Evaluation of Thigh Muscle Strength in Adolescent Patients After Anterior Cruciate Ligament Reconstruction With Lateral Extra-articular Tenodesis or Anterolateral Ligament Reconstruction

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Background: There has been increased interest in lateral extra-articular procedures, such as anterolateral ligament reconstruction (ALLR) or lateral extra-articular tenodesis (LET), to reduce anterolateral rotation instability of the knee after anterior cruciate ligament reconstruction (ACLR). Despite promising surgical outcomes with these techniques, their impact on knee strength recovery is unknown.

Hypothesis: Patients undergoing lateral extra-articular procedures at the time of ACLR would have impaired thigh muscle strength at 6 to 9 months after surgery.

Study Design: Cohort study; Level of evidence, 3.

Methods: Adolescent patients who had undergone primary unilateral ACLR with lateral extra-articular augmentation between 2017 and 2023 were identified. Patients were included if they were aged between 12 and 20 years at the time of surgery and had completed an isokinetic strength assessment at 6 to 9 months after surgery. A total of 104 participants (mean age, 16.5 ± 1.7 years; 63 female) were included in this analysis: 25 who underwent ACLR + ALLR, 17 who underwent ACLR + LET, and 62 who underwent isolated ACLR. Isokinetic knee extension and flexion strength normalized to body weight, as well as the bilateral limb symmetry index (LSI), were assessed. One-way analysis of variance and analysis of covariance were used to compare differences between surgical techniques.

Results: After adjusting for age, graft type, and time since surgery, the ACLR + LET (1.36 ± 0.52 N·m/kg) and ACLR + ALLR (1.61 ± 0.53 N·m/kg) groups had significantly less involved limb knee extension strength (P = .025), uninvolved limb knee extension strength (P = .046), and LSI for knee extension strength (P = .040) compared to the isolated ACLR group. There were no differences between the 3 groups regarding involved limb knee flexion strength (P = .222) or uninvolved limb knee flexion strength (P = .984), but the isolated ACLR group displayed a greater LSI for knee flexion strength (96.6% ± 17.8%; P = .012).

Conclusion: The addition of lateral extra-articular procedures at the time of ACLR was associated with decreased quadriceps strength at 6 to 9 months after ACLR. While lateral extra-articular procedures may enhance knee rotary stability after ACLR, prolonged rehabilitation may be needed to re-establish adequate quadriceps strength before return to sports.

Keywords: ACL; physical therapy; rehabilitation; lateral extra-articular tenodesis

Up to 90% of young athletes diagnosed with an anterior cruciate ligament (ACL) injury undergo ACL reconstruction (ACLR).[6] An increased incidence of ACL injuries and advanced surgical and treatment techniques have led to a 22% increase in the number of ACL procedures

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performed each year.[16] The rates of reinjuries and return to sports after ACLR have remained largely unchanged over the last 20 years, with higher reinjury rates in female patients and only 65% of young athletes returning to prior levels of competition.[3,33] Continued high rates of reinjuries have led to renewed interest in the anterolateral ligament (ALL), the anterolateral complex, and their relationship to the ACL and clinical outcomes.[8] Biomechanical assessments after ACLR have demonstrated persistent anterolateral rotary instability,[39,41] while clinical assessments have demonstrated continued positive pivot-shift test results postoperatively.[37] The anterolateral complex, made up of the ALL, fibers of the iliotibial band, and the capsule, has been the subject of biomechanical studies to investigate its role in resisting tibial internal rotation.[28] Additionally, knee laxity and instability have been linked to lower psychological readiness and resumption of sports.[9] These findings and increased interest in the anterolateral complex have led to the development of new surgical techniques to address these limitations.

