Analysis of Outcomes of Anterior Cruciate Ligament Repair With 5-Year Follow-up: Allograft Versus Autograft

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Purpose: To prospectively compare outcomes of primary anterior cruciate ligament (ACL) reconstruction with either Achilles tendon allograft with soft-tissue fixation or standard bone–patellar tendon–bone autograft with interference screw fixation. **Type of Study:** Prospective comparative case series. **Methods:** A group of 41 patients who underwent soft-tissue allograft reconstruction and a group of 118 patients who underwent autograft bone–patellar tendon–bone reconstruction were included in the final results. Patients were evaluated preoperatively and postoperatively at 1 to 2 weeks, 6 weeks, 3 months, 6 months, and then annually for 5 years. Objective measures of outcome included KT-1000 measurements, range of motion, ligamentous integrity, thigh atrophy, and International Knee Documentation Committee score. Subjective evaluations included patient completion of 5 questionnaires documenting functional status, pain, and health-related quality of life: (1) the short-form McGill Pain Questionnaire, (2) a patient subjective assessment of knee function and symptoms, (3) a patient subjective assessment follow-up, (4) a knee pain scale, and (5) the RAND 36-Item Health Survey. Mixed models analysis of variance was used to compare the outcomes of the treatment groups using baseline values of the study variables as a covariate. **Results:** Autograft patients reported significantly more pain on the bodily pain subscale of the RAND-36 than the allograft group at 1 week ($P = .0006$), 6 weeks ($P = .0007$), and 3 months ($P = .0270$). Autograft patients reported more pain than allograft patients on the McGill Pain Scale visual analog scale at 1 to 2 weeks ($P < .0001$) and 6 weeks ($P = .0147$). Patient assessment of function and symptoms showed that a higher proportion of patients reported normal or nearly normal knee function in the allograft group than in the autograft group at 3 months (33% *v* 14%, $P = .0558$, respectively). Fewer activity limitations were reported by allograft patients than autograft patients at 6 weeks ($P = .0501$), 3 months ($P = .0431$), and 6 months ($P = .0014$). After reconstruction, the allograft group displayed significantly more laxity in KT-1000 measurements at all time points than the autograft group ($P = .0520$). These measurements decreased over time for both groups ($P < .0001$). **Conclusions:** Five-year follow-up of patients undergoing ACL reconstruction with allograft versus autograft were compared objectively and subjectively. Both groups of patients achieved similar long-term outcomes. Overall, the allograft patients reported less pain at 1 and 6 weeks after surgery, better function at 1 week, 3 months, and 1 year, and fewer activity limitations throughout the follow-up period. **Level of Evidence:** Level II, prospective cohort study. **Key Words:** Anterior cruciate ligament reconstruction—Allograft—Autograft—Health-related quality of life—Outcomes.

The anterior cruciate ligament (ACL) continues to be the most frequently disrupted ligament of the knee,[1-3] and ACL injury is commonly encountered by the orthopaedic surgeon. The instability resulting from ACL tears is often symptomatic and may lead to progressive degeneration and long-term disability of the knee.[4] Reconstruction of the ACL is intended to restore knee joint stability, avoid long-term degenerative problems, and improve function. Whereas primary repair of the torn ACL has not been effective, ligament reconstruction with various grafts has become the standard of care. ACL reconstruction performed with current techniques is associated with a 90% success rate.[5] An excellent graft in terms of

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strength and initial fixation is the central one-third patellar tendon with attached tibial and patellar bone blocks harvested from the patient's ipsilateral knee. Although autologous bone–patellar tendon–bone (BPTB) graft is the most common construct used today, many concerns have arisen with regard to donor-site pathology.[6] These include patellar fracture, patellofemoral pain/crepitus, kneeling pain, quadriceps weakness, loss of joint motion, and patellar tendonitis or rupture. These concerns have led to the use of alternative graft sources such as fascia lata, hamstrings, and allografts.

Allografts are useful in ACL reconstruction because of their availability and obvious lack of donor-site pathology. Several studies have shown that allograft ACL reconstruction is a sound alternative to patellar-tendon autograft[7-9] with no significant difference in postoperative symptoms, activity level, functional outcomes, or physical examination measures.[10-11] Despite the failure to detect postoperative differences between autograft and allograft reconstructions, BPTB autograft is often referred to as the gold standard for ACL reconstruction. However, the use of allograft offers potential advantages of less donor-site morbidity, shorter operative time, availability of larger grafts, lower incidence of postoperative arthrofibrosis, and potential improvements in physical functioning and overall health-related quality of life.[12]

The purpose of the investigation was to perform a prospective, standardized comparison of the use of BPTB autograft and Achilles-tendon allograft without bone block for reconstruction of complete tears of the ACL. Comparisons were made from baseline (presurgery) through 3 to 5 years postsurgery and consisted of clinical outcomes as well as patient reported health-related quality of life and pain. The study hypothesis was that no significant difference in long-term outcomes would be expected when patients undergoing autograft or allograft ACL reconstruction were compared, although patients in the autograft group would experience greater discomfort and functional limitations during the initial surgical recovery period.

METHODS

From November 1994 through May 1999, 352 patients underwent unilateral ACL reconstructions; 219 of these patients were eligible to participate in the study. ACL reconstruction surgery was performed by 3 surgeons at 1 institution: 1 surgeon performed arthroscopic reconstruction using allograft and the other 2 performed arthroscopically-assisted reconstruction using BPTB autograft.

Patients were excluded from the study if they had previous injury or surgery on the affected knee, multiple ligamentous injuries, or lacked the ability to complete the study protocol. Patients with minor medial collateral ligament sprains, previous diagnostic arthroscopy, or meniscal tears were not excluded from the study. All patients provided written informed consent to participate in the study. The study was approved by the institutional review board.

Surgical Technique

All patients were examined under general anesthesia to confirm the preoperative diagnosis made by physical examination.

Autograft Technique: The intra-articular portions of the autograft ACL procedure were performed arthroscopically. First, the remnants of the ACL were debrided and its anatomic attachment points on the tibia and the femur were identified. Using commercial drill guides, 2.4-mm pins were placed from the proximal medial tibia and the posterior lateral femur through small incisions into the joint at the ACL anatomic attachment points. Some of the procedures were performed using a 2-incision technique with placement of the femoral tunnel, using an outside-in technique, and some procedures were performed using a single-incision technique with the femoral tunnel being placed using an inside-out technique. In all cases, commercial drill guides were used with the goal of placing the tunnels at the anatomic attachment points for the ACL. Once the tunnel positions were established, attention was turned to the anterior aspect of the knee where the central third of the patellar tendon was harvested using a midline incision. Bone plugs were taken from the tibial tubercle and the patella; meticulous closure of the paratenon was performed so as to avoid patella baja. The graft was prepared for insertion by placing sutures in the bone plugs followed by insertion of the bone plug and graft into the knee joint through 10-mm tunnels. Graft fixation was accomplished using titanium interference screws (Arthrex, Naples, FL) that were size-matched to the bone plugs. Placement of the graft and screw placement was checked radiographically, and the knee was taken through a full range of motion to observe any graft impingement. Notchplasties were used when necessary to prevent graft impingement. Routine closure of all wounds was performed. After surgery, all

