



Anterior Cruciate Ligament Reconstruction Using Allograft in Adults Older Than the Age of 40 Years Shows Similar Patient-Reported Outcomes Between Male and Female Patients

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Purpose: To evaluate patient-reported outcomes in patients undergoing anterior cruciate ligament (ACL) reconstruction using allograft in patients 40 years of age or older divided by sex. **Methods:** Patients age 40 years of age or older who underwent ACL reconstruction by the same surgeon using allograft via anteromedial portal technique were retrospectively identified. Patient-reported outcomes (International Knee Documentation Committee [IKDC], Knee Injury and Osteoarthritis Outcome Score, Tegner, Lysholm, Marx, and Single Assessment Numeric Evaluation) were evaluated and recorded, and outcomes were analyzed by sex. **Results:** In total, 159 patients undergoing primary ACL reconstruction were reviewed. Two-year outcomes were obtained. All patients noted improvement in patient-reported outcome measures. Male patients had overall greater postoperative patient-reported outcomes measures at all time points for IKDC, Tegner, Lysholm, Marx, and Single Assessment Numeric Evaluation scores; however, the only significant time points were IKDC 6 months ($P = .016$), 1 year ($P = .012$) and Marx 1 year ($P = .007$) and 2 year ($P = .016$). Knee Injury and Osteoarthritis Outcome Score scores similarly showed greater postoperative scores at all time points and statistical significance at 3 months ($P = .002$), 6 months ($P = .033$), and 1 year ($P = .031$). **Conclusions:** ACL reconstruction in individuals older than the age of 40 years using allograft results in good outcomes compared with preoperative status. Patient-reported outcomes were similar between male and female patients regarding most patient-reported outcome measures. **Level of Evidence:** Level III, retrospective cohort study.

Anterior cruciate ligament (ACL) surgery is one of the most common knee surgeries performed and significantly affects function and activity for many months and often years after surgery.¹ Operative management for ACL injuries has been well documented and can provide good outcomes; however, there is a risk of recurrent instability, decreased physical

activity that involves agility, and secondary structural damage to the knee, including meniscus tearing.² The decision between nonoperative and operative treatment is multifactorial in all individuals but can be even more complex in individuals who are not in high school or college participating in competitive athletics that often involve cutting and pivoting. Adults older than the age of 40 years may have a different lower-body activity demand and instability risk profile compared with high school or collegiate individuals in the setting of other extenuating circumstances, including time off from their profession as well as family care.³ Evaluating patient-reported outcomes of this older than 40 years age group can provide additional insight for patients and providers on establishing expectations of surgical outcomes.

The purpose of this study was to evaluate patient-reported outcomes in patients undergoing ACL reconstruction using allograft in patients 40 years of age or older divided by sex. We hypothesized there would be no significant differences in outcomes

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Table 1. Older Than 40 Years ACLR - KOOS Outcomes

