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Systematic Review

No evidence of reduced autograft ACL rupture rates with synthetic reinforcement: A systematic review

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A R T I C L E I N F O

Keywords:
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A B S T R A C T

Importance: Synthetic reinforcement of autografts in anterior cruciate ligament reconstruction offers theoretical benefits in terms of improved graft strength, potentially reducing graft elongation and failure. Over the past three decades, a number of synthetic/autograft combinations have been used in clinical practice.
Aim: We aimed to assess the impact of synthetic reinforcement on graft rupture rates and functional outcomes following autograft ACL reconstruction.
Evidence review: A systematic review of Pubmed, Embase and Cochrane libraries was undertaken according to the PRISMA guidelines. Published clinical studies reporting outcomes after autograft ACL reconstruction with synthetic reinforcement, with a minimum of 20 patients and two-year follow-up were included. The MINORS tool was used for methodological assessment.
Findings: Twenty articles reporting 1888 patients managed with synthetically reinforced grafts were included in the analysis. The mean MINORS score was 13 (Range, 2–22). The synthetic reinforcement used was the Kennedy ligament augmentation device in eight studies, LARS in four, Fibretape in two, Leeds-Keio in two, and Trevira ligament, Dacron, PDS and Artelon in one study each. No study reported a significant reduction in graft failure with reinforcement. Two studies reported superior KT-1000 clinical stability in reinforced grafts. One study reported superior pain, KOOS and IKDC scores and earlier return to activity in reinforced grafts.
Conclusions and relevance: In this systematic review, synthetic reinforcement of ACL autografts did not result in a reduced rate of graft rupture. A small number of studies have reported superior stability and patient-reported outcome measures with modern synthetic reinforcement techniques.
Level of evidence: 4

What is already known?

- Graft rupture remains a challenge in ACL reconstruction

What are the new findings?

- Synthetic reinforcement of ACL autografts has not been shown to reduce graft rupture rates
- A small number of studies have reported superior stability and patient-reported outcome measures with modern synthetic reinforcement techniques

Introduction

Anterior cruciate ligament (ACL) rupture occurs annually in 77 per 100,000 population and incurs substantial health and economic burden [1–3]. ACL reconstruction aims to restore knee stability to allow the return to function and protect against subsequent injury. Graft rupture occurs in 3% of patients following ACL hamstrings autograft reconstruction [4]; however, at-risk cohorts may experience rupture rates as high as 28% [5].

Reinforcement of autograft ACL reconstructions could theoretically reduce the incidence of graft rupture and improve knee stability. Those patients who are young, have small graft diameters, or who plan to return to pivoting and contact sports are at an elevated risk of graft rupture and may stand to benefit from graft reinforcement [6–8].

Autograft reinforcement options include allograft and synthetic augmentation. A recent systematic review assessing allograft

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reinforcement of hamstrings autograft found no improvement in failure rates compared to hamstrings autograft alone [9]. Reinforcement with synthetic material offers an appealing alternative. The reported success of an ultra-high molecular weight polyethylene tape with a braided polyester jacket (Fibertape, Arthrex) for ankle reconstruction [10] has generated interest in its broader applications, including reinforcing ACL grafts [11–20].

The use of synthetic materials in ACL reconstruction dates to 1914, when silver wire was used to reconstruct the ACL [21]. Since that time, polytetrafluoroethylene (Proplast, Gore Tex), polyester (Leeds Keio, Dacron), polypropylene (Kennedy LAD), polyurethane urea (Artelon), polyethylene terephthalate (LARS, Trevira-Hochfest), polydioxanone (PDS) and ultra-high molecular weight polyethylene tape with a braided polyester jacket (Fibertape) have been used as stand-alone prostheses or as reinforcements to other graft tissue. Initial enthusiasm for their immediate tensile strength, availability and lack of donor site morbidity was tempered by reports of mechanical fatigue [22], wear particle deposition [23], tunnel widening [24,25], synovitis [26], arthritic degeneration [26–29], and high failure rates [26,28–34]. Many of these synthetic devices have subsequently been withdrawn from use.

