

Anterior Cruciate Ligament Revision Reconstruction

Two-Year Results From the MOON Cohort

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INTRODUCTION

Anterior cruciate ligament (ACL) reconstruction is a common procedure in the United States. Data from approximately 10 years ago estimated 100,000 ACL reconstructions per year were performed in this country. Since then, it can be assumed that this number has continued to grow. Data from the American Board of Orthopaedic Surgery demonstrate ACL reconstruction continues to be listed as one of the top 10 most commonly performed procedures by board certification applicants.⁴ Although primary ACL reconstructions generally are a highly successful procedure, ACL grafts rupture at a rate of at least 3%, and this rate can be as high as 10% to 20% according

to some studies.^{14,21} Thus, several thousand revision ACL reconstructions are performed each year. This number will continue to rise as patients' expectations to maintain a healthy active lifestyle later in life continue to increase.

Unfortunately, it has been demonstrated in several studies that revision ACL reconstructions do not approach the success of primary ACL reconstructions.^{5,6,11,12,17} A variety of reasons may contribute to this decreased success. These may include impaired tunnel location and increased chondral and meniscal damage, as well as associated laxities and instabilities not addressed at the primary reconstruction.^{5,16} Given the relative rarity of ACL revision reconstructions, the ability to perform rigorous studies with adequate sample size is difficult; hence, high-level evidence in this area has yet to accumulate. While some studies have been performed prospectively, the majority of studies are retrospective case series.^{5,11-13} In addition, relatively few studies have used modern validated patient-based instruments as outcome measures, relying instead on physical measures of stability as the benchmark for a good outcome.^{1,3,5}

This study represents the subset of revision ACL reconstructions enrolled in the first year (2002) of the Multicenter Orthopaedic Outcome Network (MOON) cohort study for which 2 years of follow-up are available. The primary outcomes of the study were reoperation within 2 years following ACL revision reconstruction and health-related quality of life as measured by the Short Form-36 Health Survey (SF-36).

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MATERIALS AND METHODS

The MOON consortium, which is funded by the National Institutes of Health, is a hypothesis-driven, multicenter prospective cohort study of patients undergoing ACL reconstruction. Patient enrollment in the MOON cohort study began after all of the six participating centers (Washington University, St Louis, Mo; Vanderbilt University Sports Medicine, Nashville, Tenn; Cleveland Clinic Foundation, Cleveland, Ohio; Ohio State University, Columbus, Ohio; University of Iowa, Iowa City, Iowa; and the Hospital for Special Surgery, New York, NY) received institutional review board approval. All patients at the six centers who underwent ACL reconstruction by eight physicians (R.W.W., K.P.S., C.C.K., E.C.M., A.A., R.D.P., J.T.A., and R.G.M.) were enrolled. A prospective longitudinal cohort design was established to determine the demographics, associated injuries, and outcome of revision ACL reconstruction.

Patients completed a preoperative questionnaire documenting demographics, injury mechanism, patient-based outcome measures, history of previous surgery, and activity level. Surgeons completed a form documenting examination under anesthesia and the status and treatment of meniscus and articular cartilage injuries. The details of ACL reconstruction and rehabilitation milestones were recorded. A variety of techniques were used by the surgeons. These techniques included ipsilateral and contralateral autograft, Achilles, patellar tendon, and soft-tissue allograft. More detailed description of the surgeon documentation has been detailed previously.¹⁵ This study evaluates the results of revision ACL reconstruction as measured by reoperation and the SF-36 after a minimum follow-up of 2 years.

RESULTS

Between January 1, 2001 and December 31, 2001, a total of 47 revision ACL reconstructions were enrolled in the MOON prospective longitudinal cohort. Mean patient age was 28.9 years (range: 17 to 49 years). There were 33 (70%) men and 14 (30%) women. Thirty-nine (83%) patients (29 men and 10 women) were available for a minimum follow-up of 2 years.

Meniscus Tears

Medial Meniscus Tears. At surgery, 22 of the 47 patients had medial meniscus tears. Five tears required no treatment, 14 tears were treated with partial meniscectomy, 2 tears were repaired, and 1 tear was managed by meniscal transplant.

