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Comparison of Allograft Versus Autograft Anterior Cruciate Ligament Reconstruction Graft Survival in an Active Adolescent Cohort

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Background: Graft selection for anterior cruciate ligament (ACL) reconstructive surgery is a controversial topic. Few studies have compared graft outcomes in adolescents.

Purpose: To identify factors related to ACL graft failure in an adolescent cohort.

Study Design: Case-control study; Level of evidence, 3.

Methods: After institutional review board approval was obtained, adolescent subjects (age range, 11-18 years) who underwent primary ACL reconstruction surgery at a large tertiary pediatric hospital between July 2005 and July 2009 were identified through a query of *International Classification of Diseases, 9th Revision*, diagnostic and Current Procedural Terminology codes. Subject data were obtained by means of a retrospective chart review, phone survey, and the administration of functional knee outcome instruments. A multivariate Cox proportional hazards regression analysis was used to analyze factors related to graft survival.

Results: The average ages at surgery in the allograft (n = 38) and autograft (n = 35) groups were 15.29 ± 2.24 and 15.60 ± 1.57 years, respectively. There were 11 graft failures (28.95%) in the allograft group compared with 4 graft failures (11.43%) in the autograft group. In the multivariate model, graft type (P = .0352) and postoperative knee laxity according to the Lachman test (P = .0217) were the only variables significantly related to graft survival. The hazard of graft failure was 4.4 (95% CI, 1.23-18.89) times greater in the allograft group compared with the autograft group. The hazard of graft failure was 5.28 times (95% CI, 1.1-12.72; P = .0217) greater for a subject who demonstrated increased postoperative knee laxity relative to the contralateral knee. The risk for autograft failure tended to remain constant 24 to 48 months after initial surgery, whereas the risk for allograft failure continued to increase during postoperative months 24 to 48. There were no differences ($P > .05$) between the allograft and autograft groups with respect to International Knee Documentation Committee score, Lysholm score, and the rate of return to previous activity level.

Conclusion: Graft type and postoperative knee laxity were identified as significant predictors of graft survival. On the basis of this large retrospective cohort, we recommend the use of autogenous grafts in children and adolescents undergoing primary, transphyseal ACL reconstruction. Patients who demonstrate increased translation during a postoperative Lachman test should be carefully followed because of concerns for subsequent graft failure.

Keywords: anterior cruciate ligament; allograft; autograft; adolescents; graft survival

Participation in high school athletics has grown by 21% in the past decade.[26] Although encouraging, this growth has been paralleled by an increase in the incidence of athletic injuries. Anterior cruciate ligament (ACL) tears are among the most common sports-related injuries. ACL injuries affect the lives of >175,000 people in the United States each year,[16] and their incidence is highest among female athletes 15 to 24 years of age who participate in sports that require sudden decelerations, landing, and pivoting movements.[2,44]

There are few data related to ACL graft failure rates in adolescent and/or pediatric populations. In the absence of strong evidence in this population, orthopaedic surgeons must determine the optimal graft type on the basis of incorporation rate, material properties, donor site morbidity, graft availability, and cost. The purported advantages of allografts include lack of donor-site morbidity, absence of a size limitation, decreased incidence of postoperative knee stiffness and pain, preservation of the knee extensor or

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flexor mechanisms, decreased operative time (no harvesting time), lower incidence of arthrofibrosis, and improved cosmetic appearance.[17,32,34] The advantages of autografts include strong structural and fixation properties and optimal biologic incorporation.[4,19] Allografts are limited by a slower incorporation rate, risk for disease transmission, increased cost, local bone resorption, graft rejection, limited availability, and compromised material properties due to sterilization and storage procedures.[3,11,17,28] The disadvantages of autografts are specific to the source of tissue and donor-site morbidity. The disadvantages associated with bone–patellar tendon–bone autografts include anterior knee pain, loss of sensation, patellar fracture, inferior patellar contracture, patellar tendon rupture, and loss of extension torque.[10,21,24] For hamstring autografts, the disadvantages include postoperative neuroma and the possibility that the harvested tissue will be insufficient.[32,37]

