



THE ROLE OF ANTEROLATERAL LIGAMENT RECONSTRUCTION OR LATERAL EXTRA-ARTICULAR TENODESIS FOR REVISION ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION: A SYSTEMATIC REVIEW AND META-ANALYSIS OF COMPARATIVE CLINICAL STUDIES

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Faculty Disclosure



- There are no conflicts of interest to disclose
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THE ANTEROLATERAL COMPLEX OF THE KNEE



- Renewed interest in the anterolateral complex of the knee
- BM studies stress its importance as a secondary restraint to anterior displacement and tibial internal rotation ¹⁻²
- Clinically, higher pivot shift and marked anterolateral laxity ³
- Following widespread success in primary ACLR, use of lateral extra-articular tenodesis (LET) or anterolateral ligament reconstruction (ALLR) has been endorsed in revision surgery.
- Load sharing effects provide a protective element during early rehabilitation. ⁴
- Recent consensus meeting of leading experts suggest LET/ALLR should be consider when performing ACL revision ⁵



AIMS AND OBJECTIVES

• To perform a systematic review and meta-analysis on clinical comparative studies to investigate wheter revision of augmented ACLR (aACLR) with LET/ALL had superior clinical outcomes and rotational stability compared to revision of isolated ACLR (iACLR)



METHODOLOGY



<u>Literature review</u>

- PRISMA (Preferred Reported Items for Systematic Review and Meta-Analyses) criteria ⁶
- Cochrane Controlled Register of Trials, PubMed, Medline and Embase. Inception to 2nd August 2022
- Search items: 'extra-articular' OR 'tenodesis' OR 'anterolateral ligament' OR 'iliotibial' AND 'anterior cruciate ligament' AND 'revision' OR 're-operation'

<u>Eligibility criteria</u>

- Inclusion criteria: clinical comparative studies between revision surgery of aACLR with LET/ALL and iACLR
- Exclusion criteria: primary ACLR, non-human studies, purely biomechanical, case reports, expert opinions and technical tips and publications pertaining to surgical techniques
- PROMS, return to pre-injury level, post-operative rotational stability, failure and complications included

Study selection and Assessment of Quality of Studies

- Independent review of titles and abstracts by two authors (KB and HHC).
- Discrepancies resolved by senior authors (NS, RSA)
- Modified Coleman Methodological Score ⁷
- $0 100.85 100 \rightarrow \text{excellent}. 70 84 \rightarrow \text{good}. 55 69 \rightarrow \text{fair}. < 55 \text{ poor}.$
- ROBINS-I for risk of bias ⁸

Data Synthesis and Statistical Analysis

- Review Manager 5.4
- Odd Ratio for all dichotomous variables and mean differences for continuous parameters
- P value < 0.1 and I² > 50%: statistical heterogeneity -> random effects model.
 Otherwise fixed effects model used.