Overall, 2 different lateral-based soft tissue techniques are used to restore rotational stability at the time of ACLR by augmenting the anterolateral portion of the knee joint. Anatomic ALL reconstruction (ALLR) is often performed with allograft tissue, in comparison to lateral extra-articular tenodesis (LET), which involves sectioning and repositioning a portion of the distal iliotibial band, to laterally reinforce the knee. ALLR and LET have emerged as newer surgical strategies to assist in reducing rotational forces on the ACL graft in the transverse plane during cutting movements.[8]

Currently, there is no consensus on how ACL rehabilitation should be altered with these supplemental procedures, and most clinicians follow a traditional ACL rehabilitation protocol.[4] While there have been no differences between lateral extra-articular procedures with respect to restoring knee kinematics in cadaveric laboratory-based biomechanical studies,[8] there are limited comparative studies evaluating outcomes and clinical comparisons when combined with ACLR. Limited evidence suggests that lateral extra-articular procedures have a minimal impact on functional outcomes after ACLR.[10,12] Knee extension strength after ACLR remains an important factor in successful outcomes.[13] Limited knee extension strength has been linked to altered gait biomechanics, osteoarthritis, and reinjuries.[13,17,30,31] Getgood et al[10] reported no difference in functional outcomes when adding LET to primary ACLR in young active patients. However, Na et al[25] reported increased knee joint stiffness and adverse events after LET compared to those after ALLR.

This contrast in findings and potential functional limitations has increased the need to investigate the impact of lateral extra-articular procedures on thigh muscle strength. The restoration of knee extension and flexion strength at 6 to 9 months after ACLR is essential to return to sports, and understanding the impact of these procedures on knee strength can help clinicians in rehabilitation and return-to-sports planning. Therefore, the purpose of this study was to examine the differences between ACLR + ALLR and ACLR + LET in knee extension and flexion strength and patient-reported outcomes at 6 to 9 months postoperatively compared to isolated ACLR. We hypothesized that patients with lateral extra-articular procedures would show inferior knee strength compared to those without lateral stabilizing procedures at 6 to 9 months after ACLR.

METHODS

Study Design

This multisite study investigated the effects of LET and ALLR on patient-reported outcomes and knee extension and flexion strength among adolescent patients at 6 to 9 months after primary unilateral ACLR. At Connecticut Children's, a retrospective chart review of patients who completed postoperative return-to-sport testing between 2017 and 2023 was undertaken. At Michigan State University (MSU) and the University of Virginia (UVA), data were reviewed from participants who were recruited and completed prospective postoperative return-to-sports testing during the same time frame. All participants provided written informed consent (age ≥18 years) or assent (age <18 years). In the case of participants aged <18 years, a parent also provided written informed consent. The study was approved by the institutional review board at each site. We selected a time frame to include as many patients with lateral extra-articular procedures as possible. Patient data were documented, including sex, age, and body mass index at the time of surgery as well as the time from injury to surgery. Operative reports were reviewed to assess graft

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Ethical approval for this study was obtained from Connecticut Children's (No. 18-080).

type; type of lateral extra-articular procedure; and concomitant abnormalities including meniscal, chondral, and multiligament injuries.

Inclusion and Exclusion Criteria

Participants were included if they were between the ages of 12 and 20 years, underwent primary unilateral ACLR, and completed an isokinetic strength assessment between 6 and 9 months after surgery. An addition of a lateral extra-articular procedure at the time of surgery was also recorded. Participants were excluded from this analysis if they experienced a serious surgical or postoperative complication that resulted in a second surgical procedure (eg, arthrofibrosis); underwent multiligament reconstruction at the time of ACLR; had incomplete isokinetic strength or patient-reported outcome data; and had an ACL graft type other than the quadriceps tendon, bone–patellar tendon–bone, or hamstring tendon.

Rehabilitation Protocol

Patients were assigned a structured rehabilitation protocol dependent on the surgical technique and surgeon preference. The full rehabilitation protocol for each of the 3 study sites is provided separately (See Supplemental Appendix 1, available online). Briefly, at Connecticut Children's, rehabilitation after ACLR was completed at an in-house physical therapy clinic or a community clinic. At MSU, postoperative rehabilitation was completed at several community-based physical therapy clinics because of surgeon preference, patient insurance, resource availability, and geographic location, and at UVA, a hybrid of both in-house and community clinics was utilized. All patients initiated formal physical therapy within 1 week of surgery. Both Connecticut Children's and MSU recommended a hinged knee brace to be worn for 2 to 4 weeks after surgery and allowed progressive knee range of motion and weightbearing as tolerated for all patients. A hinged knee brace was recommended for 4 to 6 weeks, and range of motion was limited (0° to 90°) for up to 6 weeks per surgeon preference. At UVA, postoperative bracing was only included for patients who underwent meniscal repair at the time of surgery. At all 3 institutions, surgeon preference dictated weightbearing and bracing recommendations for patients after ACLR with a concomitant meniscal procedure.