Parameter	n	Male	n	Female	P Value
KOOS					
Preoperative	34	60.1 (56.3- 63.9)*	56	56.6 (53.6- 59.5)	.149
3 mo	33	76.2 (72.3- 80.1)	62	68.4 (65.6- 71.3)	.002
6 mo	29	81.2 (77.1- 85.2)	56	75.7 (72.8- 78.7)	.033
1 y	29	88.0 (83.9- 92.0)	57	82.5 (79.6- 85.4)	.031
2 y	36	88.7 (85.0- 92.5)	67	87.6 (84.8- 90.3)	.615
KOOS: Pain					
Preoperative	34	74.6 (70.9- 78.3)	56	73.9 (71.0- 76.7)	.765
3 mo	33	87.2 (83.5- 91.0)	62	83.0 (80.2- 85.7)	.071
6 mo	29	91.2 (87.3- 95.1)	56	86.9 (84.1- 89.7)	.084
1 y	29	93.9 (90.0- 97.9)	57	91.9 (89.0- 94.7)	.399
2 y	36	94.7 (91.0- 98.3)	67	93.7 (91.0- 96.3)	.656
KOOS: Symptoms					
Preoperative	34	68.8 (64.7- 72.8)	56	66.0 (62.9- 69.1)	.288
3 mo	33	83.5 (79.3- 87.6)	62	75.1 (72.0- 78.1)	.001
6 mo	29	87.2 (82.9- 91.6)	56	82.0 (78.9- 85.2)	.056
1 y	29	91.0 (86.7- 95.3)	57	87.0 (83.9- 90.1)	.137
2 y	36	91.0 (87.0- 95.0)	67	88.5 (85.6- 91.5)	.333
KOOS: ADL					
Preoperative	34	80.5 (77.6- 83.3)	56	83.3 (81.1- 85.5)	.116
3 mo	33	92.9 (90.0- 95.8)	62	88.6 (86.5- 90.7)	.019
6 mo	29	96.1 (93.0- 99.1)	56	93.9 (91.7- 96.0)	.243
1 y	29	97.6 (94.6- 100.6)	57	96.5 (94.3- 98.6)	.546
2 y	36	97.9 (95.1- 100.7)	67	97.1 (95.1- 99.1)	.644
KOOS: Sport					
Preoperative	31	43.0 (34.7- 51.2)	53	28.3 (22.0- 34.6)	.006
3 mo	27	58.3 (49.5- 67.1)	42	36.7 (29.7- 43.7)	.000
6 mo	26	69.8 (60.9- 78.8)	49	58.3 (51.8- 64.9)	.041
1 y	26	86.0 (77.0- 94.9)	49	74.5 (68.0- 81.1)	.043
2 y	31	83.8 (75.6- 92.1)	57	82.2 (76.1- 88.3)	.748
KOOS: Quality of Life					
Preoperative	34	31.8 (25.8- 37.8)	56	29.0 (24.4- 33.6)	.464
3 mo	33	55.1 (49.0- 61.2)	62	47.1 (42.7- 51.5)	.036
6 mo	29	60.5 (54.2- 66.8)	56	55.0 (50.4- 59.6)	.166
1 y	29	70.9 (64.6- 77.2)	57	61.0 (56.4- 65.5)	.013
2 y	36	75.3 (69.5- 81.2)	67	75.3 (71.0- 79.6)	.985

NOTE. Statistically significant values are indicated in bold.

ACLR, anterior cruciate ligament reconstruction; ADL, activities of daily living; KOOS, Knee Injury and Osteoarthritis Outcome Score.

*Values reported as estimated marginal means and 95% confidence intervals.

between sex in patients undergoing ACL reconstruction using allograft in patients 40 years of age or older.

Methods

After approval of the institutional review board (Massachusetts General Hospital, #2016P001873), patients were enrolled in the Surgical Outcome System (Arthrex, Naples, FL) patient registry. This registry was searched for patients who underwent ACL reconstruction. Inclusion criteria were patients aged 40 years or older who had ACL insufficiency (as clinically and radiographically assessed by the attending surgeon) who underwent ACL reconstruction using allograft. Exclusion criteria included any previous ACL surgery, age younger than 40 years at the time of surgery, or having had concomitant meniscus repair. Patient-reported outcomes measures (PROMs) were then evaluated by separating out primary ACL

reconstructions using allograft in individuals older than the age of 40 years. Patients were then divided by sex and their outcomes analyzed. Patient-reported outcomes included visual analog scale (VAS), Marx, Knee Injury and Osteoarthritis Outcome Score (KOOS), Western Ontario and McMaster Universities Osteoarthritis Index, International Knee Documentation Committee (IKDC), Tegner, Lysholm, Single Assessment Numeric Evaluation, and Veterans RAND 12-item Health Survey and were evaluated preoperatively as well as 3 months, 6 months, 1 year, and 2 years' postoperatively.