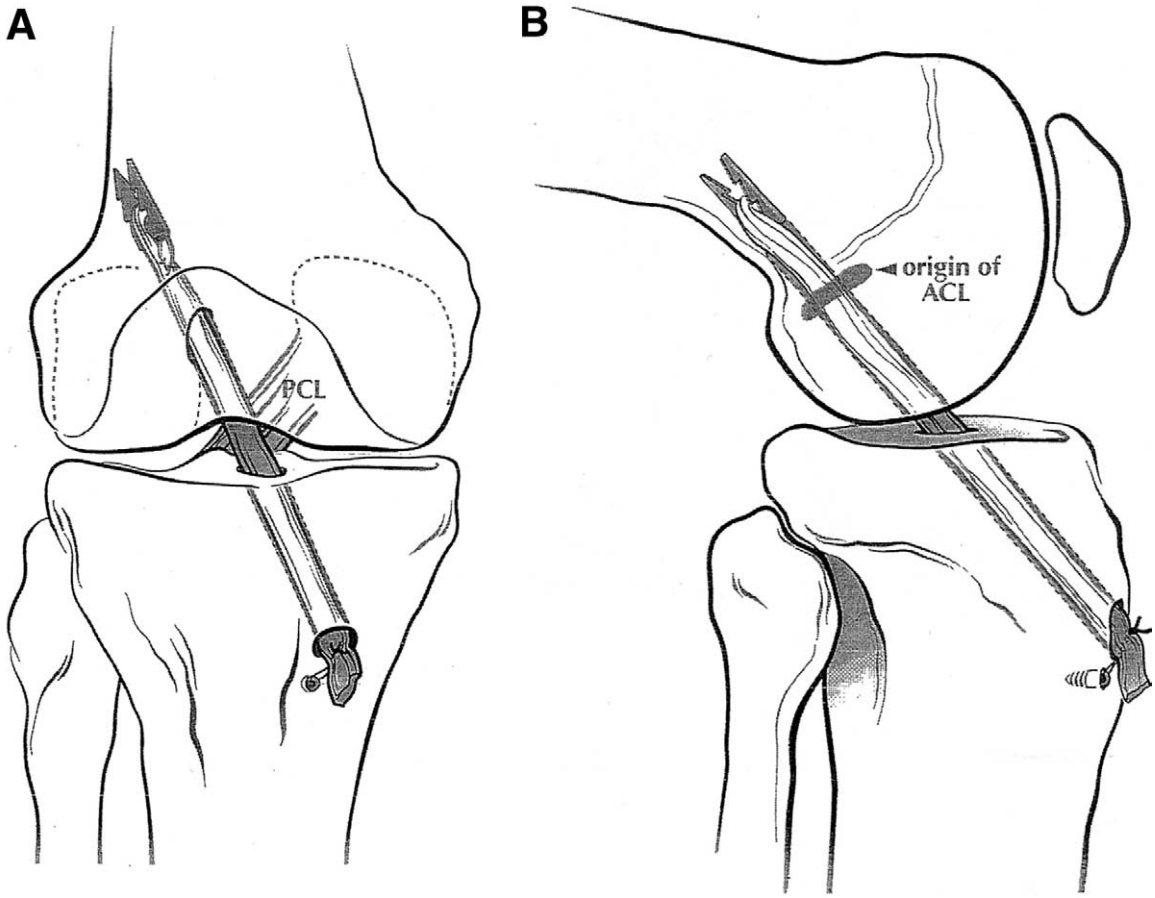

Figure 1. Allograft ACL reconstruction in (A) anterior and (B) lateral aspects, showing the placement of the Achilles tendon allograft mounted on a staple in the femoral tunnel and secured on the tibial side with a suture anchor. (Reprinted with permission.[39])

patients were placed in a standard postoperative brace locked in extension and cold therapy was applied.

Allograft Technique: Allograft ACL reconstruction was performed arthroscopically. First, the residual ACL was debrided. A tibial pin was placed 6 mm anterior to the posterior cruciate ligament in a central location using an angle finder. A drill hole was placed medially and one third the tibia diameter posteriorly to the tibial tuberosity using an 11-mm cannulated drill. A 6-mm offset guide was placed through the tibial hole to the insertion site of the ACL in the posteromedial aspect of the lateral femoral condyle. The guide pin was inserted and the position was checked radiographically. An 11-mm short-neck reamer was used to drill the femoral tunnel to a depth of 30 mm from the posterior cruciate ligament. The freeze-dried Achilles tendon allograft without bone block (Musculoskeletal Transplant Foundation, Edison, NJ) was reconstituted for 30 to 60 minutes in warm, sterile saline solution. The graft was prepared for insertion by cutting a wedge out of the distal portion of the tendon and then securing it onto a standard staple (Smith & Nephew, Andover, MA) with 4 ligatures of No. 2 Vicryl sutures (Ethicon, Somerville, NJ) (Fig 1). The graft was not pretensioned. The allograft, mounted on a staple driver, was pushed through the tibial tunnel and driven into the femoral tunnel, securing the staple in cancellous bone. Staple placement was observed arthroscopically and the positioning of the tendon was checked radiographically. The knee joint was moved through a full range of motion and checked for impingement. The distal end of the allograft was secured to the tibia with a suture anchor (Smith & Nephew) placed distal to the tibial tunnel (Fig 1). The tibial incision was sutured; the arthroscopic portals were covered with a light dressing, the knee was placed in a knee immobilizer locked in extension, and cold compresses were applied.

Rehabilitation

Both autograft and allograft patients remained in a knee immobilizer during ambulation for the first 2 weeks postoperatively. The same rapid rehabilitation program was initiated in both patient groups. Weight bearing as tolerated was allowed immediately after surgery. Active, non–weight-bearing range of motion and straight leg raises/quadriceps sets were encouraged. After 2 weeks, rehabilitation programs included active and passive range of motion up to 110° of knee flexion, continued soft-tissue mobilizations, hamstring curls, concentric hamstrings strengthening, straight leg raises with weights proximal to the knee, and calf raises. From 4 to 8 weeks postoperatively, rehabilitation focused on eccentric hamstring strengthening, hip range of motion strengthening, leg presses, and walking in a pool. Patients were allowed to progress at their own pace. Quadriceps isotonics were performed initially from 90° to 60° progressing to 90° to 40° 2 to 3 months after surgery. Submaximal isokinetic quadriceps strengthening and 1-leg balance exercises also were included. Patients were encouraged to work with light resistance within midrange of knee flexion. The following month, patients continued isokinetic strengthening progressing 5° per week. At 4 to 5 months after surgery, patients began jogging; agility drills were incorporated when quadriceps strengthening reached 90%. Patients were fitted with functional braces at 5 to 6 months if recommended by the physician/therapist or requested by the patient. Patients were discharged by the therapist if they met the following criteria: no greater than a 10% deficit in quadriceps strength, equal hamstring strength bilaterally, and satisfactory performance on agility drills.