At Connecticut Children's, patients completed an isometric strength assessment, functional strength testing, and 2 patient-reported outcome measures at 3 months after surgery. Patients who demonstrated a >70% limb symmetry index (LSI) for knee extension strength, full knee range of motion, and no pain or swelling were progressed to the next phase of rehabilitation, which included running, jump-landing, plyometrics, and agility exercises in conjunction with sport-specific drills. The late-stage rehabilitation assessment was completed at approximately 6 to 9 months after ACLR in conjunction with the surgeon's follow-up visit. At MSU and UVA, participants were recruited from the university-associated sports medicine clinic by 4 fellowship-trained orthopaedic surgeons. Patients who were recruited at MSU and UVA typically completed an initial strength assessment at 3 to 4 months postoperatively as part of prospective postoperative return-to-sport testing. Patients then completed a second strength assessment at the time point included in this study. Patients underwent rehabilitation at a variety of local outpatient rehabilitation clinics per surgeon recommendation. While general guidelines provided to local physical therapists using the surgeons' protocols were consistent with those described in the previous paragraph, it was not possible to confirm if individual physical therapists followed the protocols as described, nor was the exact duration of rehabilitation able to be confirmed.

Isokinetic Quadriceps Strength Testing

Maximum isokinetic knee extension and flexion torque were assessed by a sports medicine physical therapist or graduate sports medicine researcher using an isokinetic dynamometer (Connecticut Children's: Humac NORM [CSMI]; MSU and UVA: Biodex System 4 Pro [Biodex Medical Systems]). Comparisons between the Biodex and Humac dynamometers have shown good between-device agreement (intraclass correlation coefficient range, 0.88 to 0.92).[7] Participants were seated at 90° of hip flexion, their trunk and thigh were secured with straps, and the dynamometer's arm was secured proximal to the ankle joint. The uninvolved limb's isokinetic strength was assessed first, followed by the involved (ACL-reconstructed) limb. Participants were instructed to kick out (quadriceps) and pull back (hamstring) as hard and as fast as they could against the resistance of the dynamometer. Participants were given verbal encouragement throughout the isokinetic strength assessment to promote maximal effort.[22] Isokinetic knee extension and flexion torque were assessed through knee range of motion from approximately 0° to 90° with gravity correction applied.[42] A total of 5 consecutive trials were completed at 60 deg/s. The highest peak torque measurement (in N·m) of the 5 trials was collected, and these peak torque values were converted to an LSI, calculated as follows: (involved limb strength/uninvolved limb strength) × 100%. Peak torque was subsequently normalized to the participant's body weight (kg) and recorded for analysis (N·m/kg).

Psychological Readiness for Sport

In addition to strength testing, participants completed the ACL–Return to Sport after Injury (ACL-RSI) questionnaire to assess their emotional response, confidence, and fear of injuries after ACLR. The ACL-RSI scale is a valid, responsive, and reliable measure among the target patient population included in this study.[44] The scale is scored from 0 to 100, with 100 indicating ideal patient-reported psychological readiness for sport.[23]

Statistical Analysis

Patient and surgical characteristics were summarized using means and standard deviations for continuous

TABLE 1
Patient and Surgical Characteristics[a]

