



High Levels of Satisfaction and Adequate Patient-Reported Outcomes After Operative Reconstruction of Multiligament Knee Injury With Allograft Among Patients Aged 40 Years and Older

Alexander J. Toppo, M.D., M.P.H., Gabriel S. Perrone, M.D., Stephen M. Sylvia, M.D., Benjamin H. Miltenberg, B.A., Liam H. Power, B.A., John C. Richmond, M.D., and Matthew J. Salzler, M.D

Purpose: To describe injury characteristics and patient-reported outcomes (PROs) among patients aged 40 years and older who underwent allograft reconstruction for multiligament knee injury (MLKI). **Methods:** Records of patients aged 40 years and older who underwent allograft multiligament knee reconstruction at a single institution between 2007 and 2017 with a minimum of 2 years of follow-up were retrospectively reviewed. Demographic information, concomitant injuries, patient satisfaction, and PROs including International Knee Documentation Committee and Marx activity scores were obtained. **Results:** Twelve patients were included with a minimum follow-up time of 2.3 years (mean, 6.1; range, 2.3-10.1 years) and a mean age at surgery of 49.8 years. Seven patients were male, and the most common mechanism of injury was sport-related. The most frequently reconstructed MLKIs were anterior cruciate ligament and medial collateral ligament (4), anterior cruciate ligament and posterolateral corner (2), and posterior cruciate ligament and posterolateral corner (2). The majority of patients reported satisfaction with their treatment (11). Median International Knee Documentation Committee and Marx scores were 73 (interquartile range, 45.5-88.0) and 3 (interquartile range 0-5), respectively. **Conclusions:** Patients aged 40 years and older can expect a high level of satisfaction and adequate PROs at 2-years follow-up after operative reconstruction for a MLKI with allograft. This demonstrates that allograft reconstruction for a MLKI in older patients may have clinical utility. **Level of Evidence:** IV, therapeutic case series.

Multiligament knee injuries (MLKIs) are a rare, yet debilitating, orthopaedic condition with a variable prognosis and conflicting treatment recommendations.¹⁻⁵ The operative management of MLKI has demonstrated relatively good outcomes in the young adult and pediatric populations.⁶⁻¹⁰ Adults with MLKI treated operatively experience greater functionality, less instability, and increased return to activity compared with those treated nonoperatively.⁶⁻⁸ Similar outcomes are exhibited in the adolescent

population, with improvements in functional outcomes and high satisfaction rates following anatomic knee reconstruction.^{9,10}

Although outcomes following MLKI treatment in younger populations have been widely documented, the outcomes associated with allograft reconstruction of MLKI among older adults are not well established. Operative management of single ligamentous tears among active patients aged 40 years and older successfully restores stability and native joint kinematics

From the Department of Orthopaedic Surgery, Tufts Medical Center (A.J.T., G.S.P., S.M.S.); Tufts University School of Medicine (B.H.M., L.H.P., M.J.S.); and New England Baptist Hospital (J.C.R.), Boston, Massachusetts, U.S.A.

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Address correspondence to Matthew J. Salzler, M.D., Tufts Medical Center Biewend Building, 7th Floor, 800 Washington St., Box 306, Boston, MA 02111. E-mail: MSalzler@tuftsmedicalcenter.org

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similar to younger patients.¹¹⁻¹⁵ Further, surgical intervention decreases the risk of concomitant injuries in this cohort.¹⁶ Despite the known benefits of anterior cruciate ligament (ACL) reconstruction in this cohort, little is known about the outcomes of operative reconstruction of MLKI among older adults.

The efficacy of allograft compared with autograft reconstruction of MLKI in middle-aged adults remains poorly studied. With the exception of ACL-reconstruction outcomes, little is known about the differences between autograft and allograft reconstruction for other knee ligaments in middle-aged adults. Although allograft use in all ages results in shorter operative time, no graft harvest morbidity, and a wider array of graft sizes,^{17,18} it also exhibits weaker mechanical properties, inflammation risk, potential infectious disease transmission, and delayed incorporation or ligamentization.^{17,19-22} The effectiveness of allograft reconstruction for MLKI in middle-aged adults is poorly described.

