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Review Article

Non-Graft Related Failure Complications of Lateral Extra-articular Tenodesis with Anterior Cruciate Ligament Reconstruction: A Clinical Review

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Abstract

Many systematic reviews have extensively evaluated Anterior Cruciate Ligament (ACL) graft rupture in the setting of Lateral Extra-Articular Tenodesis (LET). However, other complications surrounding the addition of an LET may have been overlooked. This leads to a gap in the literature regarding the broader spectrum of LET complications, which underestimates a full understanding of its morbidity. This narrative review aims to fill this gap by synthesizing data from existing systematic reviews and using their primary studies in order to highlight non-graft related failure complications that were initially missed, such as hardware irritation, infections and hematoma. This study intends to provide a more comprehensive overview of non-graft failure complications for ACLR with LET that have been overlooked by previous reviews on this topic.

Keywords: Lateral Extra-Articular Tenodesis; Anterior Cruciate Ligament Reconstruction; Complications; Graft Failure; Systematic Review; Narrative Review

Introduction

Lateral Extra-Articular Tenodesis (LET) is a knee procedure that when alongside Anterior Cruciate Ligament Reconstruction (ACLR), has gained renewed interest for its ability to enhance rotational stability and reduce graft failure in high-risk patients [1]. LET is particularly appealing for athletes at high risk of reinjury and in particular, revision cases, as it has been shown to reduce graft failure rates and improve patient-reported outcomes [1]. Despite these benefits, the broader clinical picture and strict indications remain incomplete. Most systematic reviews to date have focused on binary success metrics such as graft success or return-to-play timelines-while giving limited attention to the full range of complications that may arise from LET [2-15]. This narrow focus risks underestimating the morbidity associated with the procedure. By examining the literature through a complication-centric lens, this study seeks to provide a more nuanced understanding of the risk profile associated with the addition of a LET. Our goal is to equip clinicians with a more balanced view one that includes both the biomechanical benefits and the potential complications that may influence outcomes.

The Significance of LET Complications

In recent years, ACL reconstruction has evolved from a purely mechanical reconstruction to a more holistic approach that considers joint kinematics, patient-specific risk factors and long-term joint health and rehabilitation [16]. The LET procedure has emerged as a helpful adjunct in this context, especially for younger patients with high-grade pivot shift or those undergoing

revision ACLR [17]. Its biomechanical traits limiting internal tibial rotation and anterior translation-have been well supported in both cadaveric and clinical studies [18].
However, reinforcing the lateral structures of the knee is not without consequence. While the addition of a LET may reduce graft failure, it also introduces new sources of morbidity that are often underreported or inconsistently defined in the literature.

Methodology

A Narrative Review of Systematic Reviews

To explore the full spectrum of non-graft failure complications associated with LET, a narrative review was conducted by re-analyzing the primary studies included in existing systematic reviews and meta-analyses on the subject. This was done to show a possible lack of attention towards non-graft complications in LET literature, as well as to answer the question of what LET complications exist overall. The main outcome of our study is therefore to evaluate the non-graft complications that arise with LET-paired ACLR.

First, all systematic reviews that met the following inclusion criteria were identified: having LET performed with primary ACLR, reported clinical outcomes and included human subjects (Table 1). Exclusion criteria included studies unrelated to LET or ACLR, reviews that did not report outcomes, revision ACLR studies, as well as animal, cadaveric or purely biomechanical studies. Narrative reviews were also excluded to maintain methodological consistency.

Bias of all primary studies was assessed according to the Methodological Index for Non-Randomized Studies (MINORS) and the Revised Cochrane Risk-of-Bias Tool for Randomized Trials (RoB 2.0). The MINORS scale is out of 16 for non-comparative studies and 24 for comparative studies, where each item ranges from 0 to 2. The RoB 2.0 framework assesses the quality of randomized studies based on five domains: bias arising from the randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome and selection of the reported result. Each RoB 2.0 domain is rated as low risk, some concerns or high risk of bias.

Statistical Analysis

A single-factor Analysis of Variance (ANOVA) test was done, followed by the Tukey's Honestly Significant Difference (HSD) test to obtain the p-values of all possible combinations of complication groups. The rationale of this testing was to determine the statistical significance of LET complications and whether certain ones were more prevalent than others for future clinical awareness.