	ACLR + LET (n = 17)	ACLR + ALLR (n = 25)	ACLR Only (n = 62)	*P*
Age, y	15.4 ± 1.6	17.4 ± 1.7	16.5 ± 1.6	.002
Sex				.028
Female	8 (47.1)	18 (72.0)	37 (59.7)	
Male	9 (52.9)	7 (28.0)	25 (40.3)	
Height, m	1.7 ± 0.1	1.7 ± 0.1	1.7 ± 0.1	.431
Weight, kg	69.6 ± 20.8	72.3 ± 16.6	72.5 ± 17.8	.871
Time since surgery, mo	6.2 ± 0.6	6.3 ± 0.7	6.2 ± 0.7	.811
Graft type (autograft)				.016
Quadriceps tendon	16 (94.1)	16 (64.0)	33 (53.2)	
Bone–patellar tendon–bone	1 (5.9)	2 (8.0)	15 (24.2)	
Hamstring tendon	0 (0.0)	7 (28.0)	14 (22.6)	
Medial meniscal surgery				.133
Repair	5 (29.4)	9 (36.0)	23 (37.1)	
APM	0 (0.0)	5 (20.0)	4 (6.5)	
None	12 (70.6)	11 (44.0)	35 (56.5)	
Lateral meniscal surgery				.033
Repair	4 (23.5)	14 (56.0)	15 (24.2)	
APM	0 (0.0)	1 (4.0)	1 (1.6)	
None	13 (76.5)	10 (40.0)	46 (74.2)	
ACL-RSI score	69.6 ± 12.8[b]	73.4 ± 22.2[c]	71.2 ± 17.6	.832

[a]Data are presented as mean ± SD or n (%). ACLR, anterior cruciate ligament reconstruction; ACL-RSI, Anterior Cruciate Ligament–Return to Sport after Injury; ALLR, anterolateral ligament reconstruction; APM, arthroscopic partial meniscectomy; LET, lateral extra-articular tenodesis.

[b]n = 14.

[c]n = 18.

variables and frequencies and percentages for categorical variables. Participants' age, height, weight, time since surgery, and ACL-RSI score were compared between groups using 1-way analysis of variance. Participant sex, graft type, and meniscal surgery at the time of ACLR were compared between groups using the chi-square test. Between-group comparisons of involved limb, uninvolved limb, and LSI for knee extension and flexion strength were conducted using analysis of covariance models while adjusting for the effects of participant age, graft type, and time since surgery.[19] In the case of a significant omnibus test finding, Bonferroni-corrected post hoc analyses were used to compare individual groups. All statistical analyses were conducted using jamovi (Version 2.2.5), and data visualizations were generated using ggplot2 (Version 3.4.4).

Assuming acceptable statistical power $(1 - \beta) \geq 0.80$ and an a priori alpha of 0.05, the a priori sample size estimation indicated that with 3 groups (isolated ACLR, ACLR + LET, ACLR + ALLR) and a total sample of 103 patients, we would be able to detect moderate to large between-group effects (Cohen $f = 0.35$) in our analysis of covariance models.

RESULTS

Overall, 221 patients were identified with lateral extra-articular procedures, and a total of 104 participants were included in our analysis. Between-group comparisons of patient and surgical characteristics can be found in Table 1. Significant between-group differences were observed in participant age ($P = .002$), participant sex ($P = .028$), ACL graft type ($P = .016$), and lateral meniscal surgery at the time of ACLR ($P = .033$). Unfortunately, because of a combination of changes in testing protocols and failure to complete all items on the ACL-RSI scale, data from 10 participants were not able to be included in the current analysis. When comparing the remaining 94 participants, there were no significant differences between the groups in the ACL-RSI score ($P = .832$) (Table 1).

After adjusting for age, graft type, and time since surgery, there were significant between-group differences in involved limb knee extension strength ($P = .025$) (Figure 1A), uninvolved limb knee extension strength ($P = .046$), and LSI for knee extension strength ($P = .040$) (Table 2). Post hoc analyses indicated that the ACLR + LET group had decreased involved limb knee extension strength ($P = .041$) and LSI for knee extension strength ($P = .046$) (Figure 1B) compared to the isolated ACLR group, but there were no significant differences between the ACLR + ALLR group and either the ACLR + LET or isolated ACLR group ($P > .05$) (Table 2). When comparing knee flexion strength, there were no significant between-group differences for the involved limb ($P = .222$) or the uninvolved limb ($P = .984$); however, the LSI for knee flexion strength did significantly differ between groups ($P = .012$). Post hoc analyses indicated that the ACLR + LET group had a worse LSI for knee flexion strength ($P = .017$) compared to the isolated ACLR group (Table 2).

