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# Patient Outcomes and Predictors of Success After Revision Anterior Cruciate Ligament Reconstruction

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**Background:** Patient outcomes and predictors of success after revision anterior cruciate ligament (ACL) reconstruction are currently limited in the literature. Existing studies either have a small study size or are difficult to interpret because of the multiple surgeons involved in the care of the study sample.

**Purpose:** To determine patient outcomes and predictors of success or failure after a single-stage revision ACL reconstruction by a single fellowship-trained senior surgeon at a single institution.

**Study Design:** Case series; Level of evidence, 4.

**Methods:** A total of 78 patients who underwent revision ACL reconstruction by a single surgeon from 2010 to 2014 were contacted and available for follow-up. The mean time from revision procedure to follow-up was 52 months. Those patients who were able to participate in the study sent in a completed Tegner activity level scale, International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form, and IKDC Current Health Assessment Form. The patients' medical records were also thoroughly reviewed.

**Results:** Five patients had subsequent failure after revision surgery. The median Tegner score was 6 at follow-up, and the mean subjective IKDC score was 72.5. There was no statistically significant difference in outcome scores when comparing revision graft type, body mass index, sex, need for bone grafting, and time from failure to revision. Patients with failures after primary ACL reconstruction secondary to a traumatic event were found to have statistically significantly higher IKDC scores (mean, 76.6) after revision when compared with nontraumatic failures (mean, 67.1), even when controlling for confounders ( $P < .017$ ).

**Conclusion:** Revision ACL reconstruction is effective in improving patient activity levels and satisfaction. However, the subjective IKDC results are quite variable and likely based on multiple factors. Patients with traumatic injuries contributing to graft failure after primary ACL reconstruction had a statistically significantly, although not clinically significant, higher IKDC score after revision surgery compared with nontraumatic failures. These data may be useful when counseling a patient on whether to pursue revision ACL reconstruction surgery.

**Keywords:** anterior cruciate ligament; reconstruction; revision; failure

Anterior cruciate ligament (ACL) reconstruction is one of the most common orthopaedic procedures performed annually.<sup>27</sup> In the United States, approximately 200,000 ACL tears occur each year, with a cost to the health care system of \$1 to \$2 billion.<sup>12,17,26</sup> Primary ACL reconstruction is an effective surgical treatment, with satisfactory or better outcomes in 75% to 97% of patients.<sup>18</sup> However, despite evolved techniques, some studies suggest that up to 23% of these reconstructions may fail.<sup>4</sup> For many of these patients, revision reconstruction is typically recommended.

Outcomes for revision ACL reconstruction have been mixed in the literature. Clinical failures have been

observed in up to 35% of revision patients, with return to preinjury activity level as low as 54% of patients.<sup>5,6,9,28</sup> However, there is evidence to suggest that knee stability comparable with a primary reconstruction can be achieved with revision surgery.<sup>1,13,18,24</sup> Overall, there are limited subjective outcomes in the literature regarding revision ACL reconstruction, with few identifiable risk factors for success or failure. For surgeons treating the patient with a failed primary ACL reconstruction, this information is critical to help select patients for whom a revision ACL reconstruction would be indicated and to manage appropriate expectations of knee function and activity level after revision surgery.

The purposes of this study were to assess patient outcomes of knee function and activity level after revision ACL reconstruction surgery and to identify any particular

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factors that contribute to the success or failure of a single-stage revision ACL reconstruction by a single surgeon.

## METHODS

### Patient Selection

Approval was obtained from our institutional review board to identify and contact the patients who fulfilled the parameters for the study. All patients who underwent revision ACL reconstruction by a single sports medicine fellowship-trained orthopaedic surgeon (T.J.G.) between 1999 and 2012 after a failed primary reconstruction were identified. All patients older than 18 years at the time of follow-up were considered for the study. Included patients had at least 12 months of follow-up after the revision procedure. Patients were excluded if they had more than 1 revision ACL reconstruction on the same knee or if they had combined/multiligament injuries.