The purpose of this study was to describe injury characteristics and patient-reported outcomes (PROs) among patients aged 40 years and older who underwent allograft reconstruction for MLKI. We hypothesized that MLKI patients aged 40 years and older treated operatively would demonstrate a high level of satisfaction and adequate PROs.

Methods

Following institutional review board approval (New England Baptist Hospital Institutional Review Board, #890506), a retrospective review was conducted on all patients aged 40 years and older who underwent multiligament knee reconstruction at a single institution between 2007 and 2017 with complete records and a minimum follow-up of 2 years. Patients were defined as having a MLKI if they injured 2 or more of the following ligaments or structures: ACL, posterior cruciate ligament (PCL), medial collateral ligament (MCL), lateral collateral ligament (LCL), and posterolateral corner (PLC). Evaluations and operations were all performed by 1 of 4 fellowship-trained Orthopaedic Sports Medicine surgeons at a single academic institution. All injured ligaments were reconstructed with allograft. Patients were excluded if they underwent autograft reconstruction.

Patients were diagnosed with MLKI by physical examination and magnetic resonance imaging. All operations were performed with soft-tissue allografts, which were terminally sterilized with less than 1.8 Mrad of irradiation and Allowash solution sterilization. A standardized postoperative rehabilitation protocol, based on involved ligaments, was given to all subjects. A retrospective chart review was conducted to obtain patient demographics, including age, time between injury and surgery, sex, mechanism of injury, and body mass

index. Magnetic resonance imaging results and operative notes were reviewed to determine the specific ligaments reconstructed, reconstruction technique, graft type, meniscal damage, and cartilage lesion grade. Reports of failure or repeat surgery were extracted from postoperative chart review and by patient report.

Surveys assessing patient satisfaction, procedure failure, and PROs including the International Knee Documentation Committee (IKDC) scores and Marx activity scores were mailed to all participants. All data were recorded in the REDCap electronic database (Vanderbilt University, Nashville, TN) and descriptive statistics were computed using Stata/IC, Version 15.1 (StataCorp, College Station, TX).

Results

Twelve patients met inclusion criteria with a minimum follow-up time of 2.3 years (mean: 6.1; range: 2.3-10.1) (Table 1). The mean age at surgery was 49.8 (interquartile range [IQR] 41.5-58) years. Patients were mostly male (7 [58.3%]) with left-sided injuries

Table 1. Demographics and Clinical Characteristics of Patients Aged 40 Years and Older With Multiligament Knee Injury

Total number of patients	12
Length of follow-up, y, mean (range)	6.1 (2.3-10.1)
Age at surgery, mean (IQR)	49.8 (41.5-58)
Female sex, n (%)	5 (41.7)
BMI, median (IQR)	24.5 (22.9-28.1)
Laterality, right, n (%)	4 (33.3)
Mechanism of Injury, n (%)	
Sports	8 (66.7)
Work	1 (8.3)
Other	3 (25.0)
Days between injury and surgery, median (IQR)	113.5 (35-203.5)
ICRS cartilage lesion grade 3-4, n (%)	5 (41.7)
Meniscal tear, n (%)	8 (66.7)
Concomitant meniscectomy, n (%)	6 (50.0)
Ligament reconstructed, n (%)	
ACL	10 (83.3)
PCL	5 (41.7)
MCL	4 (33.3)
LCL	3 (25.0)
PLC	6 (50.0)
Combination of ligaments injured, n (%)*	
ACL + PCL	1 (8.3)
ACL + MCL	4 (33.3)
ACL + PLC	2 (16.7)
PCL + PLC	2 (16.7)
ACL + PCL + LCL	1 (8.3)
ACL + LCL + PLC	1 (8.3)
ACL + PCL + LCL + PLC	1 (8.3)

ACL, anterior cruciate ligament; BMI, body mass index; ICRS, International Cartilage Repair Society; IQR, interquartile range; LCL, lateral collateral ligament; MCL, medial collateral ligament; PCL, posterior cruciate ligament; PLC, posterolateral corner; SD, standard deviation.

*All injured ligaments were reconstructed.

Table 2. Outcomes of Patients Aged 40 Years and Older With Multiligament Knee Injury

Satisfied patients, n (%)	11 (91.7)
IKDC score, median (IQR)	73 (45.5-88.0)
Marx score, median (IQR)	3 (0-5)

IKDC, International Knee Documentation Committee; IQR, interquartile range.