First Author (Publication Year)	Study Design	LET Complications	N	Patient Age: Mean (SD) [Range] {N}, years	Graft Type	Sex Ratio (F:M)	Follow-Up Time: Mean (SD) [Range], months
Getgood 2020	RCT	Hematoma (3), ITB snapping (2), LET hardware removal (10), Overconstrained lateral compartment (1), Hardware irritation (14)	618	18.9	HT autograft	321:297	Not reported
Getgood 2019	RCT	Not reported	600	≤ 25	HT autograft	Not reported	Not reported

Anderson 2001	RCT	None	105	23.6 {35}, 22 {35}, 20.1 {35}	BPTB autograft, HT autograft	37:68	35.4 (11.6) [24-48]
Trichine 2014	RCT	None	120	33(14–56) {60}, 26(16–64) {60}	BPTB autograft	0:120	24
Rowan 2019	Pro cohort	Persistent numbness of the infrapatellar branches of the saphenous nerve (1)	273	33(14–56) {218}, 26(16–64) {55}	HT autograft	Not reported	Not reported
Gibbs 2021	Pro cohort	Not reported	20	20.8(6.8)	QT autograft, BTB autograft	Not reported	Not reported
Barber-Westin 1993	Pro cohort	Not reported	84	24 [14-38]	BPTB autograft	25:59	37
Noyes 1991	Pro cohort	Not reported	67	26 [16-48]	Not reported	27:40	Not reported
Vadala 2013	RCT	None	60	25 [15-40]	HT autograft	60:0	44.6
Porter 2020	RCT	None	40	20.7(1.8)	HT autograft	0:40	84
Castoldi 2020	RCT	Not reported	79	19.4 [19-20.2]	BPTB autograft	Not reported	Not reported
Zaffagnini 2006	RCT	None	75	29.5 [15-49]	BPTB autograft, HT autograft	26:49	60
Zaffagnini 2008	RCT	None	72	26 [19-45]	HT autograft	32:40	36
Giraud 2006	RCT	Not reported	63	27.1(7.5){34}, 28.5(12) {29}	BPTB autograft	Not reported	Not reported
Dejour 2013	Pro cohort	Not reported	75	33.2 {25}, 27.5 {25}, 21.4 {25}	BPTB autograft, HT autograft	24:51	25
Ferretti 2016	Retro cohort	Septic arthritis (1)	139	27.3 [18-50] {71}, 25.7 [18-46] {68}	HT autograft	32:107	120

Strum 1989	Retro cohort	None	127	25.2 [16-42] {84}, 27.8 [17-57] {43}	BPTB autograft	Not reported	45.2 [24-90]
Wilson 2019	Retro case series	Not reported	60	13 [11-16]	HT autograft	21:36	38.5
Nishida 2022	RCT	Not reported	18	18.9(4.9) {9}, 22.0(8.8) {9}	QT autograft, BPTB autograft	7:11	Not reported
Sheean 2020	Pro cohort	Not reported	20	17.3 [15-24]	HT autograft, BPTB autograft, QT autograft	11:9	Not reported
Alessio-Mazzzola 2019	Retro case series	Not reported	22	23.8(4.2)	BPTB autograft	Not reported	42.2(16.9)
Grassi 2021	Retro case series	Deep infection (14), Superficial infection (16), Stiffness (6), Swelling (20)	22	22(4.5) {10}, 25.5(11) {10}	HT autograft	2:18	Not reported
Imbert 2017	Retro case series	None	7	Not reported	BPTB autograft	Not reported	Not reported
Colombet 2011	Retro cohort	Not reported	20	27.6(7.41) {10}, 27.43(7.8) {10}	HT autograft	3:17	Not reported
Meynard 2020	Retro case series	Granuloma on lateral scar (1), Neuroma near incision used to harvest hamstring tendons (1), Hypoesthesia on anterior side of tibia (2), Discomfort from interference screw near Gerdy's tubercle (3), Pain behind thigh due	50	28.5(8.1)	Not reported	17:33	9.9(2)

		to the hamstring tendon harvesting (1)					
Ahn 2021	Retro cohort	Limited flexion and pain from delayed protrusion of the bioabsorbable interference screw used for femoral fixation (1)	10	56.1(7.4)	HT autograft	5:5	Not reported
Cavaignac 2020	Pro cohort	Not reported	62	33.1(8.3) {31}, 27.2(6.7) {31}	HT autograft	Not reported	12
Kocher 2006	Retro case series	Not reported	44	10.3	Not reported	Not reported	63.6
Jorgensen 2001	Retro case series	Deep venous thromboembolism (1), Slight/moderate pain from lateral femoral hernia (9), Local irritation resulting in staple removal (48), Anterior knee pain during activity (15)	155	24	Not reported	37:117	Not reported
Green 2023	Retro case series	None	49	14.2(1)	QT autograft	21:27	24
Hantouly 2023	Retro cohort	Not reported	100	28.15	HT autograft, BPTB autograft	6:94	Not reported
Firth 2022	Case-control	Not reported	568	18.8	HT autograft	292:276	24
Perelli 2022	Retro cohort	None	66	13.5(1.2)	HT autograft	Not reported	24
Mahmoud 2022	Retro cohort	Meniscus tears requiring a subsequent	72	25(8.5)	HT autograft	17:55	10

