Combined Anterior Cruciate Ligament and Anterolateral Ligament Reconstruction Shows Superior Graft Remodeling, Maturation, and Stability Compared With Isolated Anterior Cruciate Ligament Reconstruction

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INTRODUCTION:

This study aimed to compare graft remodeling, as measured by magnetic resonance imaging (MRI), and clinical outcomes between patients who underwent isolated anterior cruciate ligament reconstruction (ACLR) versus combined anterior cruciate ligament and anterolateral ligament reconstruction (ACLR + ALLR).

METHODS:

A retrospective review was conducted on patients who underwent primary ACLR with quadruple hamstring grafts between January 2019 and March 2022, with a minimum follow-up period of 2 years. Patients were categorized into two groups based on the addition of ALLR with tibialis anterior allografts: an isolated ACLR group and an ACLR + ALLR group. Graft ligamentization was assessed using signal-to-noise quotient (SNQ) values obtained from postoperative MRI scans, with lower SNQ values indicating superior graft remodeling. Clinical outcomes were evaluated through knee stability tests (pivot-shift test, side-to-side laxity), functional outcomes, and graft retear rates. The minimal clinically important difference (MCID) for the clinical scores was calculated using the distribution-based method of a half standard deviation of the delta (difference between postoperative and baseline values). Regression analyses identified potential predictive factors for inferior ACL graft remodeling.

RESULTS:

A total of 122 patients in the isolated ACLR group and 54 in the ACLR + ALLR group were evaluated. The mean follow-up periods were similar between the groups (34.1 ± 7.4 months vs 36.4 ± 9.0 months; $P = .755$). The mean SNQ values were significantly lower in the ACLR + ALLR group compared to the isolated ACLR group (2.8 ± 1.6 vs 4.7 ± 3.5 mm, respectively; $P = .001$). Inferior ACL graft maturity was associated with an increased posterior tibial slope ($P = .016$), narrow notch width ($P = .018$), and concomitant medial meniscal lesion ($P = .017$). At the final evaluation, the ACLR + ALLR group demonstrated better rotational stability as indicated by the residual pivot-shift test ($P = .005$). No statistically significant differences were observed between the two groups in side-to-side laxity, functional outcomes, or graft retear rates. There were no differences in the percentage of patients achieving MCID for the International Knee Documentation Committee subjective score between the groups ($P = .536$).

DISCUSSION AND CONCLUSION:

The primary findings of this study indicate that combined ACLR and ALLR was associated with superior graft remodeling, as evidenced by a 1.9 lower mean SNQ value, and improved rotational stability compared to isolated ACLR. Furthermore, our results suggest that an increased PTS, decreased NWI, and concomitant medial meniscal lesion correlate with inferior maturity of the ACL graft. This study provides a valuable assessment of the beneficial impact of concurrent ALLR on ACL graft maturation and overall knee stability.

Combined ACLR and ALLR resulted in superior graft remodeling, demonstrated by a mean SNQ value that was 1.9 lower than in isolated ACLR, along with improved rotational stability.

Figure. 1. Anterior cruciate ligament (ACL) graft inclination angle measurements on magnetic resonance imaging (MRI). The inclination angle is defined by the intersection of two lines: one tangential to the anterior aspect of the ACL graft (Line A) and the other tangential to the anterior aspect of the intercondylar eminence and perpendicular to the long axis of the tibia (Line B).

Figure. 2. Evaluation of graft remodeling on MRI. Circular regions of interest (ROIs) were placed to calculate the signal-to-noise quotient (SNQ). One ROI (circled) was positioned 2 mm anterior to the patellar tendon, and three ROIs (proximal, midsubstance, and distal regions of the graft) were placed on the ACL. An additional ROI was placed on the posterior cruciate ligament.