Existing reviews of synthetic grafts have primarily assessed their use as stand-alone prostheses [35]. The aim of this study was to assess the impact of synthetic reinforcement on graft rupture rates and functional outcomes in autograft ACL reconstruction. Our hypothesis was that synthetic reinforcement would not improve the outcomes of ACL reconstruction.

Methods

Search strategy

A systematic review of the literature was conducted to identify all studies reporting autograft ACL reconstruction with synthetic augmentation. The preferred reporting items for systematic reviews and meta-analysis (PRISMA) guidelines were followed. A search of Pubmed (MEDLINE), EMBASE and Cochrane databases was undertaken to identify articles published from their earliest entry until March 2021. The search criteria used were: (anterior cruciate OR ACL) AND (augmentation OR reinforcement OR artificial OR synthetic OR Fibertape OR Internalbrace OR Kennedy ligament OR Leeds-Keio OR Dacron OR polytetrafluoroethylene OR Trevira Hochfest OR LARS OR polyethylene terephthalate*)*. Article titles and abstracts were screened according to the inclusion and exclusion criteria, and potentially relevant studies were reviewed in full text. References of relevant articles were also screened to identify additional publications. The review was not registered. Ethics approval was not sought, given it was a systematic review of existing literature.

Study selection

We included clinical studies reporting outcomes of unilateral primary ACL reconstruction using hamstrings, patella tendon or quadriceps tendon autograft with synthetic material reinforcement in a minimum of twenty patients.

We excluded studies that examined synthetic reinforcement of partial ACL injuries or ACL repair, reconstructions using fascia lata or modified Marshall-MacIntosh grafts, fixation in an over the top position, multi-ligamentous knee injuries and non-English language publications.

Data extraction

Two authors (AP, DE) independently reviewed the full-text articles and extracted data (Fig. 1). Any disagreements were resolved by consensus. The data extracted from each article included study design, number of patients, patient selection criteria, patient demographics, operative details, follow-up duration, and loss to follow-up. The reported outcome data were extracted from each study, including graft failure rate (% patients), Lachman's test (% patients grade 0–1), Pivot shift test (% patients grade 0), KT-1000 test (% patients <3 mm side–side difference), Lysholm score, Tegner score, Numerical pain score, Knee injury and osteoarthritis outcome score (KOOS), International knee documentation committee (IKDC) subjective knee form, Return to play (%), Radiographic evidence of arthritis and the occurrence of effusions or arthrofibrosis. Arthrofibrosis was identified based on reoperation for stiffness (manipulation or arthrolysis) or inability to achieve terminal extension in their operative knee [36].

Methodologic quality assessment

The level of evidence of each included study was determined based on the study design utilised [37]. The Methodological Index for Non--Randomised studies (MINORS) tool was then used to assess the quality of each study [38]. Non-comparative studies were assessed against eight items and comparative studies against 12 items. The risk of bias was quantified for each criterion on a scale; 0 (not reported), 1 (reported but inadequate), 2 (reported and adequate). Summative scores were calculated from 0 (the worst), to 18 (the best obtainable score for non-comparative studies) and 24 (the best obtainable score for comparative studies).

Methodologic quality assessment

Continuous variables are reported as mean ± standard deviation and categorical variables as percentages. A meta-analysis was not undertaken due to the heterogeneity of surgical techniques and reporting of outcomes.

Results

The search identified 3218 articles; 1411 from Pubmed, 1668 from EMBASE and 139 from the Cochrane Database (Fig. 1). Twenty-two studies reporting autograft ACL reconstruction with synthetic reinforcement met inclusion criteria (Table 1). Three studies reported the same cohort of patients at different time points, and therefore, only the publication with the longest follow-up was included for analysis [39–41]. Twenty studies were therefore included. The level of evidence of the included studies was; level 1 (n = 0), level 2 (n = 3), level 3 (n = 6) and level 4 (n = 11). Nine studies compared reinforced grafts to non-reinforced grafts (Table 2), while the remaining studies were case series. The mean MINORS score was 13 (Range, 2–22).