Lateral Meniscus Tears. Twenty-four lateral meniscus tears were noted for the 47 patients. Eleven tears required no treatment, 11 tears were treated with partial meniscectomy, 1 tear was repaired, and 1 tear was managed by meniscal transplant.

Chondral Lesions

Medial Femoral Condyle and Tibial Plateau Lesions. There were 22 medial femoral condyle chondral lesions. Using the modified Outerbridge classification system, 3 were grade I, 15 were grade II, 2 were grade III, and 2 were grade IV. The 2 grade IV lesions were treated; 1 lesion was treated with abrasion arthroplasty, and 1 lesion was treated with microfracture. Seven medial tibial plateau chondral lesions were noted; of these, 6 were grade II lesions and 1 was a grade III lesion.

Lateral Femoral Condyle and Tibial Plateau Lesions. Twenty-one lateral femoral condyle chondral lesions were noted. Four were grade I, 8 were grade II, 6 were grade III, and 3 were grade IV. The 3 grade IV lesions were treated; 2 lesions were treated with microfracture, and 1 was treated with osteochondral autografting. Eleven lateral tibial plateau lesions were noted; of these, 2 were grade I, 7 were grade II, and 2 were grade III.

Other Lesions. Fifteen trochlear groove chondral lesions were noted; of these, 10 were grade II, 3 were grade III, and 2 were grade IV. Sixteen patella chondral lesions were noted; of these, 13 were grade II and 3 were grade III.

Reoperations

Reoperation was determined for the 39 patients with 2 years of follow-up. Six (15.4%) patients underwent additional surgery: four for arthroscopic debridement and two for repeat revision ACL reconstruction. Of the six patients, three underwent a second operation including two repeat arthroscopic debridements and one of the previous revision reconstruction patients underwent repeat revision ACL reconstruction. Two patients underwent a third reoperation within the first 2 years, which consisted of arthroscopic debridement. Four (10.3%) patients underwent contralateral primary ACL reconstruction.

SF-36 Scores

The SF-36 has eight subscales (Table 1). Two subscales comprise a physical component (body pain and physical function), and two subscales comprise a mental component (mental health and vitality) (Table 2). For the mental component, differences in the preoperative and 2-year follow-up scores were not statistically significant. For the physical component, the 2-year follow-up scores were significantly higher than the preoperative scores. One other subscale, the role physical subscale, demonstrated an increase >10 points from preoperative to 2-year follow-up scores.

DISCUSSION

This study represents one of the few prospectively enrolled ACL revision reconstruction cohorts. We focused on two measures of outcome for our patients: reoperation

TABLE 1

MEAN PREOPERATIVE AND 2-YEAR FOLLOW-UP SF-36 SUBSCALE SCORES OF PATIENTS WHO UNDERWENT REVISION ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

Subscale	Mean Score	
	Preoperative	2-Year Follow-up
Body pain	54.13	64.67
General health	81.17	77.67
Mental health	73.44	73.49
Physical function	55.9	76.54
Role emotional	76.32	81.2
Role physical	48.03	67.31
Social function	73.08	81.09
Vitality	58.63	59.36

and SF-36 scores. Six (15.4%) of 39 patients needed reoperation following revision ACL reconstruction; this included 2 (5.1%) of 39 patients who underwent repeat revision ACL reconstruction. The SF-36 scores demonstrated significant improvements in the physical component but minimal impact on the mental component aspects.

This study represents the first revision ACL reconstruction study that has used the SF-36 pre- and postoperatively. The SF-36 is a generic measure of health status used in a variety of situations^{7,8,10,18,19}; it is not musculo-skeletal-specific. The designers of the instrument developed normative based scoring so that a score of 50 with a standard deviation of 10 would be equivalent to the health of the average US population. Our study demonstrated the mental component remained stable from preoperatively to postoperatively with scores above the average US population (Table 1). The two subscales that comprise the physical component scores increased significantly from pre- to postoperatively, with each subscale demonstrating an increase >10 points at 2-year follow-up (body pain score = 13 and physical function = 20) (Table 1).

Previously, Fox et al³ evaluated their nonirradiated patellar tendon allograft revision ACL reconstruction outcomes using the SF-12. No preoperative scores were presented, but the postoperative scores averaged 48 for the physical component and 55 for the mental component. Colosimo et al¹ described the use of the SF-36 in their evaluation of reharvest of ipsilateral patellar tendon autograft for ACL revision reconstruction. The authors did not present numerical data but stated that all but one patient scored in the range of the average normal US population.

