

Outcomes of Repeat Revision Anterior Cruciate Ligament Reconstruction

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Background: As anterior cruciate ligament (ACL) reconstruction is performed increasingly in the United States, the rate of revision ACL reconstruction continues to rise. A paucity of literature exists with respect to repeat ACL revision surgery.

Purpose: To evaluate the functional outcomes of patients who had undergone at least 2 revision ACL reconstructions.

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

Methods: The records of all patients who had undergone repeat revision ACL reconstructions between 1998 and 2009 were retrospectively reviewed. Data collected included patient demographics, operative findings, pre- and postoperative physical examination findings, radiographs, and Tegner, Lysholm, and International Knee Documentation Committee (IKDC) subjective scores.

Results: Fifteen patients had undergone repeat revision ACL reconstruction during the study period. Mean age was 27 years (range, 18-57 years). Mean follow-up was 5 years (range, 2-10 years). At the time of repeat revision surgery, new tunnels were drilled in 9 of 15 (60%) cases. Of those, 8 of 9 (89%) were drilled because femoral tunnels were deemed “too anterior.” During repeat revision, 11 of 15 (73%) patients were noted to have a meniscal tear, and 9 of 15 (67%) had International Cartilage Repair Society (ICRS) grade 3 or 4 chondral lesions. Mean Lysholm score was 60 preoperatively and increased to 82 postoperatively ($P < .001$). Mean preoperative IKDC score was 59, which increased to 80 postoperatively ($P < .001$). Mean preoperative Tegner score was 6.0. Mean postoperative Tegner score was 4.5, with only 4 of 15 (27%) patients having returned to their prior activity level ($P < .001$). Two patients (13%) sustained a traumatic rerupture. Presence of grade 3 or 4 chondral lesions and body mass index greater than 28 at the time of repeat revision were associated with a “fair” or “poor” outcome by Lysholm score ($P = .007$ and $P = .03$, respectively) and IKDC subjective scoring ($P = .04$ and $P = .007$, respectively).

Conclusion: Repeat revision ACL reconstruction may improve the functional outcomes of patients who have failed revision ACL reconstruction. Most patients do not return to prior activity level following repeat revision. Presence of grade 3 or 4 chondral lesions and body mass index greater than 28 were associated with worse outcomes.

Keywords: knee; ACL; revision; cartilage

Approximately 200,000 anterior cruciate ligament (ACL) ruptures occur in the United States annually, with an incidence of 36.9 per 100,000 person-years.^{14,16} Primary ACL reconstruction is a notably successful procedure, with good to excellent clinical outcomes in 80% to 90% of

patients.^{7,8,12} Failure rates for primary ACL reconstruction, as defined by recurrent laxity or graft failure, have been shown to occur in 7% to 10% of patients.^{6,17,26} Recently, mechanisms of failure for ACL reconstruction have been broadly described in 3 categories: postoperative complications, recurrent instability, and comorbidities associated with patient-specific characteristics or associated knee abnormality, such as meniscal or cartilage lesions and lower extremity malalignment.²²

As ACL reconstructions are increasingly performed in the United States, the rate of revision ACL reconstruction continues to increase. Revision ACL reconstruction is technically challenging. Difficulties and anomalies in tunnel placement, a limited choice of available grafts, and complexity in acquiring stable graft fixation are frequently encountered by arthroscopic surgeons. As a result, multiple studies evaluating revision ACL reconstruction have documented inferior outcomes relative to primary reconstructions, although these same studies have also demonstrated significant improvement with respect to International Knee Documentation Committee (IKDC),

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TABLE 1
Grading the Lysholm Knee Scoring Scale^a