		arthroscopy (3)					
El-Azab 2023	RCT	None	95	27(5.9) {48}, 28(6) {47}	Hamstring autograft	15:80	Not reported
Joseph 2020	Retro cohort	None	30	Not reported	HT autograft	5:25	Not reported
Eggeling 2022	Retro cohort	Not reported	78	32.3(10.6)	BPTB autograft, HT autograft, QT autograft	39:48	28.7 (8.8)
Minguell Monyart 2023	Pro case series	Anteroposterior instability (6), Knee pain (3), Graft re-rupture (1)	46	36.3(9.7)	Fresh frozen allografts	15:31	12
Viglietta 2022	Pro cohort	Not reported	161	28.4(6.4) {85}, 26.1(6) {79}	HT autograft	38:126	188.4
Marcacci 2009	Retro case series	Paresthesias in saphenous nerve distribution (4), Removal of staples (8)	60	Not reported	HT autograft	15:45	132
Monaco 2022	Retro cohort	Anterior knee pain (4), Symptomatic tibial tunnel cyst (1), Dysesthesia (3), Hemarthrosis (1), Growth disturbance (9)	111	16.2(1.4)	HT autograft	42:69	43.8 (17.6)
Declercq 2023	Retro case series	Graft re-rupture (3), Arthrofibrosis (1), Septic arthritis (1), Hematoma (1), Hardware irritation (1)	83	24.3	HT autograft	Not reported	67.7
Heard 2023	RCT	Infection (5), ITB snapping (2), Persistent effusion (10), Hardware removal (10), Stiffness (5), Hematoma (3),	618	18.9	HT autograft	316:302	Not reported

		Periostitis (1)					
Farinelli 2023	Retro case series	Loose body from a cartilage injury of the patella (1)	27	23.2(4.3)	QT autograft, BPTB autograft	0:27	Not reported
Alm 2020	Retro case series	Not reported	111	30.1(12.2)	QT autograft, HT autograft, BPTB autograft	43:68	24
Jacquet 2021	Retro cohort	Not reported	266	30.4(8.4)	QT autograft, HT autograft, BPTB autograft	76:190	44.3
Keizer 2023	Retro cohort	Not reported	78	27.6(7.6){42}, 31.3(8.9) {36}	BPTB autograft	21:57	43.9 (29.2)
Borim 2023	Pro case series	Hemarthrosis (1), Residual pain (1), Material discomfort (2)	19	29.8(7.5)	BPTB autograft	10:0	24
Hoekstra 1986	Retro case series	Plaster ulcer of the heel (1), Superficial wound infection (1), Transient peroneal palsy due to compression (1), Urinary tract infection (2)	27	27.3	QT autograft	4:23	Not reported
Rackemann 1991	Retro case series	Loss of extension (17), loss of flexion (12), patellofemoral crepitus (12), mechanical clunk of snap (6), anterior knee pain (4), slight ache after use (4), persistent effusion (3), removal of wire/silk (3),	74	27.2	BPTB autograft	7:67	70

		intra-articular adhesion (3), Infection (2), removal of staple (1), late infection (1)					
Johnston 2003	Retro cohort	Not reported	82	Not reported	Not reported	20:62	9.8 (3.2)
Aglietti 1992	Retro case series	None	120	Not reported	BPTB autograft, HT autograft	Not reported	24
Anderson 1994	Retro case series	Not reported	70	30 [22-60]	HT autograft	23:47	84
Yamaguchi 2006	Retro case series	Not reported	45	24.8	Not reported	13:32	Not reported
Lanzetti 2020	Retro case series	Unspecified complication (1)	42	12.5	HT autograft	12:30	96.1
Roberti di Sarsina 2019	Retro case series	Not reported	20	12.3(1.7)	HT autograft	10:10	54
Willimon 2015	Retro case series	None	21	11.8	Not reported	0:21	36
Kerschbaumer 1987	RCT	None	60	33.1	BPTB autograft	Not reported	34.8
Barrett 1995	Retro cohort	None	70	Not reported	BPTB autograft	Not reported	Not reported
Ferkel 1988	Retro cohort	Not reported	80	Not reported	Not reported	Not reported	[24-72]
Hefti 1982	Retro cohort	Not reported	87	27.3	QT autograft, BPTB autograft	Not reported	24
Kanisawa 2003	Retro cohort	Not reported	11	Not reported	HT autograft	2:9	18.7 (4.1)
Laffargue 1997	Retro cohort	Not reported	90	27	BPTB autograft, HT autograft	Not reported	12