A total of 160 consecutive patients were identified. Twenty-three patients were excluded from the study because they had already undergone at least 1 prior revision ACL reconstruction at the time of initial analysis ( $n = 22$ ) or were younger than 18 years at time of follow-up ( $n = 1$ ). The remaining 137 patients were contacted to participate in the study, of whom 78 were able to fulfill all elements of data collection and participation. Five of the 78 who responded were eliminated from the ultimate subjective functional analysis because they had a subsequent revision ACL reconstruction on the same knee. However, they were included in the failure analysis. Patients who consented to participate were asked to complete the Tegner activity level scale, International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form, and IKDC Current Health Assessment Form. The Tegner scale specifically asked patients what their activity level was prior to their initial ACL injury, after their primary ACL reconstruction, and their current activity level after the revision ACL reconstruction procedure. Patients were also asked about any complications after the surgery, including subsequent failure of the reconstruction.

Patient records and radiographs were reviewed. Data, including associated procedures performed at time of revision reconstruction, type of graft utilized, type of graft fixation, use of bone grafting, and meniscal and cartilage status of the knee, were obtained. Other variables, including body mass index (BMI), date of the primary ACL reconstruction, type of primary reconstruction graft, and circumstances of

injury leading to failure of the primary reconstruction were analyzed. Clinical records were reviewed to ascertain whether there was a specific injury causing the failure of the primary ACL reconstruction and, if so, the nature of the injury. Previous radiographs were assessed to analyze initial graft and tunnel placement from the primary ACL reconstruction.

### Surgical Procedure and Rehabilitation

The revision ACL reconstruction technique was dictated by the status of the failed primary reconstruction. A transtibial technique was used if the desired anatomic femoral attachment site could be achieved using this approach. The senior author (T.J.G.) prefers this technique for revision reconstructions using patellar tendon allograft because the transtibial approach typically provides longer femoral tunnels to accommodate the allograft and avoid graft-tunnel mismatch. If the anatomic femoral attachment site could not be satisfactorily reached, an anteromedial or 2-incision approach was then utilized. Radiographs were evaluated to determine whether previous tunnel placement was nonanatomic. In each case, the residual failed graft was debrided. Removal of both femoral and tibial hardware from the primary ACL reconstruction was performed if it interfered with the planned location of the revision graft tunnel.

If the previous tunnel overlapped with the planned revision tunnel, single-stage grafting was used on the tibial and/or femoral tunnels to fill the bony defect with either a biocomposite screw (Milagro screw; DePuy Mitek Inc) or bone graft to allow for independent drilling of the new tunnel in an anatomic location unbiased by the previous tunnel. All procedures were single-stage revision procedures; there was no staged grafting done prior to the definitive revision reconstruction. Fixation of the revision ACL graft was secured with Guardsmen interference (ConMed Inc) or Milagro biocomposite screws. Cycling of the knee was performed to assess graft isometry, and the knee was extended to ensure absence of notch impingement by the revision graft. Lachman testing was also performed to ensure stability prior to wound closure.

The postoperative rehabilitation course is similar to the senior surgeon's rehabilitation protocol after primary ACL reconstruction. In the immediate postoperative period (1-2 weeks after surgery), patients used a continuous passive motion (CPM) machine for at least 10 hours per day, with extension to  $-5^\circ$  and flexion starting at  $30^\circ$  to  $40^\circ$  and increased to  $100^\circ$  over 48 hours, when possible. Patients

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were also given a hinged knee brace and, if an autograft was used, could begin full weightbearing right away. If an allograft was used, patients were kept at partial weightbearing on the operated limb for 6 weeks after surgery, with progression to full weightbearing after this period.

Patients started physical therapy 3 to 5 days after the operation. Physical therapy consisted of exercises designed to strengthen the muscles throughout the leg (particularly quadriceps, hamstring, hip abductors, hip adductors, hip flexors, and calves). Typical exercises consisted of stationary bicycle, stretching exercises, isometric hamstring contractions, isometric quadriceps contractions, and active knee motion between 35° and 90° of motion. Ultimate goals of physical therapy included regaining full muscle strength compared with the contralateral unaffected limb and return to sports-specific training at 4 to 6 months, with the goal of return to sports by 32 to 36 weeks after revision surgery.