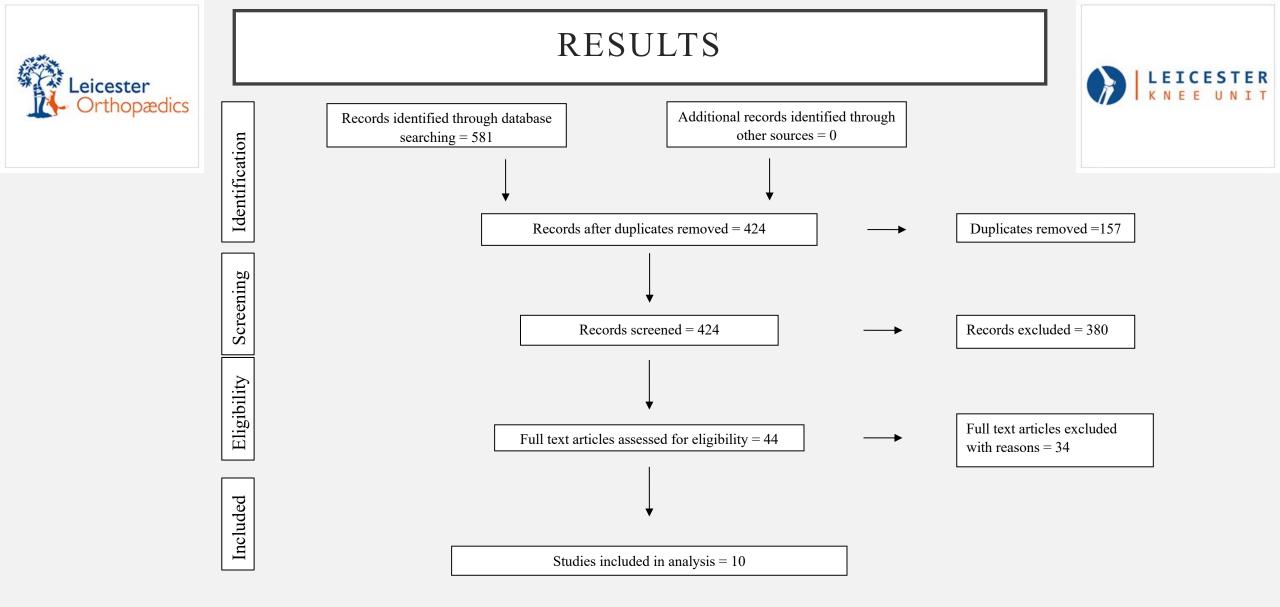


Figure 4. PRISMA flow diagram for study selection

RESULTS



- Overall quality of studies was fair (mean score, 63.2)
- 3 prospective cohorts, 7 retrospective cohort

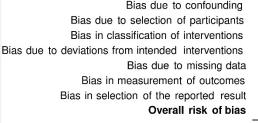
Baseline characteristics

- Total: 793 patients -> 390 iACLR, 403 aACLR with LET/ALL.
- Mean age and PROMs assessment: 29.2 years and 35 months
- Trauma common cause for failure of primary graft
- Initial primary graft reported in three studies: hamstring commonest
- 4 studies investigated higher-grade pivoting (≥2)
- 5 studies reported on rehabilitation protocol -> differed re. FWB, knee ROM and return to sports (6 to 9 months)
- Meta-analysis for \geq 4 studies
- Commonest PROMs: subjective International Knee Documentation Score (IKDC), Tegner and Lysholm (7 studies)
- Post-operative Lachmans (6 studies), post-operative pivot shift (7 studies), post-operative side to side difference (6 studies), post operative failure (5 studies)



STUDY RISK OF BIAS ASSESSMENT





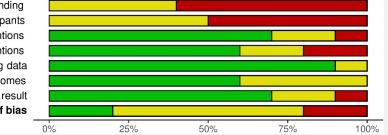


Figure 5. Risk of bias graph



Overall risk of bias was moderate to high

Table 2. Risk of bias summary. Red circle, high risk of bias; yellow circle, moderate risk of bias; green circle, low risk of bias. A: Bias due to confounding data (selection bias), B: bias in selection of participants into the study (selection bias), C: bias in classification of interventions (information bias), D: bias due to deviations from intended interventions (performance bias), E: bias due to missing data (attrition data), F: bias in measurement of outcomes (detection bias), G: bias in selection of the reported result (outcome reporting bias)



RESULTS – CLINICAL OUTCOMES AND EXAMINATION



Augmentation with LET/ALL improved post-operative IKDC score, superior rotational stability, lower side to side difference and were less likely to fail

	ACL revision + L	ET/ALL	Isolated ACL re	vision		Odds Ratio		Odds Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Fixed, 95% CI	Year	M-H, Fixed, 95% CI
Trojani 2012	67	84	50	79	30.3%	2.29 [1.13, 4.61]	2012	
DW Lee 2019	38	42	23	43	6.3%	8.26 [2.51, 27.20]	2019	
Alm 2020	55	59	9	14	2.9%	7.64 [1.72, 33.95]	2020	
Ventura 2021	11	12	8	12	1.9%	5.50 [0.51, 59.01]	2021	
Yoon 2021	10	18	3	21	3.6%	7.50 [1.61, 34.83]	2021	
Eggeling 2022	20	23	46	55	10.3%	1.30 [0.32, 5.33]	2022	
Helito 2022	54	86	42	88	44.8%	1.85 [1.01, 3.38]	2022	
Total (95% CI)		324		312	100.0%	2.77 [1.91, 4.01]		•
Total events	255		181					
Heterogeneity: Chi ² =	10.05, df = 6 (P = 1	0.12); I ^z =	40%				=	
Test for overall effect	Z = 5.38 (P < 0.00	001)					0.Ò	2 0.1 1 10 5 Isolated ACL revision ACL revision + LET/ALL