Monaco 2007	Retro cohort	Not reported	20	Not reported	HT autograft	0:20	Not reported
O'Brien 1991	Retro cohort	Not reported	80	Not reported	BPTB autograft	21:59	48
Paterson 1986	Retro cohort	Wound infection (2), Residual flexion deformity (5)	40	25.4	BPTB autograft	Not reported	2.9
Sgaglione 1990	Retro cohort	None	70	Not reported	HT autograft	Not reported	38.5
Sonnery-Cottet 2011	Case-control	Not reported	50	35	Not reported	15:35	Not reported
Verdano 2012	Retro cohort	None	40	28.75	HT autograft	8:12	48
Pernin 2010	Retro case series	Not reported	100	22.9	BPTB autograft	Not reported	294
Porter 2018	Pro cohort	Superficial wound infection (1)	38	25.2(6.0)	HT autograft	20:18	24
Ventura 2021	Retro cohort	None	24	29.3(9.5) {12}, 31.4(10.3) {12}	HT autograft	5:19	4.5
Pro: Prospective; Retro: Retrospective; RCT: Randomized Controlled Trial; N: Number of patients; F: Females; M: Males; MO, Months; ITB: Iliotibial Band; HT: Hamstrings Tendon; BPTB: Bone-Patellar Tendon Bone; QT: Quadriceps Tendon							

Table 1: Demographics of included primary studies on LET from the systematic review dataset.

Results

Search Criteria and Bias Assessment

Fourteen systematic reviews were found with the search terms "lateral extra-articular tenodesis, "anterior cruciate ligament," "systematic review," and "meta-analysis" [2-5]. Two reviewers (LN and SW) then extracted all primary studies from the fourteen systematic reviews, yielding a total of 72 unique articles (Table 1). The reviewers ensured all primary studies up to date were included, then screened all of the included articles to identify those with complications. Only 20 of the 72 studies (27.8%) met the criteria and were included in our final analysis of LET complications (Table 1).

The Cochrane and MINORS bias assessments showed that our randomized controlled trials and non-randomized controlled trials were determined to be at low risk of bias and of decent overall quality (see Appendices A and B).

Paper Demographics

In terms of paper demographics, the total number of patients identified in the included articles was N = 7,106, with sex ratios of female to male patients being reported in 51 of 72 studies (70.8%) (Table 1). Of the included papers that reported sex ratios, there were a total of 1,809 female patients and 3,101 male patients, leaving nearly 2,196 patients (30.9%) unidentifiable by biological sex (Table 1). The average age of participants in the included studies was heterogeneously reported. Twenty-six of 72 papers (36.1%) explicitly stated a mean and standard deviation that could be used to calculate a weighted mean age for the entire cohort.

Using these papers, an average age of 26.47 [26.40-26.55] (CI = 95%) was calculated for the narrative review cohort (Table 1). When LET was performed with ACLR, ACL graft type was another variable reported with diversity. Generally, the specific graft type used in the surgical procedure was reported in 63 of 72 papers (87.5%) (Table 1). Hamstring Tendon (HT) grafts seemed to be the most common, with 41 of 72 papers (56.9%) reporting the use of this graft (Table 1).. The second most common type of ACL graft in our narrative review was Bone Patellar Tendon Bone (BPTB) grafts, with 29 of 72 papers (40.2%) reporting the use of this graft among their participants (Table 1). One of the least popular graft types appeared to be Quadriceps Tendon (QT) grafts, with only 10 papers (13.9%) reporting the use of this graft (Table 1). Only 1 article reported the use of fresh frozen donor grafts (1.4%) and the anatomical origin of these donor grafts was indeterminable (Table 1).

The average follow-up time reported by included studies was also heterogeneously reported. Eight out of 72 papers (11.1%) did not report an average follow-up time after procedure. Not only this, but only 8 of 72 papers (11.1%) reported both an average follow-up time from procedure, along with a standard deviation that could be used to calculate a weighted mean follow-up for the narrative review cohort. Using the data available, a weighted average follow-up time of 31.05 [30.91-31.19] (CI = 95%) months was calculated for the cohort.

Of the 14 systematic reviews and meta-analyses found with our search terms, only 2 articles (14.3%) reported LET complications aside from graft failure. The remaining 12 articles (85.7%) did not report LET complications as a variable that the authors actively extracted or measured (Table 2).