The majority of studies in the current literature have reported similar clinical outcomes between autografts and allografts.[9] The inclusion of primarily adult subjects in these previous studies, however, limits the generalizability of their results to younger patients. Barrett et al[6] showed that highly active allograft recipients were approximately 2 to 4 times more likely to have failures compared with the failure rate of the lower activity allograft group and all subjects in the autograft group. Singhal et al[40] found that patients <25 years of age had a significantly higher failure rate compared with those >25 years of age (35% vs 13%, $P < .003$). Data from a multicenter longitudinal cohort of ACL reconstructions (the MOON Consortium[20]) revealed that there is a 60% increase in the odds of graft failure (95% CI, 37%-74%; $P < .01$) for every 10-year decrease in patient age. Given differences in the risk for ACL graft failure between older and younger populations and the lack of data regarding graft failure rates among adolescents, the purpose of this retrospective cohort study was to identify factors related to graft failure. On the basis of the adult literature, we hypothesized that allografts would be associated with a significantly higher risk for graft failure than autografts.

MATERIALS AND METHODS

After institutional review board approval was obtained, a query of *International Classification of Diseases, 9th Revision*, diagnostic and Current Procedural Terminology codes was performed to identify all subjects who underwent primary ACL reconstructive surgery at a large tertiary pediatric hospital between July 2005 and July 2009. Study exclusion criteria included the following: non-English-speaking, hybrid graft, congenital ACL deficiency, physeal sparing type reconstruction, and/or surgery performed at an outside institution. Packets containing an informative letter, the Lysholm Knee Scoring Scale, and the International Knee Documentation Committee (IKDC) outcome instrument were mailed to all subjects <19 years of age at the time of surgery who underwent arthroscopic transphyseal ACL reconstruction (Figure 1). The Lysholm knee score (range, 0-100) was chosen for its purported test-retest reliability, internal consistency, and responsiveness.[8] The IKDC instrument is a self-reported questionnaire (score range, 0-100)[18] that has been validated for use with ACL injuries, is considered the gold standard for assessing subjective knee function after ACL reconstruction, and has been identified as the top general quality-of-life instrument for assessing ACL tears, meniscal tears, and osteoarthritis.[41]

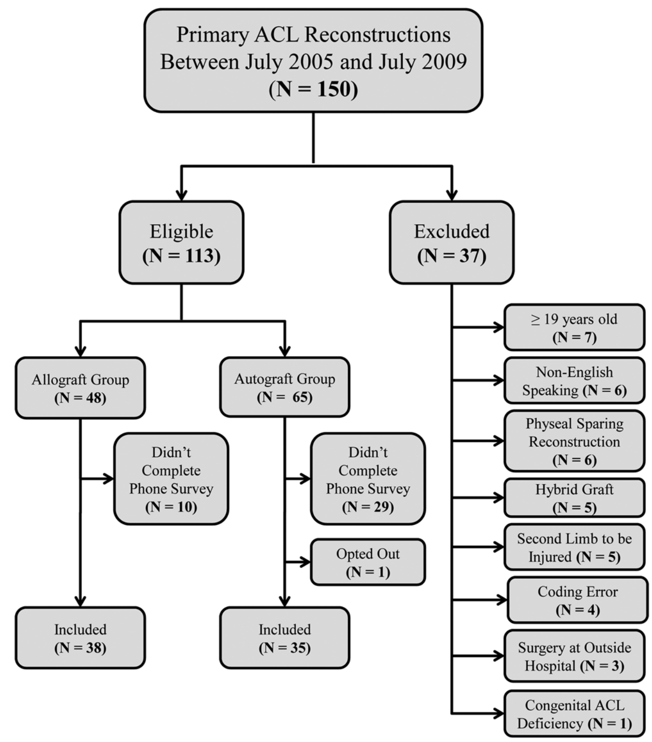

Figure 1. Summary of enrollment. ACL, anterior cruciate ligament.

Subjects' charts and preoperative radiographs were reviewed and the following variables collected: time from initial injury to ACL surgery (acute [<3 months] vs chronic [>3 months]), graft failure, time (in months) to graft

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failure from the date of initial reconstruction, graft type, timing of the initiation of postoperative physical therapy (>2 vs ≤2 weeks after surgery), whether additional procedures were performed during the initial surgery, complications, postoperative knee laxity (Lachman test), postoperative knee flexion and extension range of motion, and skeletal maturity level. Because the postoperative Lachman test results were negative (<5 mm of translation with a solid endpoint) for all subjects, knee laxity was classified according to the IKDC guidelines: normal (<3 mm of translation relative to unaffected knee) versus nearly normal (3-5 mm of translation relative to the unaffected knee). Skeletal maturity level was estimated by reviewing the appearance of the subjects' distal femoral and proximal tibial physes on their preoperative anteroposterior radiographs. Skeletal maturity level was defined as skeletally immature (both physes open at the time of surgery), approaching skeletal maturity (1 physis open at the time of surgery), or skeletally mature (both physes closed at the time of surgery).