Excellent	90-100
Good	80-89
Fair	70-79
Poor	<70

^aFrom Mitsou et al.²⁵

TABLE 2
Grading the IKDC Subjective Scoring Scale^a

Excellent	90-100
Good	80-89
Fair	70-79
Poor	<70

^aFrom Haas et al.¹⁸

Tegner, and Lysholm scores after revision reconstruction.^{9,13,17} An increased rate of concurrent articular cartilage lesions and meniscal tears has been documented at the time of revision ACL reconstruction surgery.^{1,10} Inferior outcomes are associated with revision ACL reconstruction compared with primary ACL reconstruction, particularly when chondral lesions are found at the time of the revision surgery.^{9,17} The development of posttraumatic arthritis has been associated with chronic ACL deficiency and prior meniscectomy.^{15,27,29} In addition, the development of radiographic arthritis has been correlated with the duration of instability symptoms in the ACL-deficient knee prior to revision reconstruction.⁴

The athlete with an ACL-deficient knee typically has high expectations for return to activity after surgical reconstruction.¹¹ The high numbers of primary ACL reconstruction procedures performed annually coupled with large numbers of patients returning to high-demand sports have resulted in increasing numbers of revision and repeat revision ACL reconstructions. A paucity of literature exists with respect to repeat revision surgery.

The purpose of this study was to evaluate the clinical and functional outcomes of a cohort of patients who underwent a repeat revision ACL reconstruction procedure and to describe the patients' demographics, radiographic outcomes, and associated injuries to the articular cartilage and menisci.

MATERIALS AND METHODS

After approval was gained from our institutional review board, the records of all patients 18 years and older who had undergone repeat revision ACL reconstructions between 1998 and 2009 were retrospectively reviewed. Data collection revealed 1125 primary ACL reconstructions, 96 revision ACL reconstructions, and 18 repeat revision ACL reconstructions performed during the study review period. Three patients who had undergone repeat revision ACL reconstruction were lost to follow-up. The remaining 15 patients had all undergone 3 procedures, including primary, revision, and repeat revision, with the repeat revision being performed by 1 of 2 senior surgeons (D.L.D., M.J.S.). All 15 patients had a minimum of 2 years of clinical and radiographic follow-up.

Revision ACL reconstructions were considered failures if the patient experienced a traumatic rerupture or recurrent instability with laxity on Lachman examination and rotational laxity on pivot-shift testing. Evaluation of our

patient cohort included review of patient demographics, pre- and postoperative physical examination details, and operative findings. We reviewed operative findings including the procedure performed, type of graft and graft fixation used, meniscal and cartilage status, and necessity of additional procedures such as cartilage regeneration procedures, meniscal repair, meniscal debridement, chondroplasty, or osteotomy. Pre- and postoperative imaging studies including standing AP, lateral, and Merchant view radiographs were reviewed and assessed for tibial and femoral tunnel placement according to the criteria of Aglietti et al¹ and for signs of osteoarthritis according to the Kellgren-Lawrence grading scale.^{20,23} Detailed clinical evaluation involved assessment of both pre- and postoperative Tegner, Lysholm, and subjective IKDC outcome scores.^{21,24,30} All scores were assessed pre- and postoperatively relative to the repeat revision ACL reconstruction procedure. Grouping of patient Lysholm scores into the categories *poor*, *fair*, *good*, and *excellent* was performed according to Mitsou et al,²⁵ and grouping of patient IKDC subjective scores into the categories *poor*, *fair*, *good*, and *excellent* was performed according to Haas et al.¹⁸ The status of the articular cartilage at time of diagnostic arthroscopy was graded according to the classification of the International Cartilage Repair Society (ICRS)⁵ (Tables 1 and 2).

Statistical analysis was performed using Fisher exact test (level of significance $P < .05$) for small samples and the Wilcoxon signed rank test for comparison of the pre- and postoperative IKDC subjective and Lysholm classification systems in our patient group. Analyses were performed using JMP statistical software (version 9, SAS Institute Inc, Cary, North Carolina).

RESULTS

No immediate postoperative complications were noted during our study. Fifteen patients had undergone repeat revision ACL reconstruction during the study period. The mean age in our patient cohort was 27 years, with a range from 18 to 57 years of age. There were 8 men and 7 women. The mean follow-up was 5 years, with a range from 2 to 10 years. All repeat revision ACL reconstructions were performed arthroscopically by 1 of 2 senior surgeons (D.L.D., M.J.S.). Two patients required a 2-stage procedure for bone grafting due to tunnel widening: one required isolated tibial tunnel grafting and the second patient required bone grafting of both the femoral and tibial tunnels. Twelve knees were reconstructed with patellar tendon allograft, 2 knees with

semitendinosus and gracilis hamstring autografts (1 with ipsilateral harvest and the other contralateral harvest), and 1 knee with ipsilateral patellar tendon autograft.