Complications Summary

Analysis of complications reported from 22 included studies on Lateral Extra-Articular Tenodesis (LET) reveals four primary categories: hardware, irritation and chronic pain, motion loss and stiffness and infection and wound issues (Table 3). The last column of Table 3 further illustrates the p-value results of the ANOVA and HST test, allowing us to determine statistical significance. Hardware complications were the most frequently reported, affecting 76 patients (3.01% complication rate), including issues like LET hardware removal, discomfort from interference screws and local irritation from staples or wires. This rate was statistically significant compared to all other complications ($p < 0.05$). Following this were irritation and chronic pain, reported in 57 patients (2.26%), encompassing various pain types and mechanical symptoms, also significantly different from other complication categories. Motion loss and stiffness, observed in 46 patients (1.82%), included stiffness, loss of extension and flexion and arthrofibrosis. Lastly, infection and wound issues, affecting 37 patients (1.47%), comprised superficial and deep infections. These rates for motion loss and stiffness and infection and wound issues were statistically similar ($p = 0.06$) but different from the other two categories. Table 3 highlights all of the remaining complications and corresponding data.

SR-MA Study	Complications Beyond Graft Failure (Y/N)
Feng et al. (2022)[2]	N
Onggo et al. (2022)[3]	N
Park et al. (2023)[4]	Y
Na et al. (2021)[5]	N
Kolin et al. (2024)[6]	N
Zabrzynski et al. (2025)[7]	N
Ra et al. (2020)[8]	N
Carrozzo et al. (2023)[9]	N
Hewison et al. (2015)[10]	N

Devitt et al. (03/2017)[11]	N
Mao et al. (2021)[12]	N
Damayanthi et al. (2024)[13]	N
Boksh et al. (2024)[14]	Y
Devitt et al. (10/2017)[15]	N
ACLR: Anterior Cruciate Ligament Reconstruction; SR-MA: Systematic Review and Meta-Analyses; Y: yes; N: no.	

Table 2: List of included systematic reviews and meta-analyses evaluating ACLR complications beyond graft failure.

Citation	Complication Type	Specific Complication	Total Patients per Complication Type (N)	Complication rates (%)	Significant ($p < 0.05$) compared to:
Getgood 2020, Heard 2023, Meynard 2020, Ahn 2021, Borim 2023, Jorgensen 2001, Marcacci 2009, Declercq 2023, Rackemann 1991	Hardware	LET hardware removal (10) Discomfort from interference screw near Gerdy's tubercle (3) Pain from delayed protrusion of femoral screw (1) Material discomfort (2) Local irritation with staple removal (48) Removal of staples (8) Hardware irritation (1) Removal of wire/silk (3)	76	3.011093502	All other complications
Getgood 2020, Heard 2023 Jorgensen 2001 Rackemann 1991 Minguell Monyart 2023 Meynard 2020 Borim 2023	Irritation and chronic pain	Iliotibial band snapping (2) Lateral femoral hernia pain (9) Anterior knee pain during activity (15) Anterior knee pain (4) Knee pain (3) Pain behind thigh from hamstring harvest (1) Residual pain (1) Slight ache after use (4) Mechanical clunk or snap (6) Patellofemoral crepitus (12)	57	2.258320127	All other complications
Grassi 2021 Rackemann 1991 Ahn 2021 Paterson 1986 Declercq 2023 Getgood 2020, Heard 2023	Motion Loss and Stiffness	Stiffness (6) Loss of extension (17) Loss of flexion (12) Limited flexion from screw protrusion (1) Residual flexion deformity (5) Intra-articular adhesion (3) Arthrofibrosis (1)	46	1.822503962	All except: Infection and Wound Issues *($p = 0.06$)*