Subjects also completed a phone survey that included the following questions: (1) "Have you reinjured your knee to the extent that necessitated medical attention?" (2) "Did you require ACL revision surgery?" and (3) "Have you returned to your presurgery activity level?" Among subjects who tore both ACLs at differing time points (n = 5), only the first limb to be injured was included in the analysis. On the basis of the chart review and phone survey, graft failure was the primary outcome variable of interest. Graft failure was defined as the need for revision ACL surgery and/or magnetic resonance imaging confirmation of ACL graft failure.

For all subjects, graft type selection was based on a combination of patient and/or parent and surgeon preference. The relative strengths and weaknesses associated with the different graft types were carefully explained to each patient and his or her family before a final decision was made. Hamstring tendons were the donor site for all autografts. Allografts were acquired from 4 separate tissue banks, and none were subjected to "high-dose" (>2 Mrad)[42] gamma irradiation as part of the sterilization process. Allografts included anterior tibial (n = 11), posterior tibial (n = 23), or peroneal (n = 4) tendon grafts. Arthroscopically assisted, single-incision ACL reconstruction was performed in all subjects. The femoral tunnel was drilled by using a medial portal technique with the goal of obtaining a femoral tunnel position in the center of the ACL femoral footprint bisecting the anteromedial and posterolateral bundles. The tibial tunnel was drilled by using a standard technique. The tip of the guide was centrally placed within the tibial footprint. The guide was set at 55°, and then the C-arm was used to confirm positioning of the guide pin. The treating surgeon confirmed that the guide pin was posterior to and parallel with the Blumensaat line on the lateral radiograph. All grafts were soft tissue grafts and were secured on the femoral side by using a Biomet ToggleLock device and on the tibial side by using a Biomet Washerlock screw construct. All subjects participated in a standardized, evidenced-based physical therapy supervised postoperative ACL rehabilitation program.[43] The goal of rehabilitation was to improve strength and neuromuscular control and return subjects to their preinjury activity levels.

STATISTICAL METHODS

Descriptive statistics were used to summarize the demographic and clinical characteristics, rates of graft failure, rates of return to previous activity levels, and rates of reinjury necessitating medical attention in the 2 study groups (allograft and autograft). Univariate Cox proportional hazards models were used to explore the relationship between the hazard or risk for graft failure and the following covariates: sex, age at initial surgery, delay in surgery (chronic vs acute), history of knee injury, need for additional surgical procedures during ACL surgery, graft size and initiation of physical therapy (>2 vs ≤2 weeks after surgery). Factors significant at an alpha level of .10 were considered for inclusion in the final multivariate model. A backward selection strategy was then used to eliminate nonsignificant variables. Only variables significant at an alpha level of .05 were included in the final model. The hazard ratio was used to estimate the effect size of all significant variables. Kaplan-Meier curves were used to visually describe graft survival as a function of time from surgery. Chi-square tests were also used to compare postoperative knee laxity, postoperative flexion and extension range of motion, the rate of return to previous activity level, and the reinjury rate in the allograft and autograft groups. The Wilcoxon rank sum test was used to compare group differences in knee outcome scores (Lysholm and IKDC). The functional knee scores obtained from subjects who underwent revision surgery were not included in the analysis because of the potential difficulty in differentiating functional impairments that were related to the initial reconstruction versus those related to the subsequent revision surgery.

RESULTS

The phone survey was completed by 73 of the eligible subjects (65%). The average ages at surgery in the allograft (n = 38) and autograft (n = 35) groups were 15.29 years (range, 11.2-18.7 years) and 15.60 years (range, 12.7-18.6 years), respectively. There were no differences ($P >$ .05) in the demographic and clinical characteristics between the 2 groups (Table 1). However, the duration of follow-up was significantly ($P <$ .0001) longer in the autograft group compared with the allograft group. A summary of all additional procedures that were performed during the primary reconstruction surgical procedures in the 2 groups is described in Table 2. The majority of all procedures (89.19%) were performed by the same sports medicine fellowship–trained orthopaedic surgeon (J.D.P).