All surgeries were performed by one surgeon (P.D.A.) with the use of antegrade rigid reamer tibial tunnel drilling, flexible anteromedial portal femoral tunnel drilling, and absorbable interference screw fixation on femur and tibial sides. ACL reconstruction was performed arthroscopically aided all with bone–patella tendon–bone allograft via an anteromedial portal

Table 2. Older Than 40 Years ACLR: Patient-Reported Outcomes

Parameter	n	Male	n	Female	P Value
IKDC					
Preoperative	29	47.0 (42.1-51.8)*	55	50.5 (47.0-53.9)	.244
3 mo	28	61.3 (56.4-66.2)	61	54.0 (50.7-57.3)	.016
6 mo	24	68.7 (63.6-73.9)	54	67.1 (63.6-70.5)	.596
1 y	24	84.3 (79.1-89.4)	56	76.3 (72.9-79.8)	.012
2 y	30	86.6 (81.9-91.4)	65	83.8 (80.5-87.0)	.330
Tegner					
Preoperative	29	3.3 (2.8-3.9)	55	3.8 (3.4-4.3)	.165
3 mo	28	3.1 (2.5-3.7)	61	2.9 (2.5-3.3)	.635
6 mo	24	4.0 (3.3-4.6)	54	3.3 (2.9-3.7)	.092
1 y	24	5.2 (4.6-5.8)	56	4.7 (4.3-5.1)	.175
2 y	30	5.7 (5.1-6.2)	65	5.0 (4.6-5.4)	.052
Lysholm					
Preoperative	29	63.6 (58.8-68.5)	55	64.2 (60.8-67.7)	.852
3 mo	28	80.1 (75.2-85.0)	61	76.0 (72.6-79.3)	.175
6 mo	24	87.9 (82.7-93.1)	54	83.3 (79.8-86.8)	.149
1 y	24	91.7 (86.5-96.9)	56	89.3 (85.8-92.7)	.438
2 y	30	92.8 (88.0-97.5)	65	90.1 (86.8-93.3)	.359
Marx					
Preoperative	34	9.4 (7.7-11.1)	57	8.4 (7.1-9.7)	.348
3 mo					
6 mo					
1 y	29	7.9 (6.1-9.7)	57	4.8 (3.5-6.1)	.007
2 y	36	7.9 (6.3-9.6)	67	5.4 (4.2-6.6)	.016
SANE					
Preoperative	25	39.3 (32.8-45.9)	52	43.6 (39.0-48.2)	.294
3 mo	26	62.0 (55.6-68.5)	59	61.8 (57.5-66.2)	.952
6 mo	24	74.9 (68.2-81.6)	51	71.9 (67.3-76.5)	.464
1 y	26	86.2 (79.7-92.6)	57	84.1 (79.7-88.5)	.594
2 y	35	87.0 (81.3-92.7)	66	87.5 (83.4-91.7)	.875

NOTE. Statistically significant values are indicated in bold.

IKDC, International Knee Documentation Committee; SANE, Single Assessment Numeric Evaluation.

*Values reported as estimated marginal means and 95% confidence intervals.

flexible reamer (VersiTomic; Stryker Corp, Paramus, NJ) technique on the femur and a rigid reamer on the tibia. Fixation was obtained with absorbable interference screw fixation (MILAGRO Interference Screw; DePuy Mitek, Raynham, MA). Distal fixation was performed in terminal passive extension. Postoperatively, patients started formal skilled outpatient physical therapy approximately 3 days after surgery twice a week. A continuous passive machine was used for all patients starting at 5° hyperextension and advancing to 100° of flexion as soon as tolerated. Patients were to be partial weight-bearing for approximately 6 weeks with no limitations on motion.

Patient characteristics were reported using descriptive statistics such as mean, standard deviation, and proportions. Baseline characteristics were compared between male and female patients using independent *t*-tests and Pearson χ^2 test. Linear mixed-effects regression models were used to evaluate differences in PROM scores between male and female patients at various time points after surgery. The presence of meniscal tears and cartilage injuries was considered for inclusion as covariates in the regression model but were not found to be significant in preliminary

analysis. Missing values were not imputed, and all patients who completed 2-year follow up were included in the study. Statistical significance was set at $P < .05$. Statistical analyses were performed using R, version 4.2.2 (The R Foundation for Statistical Computing, Vienna, Austria).