Figure 7. Post-operative negative Pivot shift

	ACL revisi	on + LET	ALL	Isolated	ACL revi	sion		Std. Mean Difference		Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	Year	IV, Random, 95% CI
DW Lee 2019	1.9	1.3	42	2.2	1.4	45	20.5%	-0.22 [-0.64, 0.20]	2019	
Alm 2020	1.7	1.4	59	3.8	2.5	14	13.5%	-1.25 [-1.87, -0.63]	2020	
Ventura 2021	2.8	0.4	12	3	0.9	12	9.4%	-0.28 [-1.08, 0.53]	2021	
Yoon 2021	3.9	3	18	5.9	2.8	21	12.7%	-0.68 [-1.33, -0.03]	2021	
Eggeling 2022	1.3	2	23	1.8	2.1	55	17.8%	-0.24 [-0.73, 0.25]	2022	
Helito 2022	1.6	0.9	86	2.4	1.6	88	26.0%	-0.61 [-0.92, -0.31]	2022	2
Total (95% CI)			240			235	100.0%	-0.53 [-0.81, -0.24]		•
Heterogeneity: Tau ² =	0.06; Chi ² =	9.54, df=	5 (P = 0	.09); I ² = 4	8%				-	
Test for overall effect:	Z = 3.62 (P =	0.0003)								-2 -1 U 1 2 Isolated ACL revision ACL revision + LET/ALL

Figure 8. Post-operative side-to-side difference

	ACL revision + L	ET/ALL	Isolated ACL re	vision		Odds Ratio		Odds Ratio		
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Fixed, 95% CI	Year	M-H, Fixed, 95% CI		
Trojani 2012	6	84	12	79	33.9%	0.43 [0.15, 1.21]	2012			
Alm 2020	3	59	3	14	13.6%	0.20 [0.03, 1.10]	2020	· · · · · · · · · · · · · · · · · · ·		
Yoon 2021	2	18	3	21	7.3%	0.75 [0.11, 5.07]	2021			
Eggeling 2022	3	23	6	55	9.1%	1.23 [0.28, 5.38]	2022			
Helito 2022	4	86	13	88	36.2%	0.28 [0.09, 0.90]	2022			
Total (95% CI)		270		257	100.0%	0.44 [0.24, 0.80]		•		
Total events	18		37							
Heterogeneity: Chi ² =	3.54, df = 4 (P = 0.4	47); I ² = 0 ⁴	%				0.01	0.1 1 10 100		
Test for overall effect:	Z = 2.68 (P = 0.007	")					0.01	Isolated ACL revision ACL revision + LET/ALL		