Postoperatively, Lachman test results were negative (<5 mm of translation with a solid endpoint) in all patients. However, increased laxity (nearly normal knee laxity), defined as increased translation of the surgically

TABLE 1
Demographic and Clinical Characteristics

Variable	Allograft (n = 38)	Autograft (n = 35)	*P* Value
Age at surgery, mean ± SD, y	15.29 ± 2.25	15.60 ± 1.57	.4973
Graft size, mean ± SD, mm	8.08 ± 0.59	8.17 ± 0.76	.541
Sex, No. (%)			
Male	17 (44.74)	23 (65.71)	.072
Female	21 (55.26)	12 (34.29)	
Skeletal maturity level, No. (%)			
Skeletally immature	9 (23.69)	5 (15.15)	.6466
Approaching skeletal maturity	7 (18.42)	6 (18.18)	
Skeletally mature	22 (57.89)	22 (66.67)	
Delay, No. (%)			
Acute	26 (70.27)	24 (72.73)	.820
Chronic	11 (29.73)	9 (27.27)	
Previous knee injury, No. (%)			
No	36 (94.74)	30 (85.71)	.191
Yes	2 (5.26)	5 (14.29)	
Additional procedures, No. (%)			
No	16 (42.11)	19 (54.29)	.298
Yes	22 (57.89)	17 (45.71)	
Initiation of physical therapy after surgery, No. (%)			
>2 wk	16 (42.11)	18 (51.43)	.50
≤2 wk	22 (57.89)	17 (48.57)	
Follow-up, mean ± SD, mo	32.54 ± 6.70	50.90 ± 10.76	<.0001

TABLE 2
Additional Procedures Performed[a]

Procedures	Allograft	Autograft	*P* Value
Partial lateral meniscectomy	15 (39.47)	10 (28.57)	.3268
Partial medial meniscectomy	9 (23.68)	2 (5.71)	.0320
Lateral meniscal repair	2 (5.26)	3 (8.57)	.5761
Medial meniscal repair	0 (0.00)	1 (2.86)	.4795
Chondroplasty	5 (13.16)	5 (14.29)	>.999

[a]Values are reported as number (percentage). Several subjects underwent multiple additional procedures.

TABLE 3
Knee Functional Outcome Scores[a]

Outcome Score	Allograft	Autograft
IKDC	96 (89-99)	92 (78-98)
Lysholm	91 (85-98)	90 (78-91)

[a]Values are reported as median (interquartile range). IKDC, International Knee Documentation Committee.

repaired knee relative to the contralateral knee, was noted in 10.81% of subjects in the allograft group (n = 37) and 15.63% of subjects in autograft group (n = 32). Additionally, 91.89% and 85.71% of the subjects achieved pain-free, symmetric knee flexion and extension range of motion in the allograft and autograft groups, respectively. Slight hyperextension (< –10°) was noted in 8.57% of patients in the autograft group. Minor range of motion limitations (<10° difference in range of motion between limbs) were noted in 8.11% of subjects in the allograft group compared with 5.71% of the subjects in the autograft group. There was no difference in postoperative knee range of motion (P = .1973) or laxity (P = .5538) between the 2 graft groups.

There were 11 graft failures (28.95%) in the allograft group compared with 4 graft failures (11.43%) in the autograft group. The relative risk for failure to attain one's previous activity level (1.45; 95% CI, 0.63-3.32; P = .3756) as well as the relative risk for reinjury necessitating medical attention (1.71; 95% CI, 0.77-3.79; P = .1738) was higher in the allograft group than the autograft group. However, these differences did not reach statistical significance. Among the grafts that did not fail, there was no difference in IKDC (P = .4817) or Lysholm (P = .4650) scores between the allograft group and the autograft group after surgery. Additional information regarding IKDC and Lysholm scores in the 2 graft groups is displayed in Table 3.