### Surveys and Statistical Methods

The Tegner activity level scale and both the IKDC Knee Evaluation and Current Health Assessment were collected at least 1 year postoperatively after revision ACL reconstruction. The Tegner scale was used to assess activity level of the patient prior to the primary ACL injury, after the primary ACL reconstruction, and subsequent to the revision ACL reconstruction. A “10” indicates performing at a national elite level in high-contact sports, and a “0” indicates being on sick leave or disability because of knee problems. The IKDC Knee Evaluation provided a score of 0 to 100 based on patients’ assessment of their knee function. The IKDC Current Health Assessment assesses patients’ overall health and function on a scale of 0 to 100; it was used to evaluate individual patients’ health status and can monitor and compare disease burden.

For data analysis, the Wilcoxon test was used to compare pre- and postoperative Tegner scores. Spearman correlations were used to evaluate the influence of the self-reported outcome on activity level. The Student *t* test and analysis of variance (ANOVA) were used to determine the *P* values for the IKDC score.

Multivariate analysis was also performed to compare the effect of preoperative variables (including whether the initial injury was traumatic, the type of graft used, and sex and age of the patient) on the IKDC score. Confounders were identified by comparing a variable’s univariate regression coefficient with the same variable’s multivariate regression coefficient.<sup>20</sup>

## RESULTS

Seventy-eight patients were able to participate in the study. Five of these patients had a subsequent failure of the revision graft requiring another reconstruction and were excluded from the final activity level statistical analysis (reinjury rate, 6.7%). These patients ranged in age from 21 to 54 years at time of failure and included 3 men and 2 women. Revision grafts utilized in cases with subsequent failure were patellar tendon autograft in 2 patients,

TABLE 1  
Demographic Information<sup>a</sup>

Sex, n	
Male	39
Female	34
Age at revision ACL reconstruction, y	
Mean ± SD	33.4 ± 11.8
Range	17-69
Age at follow-up, y	
Mean ± SD	37.4 ± 12.24
Range	19-72
BMI, kg/m <sup>2</sup> , n (%)	
Normal (<25)	35 (48.7)
Overweight (25-30)	24 (32.9)
Obese (>30)	8 (11.0)
Unknown	6 (8.2)
Follow-up from revision ACL reconstruction, mo,	
mean ± SD	
All patients	51.9 ± 32.4
Male	57.2 ± 32.8
Female	45.6 ± 31.2

<sup>a</sup>ACL, anterior cruciate ligament; BMI, body mass index.

patellar tendon allograft in 2 patients, and Achilles tendon autograft in 1 patient. Two patients had traumatic injuries and 3 patients had nontraumatic injuries at their time of failure. Of the remaining 73 patients, 39 were male and 34 were female. There were 35 right knees and 39 left knees that underwent revision reconstruction. The mean patient age at time of revision was 33.4 years (range, 17-69 years), and the mean age at time of follow-up was 38 years (range, 19-72 years). Height and weight information at time of revision was available for 69 patients. Of these, 35 (48.0%) had a BMI of <25 kg/m<sup>2</sup>, 24 (32.9%) had a BMI between 25 and 30 kg/m<sup>2</sup>, and 8 (11.0%) had a BMI >30 kg/m<sup>2</sup> (Table 1).

The mean time from the original ACL reconstruction to the revision ACL reconstruction was 87 months (range, 7-313 months; median, 73 months). Those without a traumatic injury causing failure of the primary ACL reconstruction had a mean time of 84 months (range, 8-313 months) from the index procedure to the revision procedure. For those with a traumatic injury, the time frame was 89 months (range, 7-281 months). For the 43 patients who suffered a traumatic injury, mean time from the injury to the revision ACL reconstruction was 9.4 months (range, 1-120 months; median, 4.5 months). Those without a traumatic injury had no comparable time frame for analysis. Mean time from revision ACL reconstruction to patient responses to the surveys was 52 months (range, 13-139 months; median, 41 months) (Table 1). There was no significant correlation between the Tegner or IKDC score and time from the primary ACL reconstruction to the revision ACL reconstruction (ie, longer time between primary ACL reconstruction and revision ACL reconstruction showed no difference in outcomes). Graft type during primary and revision ACL reconstruction was assessed and can be seen in Table 2.