Previous studies have used the SF-36 to evaluate the results of primary ACL reconstruction.^{2,9,20} The values we obtained in our revision study for SF-36 outcomes compare unfavorably to the results seen in these studies. Wexler

TABLE 2

MEAN PREOPERATIVE AND 2-YEAR FOLLOW-UP SF-36 PHYSICAL AND MENTAL COMPONENT SCORES OF PATIENTS WHO UNDERWENT REVISION ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

Component and Subscale	Mean Score	
	Preoperative	2-Year Follow-up
Physical components		
Body pain	54.13	64.67
Physical function	55.90	76.54
Mental components		
Mental health	73.44	73.49
Vitality	58.63	59.36

et al,²⁰ in a group of workers' compensation patients who underwent primary ACL reconstruction, demonstrated body pain and physical function scores of 74.86 and 88.33, respectively, compared to our corresponding values of 64.67 and 76.54. Mental component scores for mental health and vitality demonstrated less difference and were 66 and 64, respectively, compared to our corresponding values of 73 and 59. McAllister et al,⁹ in a group of elite collegiate athletes, demonstrated physical component scores of 91 and 87 for physical function and body pain. Mental component scores in their study were 79 and 68 for mental health and vitality.

Our failure rate as demonstrated by reoperation for repeat revision ACL reconstruction was 5.1% (3 revisions in 2 patients) for 39 patients. This represents an increase over our cohort's primary ACL graft rupture rate of 3%.²¹ Previous studies using a variety of outcome measures both more and less stringent than repeat revision ACL reconstruction as a measure of failure have demonstrated rates ranging from 3% to 35%.^{1,3,13,17} We believe the wide disparity in results represents both the difference in determining failures and a multitude of associated diagnoses that can contribute to the outcome of a revision ACL reconstruction. Our determination of failure as the need for repeat revision ACL reconstruction represents a functional failure but may underrepresent failed reconstructions by not including patients who choose not to go through additional surgery and those who may have instability not determined by our study design.

Our study has strengths and a few weaknesses. The results are generalizable to the sports medicine community by nature of its multicenter, multisurgeon approach. The findings represent a variety of techniques and approaches to revision ACL reconstruction. The study design is a prospective, longitudinal cohort, which epidemiologists believe is the best approach for a clinical question that is not appropriate for a randomized clinical trial. The pro-

spective nature of the study with preoperatively obtained patient-based outcome measures is a significant strength of the study. In addition, our follow-up of 83% at 2 years represents a minimal attrition bias. Weaknesses include a relatively small number of patients in the initial stages of the MOON cohort. Thus, the ability to do multifactorial analysis of the predictors of failure and decreased outcome are unable to be performed given the small number of patients. Additional years with additional patient accrual will allow this to be performed in the future.

This study with a prospective design and a high level of follow-up allows evidence-based counseling of our patients undergoing ACL revision reconstruction. Based on our study, we can advise patients they are at a 15% risk for additional surgery following revision ACL reconstruction. In addition, they can expect a significant improvement in the physical component of their general health as measured by the SF-36. Future studies need to include a greater number of patients to better analyze predictors of failure and decreased outcome.