On the basis of the univariate time-to-event analysis, sex (P = .8755), age at initial surgery (P = .9927), history of knee surgery (P = .5830), delay in surgery (P = .1705), graft size (P = .1707), need for additional surgical procedures (P = .7147), need for a medial meniscal procedure (P = .2279), the timing (≤2 vs >2 weeks) of the initiation of physical therapy after surgery (P = .1026), skeletal maturity level (P = .1416), the need for a medial meniscectomy (P = .1533), and postoperative range of motion (P = .9964) were not significantly related to the hazard or risk for graft failure. Postoperative knee laxity and graft type were significantly ($P < .05$) related to the ACL revision surgery rate in both the univariate and multivariate models. After controlling for postoperative laxity, the hazard or risk for revision surgery for a subject in the allograft group was 4.4 (95% CI, 1.23-18.89; P = .0352) times the risk for revision surgery for a subject in the autograft group. In other words, there was an 81% chance that a subject in

TABLE 4
Sources of Allografts Used

Company	n	Failure		Irradiation Technique[42]
		No	Yes	
RTI Biologics Inc (BioCleanse)	26	18	8	None
AlloSource (Sterile R)	10	8	2	Low-dose (<2 Mrad) terminal irradiation
Joint Restoration Foundation[a]	1	1	0	Low-dose (<2 Mrad) terminal irradiation
Musculoskeletal Tissue Foundation	1	0	1	Some grafts pretreated with low-dose irradiation[b]

[a]The Joint Restoration Foundation uses allografts processed by AlloSource or Community Tissue Services, both of which use terminal low-dose irradiation.
[b]Low-dose gamma irradiation (1.2-1.8 Mrad) was used when a high bioburden was believed to exist.

the allograft group would develop a graft failure before a subject in the autograft group. After controlling for graft type, the hazard or risk for graft failure for a subject who demonstrated nearly normal laxity was 5.28 times (95% CI, 1.1-12.72; P = .0217) the risk for revision surgery for a subject who demonstrated normal laxity according to the postoperative Lachman test.

Among allografts, the relationship between graft failure and sterilization technique[42] is described in Table 4. There was no difference (P = .3428) in graft survival between the low-dose (<2 Mrad) gamma-irradiated allografts and the nonirradiated allografts.

Postoperatively, none of subjects included in this cohort developed growth disturbances. Two subjects (5.71%) in the autograft group developed superficial infections that were managed with oral antibiotics on an outpatient basis. None of the subjects in the allograft group developed infections after the index procedure. Among the subjects who underwent revision surgery, 1 subject developed a superficial infection that was managed with oral antibiotics.

DISCUSSION

Graft selection for ACL reconstructive surgery is a controversial topic in the sports medicine community. Within the past 5 years, several systematic reviews[4,9,22,31] have compared autogenous and allogenous grafts on the basis of variables such as instrumented stability, subjective knee function, and risk for rerupture. Despite overlap in the studies included in the reviews, inconsistent findings have been reported. In a meta-analysis related to arthrometric knee stability, Prodromos et al[31] reported a significant ($P < .0001$) difference in the abnormal stability (side-to-side difference >5 mm) rates between allografts (14%) and autografts (5.3%). Using more stringent study inclusion criteria (excluding studies with sample sizes <15 and/or level IV studies), Carey et al[9] reported no difference in the frequency of abnormal stability among allografts and autografts (P = .63). The results actually favored allografts, for which the weighted odds of having abnormal instrumented knee laxity measurements were 1.23 times greater for an autograft (95% CI, 0.52-2.92) compared with those for an allograft.

Depending on the systematic review's inclusion criteria, different estimates regarding the odds of graft failure have also been reported. In a meta-analysis of studies comparing patellar tendon allografts and patellar tendon autografts, Krych et al[22] reported that the odds of failure for an allograft were significantly greater than the odds of failure for an autograft (odds ratio, 5.03; 95% CI, 1.38-18.33). However, when studies that used compromised sterilization processes were excluded,[15] there was no difference in the odds of graft failure ($P > .05$). Carey et al[9] concluded that there was no difference (P = .37) in clinical failure rates between graft types but reported that the weighted odds of graft failure were 39% greater among allografts compared with autografts (odds ratio, 0.61; 95% CI, 0.21-1.79). In relation to self-reported knee function, no significant differences were reported in any of the recent systematic reviews.[9,22]

In our cohort of adolescents, the rate of graft failure or rupture was higher in the allograft group compared with the autograft group (28.95% vs 11.43%). The hazard of graft failure was 4.4 (95% CI, 1.23-18.89; P = .032) times greater among subjects who received allografts compared with subjects who received autografts. Using a similar time-to-event analysis technique, Pallis et al[30] prospectively followed 120 cadets who matriculated into military service with histories of previous ACL reconstructive surgery. After controlling for sex, the hazard of graft failure was 6.7 times greater among cadets who had received allografts compared with autografts during their initial surgery (95% CI, 2.6-17.1; $P < .001$). However, information regarding type(s) of allografts included, allograft sterilization techniques, the graft selection process, and the ages of the subjects at time of initial surgery was not reported.