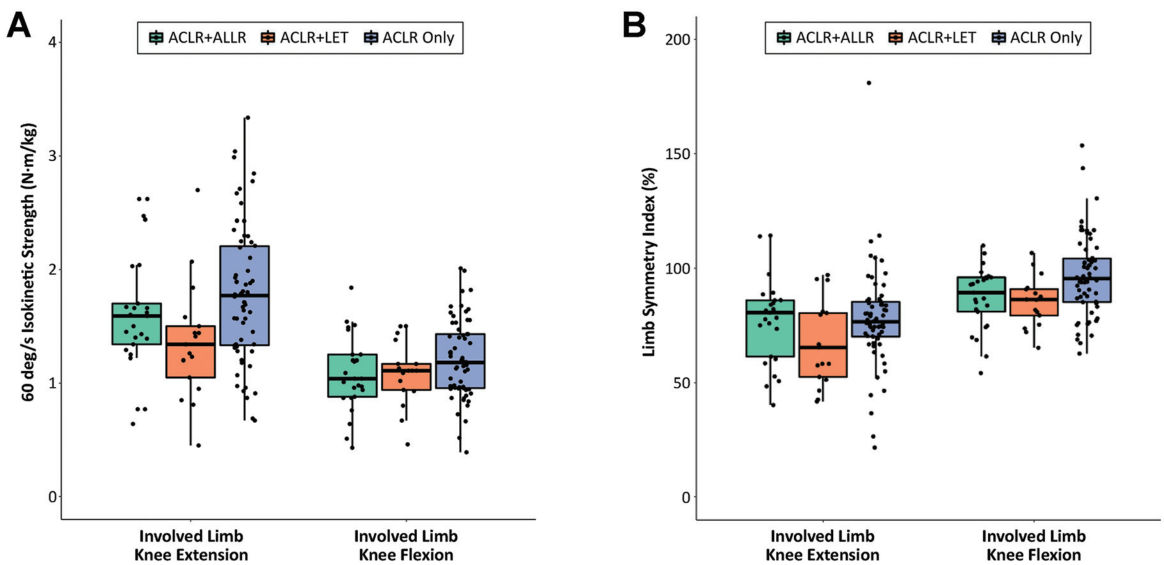

Figure 1. Box plots of (A) normalized peak torque at 60 deg/s and (B) involved limb and limb symmetry index for knee extension and flexion strength between the groups.

TABLE 2
Isokinetic Knee Extension and Flexion Strength[a]

	ACLR + LET	ACLR + ALLR	ACLR Only	P	η^2_P
Isokinetic knee extension strength					
Involved limb, N·m/kg	1.36 ± 0.52[b] 1.34 (0.89-1.79)	1.61 ± 0.53 1.59 (1.23-1.95)	1.79 ± 0.61 1.77 (0.90-2.64)	.025	0.072
Uninvolved limb, N·m/kg	2.03 ± 0.50 2.04 (1.43-2.65)	2.07 ± 0.42 2.05 (1.54-2.56)	2.35 ± 0.63 2.28 (1.46-3.10)	.046[c]	0.061
LSI, %	66.7 ± 18.3[b] 65.3 (37.5-93.1)	76.9 ± 18.4 80.6 (55.9-105.3)	77.7 ± 22.2 76.5 (61.3-91.7)	.040	0.063
Isokinetic knee flexion strength					
Involved limb, N·m/kg	1.09 ± 0.28 1.11 (0.88-1.34)	1.08 ± 0.33 1.04 (0.67-1.41)	1.21 ± 0.35 1.18 (0.71-1.65)	.222	0.030
Uninvolved limb, N·m/kg	1.29 ± 0.35 1.28 (0.86-1.70)	1.24 ± 0.30 1.25 (0.82-1.68)	1.26 ± 0.32 1.23 (0.87-1.59)	.984	<0.001
LSI, %	85.4 ± 10.8[b] 86.3 (74.8-97.8)	86.9 ± 13.8 89.3 (74.3-104.3)	96.6 ± 17.8 95.5 (76.4-114.6)	.012[d]	0.074