Study Design

The study was a prospective comparison between autograft and allograft groups. ACL reconstruction was performed by 3 surgeons at 1 institution. Data were collected when patients were evaluated preoperatively and postoperatively at 1 to 2 weeks, 6 weeks, 3 months, 6 months, and then annually for up to 5 years.

Data Collection Instruments

A knee functional assessment was performed to obtain objective measures of the clinical outcomes of the ACL reconstruction and included KT-1000 arthrometer manual-maximum difference measurements, knee range of motion, and thigh atrophy. Ligamentous integrity was evaluated using the following tests of the knee joint: medial joint opening (medial collateral ligament), lateral joint opening (lateral collateral ligament), anterior drawer (ACL), and Lachman test (ACL). In addition, the pivot-shift (knee subluxation) and crepitus (crackling or creaking of knee joint associated with movement) were used to evaluate the knee joint. The first 4 groups of the International Knee Documentation Committee (IKDC) Knee Ligament Standard Evaluation Form were used to obtain an IKDC score to provide a "quick knee profile" score. For the ligament examination section of the IKDC, data for the Lachman and the anterior drawer only were required to calculate a score on that subscale. However, if there were additional data available in section 4, they were used to calculate the subscale score. This data-analysis method was used to increase the sample size at the later follow-up time points. Subjective evaluations consisted of questionnaires completed by patients to document their functional status, pain, and health-related quality of life.

KT-1000: Maximum anterior displacement values were taken by applying a 20-lb anterior force to the arthrometer. Then, a 20-lb posterior force was applied and released to return the knee to a relaxed position. Measurements from 3 consecutive tests were averaged and rounded to the nearest 0.5 mm.

Thigh Atrophy: The diameter of the thigh was measured 8 cm from the superior pole of the patella. Comparisons were made between the measurements for the affected and unaffected thighs.

Patient Demographics: Demographic data were collected on all patients, including age, gender, ethnicity, occupation, marital status, type of insurance, and tobacco and alcohol use.

Short-Form McGill Pain Questionnaire: This questionnaire was used to document the type and intensity of pain experienced by the study participants.[13] The short-form McGill Pain Questionnaire consists of 4 subscales: pain word rating index–affective (e.g., tiring-exhausting, sickening), pain word rating index–sensory (e.g., throbbing, sharp, hot-burning), present pain intensity rated on a scale from 0 to 5, and a visual analogue scale on which patients were asked to place a mark on a 100-mm line that best described their current level of pain (varying from no pain to worst imaginable pain). This measure has shown levels of reliability and validity and has been widely used in health trials.[14] On all subscales of this questionnaire, a higher score indicated higher pain levels.

Rand 36-Item Health Survey: The RAND-36 is a generic measure of health-related quality of life and was used to assess the impact of surgery on the patients' functioning and overall quality of life.[15] The RAND-36 consists of 36 items divided into 8 individually scored subscales: physical functioning, bodily pain, role limitations due to physical health problems, role limitations due to personal or emotional problems, general mental health, social functioning, energy/fatigue, and general health perceptions. No total or overall score is calculated from this instrument. Scores on the individual subscales range from 0 to 100, with higher scores indicating better levels of functioning. This measure has excellent psychometric properties (reliability, validity, and sensitivity) and takes approximately 5 to 8 minutes to complete.

Knee Pain Scale: This questionnaire was developed to assess pain and problems associated with knee function.[16] The 21-item measure consists of the following 5 subscales: frequency of pain during ambulation, frequency of pain during transferring activities (e.g., getting in and out of a bed or chair), intensity of pain during ambulation, intensity of pain while transferring, and the frequency of experiencing knee problems (e.g., knee giving way or buckling, swelling, stiffness). Patients were asked to indicate the frequency of intensity of pain during the past week. Higher scores on these subscales indicated less pain and fewer knee problems.

Statistical Analysis

Statistical analyses were performed to assess the outcomes between the 2 ACL reconstructive procedures. The primary outcome measures of knee function and surgical success were the KT-1000 measurements taken over the 5 years after surgery. The IKDC score was also compared before and after surgery in both the allograft and autograft groups. Scores on the Rand-36, the McGill Pain Questionnaire, and the Knee Pain Scale were compared to assess the impact of the 2 procedures on the patients' health-related quality of life.

Baseline characteristics of the 2 groups were compared using t tests for continuous measures and χ-square tests or Fisher exact test for categorical variables. To assess differences between groups for pain, health-related quality of life, and other continuous measures such as the KT-1000, a mixed models analysis of variance approach was used with an exchangeable covariance structure assumed for repeated measures within an individual over time. These models contained a covariate representing the value of the outcome at baseline, as well as the factors "type of surgery" (autograft v allograft), "visit," and "type of surgery x visit" interaction terms. The interaction term was dropped from the model if $P > .05$. The "type of surgery" effect was considered statistically significant if $P \leq .05$. P values between .05 and .10 were reported if they were considered clinically significant.

RESULTS

At the time of surgery, it was determined that 18 of the 219 patients enrolled in the study were ineligible for participation (12 who did not sustain an ACL rupture, 5 who had multiple ligament injuries, and 1 patient who had a nonstandard surgical procedure). A final review of patients revealed an additional 25 patients who were excluded from the study (17 patients with previous knee arthrotomies, 6 patients who were age ineligible, 1 patient with a head injury, and 1 patient who developed a staphylococcus infection after surgery). This meant that 176 patients met the recruitment criteria. Of these 176 patients, 17 were lost to follow-up (6 allograft, 11 autograft) and thus were excluded from analysis because there were no follow-up data. Data from the remaining 159 patients (118 autografts, 41 allografts) are presented in this report. The average length of follow-up for health-related quality of life data was 4.2 years (range, 3 to 5 years). For physician-collected data, the average follow-up time was 2.2 years (range, 2.5 months to 5.9 years). Patients who refused or were unable to return for clinic visits at later time points were allowed to complete and mail in quality of life forms, which resulted in a much higher response rate for quality of life data than clinical data beyond 2 years. No significant differences in age, race, treatment group, or baseline IKDC values were found between patients who did and did not return for a clinic visit beyond 2 years. Allograft patients had a significantly longer follow-up time than autograft patients (mean, 32.3 months and 28.2 months, respectively, $P = .0295$).

The demographic characteristics of the 159 participants are presented in Table 1. Patients who underwent autograft ACL reconstruction were significantly younger than those in the allograft group (25.4 years and 29.7 years, respectively; $P = .046$). The majority of patients were non-Hispanic white males. Most listed private insurance as their primary source of health coverage. The majority of the ACL injuries in both groups were sports-related.