Mean patient age ranged from 21 to 34 years. The proportion of female patients ranged between 0 and 90%. Reconstruction was undertaken using patella tendon grafts in eight studies, hamstrings tendon grafts in 10 studies and a variety of grafts in two studies. The synthetic reinforcement used was the Kennedy ligament augmentation device in eight studies, ligament augmentation and reconstruction system (LARS) in four, Fibertape in two, Leeds-Keio in two, and Trevira ligament, Dacron, polydioxanone (PDS) and Artelon in one study each. Mean follow-up ranged from 1.2 to 25 years postoperatively.

Results of comparative studies

Graft rupture

Eight studies reported graft rupture rates in reinforced and non-reinforced grafts. No study reported a significant difference in graft rupture rates between reinforced and non-reinforced grafts [39,42–48].

Objective stability assessment

Lachman's test was reported in six studies. No study demonstrated a significant difference between reinforced and non-reinforced grafts [39,43,44,47–49].

Pivot shift testing was reported in seven studies. No study demonstrated a significant difference between reinforced and non-reinforced grafts [39,43,44,46–49].

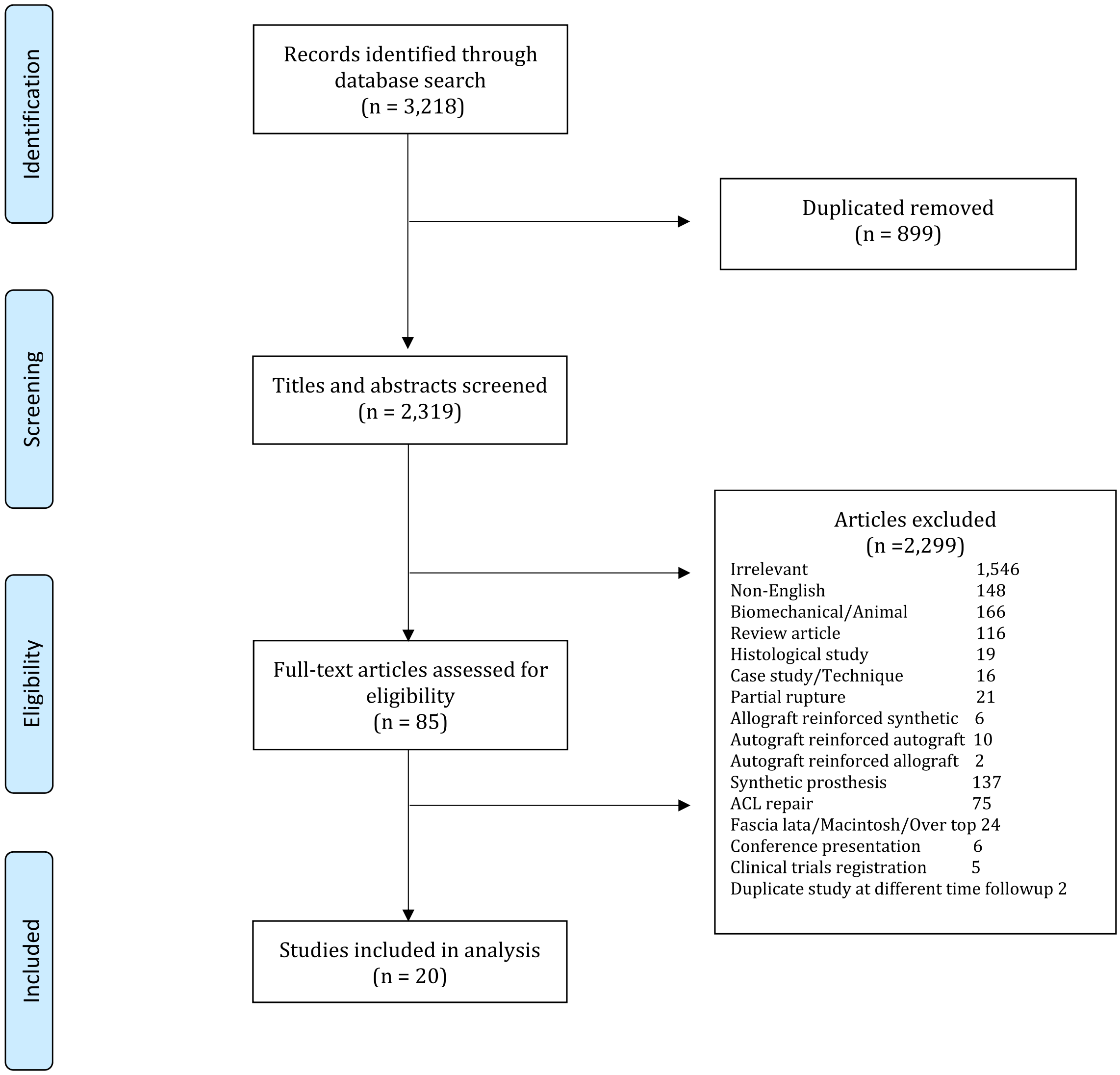

Fig. 1. PRISMA flow diagram.