Figure 9. Post-operative failure

ACL revis	ion + LET	ALL	Isolated	ACL revi	sion		Std. Mean Difference		Std. Mean Difference
Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	Year	IV, Random, 95% Cl
84.3	18.5	42	75.9	19.2	45	15.0%	0.44 [0.02, 0.87]	2019	
90	10.7	59	74	21.4	14	10.5%	1.19 [0.57, 1.80]	2020	
84.8	6	12	85.1	4.6	12	7.6%	-0.05 [-0.85, 0.75]	2021	
57.8	15.7	18	56.4	20.7	21	10.3%	0.07 [-0.56, 0.70]	2021	
90.5	11.6	19	88.4	12.7	20	10.3%	0.17 [-0.46, 0.80]	2022	
81.7	11.9	42	81.1	19.5	36	14.4%	0.04 [-0.41, 0.48]	2022	
77.5	16.2	23	80.1	14.9	55	13.4%	-0.17 [-0.66, 0.32]	2022	
83.6	9.4	86	79.1	11.7	88	18.6%	0.42 [0.12, 0.72]	2022	
		301			291	100.0%	0.27 [0.01, 0.54]		◆
0.08; Chi ² =	15.35, df	= 7 (P =	0.03); I ² =	54%				100	
Z = 2.02 (P =	= 0.04)								-1 -0.5 0 0.5 1 Isolated ACL revision ACL revision + LET/ALL
	Mean 84.3 90 84.8 57.8 90.5 81.7 77.5 83.6 0.08; Chi ² =	Mean SD 84.3 18.5 90 10.7 84.8 6 57.8 15.7 90.5 11.6 81.7 11.9 77.5 16.2 83.6 9.4	84.3 18.5 42 90 10.7 59 84.8 6 12 90.5 15.7 18 90.5 11.6 19 81.7 11.9 42 77.5 16.2 23 83.6 9.4 86 0.08; Chi ² = 15.35, df = 7 (P = 9	Mean SD Total Mean 84.3 18.5 42 75.9 90 10.7 59 74 84.8 6 12 85.1 57.8 15.7 18 56.4 90.5 11.6 19 88.4 81.7 11.9 42 81.1 77.5 16.2 23 80.1 83.6 9.4 86 79.1 301 0.08; Chi ^p = 15.35, df = 7 (P = 0.03); P =	Mean SD Total Mean SD 84.3 18.5 42 75.9 19.2 90 10.7 59 74 21.4 84.8 6 12 85.1 4.6 57.8 15.7 18 56.4 20.7 90.5 11.6 19 88.4 12.7 81.7 11.9 42 81.1 19.5 77.5 16.2 23 80.1 14.9 83.6 9.4 86 79.1 11.7 301 0.08; Chi ^P = 15.35, df = 7 (P = 0.03); I ^P = 54%	Mean SD Total Mean SD Total 84.3 18.5 42 75.9 19.2 45 90 10.7 59 74 21.4 14 84.8 6 12 85.1 4.6 12 57.8 15.7 18 56.4 20.7 21 90.5 11.6 19 88.4 12.7 20 81.7 11.9 42 81.1 19.5 36 77.5 16.2 23 80.1 14.9 56 83.6 9.4 86 79.1 11.7 88 301 291 0.08; Chi ^p = 15.35, df = 7 (P = 0.03); I ^p = 54% 54% 291	Mean SD Total Mean SD Total Weight 84.3 18.5 42 75.9 19.2 45 15.0% 90 10.7 59 74 21.4 14 10.5% 84.8 6 12 85.1 4.6 12 7.6% 90.5 11.6 19 88.4 12.7 20 10.3% 90.5 11.6 19 88.4 12.7 20 10.3% 81.7 11.9 42 81.1 19.5 36 14.4% 77.5 16.2 23 80.1 14.9 55 13.4% 83.6 9.4 86 79.1 11.7 88 18.6% 0.08; Chi ² = 15.35, df = 7 (P = 0.03); P = 54% 291 100.0%	Mean SD Total Mean SD Total Weight IV, Random, 95% CI 84.3 18.5 42 75.9 19.2 45 15.0% 0.44 (D.02, 0.87) 90 10.7 59 74 21.4 14 10.5% 1.19 [0.57, 1.80] 84.8 6 12 85.1 4.6 12 7.6% -0.05 [0.85, 0.75] 57.8 15.7 18 56.4 20.7 21 10.3% 0.07 [-0.56, 0.70] 90.5 11.6 19 88.4 12.7 20 10.3% 0.07 [-0.66, 0.82] 81.7 11.9 42 81.1 19.5 36 14.4% 0.04 [-0.41, 0.48] 77.5 16.2 23 80.1 14.9 55 13.4% -0.71 [-0.66, 0.32] 83.6 9.4 86 79.1 11.7 88 18.6% 0.42 [0.12, 0.72] 0.08; Chi ² = 15.35, df = 7 (P = 0.03); P = 54% 291 100.0% 0.27 [0.01, 0.54] 0.08; Chi ² = 15.35, df = 7 (P	Mean SD Total Mean SD Total Weight IV, Random, 95% CI Year 84.3 18.5 42 75.9 19.2 45 15.0% 0.44 [0.02, 0.87] 2019 90 10.7 59 74 21.4 14 10.5% 1.19 [0.57, 1.80] 2020 84.8 6 12 85.1 4.6 12 7.6% -0.05 [0.85, 0.75] 2021 57.8 15.7 18 56.4 20.7 21 10.3% 0.07 [-0.56, 0.70] 2021 90.5 11.6 19 88.4 12.7 20 10.3% 0.07 [-0.56, 0.70] 2022 81.7 11.9 42 81.1 19.5 36 14.4% 0.04 [-0.41, 0.48] 2022 83.6 9.4 86 79.1 11.7 88 18.6% 0.42 [0.12, 0.72] 2022 83.6 9.4 86 79.1 11.7 88 18.6% 0.42 [0.12, 0.72] 2022