[a]Data are presented as mean ± SD and median (interquartile range). All analyses were completed while adjusting for the effects of participant age, graft type, and time since surgery. Detailed models including covariate statistics can be found in Supplemental Appendix Tables A1 and A2, available online. ACLR, anterior cruciate ligament reconstruction; ALLR, anterolateral ligament reconstruction; LET, lateral extra-articular tenodesis; LSI, limb symmetry index.
[b]The ACLR + LET group performed significantly worse than the isolated ACLR group (Bonferroni-corrected post hoc analysis).
[c]Age at surgery was significantly associated with the outcome of interest.
[d]Graft type was significantly associated with the outcome of interest.

DISCUSSION

The findings of this study indicated that patients who underwent a lateral extra-articular procedure at the time of ACLR displayed significantly worse involved limb isokinetic knee extension strength, uninvolved limb isokinetic knee extension strength, and worse isokinetic knee flexion and extension LSI at 6 to 9 months after ACLR compared to patients who underwent isolated ACLR. These results partially support our hypothesis that both ALLR and LET at the time of ACLR would negatively affect knee extension and flexion strength at 6 to 9 months postoperatively. While these procedures improved linear and rotary stability at the knee, our findings indicated that patients with a lateral extra-articular procedure at the time of ACLR may benefit from enhanced focus on thigh muscle strengthening or prolonged rehabilitation to ensure adequate recovery before return to unrestricted activities.

Normalized involved limb thigh muscle strength has been linked to enhanced knee function, lower quality in jump-landing movements, and reduced risk of secondary injuries within the first 2 years after ACLR.[18,35,45] In the current study, the ACLR + LET and ACLR + ALLR groups demonstrated 25% and 11% less involved limb knee extension strength, respectively, and 10% less involved limb knee flexion strength compared to the isolated ACLR group (Table 2). Our findings are similar to those reported by Getgood et al[10]; however, it is important to note that their study included isokinetic strength data collected at 90 deg/s, which limits our ability to make a direct comparison. While the current study was not mechanistic, given what is known about the effects of lateral extra-articular procedures on knee joint biomechanics and postoperative pain, it is plausible that the observed limitations in knee extension and flexion strength in the ACLR + LET group may be related to persistent knee symptoms or delayed early rehabilitation progress due to constraints in knee range of motion.[29] Future longitudinal studies should investigate the interaction between symptoms, range of motion, and thigh muscle strength over the course of recovery in the patients undergoing ACLR + LET.

Restoring a >90% LSI for knee extension strength before return to sports remains an important point of emphasis after ACLR.[13,34] Patients in the isolated ACLR group demonstrated an approximately 10% greater LSI for knee extension and flexion strength compared to the ACLR + LET group. Reports of LSIs often vary at the 6-month time point after ACLR,[21] and it should be noted that all 3 groups displayed a less than optimal LSI. Despite the increased use of LET in conjunction with ACLR, there is not a clear understanding of the biomechanical function of this technique. Varying results of tibial internal rotation after lateral extra-articular procedures have been reported, but it appears that the fixation angle may play a significant role in determining internal rotation and, in turn, tissue tension and force production.[1] While early results are promising, it is unknown what the impact of an additional lateral restraint on iliotibial band function is, what its impact on tibial rotation is, and how this influences knee strength. Inferior knee extension and flexion strength and symmetry in the ACLR + LET and ACLR + ALLR groups may be attributed to direct results of the lateral extra-articular procedure. Although ALLR and LET are different surgical techniques, they are similar in that they both create local tissue trauma at the iliotibial band and other anatomic structures.

Pain and effusion are quite common after ACLR but may be worse with a lateral extra-articular procedure, given the additional trauma. The impacts of surgery and effusion on muscle strength after ACLR have been well documented.[26,36] Additionally, these negative impacts have been attributed to a number of mechanisms including avoidance of pain/fear of injuries, arthrogenic muscle inhibition,[20] and pain-related muscle inhibition.[11] While serious complications after this procedure are rare, increased postoperative pain has been reported in 3% to 40% of patients, and postoperative wound hematoma has been reported in 5% to 10% of patients.[32,43] It is plausible that the inhibitory effects of pain and swelling on general strength had a negative impact on quadriceps strength recovery in these patients. Future prospective work should continue to identify differences in function between procedures as well as the source of these differences to optimize and provide better patient care.