		Over-constrained lateral compartment (1)			
Grassi 2021 Ferretti 2016, Declercq 2023 Paterson 1986 Porter 2018, Hoekstra 1986 Rackemann 1991	Infection and Wound Issues	Deep infection (14) Superficial infection (16) Septic arthritis (2) Wound infection (2) Superficial wound infection (2) Late infection (1)	37	1.4659271	All except: Motion Loss and Stiffness *(p = 0.06)*
Getgood 2020 Heard 2023 Declercq 2023 Monaco 2022 Borim 2023 Grassi 2021 Rackemann 1991	Bleeding and Effusion	Hematoma (4) Hemarthrosis (2) Swelling (20) Persistent effusion (3)	29	1.148969889	Hardware *(p = 0.00)*, Irritation and chronic pain *(p = 0.00)*, Motion Loss and Stiffness *(p = 0.00)*, Infection and Wound Issues *(p = 0.01)*, Miscellaneous *(p = 0.01)*
Minguell Monyart 2023 Minguell Monyart 2023 Declercq 2023 Mahmoud 2022 Monaco 2022 Farinelli 2023	Structural Instability	Anteroposterior instability (6) Graft re-rupture (4) Meniscus tear needing arthroscopy (3) Symptomatic tibial tunnel cyst (1) Loose body from patella cartilage injury (1)	15	0.5942947702	Hardware *(p = 0.00)*, Irritation and chronic pain *(p = 0.00)*, Motion Loss and Stiffness *(p = 0.00)*, Infection and Wound Issues *(p = 0.00)*
Rowan 2019 Meynard 2020 Marcacci 2009 Monaco 2022 Hoekstra 1986	Neurological	Persistent numbness (saphenous nerve branches) (1) Neuroma near hamstring harvest site (1) Hypoesthesia on anterior tibia (2) Paresthesias in saphenous nerve distribution (4) Dysesthesia (3) Transient peroneal palsy (1)	12	0.4754358162	Hardware *(p = 0.00)*, Irritation and chronic pain *(p = 0.00)*, Motion Loss and Stiffness *(p = 0.00)*, Infection and Wound Issues *(p = 0.00)*
Jorgensen 2001 Hoekstra 1986 Meynard 2020 Hoekstra 1986 Lanzetti 2020	Miscellaneous	Deep venous thromboembolism (1) Urinary tract infection (2) Plaster ulcer (1) Granuloma on lateral scar (1) Plaster ulcer on heel (1) Unspecified complication (1)	7	0.2773375594	Hardware *(p = 0.00)*, Irritation and chronic pain *(p = 0.00)*, Motion Loss and Stiffness *(p = 0.00)*, Infection and Wound Issues *(p = 0.00)*, Bleeding and Effusion *(p = 0.01)*

Table 3: Summary of LET complications from the 22 included studies reporting postoperative complications.

Discussion

While LET has demonstrated biomechanical benefits in reducing graft failure and improving rotational stability, its broader clinical impact is more complex [18]. A closer look at the literature reveals a range of complications that can meaningfully affect patient outcomes and satisfaction (Table 1). Previous systematic reviews on LET with ACLR largely overlooked the complication profile of this procedure and thus this narrative review re-evaluated the included literature in those reviews to better characterize the complications that were found but not reported. Among the 72 primary studies reviewed in this study, fewer than half reported LET-specific complications, suggesting that adverse outcomes may be nonexistent, underreported or inconsistently tracked. However, among the subset of studies that documented complications, the most common issues were hardware-related complaints, irritation and chronic pain, as well as motion loss and stiffness.

Hardware complications, with a total of 76 reported cases and a 3.01% complication rate, ranked as the most prevalent complication type for LET surgery in our study (Table 3). This aligns with the first complication listed in a recent systematic review on this topic, that instead looked at only 7 studies as opposed to the 22 studies included in this review [19]. The rate of hardware complications in this review demonstrated statistical significance when compared to all other reported complications ($p < 0.05$), suggesting its notable effect on LET surgery (Table 3). Hardware complications are clinically relevant as they can disrupt patient recovery and satisfaction by inducing pain, restricting movement and potentially necessitating further surgical intervention [19]. A study noted that metal staples used for LET fixation have been associated with increased irritation due to their potential prominence and friction [20]. To minimize hardware-related complications, careful selection of fixation devices may help. Studies have found advantages and disadvantages among biodegradable versus metallic screws. While biodegradable screws yield less infection risk and less localization irritation of the tissues, there is a higher likelihood for tunnel widening and joint effusion than seen with metal screws [21]. Further research into hardware selection and surgical techniques can help mitigate such complications following ACLR with LET.

The second most common complication in our study was irritation and chronic pain at the LET site. Among the patients who underwent ACLR with LET in our study, a total of 57 patients in 7 included studies reported postoperative pain or joint irritation (Table 3). This complication was reported by 2.26% of all included patients and statistically significantly different from all other reported complications (Table 3). To put these statistics into perspective, the literature indicates that the prevalence of post-operative pain ranges from 6.2% to 48.4% in ACLR patients [22]. The variability of reported pain experiences in the current literature suggests this topic may be understudied, which makes it difficult to isolate the role of LET in irritation and chronic pain for these patients. Additionally, due to heterogeneity in reporting irritation and chronic pain, such as the use of differing surveys or scales for pain measurement, it is not feasible to conclude that pain experiences are substantially different in the ACLR+LET group than the ACLR group alone. Future research should objectively and consistently evaluate pain levels in patients undergoing ACLR with and without LET to help determine its specific contribution to pain patterns post-operatively.