The reason for repeat revision ACL reconstruction included traumatic rerupture in 9 patients (60%) and recurrent instability without a definite traumatic event in 6 patients (40%). Of the 9 patients with a traumatic rerupture, 8 had good or excellent results and 1 had fair or poor results according to Lysholm scoring. Of the 6 patients with recurrent instability without trauma, 1 patient sustained good or excellent results and 5 had fair or poor results. Repeat revision ACL reconstruction for recurrent instability was associated with a fair or poor outcome according to Lysholm scores ($P = .011$). According to the IKDC subjective score, of the 9 patients with traumatic rerupture, 8 had good or excellent results and 1 had fair or poor results. Of the 6 patients with recurrent instability, 1 sustained good or excellent results and 5 sustained fair or poor results. Repeat revision ACL reconstruction for recurrent instability was associated with a fair or poor outcome according to the IKDC subjective score ($P = .011$). All results were acquired after the second revision.

In review of concurrent procedures performed, 1 patient required allograft medial collateral ligament (MCL) reconstruction. No patients had significant malalignment requiring osteotomy. At repeat revision, 11 (73%) patients were noted to have a meniscal tear, including 6 patients with isolated medial meniscal tears and 4 patients with isolated lateral meniscal tears (1 patient had both medial and lateral meniscal tears). All meniscal tears were complex or horizontal cleavage type tears that required partial meniscectomy with the exception of 1 vertical longitudinal medial meniscal tear, which was repaired, and 1 complex medial meniscal tear, which required subtotal meniscectomy. Nine (67%) patients were noted to have ICRS grade 3 or 4 chondral lesions at time of diagnostic arthroscopy. Two grade 3 lesions and 1 grade 4 lesion were noted at the lateral femoral condyle. Five grade 3 lesions and 1 grade 4 lesion were noted at the medial femoral condyle. All 9 patients with grade 3 or 4 chondral lesions required chondroplasty. Microfracture was performed for the 2 patients with well-contained grade 4 lesions.

In terms of tunnel placement and fixation, the femoral fixation was accomplished using interference screws in all patients with bone-tendon-bone (BTB) allograft or autograft used for reconstruction. For the 2 patients reconstructed with hamstring tendon autograft, 1 EndoButton (Smith & Nephew, Andover, Massachusetts) and 1 bioabsorbable screw were used for femoral fixation. At the time of repeat revision, new tunnels, either femoral or tibial, were drilled in 9 cases (60%). Three of the 9 patients required both tunnels to be redrilled. The previous femoral tunnel was reused in 6 cases. Femoral tunnel redirecting was required for 9 cases. Of these 9 patients, 8 (89%) had a prior femoral tunnel that was noted to be “too anterior” according to the criteria of Aglietti et al,¹ both on preoperative radiographs and at the time of arthroscopy (Figure 1). The remaining patient’s prior femoral tunnel was noted to be “too posterior” at the time of arthroscopy. All prior femoral hardware was removed with the exception of 1 case, in which a new



Figure 1. Example of “too anterior” femoral tunnel placement noted before repeat revision.

femoral tunnel completely avoided the prior malpositioned tunnel, and a prior interference screw was retained. Tibial fixation was accomplished with interference screw fixation in all patients in whom BTB allograft or autograft was used for reconstruction. For the 2 patients reconstructed with hamstring autograft, 1 patient required a bicortical screw with washer placement whereas the other required use of 1 bicortical screw and washer as well as a bioabsorbable interference screw for fixation. The prior tibial tunnels were reused in 12 cases. The tibial tunnels of the remaining 3 patients that required redrilling were noted to be “too posterior,” each requiring redirecting. All tibial hardware was removed at the time of repeat revision.