Other knee pathologies in the study patients were

TABLE 1. *Demographic Characteristics of the Allograft and Autograft Study Participants*

	Allograft (n = 41)	Autograft (n = 118)	*P* Value
Age			
Mean age (yr)	29.7	25.4	.0458
Gender			
Male (n)	58% (24)	73% (85)	.0927
Race			
Non-Hispanic white	88%	85%	.8519
African-American	12%	15%	
Marital status			
Married	37%	23%	.0920
Insurance (%)			
Private insurance	85%	76%	.4550
Workers' Compensation	7%	10%	
Other	8%	14%	
Type of injury			
Auto	2%	3%	.5306
Sports	80%	74%	
Work-related	2%	9%	
Other/missing	15%	14%	

documented and included meniscal tears, medial collateral ligament and posterior cruciate ligament tears, and articular cartilage defects (Table 2). Based on results of the Fisher exact test, there was no significant difference between the allograft and autograft patients with respect to the occurrence of other knee pathologies.

Objective Measures

Results of the KT-1000 arthrogram measurements indicated that the mean values decreased over the 5-year follow-up period for patients in both surgical groups, with allograft patients tending to have higher values (anterior mean measures across time, 3.0 mm) than autograft patients (anterior mean, 2.8 mm) (P = .0520; estimated mean difference, 0.24; 95% CI [confidence interval], 0.01-0.47). When comparing side-to-side KT-1000 measures between affected and unaffected knees, no significant effect of surgical treatment was observed through 5 years of follow-up (Fig 2).

The various components of the knee functional assessment indicated no differences in the 2 surgical groups related to the type of surgery they had (Table 3 and Table E1, online only; available at www.arthroscopyjournal.org). However, both the allograft and autograft groups showed significant improvements over time after surgery.

There were no differences in the overall IKDC evaluation between the allograft and autograft patients except at 2-year follow-up (P = .0374) (Table 4). At this time, more patients were categorized as "normal" and fewer patients were categorized as "severely abnormal" in the allograft group compared with the

TABLE 2. *Concomitant Meniscal Tears, Ligament Tears, and Articular Cartilage Defects in the Allograft and Autograft Groups*

	Allograft (n = 41)	Autograft (n = 118)
ACL tear only	42% (17)	38% (45)
ACL tear + meniscal tear	27% (11)	31% (36)
ACL tear + articular cartilage defect	12% (5)	15% (18)
ACL tear + meniscal tear + articular cartilage defect	17% (7)	14% (16)
ACL tear + other ligament tear	2% (1*)	1% (1†)
ACL tear + meniscal tear + other ligament tear	0% (0)	1% (1*)
ACL tear + articular cartilage defect + other ligament tear	0% (0)	1% (1*)

NOTE. P = .8907, Fisher exact test.
*MCL tear.
†Partial PCL tear.

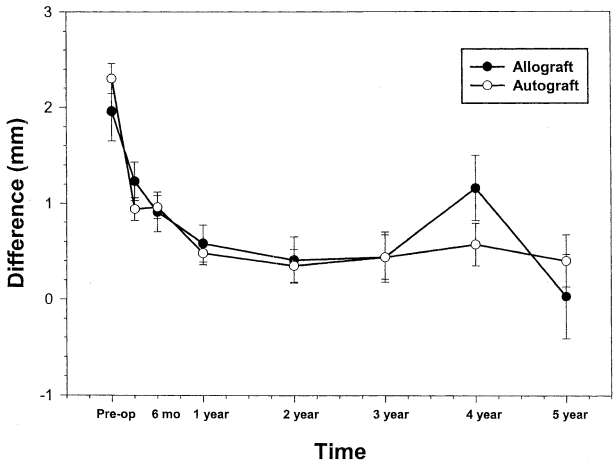

FIGURE 2. KT-1000 measurements of anterior displacement values. The graph indicates the differences between the allograft and autograft patients.

autograft group. No differences were found for the 2 treatment groups at any time point for the IKDC symptoms subscale or ligament examination subscale. However, for the patient assessment subscale, at 1 year of follow-up, more allograft patients than autograft patients classified themselves as "normal" (P = .0103). The knee range of motion subscale was significantly different between the 2 groups at baseline (P = .0332) and 2 years (P = .0237) with more allograft patients exhibiting "abnormal" profiles at baseline and fewer allograft patients than autograft patients exhibiting "abnormal" profiles at 2 years.

Health-Related Quality of Life

Results of the analyses of the Rand-36 indicated that 3 subscales showed significant differences between the surgical groups during the first year after surgery (Table E2, online only; available at www.arthroscopyjournal.org). The physical functioning of the patients was significantly better in the allograft groups at 1 to 2 weeks (P = .0016), at 3 months (P = .0494), and 1 year after surgery (P = .0409). Participants in the allograft group were also less likely to have limitations in performance of their usual roles due to their physical health at 6 weeks (P = .0501; mean, 35.7 and 22.2, respectively; estimated difference, 13.6; 95% CI, 0.1- 27.1), at 3 months (P = .0431; mean, 55.4 and 40.5, respectively; estimated difference, 14.9; 95% CI, 0.6-29.2), and at 6 months postoperatively (P = .0014; mean, 88.0 and 63.2, respectively; estimated difference, 24.8; 95% CI, 9.7-39.9). In addition, pain was reported to be less severe in the allograft patients at 1 to 2 weeks (P = .0006; mean, 33.0 and 49.4, respectively; estimated difference, 16.4; 95% CI, 3.8-22.6), at 6 weeks (P = .0007; mean, 61.1 and 74.8, respectively; estimated difference, 13.6; 95% CI, 5.7-21.5), and at 3 months postoperatively (P = .0270; mean, 83.7 and 74.4, respectively; estimated difference, 9.3; 95% CI, 1.04-17.6). No significant differences were observed between the 2 surgical groups on any of the Rand-36 subscales after the 1-year assessment evaluation.

A more in-depth assessment of pain was completed using the McGill Pain Questionnaire (Table E3, online only; available at www.arthroscopyjournal.org). Differences were observed between the surgical groups on the sensory subscale of the McGill Pain Questionnaire at 1 to 2 weeks postoperatively (P = .0001). Patients in the autograft group described the sensory aspects of their pain as being greater than those in the allograft group and rated their overall pain as greater than the allograft pa-

TABLE 3. *Knee Functional Assessment*

	Estimated Treatment Effect (95% CI)	Treatment P Value	Time P Value
Range of flexion (involved knee only)	0.22 (–3.0-3.46)	.8919	<.0001
Crepitus % with greater than mild pain*	1.3 (0.9-1.9)	.1811	<.0001
Thigh atrophy	−.1054 (−34-.11)	.3620	<.0001
Laterial joint opening (% 3+mm)	1.02 (0.6-1.8)†	.9486	<.0001
Medial joint opening (% 3+mm)	1.4 (0.8-2.3)†	.2291	<.0001
Anterior drawer (3+mm displacement)	1.06 (0.7-1.6)†	.7791	<.0001
Lachman (% 3+mm displacement)	1.2 (0.8-1.6)†	.4012	<.0001
Pivot-shift (% gross, clunk, or glide)	1.1 (0.6-1.9))†	.8411	<.0001

*Crepitus was considered present if any choice beyond mild pain in any of the 3 areas of crepitus was marked.