Patient activity level was assessed using the Tegner scale. There was a significant difference in Tegner score

TABLE 2  
Primary and Revision ACL Graft Use<sup>a</sup>

	n (%)	Months to Follow-up From Revision ACL Reconstruction, Mean ± SD
Primary ACL Graft Use		
Patellar tendon autograft	26 (35.6)	
Patellar tendon allograft	10 (13.7)	
Hamstring tendon autograft	15 (20.5)	
Hamstring tendon allograft	2 (2.7)	
Posterior tibial tendon allograft	1 (1.4)	
Tibialis anterior allograft	4 (5.5)	
Allograft (unspecified)	5 (6.8)	
Unknown	10 (13.7)	
Revision ACL Graft Use		
Patellar tendon allograft	53 (72.6)	55.3 ± 32.4
Patellar tendon autograft	18 (24.7)	44.9 ± 32.5
Hamstring autograft	2 (2.7)	24.5 ± 12.0

<sup>a</sup>ACL, anterior cruciate ligament.

TABLE 3  
Tegner Scores<sup>a</sup>

	After Primary ACL Reconstruction	After Revision ACL Reconstruction
Preinjury	9	7
Median	7	6
Quartiles (25th-75th percentile)	7-9	5-8
Range	1-10	2-10

<sup>a</sup>ACL, anterior cruciate ligament.

before the original injury (score, 9) and after the first reconstruction (score, 7) ( $P < .001$ ). Similarly there was a significant difference in scores prior to the original injury (score, 9) and after the second reconstruction (score, 6) ( $P < .001$ ). There was also a statistically significant difference in scores after the first reconstruction when compared with those after the second reconstruction ( $P = .0483$ ) (Table 3).

The mean IKDC score after revision ACL reconstruction was 72.5. According to the IKDC grading system originally utilized by Haas et al<sup>16</sup> and later utilized by Griffith et al,<sup>14</sup> 10 patients (12.7%) had an excellent IKDC grade (score, 90-100), 19 (24.1%) had a good IKDC grade (score, 80-90), 26 (32.9%) had a fair IKDC grade (score, 70-80), and 24 (30.4%) had a poor IKDC grade (score, <70). There was no significant difference between male (75.2) and female (69.3) subjective IKDC scores ( $P = .13$ ). There was no statistically significant correlation between BMI and IKDC scores ( $P = .58$ ) (Table 4).

Forty-three patients could attribute a traumatic injury to the failure of their primary ACL reconstruction, meaning there was a discrete event or injury that caused the primary ACL reconstruction to fail. Twenty-eight patients had a nontraumatic failure of their primary ACL reconstruction, meaning there was no specific event that caused the primary ACL reconstruction to fail. In

TABLE 4  
IKDC Scores After Revision ACL Reconstruction<sup>a</sup>

	IKDC Score, Mean ± SD	<i>P</i> Value
All patients (N = 73)	72.5 ± 16.6	
Sex		
Male (n = 39)	75.2 ± 14.7	.13 <sup>d</sup>
Female (n = 34)	69.3 ± 18.3	
BMI <sup>b</sup>		
Normal weight (18-25 kg/m <sup>2</sup> ; n = 35)	73.8 ± 15.0	.58 <sup>e</sup>
Overweight (25-30 kg/m <sup>2</sup> ; n = 24)	73.5 ± 16.3	
Obese (>30 kg/m <sup>2</sup> ; n = 8)	65.2 ± 22.9	
Graft type		
Patellar tendon allograft (n = 53)	73.8 ± 14.6	.22 <sup>d</sup>
Patellar tendon autograft (n = 18)	66.7 ± 21.1	NA
Hamstring autograft (n = 2)	89.7 ± 1.63	
Traumatic injury <sup>c</sup>		
Yes (n = 43)	76.6 ± 15.5	.016 <sup>d</sup>
No (n = 28)	67.1 ± 16.4	
Bone grafting		
None (n = 47)	70.5 ± 15.4	.33 <sup>e</sup>
Tibia (n = 12)	72.6 ± 17.5	
Femur (n = 8)	82.1 ± 15.8	
Both bones (n = 6)	74.9 ± 24.2	
Age group at follow-up		
<30 y (n = 24)	76.5 ± 15.4	.09 <sup>e</sup>
30-50 y (n = 38)	72.6 ± 17.1	
>50 y (n = 11)	63.3 ± 15.1	

<sup>a</sup>ACL, anterior cruciate ligament; BMI, body mass index; IKDC, International Knee Documentation Committee; NA, insufficient data to analyze.