Pre- and postoperative Tegner, Lysholm, and subjective IKDC outcome scores were reviewed for our patient cohort. The mean preoperative IKDC score was 59 (interquartile range [IQR], 15). The mean postoperative IKDC score increased to 80 (IQR, 23) at the time of final follow-up ($P = .004$). The mean preoperative Lysholm score was 60 (IQR, 18). The mean postoperative Lysholm score increased to 82 (IQR, 16) at the time of final follow-up ($P = .003$). The mean preinjury and postoperative Tegner scores were 6.0 (IQR, 3) and 4.5 (IQR, 3), respectively ($P = .001$). Only 4 (27%) patients had returned to their prior activity level at final follow-up.

With regard to anterior-posterior and rotational laxity, before surgery, 15 of 15 patients had a 2+ or greater on Lachman examination. At latest follow-up, after repeat

TABLE 3
Clinical Outcome Grades for All Patients (N = 15)
According to Lysholm Knee Scores^a

	Excellent or Good	Fair or Poor	P Value ^b
Body mass index			
<28	7	3	
>28	0	5	.03
ICRS grade			
0-2 lesions	6	0	
3 or 4 lesions	2	7	.007
Meniscal tear			
Present	4	7	
Absent	3	1	.28

^aICRS, International Cartilage Repair Society Grading.

^bSignificant P value <.05.

TABLE 4
Clinical Outcome Grades for All Patients (N = 15)
According to IKDC Subjective Knee Scores^a

	Excellent or Good	Fair or Poor	P Value ^b
Body mass index			
<28	8	2	
>28	0	5	.007
ICRS grade			
0-2 lesions	5	1	
3 or 4 lesions	2	7	.04
Meniscal tear			
Present	4	7	
Absent	3	1	.28

^aICRS, International Cartilage Repair Society Grading.

^bSignificant P value <.05.

revision, 12 of 15 patients had a negative Lachman score ($P < .001$). Before surgery, 15 of 15 patients had a positive, 2+ pivot-shift test. At latest follow-up, after repeat revision, 11 of 15 had a negative pivot-shift test ($P = .009$).

Body mass index was reviewed for each patient at the time of presentation for surgery. The average BMI in our patient cohort was 27.3, with a range of 21 to 35. Five patients in our cohort had a BMI greater than 28, and 10 patients had a BMI less than 28. According to Lysholm scoring, all 5 patients with a BMI greater than 28 had fair or poor results. Of the 10 patients with BMI less than 28, 7 had good or excellent results and 3 had fair or poor results. According to IKDC subjective scoring, all 5 patients with a BMI greater than 28 had fair or poor results, and of the 10 patients with BMI less than 28, 8 had good or excellent results and 2 had fair or poor results. Therefore, BMI greater than 28 was associated with a fair or poor clinical outcome according to both Lysholm ($P = .03$) and IKDC ($P = .007$) scoring systems.

Radiographs for each patient were reviewed preoperatively before repeat revision reconstruction and postoperatively after repeat reconstruction at final follow-up. Preoperatively, at the time of clinical presentation for repeat revision ACL reconstruction, 5 patients in our cohort had, according to the Kellgren-Lawrence grading system, grade 2 tibiofemoral osteoarthritic changes. Three of these patients had concurrent grade 2 patellofemoral osteoarthritic changes. The remaining 10 patients had grade 1 tibiofemoral and patellofemoral changes. Postoperatively, at the time of final follow-up, 4 patients had Kellgren-Lawrence grade 2, 3 patients had grade 3, and 2 patients had grade 4 tibiofemoral osteoarthritic changes. All 3 patients with grade 2 tibiofemoral changes had concurrent grade 2 patellofemoral changes. The 2 patients with postoperative grade 4 tibiofemoral changes had concurrent grade 2 patellofemoral osteoarthritic changes. Nine of 15 (60%) patients in our cohort experienced a progression in radiographic osteoarthritic changes in either the medial or lateral tibiofemoral compartment at an average follow-up of 5 years. Of these 9 patients, 6 had required a partial meniscectomy and 1 had undergone a subtotal meniscectomy in the corresponding osteoarthritic compartment at the time