Table 1. Baseline Demographic and Clinical Characteristics*

Variable	Isolated ACLR (n = 122)	ACLR + ALLR (n = 54)	*P* Value†
Age at surgery (y)	28.7 ± 12.0	26.7 ± 10.6	0.322
Sex			0.999
Male	100 (82.0)	44 (81.5)	
Female	22 (18.0)	10 (18.5)	
Body mass index (kg/m²)	23.6 ± 4.1	23.6 ± 3.9	0.934
Time between injury and surgery‡ (mo)	3.3 ± 4.1	4.2 ± 9.0	0.473
Follow-up period (mo)	34.1 ± 7.4	36.4 ± 9.0	0.127
Preoperative pivot-shift test			0.058
0/1	66 (54.1)	17 (31.5)	
2/3	56 (45.9)	37 (68.5)	
Side-to-side laxity difference§ (mm)	8.6 ± 2.7	8.3 ± 2.6	0.309
Medial meniscal lesion	60 (54.1)	27 (60.2)	0.420
Lateral meniscal lesion	29 (25.7)	9 (18.7)	0.301
Morphological features			
Hip-knee-ankle angle (deg)	1.0 ± 3.0	0.8 ± 2.8	0.628
Posterior tibial slope (deg)	9.1 ± 1.7	8.8 ± 1.8	0.090
Lateral femoral condyle ratio (%)	66.9 ± 3.2	67.7 ± 3.1	0.104
Notch width index (%)	28.5 ± 1.2	28.5 ± 1.4	0.100
ACL graft surgical inclination (deg)	55.3 ± 5.6	53.8 ± 5.6	0.789

*Values are presented as mean ± standard deviations or n (%).

†The Mann–Whitney *U* test was used to analyze differences in age. An independent *t* test was used to analyze differences in the body mass index, time interval between injury and surgery, follow-up period, preoperative side-to-side laxity, difference, and radiologic findings. The chi-square or Fisher's exact test was used to analyze differences in sex, preoperative pivot-shift grade, meniscus lesions, and meniscal injury treatment. Bold values indicate statistical significance ($P < .05$).

‡ACLR, anterior cruciate ligament reconstruction; ALLR, anterolateral ligament reconstruction.

Table 2. Multivariable Analysis of Predictive Factors Variables and the Extent of SNQ Values Using a Generalized Linear Model

	Multivariate Analysis	
	Estimate (95% CI)	*P* Value*
Age	0.010 (−0.027 to 0.048)	0.422
Sex (Female vs. male)	−0.652 (−1.317 to 1.232)	0.060
Body mass index	−0.057 (−0.116 to 0.870)	0.180
Time from injury to surgery	−0.048 (−0.102 to 0.258)	0.131
Preoperative pivot-shift grade		
Grade 2 or 3 vs grade 0 or 1	0.454 (−0.499 to 1.808)	0.269
Side-to-side laxity	−0.177 (−0.265 to 0.373)	0.168
Combined medial meniscal lesion (present vs. absent)	1.344 (0.2886; 1.432)	**0.017**
Combined lateral meniscal lesion (present vs. absent)	−0.100 (−1.488 to 1.147)	0.193
ALLR	−1.503 (−2.001 to −0.430)	**0.008**
Hip-knee-ankle angle	0.007 (−0.385 to 0.255)	0.901
Posterior tibial slope	0.172 (0.0746 to 0.671)	**0.016**
Lateral femoral condyle ratio	−0.070 (−0.260 to 0.182)	0.453
Notch width index	−0.150 (−0.999 to −0.101)	**0.018**
ACL graft inclination	−0.031 (−0.110 to 0.031)	0.317

*Bold font indicates a statistically significant difference.

‡SNQ, signal-to-noise quotient; ALLR, anterolateral ligament reconstruction; ACL, anterior cruciate ligament.

Table 3. Comparison of Postoperative Clinical Outcomes Among Groups*

	Isolated ACLR (n = 122)	ACLR + ALLR (n = 54)	*P* Value†
Lysholm score	88.7 ± 7.9	89.3 ± 8.1	0.318
IKDC subjective score	85.3 ± 11.8	85.9 ± 10.5	0.478
Tegner activity scale	5.3 ± 1.3	5.2 ± 1.4	0.950
Postoperative side-to-side laxity (mm)	3.3 ± 2.0	3.3 ± 1.4	0.300
Residual pivot-shift	17 (16.3)	7 (8.2)	**0.005**
Retear	7 (5.7)	1 (1.8)	0.410

*Values are presented as mean ± standard deviation or n (%).

†The Mann–Whitney *U* test was used to analyze differences in all clinical scores. The chi-square or Fisher's exact test was used to analyze differences in pivot-shift grade and retear. An independent *t* test was used to analyze differences in postoperative side-to-side laxity. Bold font indicates a statistically significant difference.

‡ACLR, anterior cruciate ligament reconstruction; ALLR, anterolateral ligament reconstruction; IKDC, International Knee Documentation Committee.