Results

A total of 159 patients aged 40 years or older undergoing primary ACL reconstruction with bone–patella tendon–bone allograft (LifeNet, Virginia Beach, VA) were identified (Tables 1 and 2). These included 59 male (average age 49.8, median age 49.0, range 40-67 years) and 100 female (average age 47.2, median age 46, range 40-58 years) patients. Average time from injury to surgery was 19.9 months (median 75 months, standard deviation 69.4, range 6-144 months).

Preoperative evaluations showed no significant differences except the preoperative KOOS Sport ($P = .02$), where the mean score for male patients was 42.6 ($n = 31$) and the score for female patients was 28.6 ($n = 53$) (Table 1). Notably, IKDC scores for female patients were slightly greater preoperatively (50.5 vs 47.0, $P = .244$).

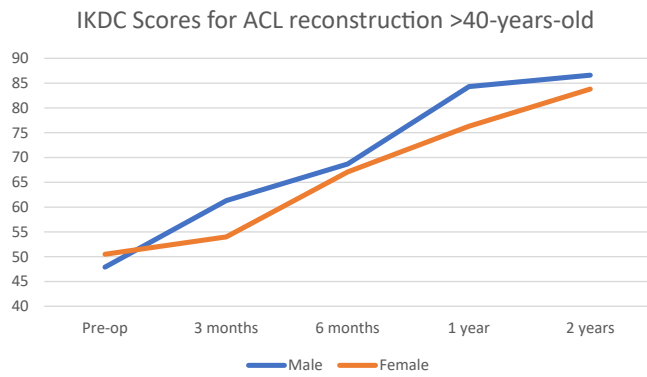


Fig 1. IKDC scores in patients undergoing ACL reconstruction using allograft ages 40 and over. (ACL, anterior cruciate ligament; IKDC, International Knee Documentation Committee.)

Tegner scores preoperatively were similar between sexes (male 3.34 and female 3.84, $P = .165$).

Postoperatively, all patients noted improvements in outcomes (Table 2). Lysholm, Single Assessment Numeric Evaluation, and Tegner scores showed no significant differences up to 2 years from surgery. IKDC scores showed female patients had lower scores at all postoperative time points but only statistically significant at 3 months ($P = .016$) and at 1 year ($P = .012$) (Fig 1). Marx scores showed lower scores at 1 year (4.84 vs 7.88, $P = .007$) and 2 years (5.38 vs 7.94, $P = .016$) for female patients compared with male patients, however (Fig. 2). Postoperatively, Tegner scores for male patients were greater at all time points but not statistically significant.

Postoperative KOOS scores showed improvements in all categories for both sexes (Table 1). Male patients had significantly greater KOOS scores at 3 months (0.002), 6 months (0.033), and 1 year (0.031) but not at the 2-year time point ($P = .615$). KOOS subscores can be found in Table 1.

Discussion

ACL reconstruction using allograft in patients aged 40 years or greater leads to overall improvements with minimal differences when comparing male and female patients. Female patients may have slightly lower earlier PROMs and overall lower activity scores postoperatively, but these were limited findings. We had 100 female and 59 male patients in our cohort, which reflects the increased ratio of female-to-male risk of ACL injury in the general population, although this could simply be who was compliant with completing their PROM surveys. Evaluating ACL surgical outcomes in the older than 40 years age group is not a novel concept, with a multitude of studies having evaluated this previously, including those aged 40 and older as well as aged 50 and older.⁴⁻⁶ However, there is not a