<sup>b</sup>Unknown for 6 patients.

<sup>c</sup>Unknown for 2 patients.

<sup>d</sup>Student *t* test.

<sup>e</sup>Analysis of variance.

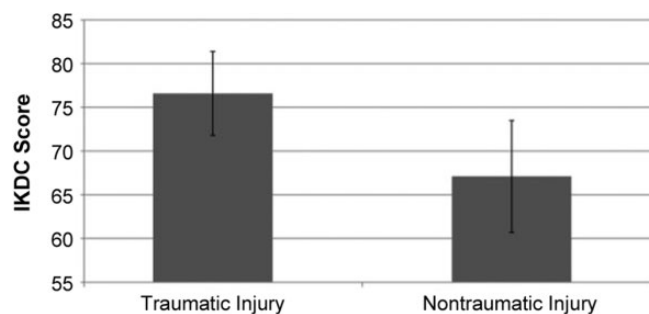


Figure 1. Outcomes of patients after revision anterior cruciate ligament reconstruction based on traumatic versus nontraumatic injury of primary reconstruction. IKDC, International Knee Documentation Committee.

these cases, the patient reported a gradual instability developing in the knee over time. There were 2 patients for whom it was unclear whether there was a traumatic injury based on their records and the patient responses to the questionnaire. Those patients who suffered a traumatic injury that caused their primary ACL reconstruction to fail had a mean IKDC score of 76.6, while those with a nontraumatic failure of their ACL had a mean

TABLE 5  
Multivariate Analysis<sup>a</sup>

	Correlation Coefficient	Standard Error	t Statistic	P Value	Lower 95%	Upper 95%
Intercept	74.66	6.49	11.51	3.11E-17	61.70	87.61
Revision graft (0 = PT Auto, 1 = PT Allo)	13.88	4.24	3.27	.0017	5.40	22.35
Age (current)	-0.54	0.14	-3.78	.00034	-0.82	-0.25
Trauma (1 = yes, 0 = no)	8.38	3.57	2.35	.022	1.27	15.51
Sex (0 = F, 1 = M)	7.02	3.59	1.96	.055	-0.15	14.18

<sup>a</sup>F, female; M, male; PT Allo, patellar tendon allograft; PT Auto, patellar tendon autograft.

score of 67.1, which was statistically significant ( $P < .016$ ) (Table 4 and Figure 1), although since the difference was less than 12 (score, 9.5), it is not considered clinically significant. There was a slight difference in Tegner scores between the 2 groups: The median for those with a traumatic failure was 6, while the median for those without a traumatic injury was 5.5, which did not reach significance.

Using univariate analysis, there was not a significant difference in IKDC score among the different revision graft types after revision ACL reconstruction ( $P < .22$ ). There was also no difference in current Tegner activity level after revision ACL reconstruction: Those who had a patellar tendon allograft had a median level of 6 after their revision procedure, those who had a patellar tendon autograft had a median level of 5.5, and those with a hamstring autograft had a 5.5.

Multiple regression analysis was used to determine whether there was any confounding among the different preoperative variables and to determine whether preoperative variables had greater effect when controlling for confounders.

Using multiple regression analysis, it was found that the type of graft used for the revision ACL reconstruction did have a confounding effect on outcomes for traumatic injury; however, the effect that the traumatic injury had was found to be enhanced (regression coefficient increased from 9.5 to 10.5 when controlling for type of graft). Age, revision graft, and traumatic injury were found to have a significant effect on outcomes when controlling for other factors; sex, however, had no effect on outcomes when controlling for confounders (Table 5).

The senior author (T.J.G.) was the surgeon for the primary ACL reconstruction in 7 of 73 patients in the study. Of those, 4 were considered to have a traumatic failure of their revision ACL reconstruction and 3 had a nontraumatic failure.