†Odds ratios: relative odds of autograft versus allograft patients being in the "worst" category (e.g., 3+mm varus). An odds ratio >1 implies the autograft group was more likely than the allograft group to be in the "worst" category. An odds ratio <1 implies the reverse. An odds ratio ≅0 implies both groups have similar odds of being in the "worst" category.

TABLE 4. *Treatment Comparisons of the IKDC*

	Baseline		3 Months		6 Months		1 Year		2 Years	
	Allo % n = 31	Auto % n = 79	Allo % n = 23	Auto % n = 67	Allo % n = 20	Auto % n = 62	Allo % n = 27	Auto % n = 56	Allo % n = 18	Auto % n = 28
Overall IKDC										
Normal	0	0	0	0	0	0	18	16	33	11
Nearly normal	0	1	13	6	35	31	44	45	56	39
Abnormal	6	14	52	60	40	55	22	17	11	32
Severely abnormal	94	85	35	34	25	14	15	12	0	18
	$P = .5277$		$P = .5229$		$P = .4217$		$P = .9587$		$P = .0374$	
Patient subjective assessment										
Normal	0	0	7	1	16	14	67	32	59	53
Nearly normal	17	18	57	43	68	64	30	57	37	36
Abnormal	58	46	32	46	12	21	3	9	4	6
Severely abnormal	25	36	4	9	4	1	0	1	0	4
	$P = .4220$		$P = .1765$		$P = .6052$		$P = .0103$		$P = .8386$	
Symptoms										
Normal	3	0	0	4	8	11	47	48	79	48
Nearly normal	8	8	22	16	25	30	30	31	11	39
Abnormal	48	48	56	60	46	48	13	13	11	10
Severely abnormal	24	44	22	19	21	10	10	7	0	3
	$P = .4807$		$P = .7612$		$P = .6065$		$P = .9707$		$P = .0711$	
Range of motion										
Normal	8	20	20	28	40	48	44	53	63	32
Nearly normal	33	30	52	49	40	32	30	29	37	36
Abnormal	22	35	16	13	10	18	15	14	0	25
Severely abnormal	36	15	12	10	10	2	11	3	0	7
	$P = .0332$		$P = .8703$		$P = .2477$		$P = .5659$		$P = .0237$	
Ligament exam										
Normal	5	3	56	58	64	52	79	67	58	64
Nearly normal	15	16	44	41	36	43	21	30	42	35
Abnormal	15	16	0	1	0	0	0	0	0	0
Severely abnormal	74	75	0	0	0	4	0	3	0	0

NOTE. *P* values obtained from Fisher exact test.

tients on the visual analogue scale at 1 to 2 weeks ($P < .0001$; mean, 48.8 and 24.5, respectively; mean difference, 24.3; 95% CI, 12.0-32.4), and at 6 weeks postoperatively ($P = .0147$; mean, 25.4 and 13.9, respectively; mean difference, 11.5; 95% CI, 0.9-19.1), as well as on the Perceptions of Pain Intensity item at 1 to 2 weeks postoperatively ($P = .0007$). No significant differences were observed between the 2 patient groups on any of these subscales after the 6-week assessment.

Pain and problems specific to the knee were assessed using the Knee Pain Scale (Table E4, online only; available at www.arthroscopyjournal.org). The frequency of pain on transferring was greater for the autograft than allograft patients 1 to 2 weeks postoperatively ($P = .0012$) and at 6 weeks ($P = .0046$). Similarly, the frequency of pain on ambulation was greater for the autograft patients 1 to 2 weeks after surgery ($P = .0053$), 6 weeks ($P = .0393$), and 6 months postoperatively ($P = .0088$). The severity of pain while transferring was higher in the autograft group 1 to 2 weeks after surgery ($P = .0027$), and the severity of pain during ambulation was higher in the allograft group 6 months ($P = .0482$) and 1 year postoperatively ($P = .0446$). Knee problems were found to be greater in the autograft group at 1 to 2 weeks ($P = .0002$) and 6 weeks postoperatively ($P = .0014$) and was marginally significant at 3 months postoperatively ($P = .0507$). No significant differences were observed between the 2 patient groups on any of these subscales after the 1-year assessment point.

DISCUSSION

Reconstruction of the injured ACL has been performed using a variety of autograft and allograft ligament substitutes. The use of autologous BPTB has been considered the gold standard and the first choice

of many surgeons for a variety of reasons.[17,18] Multiple studies have shown good results using this method.[6,19-21] Autologous tissue avoids the perceived risk of disease transmission that is associated with allografts. Although the composite risk of harvesting and processing tissues from donors who are HIV-antigen positive but are antibody negative is 1 in approximately 1,000,000,[22] it is nonetheless unacceptable for some patients and surgeons. In terms of biologic aspects, autografts may be superior with regard to graft incorporation and initial strength. Histologically, allografts have been shown to be slower to incorporate into the host tissue,[23] possibly requiring as long as 3 years to gain full strength. Greater strength and stability of autografts have been shown in comparison with allografts at 6 months in a goat model.[24] The superiority of the BPTB graft for initial strength has also been shown in a human cadaver model.[25]

In addition, several investigators have noted a tendency for increased laxity associated with allografts in the long term. Shelton et al.[11] reported a trend for patients with allografts to experience increased glide on pivot shift testing at 2 years, although this finding was not statistically significant. Noyes et al.[9] found greater anteroposterior translation with fascia lata allografts compared to patellar tendon autografts. Furthermore, others have reported a higher rate of traumatic rerupture associated with allograft ACL reconstruction.[26,27]

Many surgeons have continued to favor the use of BPTB autograft. However, several drawbacks associated with the use of autograft patellar tendon have been noted, primarily regarding donor-site morbidity with associated extensor mechanism problems. Patellofemoral pain and concomitant crepitus have been shown to be a significant problem, occurring in as many as 80% of patients.[6,28,29] Significant quadriceps weakness was documented in 18% to 65% of patients as late as 2 years after ACL reconstruction.[28,29] Other complications associated with BPTB ACL reconstructions include joint stiffness,[30] flexion contracture,[29] difficulty with kneeling and knee extension,[28] and patellar fracture.[31] In addition, the overall costs of autograft ACL reconstruction can be greater than that of allograft because of increased surgical and anesthesia time ($5,332 *v* $4,285, respectively).[32] As a result, many surgeons have used allografts in an attempt to avoid these problems.

