+ (0%) Pivot shift: grade 0 (86%), grade 1+ (14%), grade 3+ (0%) KT-1000: 2.1 ± 2.3 mm (40%), < 3 mm (0%), > 5 mm (0%)	Objective IKDC: A (13%), B (80%), C (17%), D (0%)	13
Pascual-Garrido et al.[18]	BPTB & tibialis anterior	47	4.6 ± 2.5	KT-1000: < 2 mm (81%), > 5 mm (2.1%)	Reported the overall condition of their knee as excellent or good in 85% of the patients (10 excellent, 33 good)	2
Zaffagnini et al.[16]	Achilles	26	6.0 ± 1.6	KT-1000: < 3 mm (30%), > 5 mm (9%)	Lysholm (83.8)	19
Chougule et al.[13]	Hamstring	19	6 (3–9)	KT-1000: < 3 mm (80%), > 5 mm (5%) Lachman: grade 1+ (70%), grade 3+ (10%) Pivot shift: grade 0 (75%), grade 2+ or more (5%)	Lysholm (89.7), Tegner scale (7.1)	5
Lawhorn et al.[15]	Tibialis anterior	48	2	90% with normal stability and 10% with nearly normal stability	IKDC (90.9), functional IKDC scores normal (90%), and nearly normal (10%)	0
Johnson et al.[19]	Mixed	25	2.3 (2–3)	KT-1000: < 3 mm (20%), > 5 mm (36%) Pivot shift: grade 0/1+ (80%)	Modified Cincinnati Knee Score (68) 88% rated abnormal by the IKDC guidelines.	12
This study	QTPB	38	2.8 ± 1.6	Grade 0/1+ Lachman and 0/1+ pivot shift (90%), 1+ pivot shift (29%) KT-1000: ≤ 3 mm (60.5%), > 5 mm (0%)	Lysholm (81.1), Tegner (5), KOOS (95.5), and IKDC (70.4)	11

ACLR: anterior cruciate ligament reconstruction, BPTB: bone-patellar tendon-bone, KOOS: Knee injury and Osteoarthritis Outcome Score, SF-12: 12-item short form survey, IKDC: International Knee Documentation Committee, QTPB: quadriceps tendon-patellar bone.

and tibialis anterior tendon allografts reported superior outcomes in terms of knee arthrometry and physical examinations with more than 80% of patients showing grade 0 in pivot shift test and < 3 mm laxity in knee arthrometry. On the other hand, some other studies[16,17] showed similar to inferior results in terms of knee stability with less than 60% of the patients showing < 3 mm knee laxity in knee arthrometry. Although clinical scores were similar or superior in previous studies that utilized other allografts with a minimum average postoperative Tegner scale of 5.0, preoperative clinical scores including Tegner scale were generally higher in those studies and these preoperative differences may have accounted for the postoperative differences. The re-rupture rate after revision ACLR in this study (11%) was also similar to the rate reported in these previous allograft studies, which ranged from 0 to 19%.

According to a biomechanical study,[8] quadriceps tendons exhibited a significantly higher displacement at maximum load and significantly lower stiffness than Achilles tendons. In the study, Achilles tendons had a higher bone avulsion rate than quadriceps tendons. Moreover, fibers of Achilles tendon spiral by up to 90°, producing an area of concentrated stress.[20] For these reasons, quadriceps tendon graft could be a better alternative in ACLR. QTPB is advantageous to QT grafts especially in revision ACLRs since the enlarged tunnels can be filled in by the bone blocks. However, there are some concerns of patella fracture in harvesting QTPBs and the complication rate was about 4% in a long-term study.[21] There were no concerns of patella fracture in this study because allograft QTPBs were used. BPTB can be another alternative with good stability and QT-like morphology. However, donor site morbidity is significantly higher when BPTB autografts are used.[22] Another recent study[23] has even reported the possibility of partial thickness harvesting in ACLRs using QTPB autografts with good short-term clinical outcomes. QTPB has no concerns of graft-tunnel length mismatch unlike BPTB grafts.[24] Moreover, 1 clinical study[25] reported superior clinical outcomes in QTPBs when compared to BPTBs in short-term follow-up of ACLRs.