of repeat revision. No statistical association, however, between meniscectomy and a progression in radiographic tibiofemoral osteoarthritic grade was noted ($P = .38$). Six of the 9 patients with an increase in radiographic osteoarthritic changes were noted to have grade 3 or 4 chondral lesions in the corresponding compartment noted at the time diagnostic arthroscopy and repeat revision ACL reconstruction. No statistical association was noted between recognition of grade 3 or 4 chondral lesions at the time of surgery and an increase in radiographic tibiofemoral osteoarthritic grade at the time of follow-up ($P = .62$). At final follow-up, tunnel placement assessment revealed correct positioning of both femoral and tibial tunnels on the radiographs of all 15 patients as according to the criteria of Aglietti et al.¹

Of the 9 patients with ICRS grade 3 or 4 chondral lesions at the time of repeat revision, 7 had fair or poor results and 2 had good or excellent results according to Lysholm scoring. All 6 patients with cartilage lesions grade 2 or less sustained good or excellent results. According to the IKDC subjective score, of the 9 patients with grade 3 or 4 cartilage lesions, 7 had fair or poor results and 2 had good or excellent results. Of the 6 patients with grade 2 or less cartilage lesions, 5 sustained good or excellent results and 1 sustained fair results. Grade 3 or 4 lesions were associated with fair or poor outcome according to the Lysholm score ($P = .007$), and they were also associated with a fair or poor outcome according to the IKDC subjective score ($P = .04$).

Of the 11 patients with at least 1 meniscal tear discovered at the time of repeat revision, 7 had fair or poor results and 4 had good or excellent results according to both the Lysholm score and the IKDC subjective score. Of the 4 patients without a meniscal tear, 1 had fair or poor results and 3 had good or excellent results according to the Lysholm score and IKDC subjective score. No statistical association was found between meniscal tears and outcomes according to Lysholm or IKDC subjective scoring ($P = .28$ and $P = .28$, respectively). In our patient cohort, 9 patients sustained both a meniscal tear and a grade 3 or 4 cartilage lesion in the same compartment of the knee. Notably, all 9 patients with a grade 3 or 4 cartilage lesion had a meniscal tear within the corresponding knee

compartment. Two patients had a meniscal tear with grade 2 or less cartilage lesion in the same compartment, and 4 patients had no meniscal tear and a grade 2 or less cartilage lesion. A meniscal tear was associated with grade 3 or 4 cartilage lesion in the same compartment of the knee at the time of arthroscopy ($P < .01$) (Tables 3 and 4).

Two patients (13%) sustained a traumatic rerupture of their graft after repeat revision ACL reconstruction. One patient, a 35-year-old man with a postoperative Tegner score of 3, sustained a traumatic twisting injury causing a recurrent ACL rupture 36 months after repeat revision and elected to proceed with nonoperative management. The other patient, a 30-year-old man with a postoperative Tegner score of 4, sustained a traumatic injury 55 months after surgery and elected to undergo a third revision ACL reconstruction.

DISCUSSION

In our study, 15 patients had undergone repeat revision ACL reconstruction over an 11-year period. Mean Lysholm and IKDC subjective scores increased significantly after repeat revision surgery. In contrast, mean Tegner scores were reduced postoperatively, with most patients not returning to their prior activity level. The presence of grade 3 or 4 chondral lesions and BMI greater than 28 at the time of repeat revision were associated with a fair or poor outcome by Lysholm and IKDC subjective scores.

There are multiple limitations to our study. First, this is a retrospective review that contains a relatively small cohort of patients. However, repeat revision ACL reconstruction is a relatively uncommon procedure, and to our knowledge this is the largest series of clinical outcomes of this procedure reported in the literature. Second, no control group of patients was studied to compare results of nonsurgical treatment with results of the index procedure. Finally, 2 surgeons performed the repeat revision ACL reconstructions during an 11-year period.

