Original Article

Anterior Cruciate Ligament Reconstruction Using Bone—Patellar Tendon—Bone Allograft in Patients Aged 50 and Older Leads to Improved Activity Levels and Acceptable Patient-Reported Outcomes

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Purpose: To evaluate patient-reported outcomes in patients aged 50 years and older undergoing anterior cruciate ligament reconstruction (ACLR) using bone—patellar tendon—bone (BPTB) allograft with minimum 2-year follow-up. **Methods:** A retrospective review was performed on a consecutive series of patients aged 50 and older who underwent ACLR using BPTB allograft by a single surgeon with minimum 2-year follow-up. Postoperative International Knee Documentation Committee (IKDC), Lysholm, and Physical Component Summary of the 12-item Short-Form Health Survey were used to assess outcomes, as well as preoperative and postoperative Tegner activity scores, which were compared using a paired sample *t* test. **Results:** Fifty patients met inclusion criteria, with a mean age of 55.3 ± 4.4 years and mean follow-up of 4.8 ± 1.9 years. Tegner activity scores improved from a mean preoperative score of 3.26 to a mean postoperative score of 5.25 ($P < .001$). The mean postoperative scores for Lysholm, IKDC, and Physical Component Summary were 87.3, 81.1, and 54.3, respectively. In total, 36 (72%) patients achieved a patient acceptable symptom state score for IKDC and 37 (74%) patients achieved a minimal clinically important difference for Tegner activity score. Thirty-eight (76%) patients reported good-to-excellent results, 6 (12%) patients reported fair results, and 6 (12%) patients reported poor results. **Conclusions:** ACLR with BPTB allograft in patients aged 50 and older leads to good patient-reported outcomes with significantly increased postoperative activity status at a minimum 2-year follow-up. **Level of Evidence:** Level IV, therapeutic case series.

Anterior cruciate ligament (ACL) tears are the most common ligamentous injury, with an annual incidence of 68.6 per 100,000 person-years.[1] The ACL is essential for normal knee kinematics, and injury to the ACL may result in subsequent meniscal damage, recurrent instability, and articular cartilage pathology across all age groups.[2-4] Outcomes following anterior cruciate ligament reconstruction (ACLR) are well studied and documented, although the majority of ACLR studies predominately focus on patients younger than 50 years old.[5-7]

However, due in part to improved surgical techniques and rehabilitation protocols, the incidence of ACLR in patients older than 50 years is increasing.[8] In recent years, there is also a growing body of literature on the outcomes of ACLR in older patients, although most reported cohorts include multiple reconstruction techniques or have low numbers of bone—patellar tendon—bone (BPTB) allograft cases.[9-14] Allograft BPTB graft may provide the benefits of less operative time and no donor-site morbidity. Additionally, BPTB may result in improved graft strength[15] and incorporation time when compared with other allograft options in rabbit models.[16]

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The purpose of this study was to evaluate patient-reported outcomes (PROs) in patients aged 50 years and older undergoing ACLR using BPTB allograft with minimum 2-year follow-up. The hypothesis was that postoperative Tegner activity scores would improve with a minimal clinically important difference (MCID) compared with preoperative values and that the majority of patients would achieve a patient acceptable symptom state (PASS) for International Knee Documentation Committee (IKDC) score.