Motion loss and stiffness were the third most common complaints among patients who received ACLR with LET, corresponding to 1.82% of all complications reported in this study (Table 3). Additionally, this complication rate was found to be statistically significantly different from all other reported complications except for infection and wound issues (Table 3). The observed rate of mobility and stiffness-related complications among isolated ACLR patients is 1.5% and future comparative studies can be done to determine if there is a statistically significant difference between ACLR+LET cohorts, as these rates are fairly similar [23].

Limitations

A key challenge in understanding the true complication profile of Lateral Extra-Articular Tenodesis (LET) lies in the methodological inconsistencies across the literature. Systematic reviews, while valuable for summarizing large bodies of evidence, are only as robust as the studies they include. Unfortunately, many of the primary studies were heterogeneous, including varied study designs, sample sizes and limited follow-up durations.

Another limitation in standardization is in what different studies would constitute a complication. For example, some studies may classify postoperative stiffness as a complication, while others may consider it a normal part of recovery. While 20 primary articles allow a preliminary understanding of trends, the majority of the systematic review articles did not report LET complications. This limited our sample size and the ability to develop stronger claims about what LET complications exist overall. Further limitations in the literature include the absence of reporting valuable variables in ACLR and LET procedures, such as

sex ratios of included patients. As discussed previously, the sex ratios of female to male patients were unreported in 21 out of 72 papers (29.2%); not only this, but the overall narrative review cohort itself manifested a total sex ratio of 1,809:3,101 females to males. With 1.7x the number of included males than females, this ratio begs the question of how generalizable ACLR and LET procedural data are to the population with the highest prevalence of ACL injuries: females [24]. While women are anywhere from 2 to 8x more likely to acquire an ACL tear than their male counterparts, women comprised only 36.8% of the narrative review cohort [24]. Thus, a major limitation of the LET literature is the lack of female patient data inclusion, which is highly problematic given the abundance of ACL tears prevalent in females.

A similar statement can be made about the heterogeneity in reporting average follow-up time. While a weighted average follow-up time of 31.05 [30.91-31.19] (CI = 95%) months was calculated for the cohort, the limited reporting of follow-up times across the 72 primary studies (48 studies; 66.7%) reduces the credibility and trustworthiness of this statistic.

Future Directions: Moving Toward a More Complication-Aware Approach

As LET continues to gain traction as an adjunct to ACL reconstruction, future research may benefit from a shift toward more comprehensive and standardized evaluation of complications. Studies could move beyond graft survival as the dominant endpoint and instead prioritize complication profiles as primary outcomes. This approach might include systematic assessment of donor-site pain, sensory disturbances, hardware-related symptoms and functional limitations, allowing for a more transparent understanding of procedure-related morbidity. Additionally, stratifying complications by surgical technique remains an important unmet need. The primary studies reviewed (Table 1) did not specify whether complication rates differed by technique, despite substantial variability in LET procedures, including open versus minimally invasive approaches and differing fixation methods such as staples or suture anchors. Future investigations could aim to clarify whether certain techniques are associated with higher or lower complication burdens, which may help surgeons tailor operative decisions to individual patient risk profiles.

Long-Term Outcomes and Reporting Integrity

Long-term follow-up is also essential. Many LET complications, especially those related to joint degeneration or biomechanical over-constraint, may not become apparent until several years after surgery [27]. Studies with extended follow-up periods and radiographic assessments can help clarify whether LET contributes to chronic joint issues like osteoarthritis [27]. To continue, given the current lack of consistency and transparency in reporting, establishing a standard protocol for purporting follow-up time is crucial; future studies should maintain awareness of the loss of credibility and trustworthiness from inconsistent data reporting practices and the wide effects this has on generating statistics such as average follow-up time.

Lastly, it is also important to mention the lack of appropriate gender distribution in the literature. Given the heightened probability of ACL injuries in females than males, future studies should prioritize expanding honest reporting practices in sex ratios of data as well as actively and meaningfully including more members of at-risk populations in their research. Inclusivity is the key to valuable, generalizable data and ignoring this principle may lead to a lack of relevance and applicability of research findings.

Conclusion

While the LET effectively reduces graft failure when combined with ACLR, this narrative review highlights the rare complications that accompany this adjunct procedure. Hardware irritation, infections and hemorrhages emerged as the most common non-graft failure issues in this review. These findings note a need for more standardized, complication-aware research to support surgical decision-making for LET patients.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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Data Availability Statement
Not applicable.

Ethical Statement
The project did not meet the definition of human subject research under the purview of the IRB according to federal regulations and therefore, was exempt.