Failures of primary ACL reconstruction have been documented in the literature as occurring in 7% to 10% of patients.^{6,17,26} Most published studies of revision reconstruction report higher failure rates and inferior results when compared with primary ACL reconstruction.¹⁹ Noyes and Barber-Westin²⁶ in 2001 reported a graft failure rate of 24% in their revision ACL reconstruction population, compared with a 7% failure rate in patients undergoing primary ACL reconstruction. Wegrzyn et al,³¹ however, in a study of 10 patients with repeat revision ACL reconstruction, the only published study of repeat revision ACL reconstruction of which we are aware, observed no failures with an average of 3 years of follow-up. Our study found a failure rate of 13% by traumatic graft reruptures. It is important to note that the 2 reruptures in our study occurred at 3 to 5 years after repeat revision ACL reconstruction.

In terms of clinical outcomes of revision ACL reconstruction, prior studies have documented inferior outcomes relative to primary reconstructions yet have shown significant

improvement with respect to IKDC subjective, Lysholm, and Tegner scoring.¹³ Grossman et al¹⁷ reported mean post-revision ACL reconstruction Lysholm, Tegner, and subjective IKDC scores of 86.6, 11.86, and 85.86, respectively, with 3- to 9-year follow-up. In a series by Bach,³ 87% of patients who underwent revision ACL reconstruction were either mostly or completely satisfied with their clinical results. However, at only 1 year of follow-up, based on age- and sex-matched controls, Harilainen and Sandelin¹⁹ reported a statistically significant inferiority of revision ACL reconstruction compared with primary ACL reconstruction with respect to Lysholm scores. Wegrzyn et al,³¹ in the above-noted study of 10 patients with repeat revision ACL reconstruction, observed that 70% of patients had good/excellent results based on IKDC assessment. In our study, 47% and 60% of patients had good/excellent results postoperatively according to Lysholm and IKDC subjective results, respectively. We also found a statistically significant improvement in IKDC and Lysholm scores in our 15-patient cohort at an average of 5 years of follow-up. In contrast, our mean preinjury Tegner score of 6.0 was reduced to 4.5, with only 4 of the 15 (27%) patients in our study returning to their prior activity level by final follow-up. Most patients in our study, at final follow-up, stated that they had elected to restrict their activities after undergoing repeat revision surgery, regardless of their clinical outcomes, which may account for the decreased activity level.

Multiple prior studies have displayed an increased rate of concurrent meniscal tears and articular cartilage lesions during revision ACL reconstruction.^{2,10} Inferior outcomes have been demonstrated in patients undergoing revision ACL reconstruction with either chondral lesions or meniscal tears treated at the time of revision.^{9,17} Grossman et al¹⁷ found that lower subjective and objective IKDC scores were attained in patients who had undergone meniscectomy or were found to have significant cartilage damage in conjunction with a revision ACL reconstruction. Wegrzyn et al³¹ demonstrated statistically significantly poorer IKDC outcome scores in their group of 10 patients with severe articular cartilage degeneration who underwent repeat revision ACL reconstruction. In our study, ICRS grade 3 or 4 cartilage lesions were statistically associated with fair or poor clinical outcomes according to both Lysholm and IKDC subjective scores.

Salmon et al²⁸ in 2006 noted a correlation between chondral lesions seen at the time of revision surgery and degenerative changes seen at 5- to 9-year follow-up. Recurrent instability in the presence of ACL deficiency and prior meniscectomy have also been associated with early degenerative knee changes in multiple studies.^{15,27,29} Furthermore, a correlation between the development of radiographic arthritis and the duration of instability symptoms before revision reconstruction has been demonstrated.⁴ In our series, we found that 60% of our patients had an increase in osteoarthritic changes according to the Kellgren-Lawrence grading system upon final follow-up. However, we were unable to demonstrate statistical correlation between the development of osteoarthritic changes and

either partial meniscectomy or grade 3 or 4 cartilage lesions documented at the time of repeat revision. This may have manifested in longer term follow-up.

In conclusion, repeat revision ACL reconstruction, according to Lysholm and IKDC subjective scoring, was found to improve the clinical outcomes in our cohort of 15 patients who had failed revision ACL reconstruction. Most patients in our study, however, did not return to their prior activity level following repeat revision. The presence of grade 3 or 4 chondral lesions and a BMI greater than 28 were associated with worse functional outcomes.

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