Methods

Following institutional review board approval, a consecutive series of patients aged 50 and older who underwent ACLR using BPTB allograft by a single fellowship-trained surgeon in the United States were retrospectively reviewed. Study inclusion criteria were age 50 years or older at the time of surgery, ACL-deficient knee, 1 or more episodes of knee instability, reconstruction using BPTB allograft, complete PROs, and minimum of 2 years' follow-up. Patients were excluded if concurrent ligamentous or bony procedures were performed. ACL tear was diagnosed based on subjective knee instability, positive Lachman test, and magnetic resonance imaging confirmation of a ruptured ACL. Decision to undergo ACLR was a shared decision with the patient, given their desired activity level, preinjury knee symptomatology, physiologic age, and degree of degenerative changes present on radiographs. Kellgren—Lawrence grade 4 osteoarthritis was a contraindication to ACLR, whereas grade 3 was a relative but not strict contraindication depending on the patient. All patients engaged in a structured physical therapy rehabilitation protocol to regain their range of motion (ROM) preoperatively. Charts were reviewed to identify patient demographics, surgical procedure, perioperative complications, and reports of retear or clinical failure. All patients were contacted by mail and telephone after a minimum of 2 years postoperatively to collect outcome measures. PROs included preoperative and postoperative Tegner activity score and postoperative IKDC, Lysholm, and Physical Component Summary of the 12-item Short-Form Health Survey. The PASS score for IKDC was set at 75.9, and MCID for Tegner activity score was set at 1, in accordance with literature standards.[17,18] Patients were categorized based on Lysholm score, with excellent results between 95-100, good results between 84-94, fair results between 65-83, and poor results less than 65.[19] Preoperative and postoperative Tegner scores were compared using a paired sample *t* test performed with a statistical significance set at $P < .05$ and using the XL Stat PRO software package (New York, NY).

Surgical Technique

Anesthesia included general anesthesia and a femoral nerve block. All patients underwent an examination under anesthesia for ROM and stability testing including Lachman, pivot shift, anterior and posterior drawer, and dial test to confirm anterior joint subluxation and to evaluate for concurrent ligamentous injury. The BPTB allograft was prepared to fit through a 10-mm spacer on the back table with 25- to 35-mm-long bone blocks. The graft was taken from the center of the patellar tendon. A diagnostic knee arthroscopy was then performed, and concomitant intra-articular pathology was identified and addressed. Using a tibial guide set at 55 degrees, a 10-mm tibial tunnel was established. A 10-mm transtibial femoral tunnel was then drilled, in accordance with described techniques which recreate the anatomic footprint.[20,21] The graft was passed and fixed in full extension with bioabsorbable interference screws in all patients. All grafts were sterilized using MTF and LifeNet Allowash solution.

Postoperative Rehabilitation Protocol

All patients underwent a standard postoperative ACLR allograft protocol at the treating physician's office. This protocol consisted of 5 phases to protect the reconstructed ligament and ease patients back into activity with an emphasis on early ROM. Patients were partial weight-bearing for 6 weeks with ROM between 0 and 90° allowed in a hinged knee brace before weaning to weight-bearing and ROM as tolerated. Heel slides and quadriceps sets were started in the immediate postoperative period, stationary bike was initiated at postoperative week 2, and single-leg strengthening was initiated at postoperative week 6. Patients could return to most strenuous job-related activities in 4 to 6 months. Return to running was permitted at 4 months with a custom-fit brace, with no restrictions at 6 months as long as strength and motion had been restored. All patients continued brace use for 1 year postoperatively.

Results

Fifty patients qualified for inclusion with a mean age of 55.3 ± 4.4 years and mean follow-up of 4.8 ± 1.9 years, with 28 (56%) patients being female (Table 1). Tegner activity scores improved from a mean preoperative score of 3.26 ± 2.0 to a mean postoperative score of 5.25 ± 1.5 ($P < .001$). The mean postoperative scores for IKDC, Lysholm, and Physical Component Summary were 81.1 ± 16.1, 87.3 ± 15.1, and 54.3 ± 6.5, respectively. In total, 36 (72%) patients achieved a PASS score for IKDC and 37 (74%) patients achieved a MCID for Tegner activity score. Based on Lysholm scores, 24 (48%) patients reported excellent results, 14 (28%) reported good results, 6 (12%) reported fair

Table 1. Patient Demographics and Functional Outcomes

	Values
Number of patients, n	50
Age at surgery, y, mean (SD)	55.3 (4.4)
Length of follow-up, y, mean (SD)	4.8 (1.9)
Female sex, n (%)	28 (56%)
Preoperative Tegner, mean (SD)	3.26 (2)*
Postoperative Tegner, mean (SD)	5.25 (1.5)*
IKDC, mean (SD)	81.1 (16.1)
Lysholm, mean (SD)	87.3 (15.1)
SF-12 Physical, mean (SD)	54.3 (6.5)
SF-12 Mental, mean (SD)	51.8 (8.1)

IKDC, International Knee Documentation Committee; SD, standard deviation; SF, short form.
*$P < .001$, paired sample t test.

results, and 6 (12%) reported poor results (Table 2). There were no reported clinical failures or surgical complications, including postoperative infections, deep venous thromboses, or further surgical procedures.