Multiple studies have found that allograft tissue is an acceptable alternative to autograft for ACL reconstruction.[7-9,33-36] Although there are few long-term results reported in the literature, satisfactory long-term (5 to 9 years) results have been documented for allografts with respect to function and laxity by Noyes and Barber-Westin.[8] Several other trials comparing the 2 grafts showed similar results with each graft. A 3- to 5-year retrospective follow-up study[10] of patients who underwent BPTB autograft and allograft procedures found that there were no significant differences in levels of knee activity, symptoms, patient subjective knee rating, Cincinnati Knee Scores, anterior laxity, functional strength, and overall knee rating between the 2 groups.[10] This study did note a clinically insignificant loss of terminal extension in the autograft group. Similarly, Lephart et al.[34] showed quadriceps strength and functioning to be the same at 1 to 2 years postoperatively for both types of grafts. Saddemi et al.[35] found no significant differences at a minimum of 2 years in patients receiving autografts versus allografts with respect to length of hospital stay, thigh atrophy, knee joint laxity, strength, range of motion, patellofemoral symptoms, and complications.[35] In another study, allografts were shown to be superior with decreased anterior laxity and increased quadriceps strength when compared with autografts at 18 to 36 months.[36]

Despite the increased incidence of traumatic rerupture of allografts, Stringham et al.[26] also found, in a retrospective study, no significant differences between autograft and allograft groups in terms of Lysholm and Tegner knee-rating scales, physical examination findings, isokinetic strength measures, and instrumented laxity.[26] Shelton et al.[11] prospectively evaluated autograft and allograft patellar tendon ACL reconstruction patients at a minimum of 2 years. Again, no significant differences were shown with regard to pain, swelling, arthrometer values, and physical examination findings at all data points from 3 to 24 months.[11] An evaluation of the same patients 5 years later continued to show no difference in pain, giving way, physical examination, and arthrometer testing. There was also no change in the trend for glide on pivot-shift testing, no late stretching of grafts, and equal numbers of ruptures (1) in each group.[37] Furthermore, there was a trend toward loss of extension in autograft patients versus allograft patients (2.47° *v* 1.07°, respectively), which was not evident at 2 years.

Overall, there is sufficient experience reported in the literature to support the use of either autografts or allografts for ACL reconstruction. Both types of reconstructions are excellent for consistent restoration of knee stability and function, with good to excellent results reported by more than 90% of patients. Although there is a trend for long-term increased joint

laxity in allograft patients, statistically significant differences are rare. The clinical significance of this trend appears to be negligible because overall results are still excellent. In addition, the concern over extensor mechanism problems associated with the use of autografts has not been clearly defined in long-term, prospective comparative studies.

Previous studies have failed to include data on pain from the short-term postoperative period. Analysis of the present study data shows that allograft patients reported significantly less pain than autograft patients as assessed by the Rand-36 bodily pain subscale, the McGill Pain Questionnaire, and the Knee Pain Questionnaire. Significant differences on the Rand-36 pain subscale and the McGill Pain Questionnaire were reported primarily within the first 3 months after surgery, although allograft patients reported less frequent pain during ambulation as assessed by the Knee Pain Questionnaire at 6 months and less severe pain on ambulation at 6 months and 1 year than did autograft patients. Although previous studies have shown no differences in pain ratings between groups at 3 months,[11,37] the current study found that allograft patients experience significantly less pain, primarily within the first 3 months of the postoperative period. The allograft patients may also have more infrequent or less severe episodes of pain on ambulation through the 1-year period after surgery compared with the patients undergoing autograft reconstruction. This difference in pain is certainly related to the larger incision required for harvest of the central patellar tendon and the resulting bony defect that is associated with the autograft procedure. In the present study, patients in both groups had bone tunnels drilled in a similar fashion, with the autograft patients requiring open harvest of the tendon. In contrast, for the allograft procedure, a 2-cm incision over the proximal medial tibia was used for passage of the graft in addition to the standard arthroscopic portals. This difference in surgical incisions likely accounts for the difference in postoperative pain levels. An expected reduction in postoperative pain associated with allograft reconstruction procedure may be a significant factor for patients who desire a less painful recovery and a quicker return to work. Other measures of postoperative morbidity showed no differences between the 2 surgical groups. Range of motion and thigh atrophy were similar for both autograft and allograft patients at all time points. These findings confirm the results from other studies that found no significant differences in the early postoperative period.[35] There were no incidences of patellar tendon rupture or patellar fracture. Quadriceps atrophy and loss of knee range of motion may be no more significant with patellar tendon harvest than with allograft reconstruction. Although the incidence of extensor mechanism dysfunction is significant after ACL reconstruction,[28-30] this outcome has been reduced with aggressive, early rehabilitation,[7,38] as was employed in this study. The use of early rehabilitation may account for the lack of difference between groups.

The IKDC evaluations also showed no difference between the autograft and allograft patients in regard to symptoms or ligament examination. However, at 1 year and 2 years after surgery, more allograft patients considered themselves to be normal compared with the autograft group. Knee range of motion was abnormal in fewer allograft patients than autograft patients at 2 years. This may reflect a loss of extension in the autograft patients as a result of prepatellar scarring related to the surgical technique. The reason why more allografts had abnormal knee range of motion at baseline is unknown. Regardless of the reason, fewer allograft patients had abnormal range of motion at 2 years.

With the significant loss to follow-up of physician-collected data (IKDC, range of motion, KT-1000) after 2 years, there was concern that biased estimates of treatment effect at later time periods might result. Statistical models (mixed-models analysis of variance) were chosen that allowed for use of all available data, including data from patients with incomplete follow-up times. Although no differences were found in age, race, or baseline IKDC values between those who had and did not have data beyond 2 years, there is still the chance that a bias exists. Therefore, estimates of treatment effect beyond 2 years for physician-collected data should be considered with caution. As was noted earlier, fewer autograft than allograft patients returned for later follow-up visits, and this may be partially explained by the fact that, as a group, they were younger and more likely to be single (i.e., more mobile).

With regard to laxity, the present study data show no difference in anterior laxity on KT-1000 arthrometer testing for allografts versus autografts (3.0 mm *v* 2.8 mm, respectively) at all time points postoperatively ($P = .0520$). Similarly, no significant difference was noted in side-to-side testing, and there was no increase in laxity over time. This would suggest that, in our study, allograft patients had marginally greater laxity than autograft patients overall but no significant side-to-side differences. In addition, subjective laxity evaluations provided by patient reports included no clinical symptoms of instability or giving way. Other studies have reported increased laxity that was not associated with significant

symptoms or functional limitations.[11] In addition, the increased laxity may be accounted for by the surgical technique used in allograft reconstruction, which does not involve tensioning of the graft during fixation. However, increased laxity could also be a function of an inherently less rigid graft.

A review of the literature found no reports of health-related quality of life measures following ACL reconstruction. There are minimal reports of patient function and satisfaction using standardized measures. In the current study, Rand-36 data were collected from patients at baseline and at all follow-up visits. Allograft patients reported fewer role limitations caused by physical health problems compared with autograft patients from 6 weeks to 6 months postoperatively, and better overall physical functioning at 1 to 2 weeks, 3 months, and 1 year postoperatively. No significant differences were found on these subscales after 1 year, suggesting that autograft patients may experience role limitations only during the short-term postoperative period. The difference in activity may be accounted for by the fact that manipulation of the extensor mechanism is not part of the allograft reconstruction procedure. In addition, there is a possibility that the allograft construct cannot constrain the knee by overtightening of the graft.