Prior studies have reported that patients undergoing lateral extra-articular procedures at the time of ACLR improve rotational stability and have superior long-term outcomes compared to patients undergoing isolated ACLR.[10,12,14,15] Improved rotational stability has also been linked to improved psychological readiness in patients after ACLR.[9,38] While the underlying source of this association has not been fully described, it has been hypothesized that patients with greater knee laxity after ACLR may experience worse knee-related confidence and a greater fear of injuries as a result of laxity or instability. Despite evidence that lateral stabilizing procedures reduce knee laxity, we did not observe differences in ACL-RSI scores between the different procedures. This is consistent with recent work by Moussa et al,[24] showing no differences in ACL-RSI scores at a later time point when adding a lateral extra-articular procedure. This may suggest that while adding a lateral extra-articular procedure may have a positive effect on knee stability, the inclusion of these procedures may not play a meaningful role in enhancing psychological readiness for sports. Future work should aim to explore this relationship further.

Similar results of decreased quadriceps strength at 6 months after ACLR have been reported, with 2 earlier studies finding a similar trend when comparing ACLR with a bone-patellar tendon-bone graft to LET, although at a much later postoperative time point (>12 months).[2,27] Although the gold standard for return to play is closer to 9 months, the 6-month time point is a critical one because many young athletes will begin the process of returning to sports activities in a controlled manner. With this paradigm shift of return to sport at 9 months, and knowing that clinically significant changes in quadriceps strength can take a minimum of 8 weeks,[5] consistent isokinetic strength testing can be clinically valuable to assist in determining physical readiness at 9 months. Although evidence suggests that LET and ALLR benefit the patient in the long term, our results suggest that there were still deficits in strength at 6 months after ACLR.

Our findings indicated that patients with lateral extra-articular procedures had decreased quadriceps strength compared to patients who only underwent ACLR. Prior work has shown that a minimum of 2 months is needed to observe clinically significant improvements of approximately 10% in limb symmetry.[5] This would suggest that to achieve optimal knee strength and limb symmetry, return to play would not occur until ≥10 months after ACLR. It is well documented that age, sex, and graft type have a significant impact on knee extension strength recovery. Knee strength recovery is multifactorial, and it appears that quadriceps tendon and bone–patellar tendon–bone autografts display more limited knee extension strength at the time of return to play than hamstring tendon grafts. Additionally, female and older adolescent patients demonstrate more limited knee extension strength.[40] Despite these findings, our results showed that even when controlling for age, sex, and graft type, patients with lateral extra-articular procedures displayed inferior knee extension strength at 6 to 9 months after ACLR.

Limitations

This study is not without limitations. Our findings are intentionally limited to adolescent and young adults who have undergone ACLR. While this is a focused population, it limits generalizability to patients outside of the age range included in this study. Based on the retrospective nature of this study, our inclusion criteria (1) did not include all patients who completed testing at each institution, (2) did not link the findings of this study to long-term outcomes such as successful return to sports or reinjuries, and (3) hindered our ability to draw causal links between lateral extra-articular procedures and negative clinical outcomes. Finally, while we accounted for graft type as a covariate and attempted to distribute graft types in our sampling, this imbalance may have impacted our outcomes. Future studies should investigate differences with more homogeneous graft types. Future studies should also place a high priority on investigating how lateral extra-articular procedures impact knee extension and flexion strength in a longitudinal manner.

CONCLUSION

The addition of lateral extra-articular procedures at the time of ACLR negatively impacted quadriceps strength during a key postoperative time frame. Health care providers and rehabilitation specialists should use these findings to help with return-to-sports planning. While preliminary studies indicate that these procedures reduce reinjuries after ACLR, future work is still needed to fully understand the impact of lateral extra-articular augmentation on clinical outcomes in this patient population.

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