Figure 6. Post-operative IKDC score



RESULTS – PRE-OPERATIVE HIGH GRADE KNEE LAXITY (≥ 2)



Sub-group analysis of those with pre-operative high grade knee laxity revealed even greater performance in post-operative IKDC score and a significant improvement in Lysholm score for the augmentation group

	ACL revis	sion + LET	ALL	Isolated	ACL rev	ision		Std. Mean Difference		Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	Year	IV, Random, 95% CI
DW Lee 2019	84.3	18.5	42	75.9	19.2	45	27.6%	0.44 [0.02, 0.87]	2019	
Alm 2020	90	10.7	59	74	21.4	14	19.2%	1.19 [0.57, 1.80]	2020	
Yoon 2021	57.8	15.7	18	56.4	20.7	21	18.7%	0.07 [-0.56, 0.70]	2021	
Helito 2022	83.6	9.4	86	79.1	11.7	88	34.5%	0.42 [0.12, 0.72]	2022	
Total (95% CI)			205			168	100.0%	0.51 [0.16, 0.86]		•
Heterogeneity: Tau ² = Test for overall effect:			= 3 (P = 0	1.08); I² = 5	6%				-	-2 -1 0 1 2 Isolated ACL revision ACL revision + LET/ALL

Figure 10. Post operative subjective IKDC

	ACL revis	ion + LET	ALL	Isolated	ACL revi	sion		Std. Mean Difference		Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI	Year	IV, Fixed, 95% CI
DW Lee 2019	90.2	19.4	42	87.5	20.4	45	26.1%	0.13 [-0.29, 0.56]	2019	
Alm 2020	95	10.8	59	75.5	20.8	14	11.6%	1.46 [0.83, 2.09]	2020	````
Yoon 2021	58.7	16.1	18	62	21.3	21	11.6%	-0.17 [-0.80, 0.46]	2021	
Helito 2022	87.9	8.7	86	82.6	11.1	88	50.6%	0.53 (0.23, 0.83)	2022	
Total (95% CI)			205			168	100.0%	0.45 [0.24, 0.67]		•
Heterogeneity: Chi ² = 1	15.96, df = 3	(P = 0.00	01); I ² = 8	1%					12	
Test for overall effect: 2	Z= 4.12 (P <	< 0.0001)								Isolated ACL revision ACL revision + LET/ALL

Figure 11. Post-operative Lysholm score



DISCUSSION



- ACL with LET/ALL -> better IKDC score, lower incidence in rotational laxity, greater stability in side-to-side difference and lower failure rates
- Should we perform ALL/LET augmentation in all patients?
- Pre-operative higher grade (≥ 2) laxity -> even further improvement of IKDC score and improved Lysholm score.
- Low grade pivoting < 2 could indicate intact ALL. May explain similar results in other Lysholm and Tegner in all studies.
- Revision ACL surgery is a salvage procedure
- Equal distribution of concomitant injuries, harvesting options and patient-related factors
- Limitations: retrospective designs of studies, short follow up (35 months), subjective measurement for pivot test, differences in rehabilitation between studies



CONCLUSION



• Despite limitations, this meta-analysis provides useful information for clinicians.

• Lateral extra-articular augmentation to a revision ACLR improved subjective IKDC scores, rotational stability and reduced failure rates compared to isolated ACLR revision.

• Although there remains controversy on the necessity of augmenting all revision ACLRs, the current metaanalysis advocates adding a lateral extra-articular procedure in those with a higher-grade pivot shift.

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