Informed Consent Statement
Informed consent was taken for this study.

Authors' Contributions
All authors contributed equally to this paper.

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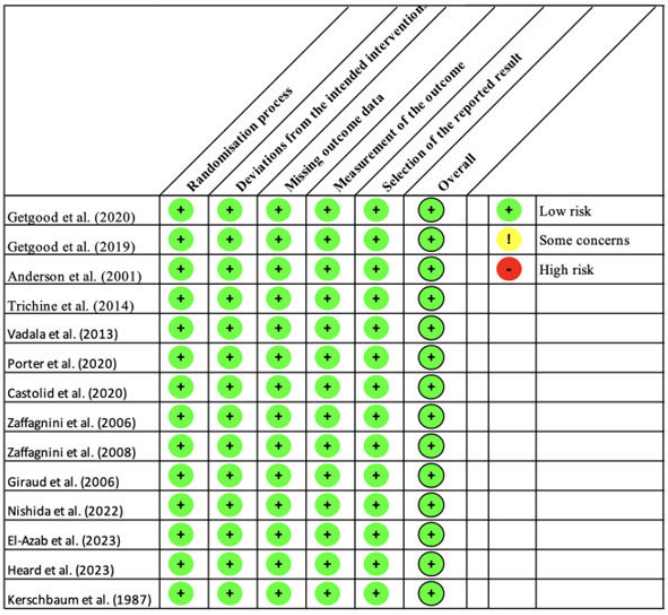
Appendix



Appendix A: Cochrane risk of bias 2.0 assessment for 14 Randomized Controlled Trials (RCTs) included in this study.

Author (Year)	"Comparative" or "Non-comparative" Study	MINORS Score	1: Clearly stated aim	2: Inclusion of consecutive patients	3:Prospective collection of data	4: End points apropriate to study aim	5: Unbiased assessment of study end point	6: Follow-up period appropriate to study aim	7: Less than 5% lost to follow up	8: Prospective calculation of the study size	9: Adaquate control group	10: Contemporary groups	11: Baseline equivalence of groups	12:Adaquate statistical analysis
Rowan 2019	Comparative	22	2	2	2	2	0	2	2	2	2	2	2	2
Gibbs 2021	Comparative	22	2	2	2	2	0	2	2	2	2	2	2	2
Barber-Westin 1993	Comparative	22	2	2	2	2	0	2	2	2	2	2	2	2
Noyes 1991	Comparative	22	2	2	2	2	0	2	2	2	2	2	2	2
Dejour 2013	Comparative	22	2	2	2	2	0	2	2	2	2	2	2	2
Ferretti 2016	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Strum 1989	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Wilson 2019	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Sheean 2020	Comparative	22	2	2	2	2	0	2	2	2	2	2	2	2
Alessio-Mazzzola 2019	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Grassi 2021	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Imbert 2017	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Colombet	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Meynard	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Ahn 2021	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Cavaignac 2020	Comparative	22	2	2	2	2	0	2	2	2	2	2	2	2
Kocher 2006	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Jorgensen 2001	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Green 2023	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Hantouly 2023	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Firth 2022	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Perelli 2022	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Mahmoud 2022	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Joseph 2020	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Eggeling 2022	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Minguell Monyart 2023	Non-comparative	14	2	2	2	2	0	2	2	2	-	-	-	-
Viglietta 2022	Comparative	22	2	2	2	2	0	2	2	2	2	2	2	2
Marcacci 2009	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Monaco 2022	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Declercq 2023	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Farinelli 2023	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Alm 2020	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Jacquet 2021	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Keizer 2023	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Borim 2023	Non-comparative	14	2	2	2	2	0	2	2	2	-	-	-	-
Hockstra 1986	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Rackemann 1991	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Johnston 2003	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Aglietti 1992	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Anderson 1994	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Yamaguchi 2006	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Lanzetti 2020	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Roberti di Sarsina 2019	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Willimon 2015	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Barrett 1995	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Ferkel 1988	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Hefti 1982	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Kaniawa 2003	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Laffargue 1997	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Monaco 2007	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
O'Brien 1991	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Paterson 1986	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Sgaglione 1990	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Sonnery-Cottet 2011	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Verdano 2012	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2
Pernin 2010	Non-comparative	10	2	2	0	2	0	2	2	0	-	-	-	-
Porter 2018	Comparative	22	2	2	2	2	0	2	2	2	2	2	2	2
Ventura 2021	Comparative	18	2	2	0	2	0	2	2	0	2	2	2	2

Appendix B: MINORS risk of bias assessment for the 58 non-randomized studies included in this study.