REFERENCES

- Colosimo AJ, Heidt RS Jr, Traub JA, Carlonas RL. Revision anterior cruciate ligament reconstruction with a reharvested ipsilateral patellar tendon. *Am J Sports Med.* 2001;29:746-750.
- Ferrari JD, Bach BR Jr, Bush-Joseph CA, Wang T, Bojchuk J. Anterior cruciate ligament reconstruction in men and women: an outcome analysis comparing gender. *Arthroscopy.* 2001;17:588-596.
- Fox JA, Pierce M, Bojchuk J, Hayden J, Bush-Joseph CA, Bach BR Jr. Revision anterior cruciate ligament reconstruction with nonirradiated fresh-frozen patellar tendon allograft. *Arthroscopy.* 2004;20:787-794.
- Garrett WE Jr, Swiontkowski MF, Weinstein JN, et al. American Board of Orthopaedic Surgery Practice of the Orthopaedic Surgeon: part-II, certification examination case mix. *J Bone Joint Surg Am.* 2006;88:660-667.
- George MS, Dunn WR, Spindler KP. Current concepts review: revision anterior cruciate ligament reconstruction. *Am J Sports Med.* 2006;34:2026-2037.
- Johnson DL, Swenson TM, Irgang JJ, Fu FH, Harner CD. Revision anterior cruciate ligament surgery: experience from Pittsburgh. *Clin Orthop Relat Res.* 1996;325:100-109.
- Keller SD, Ware JE Jr, Hatoum HT, Kong SX. The SF-36 Arthritis-Specific Health Index (ASHI), II: tests of validity in four clinical trials. *Med Care.* 1999;37(5 suppl):MS51-60.
- Kosinski M, Keller SD, Hatoum HT, Kong SX, Ware JE Jr. The SF-36 Health Survey as a generic outcome measure in clinical trials of patients with osteoarthritis and rheumatoid arthritis: tests of data quality, scaling assumptions and score reliability. *Med Care.* 1999;37(5 suppl):MS10-22.
- McAllister DR, Tsai AM, Dragoo JL, et al. Knee function after anterior cruciate ligament injury in elite collegiate athletes. *Am J Sports Med.* 2003;31:560-563.
- McHorney CA, Ware JE Jr, Lu JF, Sherbourne CD. The MOS 36-item Short-Form Health Survey (SF-36), III: tests of data quality, scaling assumptions, and reliability across diverse patient groups. *Med Care.* 1994;32:40-66.
- Noyes FR, Barber-Westin SD. Anterior cruciate ligament revision reconstruction: results using a quadriceps tendon-patellar bone autograft. *Am J Sports Med.* 2006;34:553-564.
- Noyes FR, Barber-Westin SD. Revision anterior cruciate ligament reconstruction using a 2-stage technique with bone grafting of the tibial tunnel. *Am J Sports Med.* 2006;34:678-679.
- Salmon LJ, Pinczewski LA, Russell VJ, Refshauge K. Revision anterior cruciate ligament reconstruction with hamstring tendon autograft: 5- to 9-year follow-up. *Am J Sports Med.* 2006;34:1604-1614.
- Spindler KP, Kuhn JE, Freedman KB, Matthews CE, Dittus RS, Harrell FE Jr. Anterior cruciate ligament reconstruction autograft choice: bone-tendon-bone versus hamstring: does it really matter? A systematic review. *Am J Sports Med.* 2004;32:1986-1995.
- Spindler KP, Warren TA, Callison JC Jr, Secic M, Fleisch SB, Wright RW. Clinical outcome at a minimum of five years after reconstruction on the anterior cruciate ligament. *J Bone Joint Surg Am.* 2005;87:1673-1679.
- Thomas NP, Kankate R, Wandless F, Pandit H. Revision anterior cruciate ligament reconstruction using a 2-stage technique with bone grafting of the tibial tunnel. *Am J Sports Med.* 2005;33:1701-1709.
- Uribe JW, Hechtman KS, Zvijac JE, Tjin-A-Tsoi EW. Revision anterior cruciate ligament surgery: experience from Miami. *Clin Orthop Relat Res.* 1996;325:91-99.
- Ware JE Jr, Keller SD, Hatoum HT, Kong SX. The SF-36 Arthritis-Specific Health Index (ASHI), I: development and cross-validation of scoring algorithms. *Med Care.* 1999;37(5 suppl):MS40-50.
- Ware JE Jr, Sherbourne CD. The MOS 36-item short-form health survey (SF-36), I: conceptual framework and item selection. *Med Care.* 1992;30:473-483.
- Wexler G, Bach BR Jr, Bush-Joseph CA, Smink D, Ferrari JD, Bojchuk J. Outcomes of anterior cruciate ligament reconstruction in patients with workers' compensation claims. *Arthroscopy.* 2000;16:49-58.
- Wright RW, Dunn WR, Amendola A, et al. Risk of tearing the intact anterior cruciate ligament in the contralateral knee and rupturing the anterior cruciate ligament graft during the first 2 years after anterior cruciate ligament reconstruction: a prospective MOON cohort study. *Am J Sports Med.* 2007;35:1131-1134.