During the revision procedure, 79.5% (58/73 patients) concurrently underwent a partial meniscectomy, 52.1% (38/73) underwent chondroplasty, 37.0% (27/73) underwent a revision notchplasty, and 8.2% (6/73) underwent microfracture (Figure 2). These procedures led to no significant difference in either IKDC scores or Tegner scores after the revision ACL reconstruction based on univariate analysis.

Fifty-four patients had range of motion data documented in their records at least 1 year after surgery. Twenty-three patients had  $\geq 140^\circ$  of flexion, 11 had  $135^\circ$

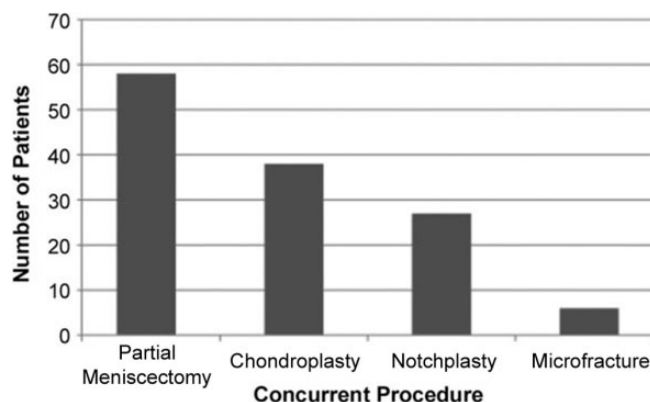


Figure 2. Concurrent procedures with revision anterior cruciate ligament reconstruction.

TABLE 6  
Postoperative Visit Examination Flexion Contractures<sup>a</sup>

Flexion Contracture, deg	No. of Patients (%)
No flexion contracture	48 (89)
3	2 (3.7)
5	2 (3.7)
10	2 (3.7)

<sup>a</sup>Data available for 54 of 73 patients.

of flexion, and 20 patients had  $\leq 130^\circ$  of flexion. Six patients had a flexion contracture at last follow-up visit: 2 patients had a  $3^\circ$  flexion contracture, 2 had a  $5^\circ$  contracture, and 2 had a  $10^\circ$  contracture (Table 6).

## DISCUSSION

The rate of revision ACL reconstruction surgery is likely to continue to increase as the number of primary reconstructions being performed rises.<sup>2</sup> Revision surgery is more technically demanding since the prior graft must be removed, the original tunnels must be considered, removal of hardware is often required, and bone grafting may be necessary.<sup>3</sup> Often, concomitant pathology is also encountered, which must be addressed. These reasons are likely responsible for the inferior outcomes of revision surgery when compared with primary reconstruction.

A retrospective study by Ahn et al<sup>1</sup> examined 55 patients after revision ACL reconstruction with the use of patellar allograft, double-looped semitendinosus and gracilis autograft, and Achilles allograft; the mean IKDC score postoperatively was 84.5 (N = 55; range, 71-94). Another retrospective revision ACL reconstruction study led by Grossman et al<sup>15</sup> reported a mean IKDC score of 84.8 (N = 29; range, 0-100) using bone-patellar tendon-bone (BPTB) allograft, contralateral BPTB autograft, and 1 Achilles allograft. Fox et al<sup>10</sup> reported a mean IKDC score of 71 (N = 32; range, 23-97) after revision reconstruction, suggesting there is variability in subjective outcomes. Moreover, the mean age for the patients in this study was 33 years—slightly older than the mean for the patients in the other studies (31.6 years<sup>1</sup> and 30.2 years<sup>15</sup>) and may have contributed to the relatively low IKDC score in this study. The median Tegner score of 6 after revision ACL reconstruction in this study is in a similar range to other prior studies.<sup>11</sup>

Interestingly, our investigation shows that a traumatic injury of the reconstructed ACL correlated with a statistically significant improvement in the subjective IKDC score after revision when compared with a failed ACL reconstruction without a traumatic cause, even after controlling for age, sex, and graft type. We have found no prior report of this finding in the literature.<sup>11</sup> However, the difference between the 2 groups is only 9.5; a difference of 12 is required to find this result clinically significant.