(8 [66.7%]) and were primarily injured playing sports (8 [66.7%]). The ligaments most frequently injured included the ACL (10 [83.3%]), PLC (6 [50.0%]), and PCL (5 [41.7%]).

ACL + MCL injury was the most common MLKI pattern (4 [33.3%]) followed by ACL + PLC (2 [16.7%]) and PCL + PLC (2 [16.7%]) injury. Remaining injury patterns (all experienced by 1 patient [8.3%] each) included ACL + PCL, ACL + PCL + LCL, ACL + LCL + PLC, and ACL + PCL + LCL + PLC. All injured ligaments were reconstructed with allograft.

Five patients (41.7%) exhibited grade 3-4 ICRS cartilage lesions whereas 8 patients (66.7%) had meniscal tears diagnosed intraoperatively. Among these patients, 6 (50.0%) underwent meniscectomy. The meniscal tears in the remaining 2 patients were deemed stable and left alone.

The majority of patients reported satisfaction with their treatment (11 [91.7%]) (Table 2). Median IKDC and Marx scores were 73 (IQR 45.5-88.0) and 3 (IQR 0-5), respectively.

Discussion

In our study, patients were most often injured playing sports (8/12 [66.7%]); most frequently sustained ACL + MCL (4 [33.3%]), ACL + PLC (2 [16.7%]), and PCL + PLC (2 [16.7%]) injuries; and commonly exhibited meniscal tears (8/12 [66.7%]). Eleven of 12 patients (91.7%) were satisfied with their procedure. Median IKDC and Marx scores were 73 (IQR 45.5-88.0) and 3 (IQR 0-5), respectively.

Although injury characteristics and outcomes of MLKI have been widely documented in younger adults and adolescents, current knowledge of these outcomes among middle-aged patients is limited. Most adult MLKI cohorts evaluated in the literature are no older than their late 30s.²³⁻²⁵ Furthermore, increased age traditionally has been associated with decreased risk for MLKI, likely due to lower rates of sports participation and lower risk of high-energy trauma.²³⁻²⁵ Our cohort exhibited the same common mechanisms of injury, with middle-aged patients primarily sustaining MLKIs while playing sports. A male predilection for MLKI has been described in previous case series.²⁴⁻²⁶ This was also seen in our sample, in which 8 of 12 patients were men. Although there is no clear explanation for this, it has been postulated that the difference in prevalence

may be attributed to greater male participation in contact sports that involve a greater risk of knee injury.²⁷ The patient sample described in our study exhibited similar patterns of ligamentous injury to those documented among younger patients with MLKIs.²⁸⁻³⁰

The influence of age on outcomes after operative treatment of MLKI remains largely unexplored. In their study of outcomes following multiligament knee reconstruction in 125 MLKI patients, Levy et al.³¹ found that age of 30 years or older was a risk factor for inferior clinical and functional outcomes, with patients aged 41-50 years and 51+ years exhibiting respective mean IKDC scores of 68 and 71. Our patient sample, which explicitly defined injury characteristics in this middle-aged cohort, reported similar average IKDC scores (median 73) with a wide IQR (45.5-88.0). Interestingly, both the scores discussed herein and those of similarly aged patients from Levy et al.³¹ were greater than those exhibited by patients with MLKIs between 31 and 40 years but lower than those reported by younger patients. The reason for this is unclear, although patient age is thought to be inversely related to physical activity and baseline functional status.^{31,32}

For comparison, IKDC and Marx activity scores have been studied in patients aged 40 years and older who underwent ACL reconstruction exclusively. The historic patient acceptable symptom state for IKDC scores in this cohort has been defined as 75.9.^{33,34} A recent systematic review of middle-aged adults who underwent operative management of ACL injury found that 77% of patients studied in the literature achieved this threshold, with average postoperative IKDC scores ranging from 67.8 to 91.4.³⁵ Marx scores among these patients have been less frequently reported, although a recent study of 201 patients showed a median score of 6.0 (IQR 2-10) in patients with intact ACL reconstruction graft and a median of 1.5 (IQR 0-7) in patients with graft failure.³⁶ Furthermore, 182 of 201 (90.5%) of these patients were satisfied with their procedure. The IKDC Marx activity scores and satisfaction levels for our cohort were comparable with those in patients undergoing ACL reconstruction.