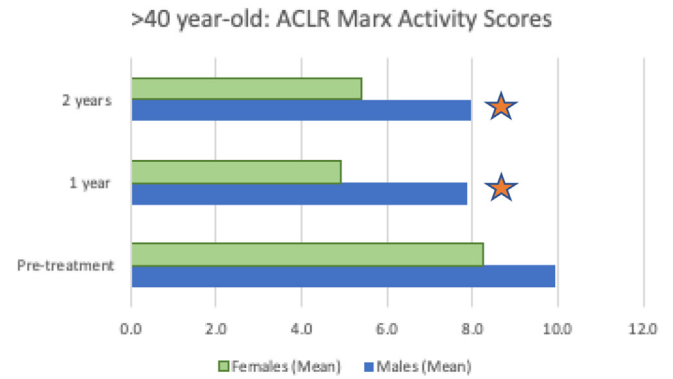


Fig 2. Older than 40 years ACLR - Marx activity scores. Star = statistically significant. (ACLR, anterior cruciate ligament reconstruction.)

significant number comparing these outcomes based on sex. In one of the more recent meta-analyses that included 627 patients, patient outcomes evaluated included IKDC (weighted mean, 59.6), Lysholm (weighted mean, 91.7), and Tegner activity (weighted mean, 4.8) scores, similar to our study's patient cohort.⁴ However, this meta-analysis did not subdivide by sex. In our patient cohort, IKDC scores were greater (1-year and 2-year average; 82.3) and Tegner scores were slightly greater (1-year and 2-year average; 5.1), whereas Lysholm scores were slightly lower at 1- and 2-year averages (1-year and 2-year average; 90.7). This difference in IKDC scores between the meta-analysis and our cohort may potentially have something to do with duration of time before surgery (19.9 months in our cohort vs 32 months in the cohort from Brown et al.⁴), as it has been well documented that prolonged duration of time from injury to surgery can lead to increased odds of meniscal injury and additional ligamentous injury including patients older the age of 40 years, with some studies citing 1-year as the time differentiator between additional injury occurring like meniscus tearing that has been well documented to negatively affect patient outcomes.⁷⁻⁹ There have been investigations that say that patients may actually benefit from delayed ACL reconstruction if they wait a few years; however, the development of meniscus tears was not well reported or controlled for.¹⁰

The patient older than the age of 40 years may have lower physical demands and/or expectations compared with a high school or collegiate athlete but will be undergoing the same procedure. Understanding patient expectations after surgery can help guide both the patient and provider with graft choices. In evaluating our patient cohort, Marx scales preoperatively were 9.4 (male patients) and 8.4 (female patients), but evaluating patients from the STABILITY trial, which looked at ACL reconstructions in athletes younger than the age of 25 years, baseline Marx scales were 12.1 to 12.7.¹¹ This type

of discrepancy in activity level may have something to do with outcomes of this younger/higher-level group compared with those 40 years of age. Someone who is playing competitive collegiate lacrosse who gets back to recreational lacrosse once a week will show as a significant decrease in various PROMs, whereas the older than 40 recreational athlete who plays recreational lacrosse once a week and gets back to that same level will not show as significant a decrease but may not be nearly as much of a postoperative challenge to get back to that same level. This is also seen when subdividing the mature athlete such as in the study from Panisset et al.,¹² in which the authors compared results of ACL reconstruction in patients between the ages 40 years and younger (mean age 26.7 years) with patients aged 50 years or older (mean age 54.8 years).¹² This showed good postoperative stability, with a greater incidence of meniscus tears and lower Tegner scores in the older group. Understanding these variances is important when looking at outcomes in various patient populations both for the patient as well as clinician.

A strength of this study is that this patient cohort was all with a single surgeon, with all surgeries being performed with the same type of allograft via the same technique with the same postoperative protocol. Two-year outcomes were available for at least 90 patients older than the age of 40 years.

Limitations

The limitations of this study are that the retear rate was not a collected data point by the registry used and therefore not available for review. Further, our number of male patients (n = 59) was notably lower than our female cohort (n = 100), which limited a direct sex comparison of outcome.

Conclusions

ACL reconstruction using allograft in individuals older than the age of 40 years results in good outcomes compared with preoperative status. Patient-reported outcomes were similar between male and female patients on most PROMs.

Disclosure

The authors (S.H., B.B., N.P., V.N., P.A.) report no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as [supplementary material](#).

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