Discussion

We found good patient-reported clinical outcomes of ACLR with BPTB allograft in patients aged 50 years and older at mean 5-year follow-up. Tegner activity scores significantly improved postoperatively. The majority of patients reported good-to-excellent results, similar to previous studies evaluating other techniques.[22,23] The present dataset represents a large cohort of ACLR using entirely BPTB allograft for this age group with validated outcome scores. These results suggest that patients older than 50 years can expect improved function and good-to-excellent outcomes from ACLR using BPTB allograft with minimal complications.

We believe BPTB allograft is an excellent graft choice in this population, given the faster surgical recovery, decreased donor-site morbidity, less operative time, less postoperative pain, and decreased risk of patellar tendon rupture or patellar fracture associated with allografts when compared to autografts.[24,25] Although failure rates have been shown to be greater with allograft than autograft reconstruction, studies have suggested that this finding may be age-dependent, with some registries suggesting equivalent re-tear rates in older patients.[25-27] When selecting among allografts, there is limited support in the literature given that allografts are generally grouped together. Our preference for BPTB allograft stems from its low rate of failure, biomechanical properties, and strength of fixation.[28] Bone-to-bone healing has also been suggested to be superior to soft tissue-to-bone healing with regards to graft strength[15] and incorporation time in a rabbit model.[16] Furthermore, evidence of the limitations of soft tissue allografts has been reported.[29]

There are few studies that evaluate BPTB allografts in patients 50 years of age and older. Dahm et al.[30] studied 34 patients (35 knees) older than the age of 50 who underwent ACLR, 23 with BPTB allograft and 12 with BPTB autograft. Postoperatively, only 2 knees (6%) had a positive Lachman, and postoperative improvement was seen in IKDC, Lysholm, and University of California Los Angeles activity scores. Good outcomes have been shown in several other studies of ACLRs in older patients using various grafts, with the most commonly studied grafts being hamstring allograft and autograft.[12,13,23,31-33] Fayard et al.[33] investigated outcomes of ACLR in a multicenter retrospective study of 398 patients older than the age of 50 years. Their cohort consisted of 32% BPTB grafts and 68% hamstring grafts, although they did not specify the proportion of allograft and autograft. In total, 83% of their patients returned to sport, and significant improvements were noted in laxity as well as clinical outcome scores. A recent systematic review of ACLR in patients older than 50 years old found good results with all graft types, although only 65 patients (13.8% of their population) had BPTB allograft, and they did not stratify results by allograft source.[34]

When considering ACLR in the older population, nonoperative treatment must certainly be considered. While many patients aged 50 and older may have acceptable function with a torn ACL, studies have shown that age alone is not a contraindication to ACLR.[34] Additionally, more important than chronologic age is physiologic age. Surgeons must select motivated patients desiring return to high levels of activity when considering an ACLR in this age group.

Limitations

There are several limitations to this study. The retrospective design enables subject response and recall bias. The surgeries were performed by a single surgeon, which limits the generalizability of the study. There is no comparison group of different graft types, different age groups, or nonoperative treatment, which would help place our data in context. Further data on preinjury outcome scores would have allowed more in-depth analysis of patients' return to their baseline functional level. Additionally, given that only patients with complete PROs were included, there could be a component of selection bias. There was no standardized method for addressing additional intra-articular pathology. Finally, our measured outcomes consist of

Table 2. Lysholm Score Categories

Score (points)	N (%)
Excellent (95-100)	24 (48%)
Good (84-94)	14 (28%)
Fair (65-83)	6 (12%)
Poor (<65)	6 (12%)

subjective PROs without objective data. This particularly complicates clinical failures, or retears. This population may not be aware of a retear several years postoperatively, given that demand on the knee tends to decrease with age.

Conclusions

ACLR with BPTB allograft in patients aged 50 years and older leads to good PROs with significantly increased postoperative activity status at a minimum 2-year follow-up.

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