The Kaplan-Meier survival plot used in the present study provides a unique perspective on the timing of the graft failures between the 2 groups. The risk for autograft failure tended to remain constant 24 to 48 months after initial surgery, whereas the risk for allograft failure continued to increase during postoperative months 24 to 48 (Figure 2). This trend suggests that the autografts primarily failed within 2 years of initial surgery compared with the allografts, which continued to fail 2 years after surgery. Concerns regarding potential deterioration in the stability of allografts over time have been raised in past research.[19,29] On the basis of the histopathologic examination of retrieved whole ACL grafts (9 allografts and 1 autograft), Malinin et al[23] noted that attachment of the graft to

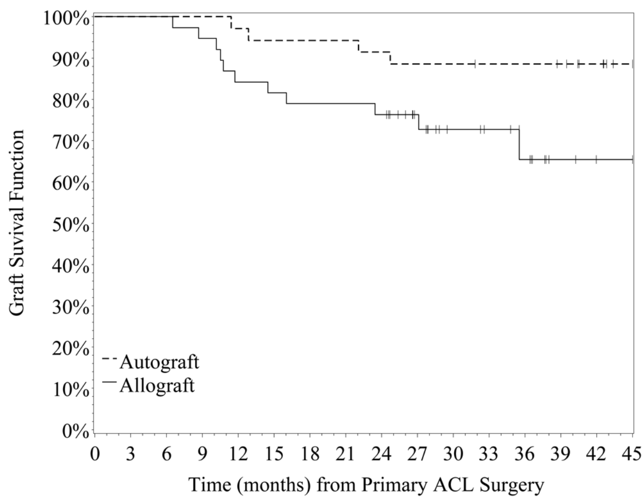

Figure 2. Graft survival in the first 45 months after initial anterior cruciate ligament reconstructive surgery. A vertical tick mark indicates that a subject was censored (lost to follow-up).

the bone tunnel wall may take >2 years. The authors suggested that complete remodeling may take ≥3 years. On the basis of our data alone, it is unclear why the probability of graft survival continued to decrease in the allograft group. This is, however, a factor that should be considered by the surgeon when determining optimal graft type and, equally important, when educating recovering adolescent athletes about the importance of continued participation in preventative rehabilitation training after surgery.

Because the majority of ACL ruptures occur in the athletic population, one of the most important metrics of success after ACL reconstructive surgery is the ability of the patient to return to his or her previous activity level. In previous studies, the Tegner activity level scale has been used to compare pre- and postsurgical activity levels. We were unable to assess presurgery activity levels in this retrospective study and thus used a phone survey to do so. Although nonsignificant (P = .3756), the risk for failure to achieve one's preinjury activity level was 1.45 times greater in the allograft than the autograft group. This finding is consistent with previous literature in which the proportion of subjects able to return to their preinjury activity levels has tended to be higher among autografts compared with allografts.[22] Self-reported knee function scores were very high among subjects who did not require revision surgery. Among all subjects, the median IKDC and Lysholm scores in both groups were ≥90 after surgery.

Reinjury is a common concern among patients undergoing ACL reconstructive surgery. Graft failure rates in the current literature vary widely depending on the age of the subject as well as the types of grafts used, definitions of graft failure, and surgical techniques. Among adult studies that included complete information about the types of grafts used, the rates of reinjury with instability and/or subsequent revision surgery generally range between 0% and 24%[6,33] for allografts and between 0% and 21%[1,15] for autografts. Allograft failure rates as high as 45% have been reported by Gorschewsky et al,[15] but the sterilization procedures used in the aforementioned study (high radiation plus osmotic treatment, oxidation, and solvent drying with acetone) may be related to the elevated failure rate. Among skeletally immature subjects, the rate of graft failure is similar. In a meta-analysis of ACL surgical outcomes among young adolescents and children, the overall, weighted rerupture rate was estimated at 4.8% (95% CI, 2.9%-6.7%).[13] This estimate may be misleading because of the inclusion of physeal-sparing and transphyseal surgical techniques, a wide variety of graft types, as well as subjects who underwent primary reconstruction and reconstruction secondary to nonoperative management. Among the studies that have included results from a minimum of 5 subjects who underwent primary transphyseal reconstructions, the rerupture rates reported range from 0% to 35%[12,38] for allografts and 0% to 14%[7,14] for autografts.