Although there are no significant functional or clinical differences between the 2 groups at 5 years, the initial differences during the first year are significant. Because of the reduction in pain in the short term, allograft reconstruction may be a more attractive option for patients unable to be absent from their jobs for extended periods. A patient receiving an allograft may experience fewer activity limitations and, therefore, may benefit from improved health-related quality of life and function for up to 1 year after surgery.

There are several limitations to this study. Randomization was not used to assign patients to the 2 surgical groups. Instead, patients received either allograft or autograft ACL reconstruction based on the surgeon performing the procedure. It is conceivable that some patients may have self-selected their procedure based on their knowledge of the specific procedure performed by that surgeon. This introduces selection bias into the analysis, which can only be avoided with randomization. In addition to follow-up of patients who received 2 different types of grafts, the graft fixation methods used in the study patients were different, i.e., interference screws for the autografts and staples and suture anchors for the allograft procedures. Data were not collected in a blinded fashion. In an attempt to decrease observer bias, data collectors were used rather than the surgeons to obtain measurements, but staff were still not blinded to the patients' type of surgery. Attrition of the original patient sample was also a significant problem after 1-year of follow-up. This was partly the result of the fact that a large number of patients were college students; the majority of these students moved away from the area some time after their surgery and were unable to return for follow-up clinical assessments. However, the majority of these patients continued to complete health-related quality of life and other self-report questionnaires by mail. It is also possible that patients with poorer outcomes refused to return because they were less satisfied with their care. Conversely, patients who had good results may not have returned because they did not deem it necessary.

CONCLUSIONS

Reconstruction of the ACL using either BPTB autograft or freeze-dried Achilles tendon allograft was successful for establishing knee stability that was maintained for up to 5 years. Allograft patients reported fewer role limitations due to physical health problems compared with autograft patients from 6 weeks to 6 months postoperatively, and better overall physical functioning at 1 to 2 weeks, 3 months, and 1 year. Significant differences on the Rand-36 pain subscale, the Knee Pain Questionnaire, and the McGill Pain Questionnaire were also observed primarily within the first 3 months of surgery, although allograft patients reported less frequent pain during ambulation at 6 months, and less severe pain on ambulation at 6 months and 1 year than did the autograft patients. No significant differences were found on any of these subscales after 1 year, suggesting that autografts may have more role limitations only during the short-term postoperative period. Patients with autograft reconstructions had less anterior translation as assessed by arthrometer measurements, but no clinical differences were seen between groups with regard to knee stability. The results of this study suggest that ACL reconstructions with either patellar tendon autograft or Achilles tendon allograft are reasonable choices for ACL reconstruction. However, the allograft reconstruction procedure may result in less pain and functional limitations in the short-term, postoperative period.

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TABLE E1. *Appendix to Support Table 3*

	Baseline (n)	6 Weeks (n)	3 Months (n)	6 Months (n)	1 Year (n)	2 Years* (n)	3 Years* (n)	4 Years* (n)	Time Effect *P* Value	Treatment Effect (95% CI) (*P* value)
Range of flexion	Allo 122.2 (20) Auto 129.7 (66)	95.1 (25) 85.8 (70)	131.4 (20) 127.1 (68)	136.4 137.4	139.6 (28) 140.9 (58)	139.1 (19) 141.9 (29)	144.0 (12) 137.2 (19)	130.5 132.5	<.0001	0.22 (−3.0-3.5) *P* = .8919
Crepitus (patello-femoral % with >mild pain)	Allo 28% Auto 32%	24% 23%	27% 30%	24% 34%	42% 50%	43% 68%	25% 33%	0% 31%	<.0001	1.3 (0.9-2.0)† *P* = .1548
Thigh atrophy (uninvolved-involved knee)	Allo 0.46 Auto 0.84	1.2 0.9	0.9 0.8	0.2 0.6	0.1 0.5	0.4 0.4	0.4 0.4	0.60 0.0	<.0001	−0.1054 (−.34-0.11) *P* = .3630
Varus %>2 mm	Allo 23% Auto 26%	4% 5%	0% 1%	0% 3%	11% 6%	0% 10%	25% 11%	40% 23%	.0032	1.02 (0.6-68)† *P* = .9486
Valgus %>2 mm	Allo 36% Auto 23%	12% 5%	4% 3%	0% 3%	11% 9%	0% 10%	25% 17%	20% 23%	.0181	1.4 (0.8-2.3)† *P* = .2291
Anterior drawer (% w/3 + mm)	Allo 90% Auto 87%	32% 35%	32% 28%	20% 27%	16% 25%	28% 30%	25% 22%	40% 38%	.6656	1.06 (0.7-1.6)† *P* = .7791
Lachman (mm of displacement %w/3 mm)	Allo 92% Auto 93%	44% 36%	36% 43%	18% 32%	39% 28%	28% 40%	25% 28%	33% 45%	.1567	1.2 (0.8-1.6)† *P* = .4012
Pivot-shift (% gross, click, or glide)	Allo 67% Auto 67%	13% 6%	5% 9%	7% 9%	12% 7%	14% 16%	12% 11%	0% 0%	.9612	1.1 (0.6-1.9)† *P* = .8411

*Numbers very small.
†Odds ratios (OR): relative odds (autograft *v* allograft) of having the "worst" outcome; an OR = 1 indicates both treatment groups have similar odds of having the "worst" outcome; an OR >1 indicates that the autograft group has a higher odds of having the "worst" outcome; an OR <1 indicates that the allograft group has a higher odds of having the "worst" outcome.

TABLE E2. *Adjusted Mean Scores and Standard Errors (SE) for the Rand-36 Subscales by Surgical Group, From Baseline Through 1 Year*