Prior studies have examined the frequency of traumatic causes of primary ACL reconstruction failure, which have ranged from 30% to 65%; however, we could not find any previous study comparing subjective outcomes between patients who had a traumatic failure of their primary ACL reconstruction and those who did not.<sup>7,19,21-23,25</sup> A statistically significantly higher subjective outcome could be considered slightly counterintuitive in traumatic causes of failure, as there can be primary concomitant damage to articular cartilage and menisci during a traumatic ACL rupture.<sup>19</sup> However, we believe that nontraumatic failures may cause progressive attenuation of surrounding soft tissue constraints in the knee prior to failure, as well as associated articular cartilage and meniscal damage. Further research with a prospective case-control study is warranted to elucidate whether it is reasonable to expect superior outcomes of a revision ACL reconstruction after traumatic cause of failure.

There was more of a mixed picture when examining the difference in outcomes based on the type of graft used. When using univariate analysis for subjective outcomes, there was no significant difference found between patellar tendon autograft, patellar tendon allograft, and hamstring autograft. This is consistent with a prior study by Ahn et al,<sup>1</sup> in which patients had similar postoperative IKDC scores for hamstring autograft, patellar autograft, and Achilles autograft. A literature review by Kamath et al<sup>18</sup> noted that patients had no significant difference in clinical outcomes based on graft type. However, when controlling for traumatic injury and age, the type of graft used is significant (hamstring autograft is superior, followed by patellar tendon allograft and then patellar tendon autograft). Since hamstring autograft was used in only 2 patients in our

study, we cannot draw any conclusions in this regard. A randomized controlled trial in which patients are each placed into different revision grafts would be most effective in determining whether one can expect different clinical outcomes.

Importantly, we found no significant difference in subjective outcomes for patients who underwent concurrent partial meniscectomy, notchplasty, chondroplasty, or microfracture at the time of their revision reconstruction. A prior study by Grossman et al<sup>15</sup> demonstrated worse outcomes after revision ACL reconstruction when there was significant concurrent medial compartment pathology. Another study by Daimantopoulos et al<sup>8</sup> showed patients had a superior IKDC score if patients had no or minor cartilage lesions versus major cartilage lesions. While this is an apparent discrepancy with our study, the severity of the chondral lesions that required chondroplasty in the revision ACL reconstruction is variable and may not have been significant. Moreover, the operative description in the study by Daimantopoulos et al<sup>8</sup> does not indicate that chondroplasty was performed, which may explain the difference in IKDC scores for those with chondral lesions versus those without.

A strength of this study is that all surgeries were performed by a single fellowship-trained senior sports medicine surgeon (T.J.G.) utilizing the same operative approach to bone loss and graft selection. In addition, all patients underwent a standard postoperative rehabilitation protocol. This study size also compares favorably to previous reports in the literature.

Limitations of the study include an effective response rate of 57%. However, the retrospective nature of the study makes it difficult to follow up on patients who may move or otherwise become unavailable years after surgery. As we aimed to assess subjective outcomes after surgery, objective IKDC data or KT-2000 arthrometer testing was not assessed. Another limitation is that there were some data that were unavailable after reviewing our patient records, including the type of graft used for the primary ACL reconstruction in 20.5% of patients, which would have been helpful in evaluating the results.

While the Tegner activity level has a relatively narrow range after revision ACL reconstruction and reflects a relatively advanced level of activity, the subjective IKDC results are more variable. Patients with traumatic injuries contributing to graft failure after primary ACL reconstruction had a statistically significantly higher mean IKDC score after revision surgery based on both a univariate and multivariate analytical approach. Thus, a history of a traumatic injury may be helpful in anticipating postoperative outcomes; in addition, age and graft type may also be helpful, although they were only statistically significant when controlling for confounders. A prospective cohort study that compares those with a traumatic rupture prior to a revision ACL reconstruction and those without a traumatic rupture prior to a revision ACL reconstruction, along with other variables such as graft type, would more clearly elucidate proper expectations for patients. That being said, the results of this study show that excellent patient-reported outcomes can be achieved for revision ACL reconstruction.

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