The overall, combined failure and rupture rate in this cohort of adolescent subjects was 20.55%. Postoperatively, the median Tegner activity level among all subjects in our cohort was 7, and thus, the high failure rate may be due to the inclusion of the combination of young and highly active populations, factors that have been associated with increased risk for failure in previous research.[5,6,20,39] Other factors significantly related to graft failure in the current literature include sex[39] and mechanism of initial injury.[36] In this study, other than graft type, the only variable significantly related to graft failure was the results of the postoperative Lachman test. Subjects who demonstrated increased translation relative to their contralateral knees were significantly more likely to require revision surgery. Specific attention should be given to these subjects who exhibit increased laxity during postoperative Lachman examinations. In cases in which instability persists and/or is excessive, the treating surgeon should consider performing repeat magnetic resonance imaging to rule out graft resorption and/or failure.

Among allografts, the sterilization process has also been cited as a potential cause of graft failure.[15,27] In a meta-analysis of knee stability after ACL reconstruction, Prodromos et al[31] reported a significant difference ($P < .0001$) in abnormal stability rates (side-to-side difference > 5 mm) among irradiated (31%) versus nonirradiated allografts (12%). However, conclusions regarding relation between irradiation and knee stability and graft failure are complicated by differences in the irradiation doses that were used in the studies included in this meta-analysis, as well as the lack of studies in the current literature that directly compared graft failure rates between nonirradiated allografts and low-dose irradiated allografts. Furthermore, several studies have provided evidence that there is no difference in graft failure rates between low-dose irradiated allografts and autografts.[33,35] In our study, there was no difference in graft survival between the irradiated and the nonirradiated grafts. Graft failure rates for irradiated (25%) and nonirradiated (31%) grafts were very similar (see Table 4). However, we would like to emphasize the fact the use of numerous tissues banks, different graft types, and small numbers limit the generalizable conclusions that can be drawn from this study about the relationship between irradiation and graft survival.

Overall, the cause of graft failure in our population of young, active athletes was not fully understood. In future research, we aim to study compliance with postoperative rehabilitation recommendations as well as psychological factors, such fear of return to activity, in an effort to better understand the patterns of graft failure in adolescent populations.

The strengths of the present study include large numbers, the inclusion of skeletally immature patients, the use of validated knee outcome instruments, and the limited number of surgeons involved in treatment of the patients included in the cohort. However, this study was not without limitations. Because of the lack of randomization, graft choice in our cohort may have been driven by personality- and lifestyle-related factors that could not be accounted for in this study, such as a preponderance toward risk-taking behavior and/or a desire to return to competition as quickly as possible. The proportion of the eligible subjects who completed the phone survey (65%) was less than ideal. Furthermore, objective measures, such as radiographic assessment of mechanical axis and lower extremity alignment and instrumented joint laxity, were not collected during the pre- and postoperative follow-up visits. Because of the difficulty associated with obtaining objective measures of knee laxity in conscious patients,[25] we do not believe the absence of objective measures of postoperative knee stability to be a major limitation. Finally, the duration of follow-up was significantly longer in the autograft group in than allograft group. Because we only included subjects who completed the phone survey, it is not clear why the duration of follow-up was longer in the autograft group. Assuming that an increased duration of follow-up would tend to bias results toward a higher failure rate in the group with an increased duration of follow-up (autograft group), we do not believe this to be a significant limitation, given that the graft failure rate was significantly lower in the autograft group.

CONCLUSION

In this large cohort of skeletally mature and skeletally immature adolescents, ACL graft survival was significantly related to graft type. Subjects who received allografts were more likely to have graft failure than those receiving autografts (29% vs 11%). We believe that this study supports previously published work suggesting that allograft reconstruction of the ACL in adolescents results in higher rates of graft failure. Therefore, we are in favor of the use of autogenous grafts during primary ACL reconstructions in adolescent populations.

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