Several studies have compared the clinical outcomes of autografts to those of allografts in ACLR. Some of these studies reported that outcomes of allografts were not inferior to those of autografts.[15,17,26] However, some others insisted that using allografts was inferior to autografts.[7,27,28] To date, there have been 2 revision ACLR studies utilizing QTPB autografts. Noyes and Barber-Westin[3] have reported the results of 21 patients with a mean follow-up of 48 months (range, 25–83 months). Knee stability significantly improved postoperatively. However, 23.8% (5 of 21 patients) showed more than 5 mm displacement in knee arthrometry and 19.0% (4 of 21 patients) showed grade 2 or 3 pivot shift test during the postoperative follow-up. In comparison, knee stability was better in our study. Garofalo et al.[4] have reported the results of 28 patients with a mean follow-up of 4.2 years (range, 3.3–5.6 years). The number of patients that presented with grade 3 in Lachman test decreased from 12 to 3. No patients had grade 2 or 3 pivot shift test postoperatively. Knee arthrometry results also showed significant improvement, with only 1 case showing more than 5 mm displacement postoperatively. Mean Lysholm score improved significantly from 68.0 ± 12.5 to 93.6 ± 8.8. Mean Tegner activity score also improved significantly from 4.2 ± 1.5 to 6.1 ± 1.4. These were better than the results of our study.

Second-look arthroscopic examination in the present study showed at least partially-covered synovia in 81% of patients. Graft was intact in half of the patients. There were differences in graft integrities between full synovialized and rare synovialized patients; however, it was not statistically significant ($p = 0.071$). Out of the 5 patients who showed full synovialization, 4 patients had grade 1 integrity and 1 patient had grade 2 integrity. In the rare synovialization group (n = 3), 2 patients had grade 2 and 1 patient had grade 1 graft integrity. There were no significant differences in PROMs and manual laxity tests between different synovialization extents. Since no study has yet described the arthroscopic results of revision ACLR, the authors compared our results with the previously reported studies on primary ACLRs. Choi et al.[29] have performed ACLRs using tibialis tendon allografts and at least partial synovial coverage was observed in 83% of the patients. Partial coverage was observed in 66% of patients in another study by Yoo et. al.[30] that also used tibialis tendon allograft. Lee et al.[31] have used BPTB allograft in ACLR and found that 62.5% of the patients showed synovial coverage of over 50%. Graft integrity results of other allografts were also similar to those of our study. Yoo et al.[30] reported that 96% of the cases showed partially torn grafts. These results suggest that graft integrity and synovialization in ACLR using QTPB allograft might be as good as ACLR using other allografts.

Several studies[32-34] have demonstrated the effectiveness of anterolateral ligament reconstructions in revision ACLRs. However, to include as many patients as possible in analyzing the clinical outcomes of revision ACLRs using QTPB allografts, the authors excluded recent cases in which anterolateral ligament reconstruction or tenodesis were performed in combination. Anterolateral ligament reconstruction was not usually performed in our institution during the study period (until February 2020). Therefore, the authors instead tried to focus on the clinical results of a particular type of allograft (QTPB) in revision ACLRs. This could be one of the limitations of the study since the absence of anterolateral ligament reconstruction may have led to inferior clinical outcomes.

This study has several other limitations. First, it was a retrospective case series study. The number of patients was relatively small due to a low incidence of revision ACLR. Second, there was no comparative group. Therefore, direct comparison with other types of grafts was not possible and future comparative studies with autografts or other types of allografts are warranted. Third, to include as many as possible in a small group of patients, the study subjects were quite heterogeneous that included 2-stage surgeries and concomitant cartilage and meniscus surgeries. These concomitant procedures may have led to inferior outcomes such as in clinical scores. Therefore, the results of this study should be carefully interpreted when comparing directly with the clinical outcomes of other types of grafts in revision ACLRs. Lastly, the follow-up period of 2 years was relatively short especially considering that graft-related complications may occur beyond 2 years. Future longer follow-up studies may bring light on long-term complications. Nevertheless, to the best of our knowledge, this is the first study on clinical results of revision ACLRs using QTPB allografts. The usage of second-look arthroscopy to directly visualize graft integrity was notable in this study.

QTPB allograft showed satisfactory clinical outcomes in revision ACLR and thus could be a good alternative when autograft harvesting is not optimal.

CONFLICT OF INTEREST

Du Hyun Ro is an editorial board member of the journal but was not involved in the peer reviewer selection, evaluation, or decision process of this article. No other potential conflicts of interest relevant to this article were reported.

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