Our study suggests that allograft reconstruction for MLKI treatment among patients aged 40 years and older may yield acceptable outcomes. Autograft versus allograft reconstruction for ligamentous knee injury remains a controversial topic. Allograft poses a number of benefits compared with autograft, including reduced operative time, no morbidity associated with graft harvest, a greater range of available graft sizes, and decreased cost.^{17,18} However, this comes at the expense of potentially delayed bone integration and adverse effects on ligamentization, as well as the risk of possible inflammatory response and transmission of infectious disease.^{17,19-22,37-39}

Although autograft use is linked to improved outcomes in primary and revision ACL reconstruction among younger, more active cohorts,⁴⁰ little to no difference in clinical outcomes has been found for ACL and PCL reconstruction with allograft versus autograft in the adult population overall.^{41,42} Data comparing the use of autograft and allograft for reconstruction of other extra-articular knee structures such as the LCL and PLC are relatively sparse⁴³; thus, it remains unclear whether autograft and allograft perform differently when used to reconstruct the cruciate versus the collateral ligaments. Despite this, our sample reported high levels of satisfaction after receiving allograft reconstruction for MLKI, suggesting that this is a viable treatment option for patients aged 40 years and older.

Articular degeneration, which becomes more common with age, has been associated with inferior functional outcomes. Ahldén et al.⁴⁴ showed that patients who sustained chondral or meniscal injuries in addition to ACL tears had worse Knee Injury and Osteoarthritis Outcome Score scores 1 year postoperatively as well as worse sport/recreation subscale scores 5 years postoperatively. King et al.⁴⁵ established that injury to both the lateral and medial menisci or articular cartilage was linked to poorer IKDC scores 6 years after injury. Fanelli et al.⁴⁶ demonstrated a 16% difference in rates of cartilage injury between knee dislocation patients younger than 30 years of age and older than 30 years of age, although this difference was not statistically significant. They also showed that roughly one quarter of patients who sustained knee dislocations had evidence of osteoarthritis on imaging 10 years' postinjury. It has been demonstrated that psychosocial factors and other non-knee injuries for polytrauma patients may have significant bearing on functional outcomes after MLKI as well.⁴⁷

Optimal surgical intervention for MLKI treatment remains controversial. Ideally, a randomized control trial accounting for patient characteristics could determine which surgical technique yields the best outcomes. However, the high incidence of concomitant injuries along with the low incidence of MLKI make such a study considerably challenging. Several retrospective reviews have demonstrated that surgical reconstruction is associated with better subjective patient function and Tegner, Lysholm, and IKDC scores.⁴⁸⁻⁵¹ Thus, the gold standard for MLKI treatment is operative repair or reconstruction.⁵² Both Levy et al.⁵³ and Stannard et al.⁵⁴ reported better outcomes with reconstruction versus repair and have delineated a staged procedure for MLKI reconstruction,⁵⁵ as some providers prefer treatment with staged procedures.⁵⁶

Limitations

There are several limitations to the present study. The investigation was retrospective in design with

prospective follow-up. For this reason, recall bias may have affected our results. The small sample size, as a result of the low incidence of MLKI in the general population, precluded subgroup analysis of patients with different injury characteristics and outcomes. Patients in our cohort were treated by 1 of 4 different surgeons, although the same surgical technique and rehabilitation protocol were used by all providers. In addition, patients who did not achieve 2-year follow-up could have led to selection bias. Preoperative PROs were not available for comparison with postoperative outcomes reported. It is also difficult to isolate symptoms related to ligamentous injury and those related to the injuries that often accompany MLKI such as meniscal and cartilage injuries. For this reason, attributing a patient's functional status to concomitant injuries or ligamentous instability in and of itself is challenging.

Conclusions

Patients aged 40 years and older can expect a high level of satisfaction and adequate PROs at 2 years follow-up after operative reconstruction for a MLKI with allograft. This demonstrates that allograft reconstruction for a MLKI in older patients may have clinical utility.

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