		Baseline		1-2 Weeks		6 Weeks		3 Months		6 Months		1 Year	
Subscale	Type	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Physical functioning	Allo	56.4	4.5	33.2	4.0	62.9	3.2	77.6	3.5	87.8	3.6	95.1	3.4
(range of score 0-100)	Auto	57.4	2.6	18.8	2.1	57.7	2.1	69.4	2.2	81.4	2.2	86.8	2.2
		$P = .8468$		$P = .0016$†		$P = .1816$		$P = .0494$*		$P = .1317$		$P = .0409$*	
Role limitations physical	Allo	35.8	6.5	10.5	7.4	35.7	5.8	55.4	6.2	88.0	6.7	92.1	6.0
(range 0-100)	Auto	25.0	3.5	0.4	3.7	22.2	3.8	40.5	3.9	63.2	3.9	85.3	3.8
		$P = .1290$		$P = .2258$		$P = .0501$*		$P = .0431$*		$P = .0014$†		$P = .3413$	
Role limitations emotional	Allo	82.9	4.8	75.6	6.6	84.1	5.1	91.6	5.5	95.4	6.0	95.3	5.3
(range 0-100)	Auto	75.5	3.6	62.4	3.3	73.5	3.4	81.2	3.4	87.4	3.4	92.6	3.4
		$P = .2189$		$P = .0753$		$P = .0848$		$P = .1116$		$P = .2447$		$P = .6695$	
Energy/fatigue	Allo	69.6	3.2	48.2	4.1	66.1	3.4	69.8	3.5	76.0	3.6	75.4	3.4
(range 0-100)	Auto	59.5	2.0	48.2	2.1	63.9	2.0	70.4	2.1	74.5	2.1	74.5	2.1
		$P = .0105$*		$P = .9989$		$P = .5751$		$P = .8762$		$P = .7236$		$P = .8276$	
Emotional well-being	Allo	80.1	2.6	78.9	2.8	85.2	2.3	85.3	2.4	90.0	2.5	89.5	2.4
(range 0-100)	Auto	77.5	1.6	74.4	1.5	83.9	1.5	84.8	1.5	86.9	1.5	86.1	1.5
		$P = .4145$		$P = .1676$		$P = .6342$		$P = .8478$		$P = .3001$		$P = .2290$	
Social functioning	Allo	72.1	4.4	55.9	4.2	76.3	3.6	85.8	3.6	95.4	3.7	97.2	3.4
(range 0-100)	Auto	70.1	2.5	47.9	2.2	69.9	2.2	78.7	2.2	87.7	2.2	90.3	2.2
		$P = .6828$		$P = .0969$		$P = .1158$		$P = .0912$		$P = .0741$		$P = .0928$	
Pain (range 0-100)	Allo	61.9	4.1	49.4	4.2	74.8	3.4	83.7	3.6	85.5	3.8	91.5	3.4
	Auto	58.5	2.5	33.0	2.2	61.1	2.2	74.4	2.2	80.4	2.2	86.3	2.2
		$P = .4825$		$P = .0006$‡		$P = .0007$‡		$P = .0270$*		$P = .2421$		$P = .2040$	
General health perceptions	Allo	88.6	2.1	85.9	2.8	85.1	2.2	85.4	2.4	84.6	2.5	84.8	2.4
(range 0-100)	Auto	83.0	1.6	82.5	1.5	83.2	1.5	83.5	1.5	86.1	1.5	88.1	1.5
		$P = .0379$*		$P = .2848$		$P = .4750$		$P = .5096$		$P = .6263$		$P = .2415$	

*$P \leq .05$.
†$P < .01$.
‡$P < .001$.

TABLE E3. *Adjusted Mean Scores and Standard Errors (SE) for the McGill Pain Questionnaire Subscales by Surgical Group, From Baseline Through 1 Year*

		Baseline		1-2 Weeks		6 Weeks		3 Months		6 Months		1 Year	
Subscale	Type	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Affective (range of score 0-14)	Allo	5.8	0.29	5.5	0.32	4.9	0.28	4.5	0.27	4.2	0.29	4.5	0.28
	Auto	5.6	0.17	6.0	0.17	4.9	0.17	4.8	0.17	4.5	0.17	4.3	0.18
		$P = .5352$		$P = .1729$		$P = .7872$		$P = .3648$		$P = .4107$		$P = .5770$	
Sensory (range of score 0-12)	Allo	16.2	0.80	17.1	0.95	14.2	0.81	13.1	0.86	92.6	0.93	12.7	0.83
	Auto	16.6	0.55	21.3	0.53	15.4	0.53	14.5	0.54	13.6	0.53	12.8	0.56
		$P = .6670$		$P = .0001$‡		$P = .2165$		$P = .1665$		$P = .3617$		$P = .9409$	
Visual analogue scale (range 0-100)	Allo	27.0	4.65	24.5	4.68	13.9	3.97	11.5	3.90	5.1	4.29	4.5	4.08
	Auto	32.3	3.25	48.8	2.47	25.4	2.55	17.6	2.66	14.3	2.54	11.9	2.61
		$P = .3878$		$P = .0001$‡		$P = .0147$*		$P = .2009$		$P = .0652$		$P = .1258$	
Perceptions of pain intensity (range 0-5)	Allo	1.7	0.21	1.4	0.20	1.2	0.17	0.8	0.17	0.7	0.19	0.4	0.17
	Auto	1.5	0.13	2.2	0.11	1.2	0.11	1.1	0.12	0.9	0.11	0.89	0.12
		$P = .5563$		$P = .0007$†		$P = .7103$		$P = .1425$		$P = .4948$		$P = .0596$	

*$P < .05$.
†$P < .001$.
‡$P < .0001$.

TABLE E4. *Adjusted Mean Scores and Standard Errors (SE) for the Knee Pain Scale by Surgical Group, From Baseline Through 1 Year*

		Baseline			1-2 Weeks			6 Weeks			3 Months			6 Months			1 Year		
Subscale	Type	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE
Frequency of pain-transferring (range of score 1-5)	Allo	37	3.1	0.20	20	2.9	0.19	31	4.2	0.16	28	4.2	0.16	25	4.7	0.17	31	4.8	0.16
	Auto	107	3.4	0.11	79	2.1	0.10	79	3.6	0.10	70	4.1	0.11	77	4.3	0.10	76	4.5	0.10
		$P = .1718$			$P = .0012$†			$P = .0046$†			$P = .4367$			$P = .0977$			$P = .2598$	
Severity of pain transferring (range 1-6)	Allo	37	2.1	0.13	19	2.4	0.12	30	1.5	0.10	28	1.4	0.11	23	1.3	0.11	31	1.2	0.10
	Auto	107	2.0	0.09	74	2.9	0.07	77	1.7	0.06	72	1.5	0.07	77	1.4	0.07	76	1.2	0.10
		$P = .6555$			$P = .0027$†			$P = .0570$			$P = .5737$			$P = .2673$			$P = .5950$	
Frequency of pain ambulation (range 1-5)	Allo	38	2.7	0.23	20	2.8	0.20	31	3.6	0.17	28	4.1	0.18	25	4.6	0.19	32	4.7	0.17
	Auto	107	3.2	0.12	76	2.0	0.11	79	3.2	0.11	71	3.8	0.11	76	4.1	0.11	76	1.3	0.11
		$P = .0438$*			$P = .0053$†			$P = .0393$*			$P = .1135$			$P = .0088$†			$P = .0816$	
Severity of pain transferring (range 1-6)	Allo	36	2.4	0.19	19	2.8	0.15	30	1.9	0.13	28	1.6	0.13	25	1.3	0.13	32	1.2	0.12
	Auto	106	2.2	0.10	70	2.9	0.08	77	2.1	0.08	72	1.7	0.08	76	1.5	0.08	76	1.4	0.08
		$P = .2344$			$P = .1239$			$P = .2428$			$P = .0743$			$P = .0482$*			$P = .0446$*	
Knee problems (range 1-5)	Allo	36	3.3	0.14	20	2.8	0.12	30	3.9	0.10	24	4.2	0.11	25	4.3	0.11	29	4.4	0.11
	Auto	106	3.5	0.07	74	2.1	0.07	78	3.5	0.07	71	4.0	0.07	76	4.2	0.07	74	4.2	0.07
		$P = .2262$			$P = .0002$‡			$P = .0014$†			$P = .0507$			$P = .1546$			$P = .1100$	

*$P \leq .05$.
†$P < .01$.
‡$P < .001$.