KT-1000 was reported in seven studies. Three studies reported no significant difference in KT-1000 stability with or without reinforcement [43,44,49]. Two studies reported superior stability in reinforced grafts: Hamido et al. found better stability in undersized hamstrings grafts reinforced with LARS compared to regular-sized hamstrings autografts alone ($p = 0.013$) [42]. Elveos et al. reported superior mean KT-1000 stability in patella tendon grafts reinforced with a polypropylene augment at 25-year follow-up, compared to patella tendon alone (KT-1000 Mean 2 mm ± NR vs 0 mm ± NR $p = 0.02$) [39].

Patient reported outcomes

Lysholm score was reported in six studies. No study reported significantly different Lysholm scores at postoperative follow-up between reinforced and non-reinforced grafts [39,42,44,47–49].

Tegner score was reported in seven studies. No study reported a significantly different Tegner score between reinforced and non-reinforced grafts [39,42–44,47–49].

Numerical pain scores were reported in two studies. Bodendorfer et al. found superior mean and maximum numeric pain scores at mean 29-month follow-up in 30 patients with Fibertape-reinforced hamstrings grafts compared to 30 matched patients managed with hamstrings grafts alone (Mean: 1.7 ± 1.9 vs 0.6 ± 1.7), $p = 0.02$) (Maximum: 3.4 ± 2.3 vs 1.6 ± 1.8, $p = 0.004$) [45]. The degree of improvement in maximum daily pain score was greater in patients managed with reinforced grafts (-3.5 ± 2.5 vs -5.6 ± 2.4, $p = 0.003$). In contrast, Barrett et al. found higher mean pain scores in Kennedy LAD reinforced grafts at 2-year follow-up (1.3 ± NR vs 2.7 ± NR, $p = 0.01$) [44].

KOOS was reported in three studies. Two studies found no significant difference in KOOS with reinforcement using Kennedy LAD and LARS fibres [39,42]. Bodendorfer et al. reported superior outcomes in reinforced grafts in the KOOS sport and recreation and quality of life subsections [45].

The IKDC was reported in four studies. Three studies found no significant difference in the proportion of patients with grade A or B knees between reinforced and non-reinforced grafts [42,43,48]. Bodendorfer et al. reported superior mean IKDC in Fibertape reinforced grafts (73 ± 20 vs 88 ± 14, $p = 0.006$) [45].

Five studies reported a return to play. Four studies reported no significant difference in return to preinjury activity between reinforced and non-reinforced grafts [39,44,47,49]. Bodendorfer et al. reported a significantly earlier return to preinjury activity levels with graft reinforcement (12.8 ± 3.9 vs 9.2 ± 2.1 months, $p = 0.002$) [45].

Radiographic evaluation

Radiological evaluation was reported in five studies with follow-ups ranging from 24 to 300 months. No study reported a significant

Table 1
Characteristics of included studies.

Study	Design	Level of evidence	Patients with reinforced grafts (n)	Control group	Sex (F %)	Age mean (yrs)	Graft	Reinforcement	Graft fixation Femur	Graft fixation tibia	Follow-up duration mean (months)	MINORS score
Elveos et al. 2018	RCT	2	49	PT auto	55%	27 ± NR	PT auto	Kennedy	Staples	Staples	300 ± NR	21
Peterson et al. 2014	RCT	2	96	PT auto	33%	27 ± 7	PT auto	Artelon	Screw	Screw	48 ± NR	22
Barrett et al. 1993	Comparative-Prospective	2	25	PT auto	32%	25 ± NR	PT auto	Kennedy	Screw	Screw	24 ± NR	19
Bodendorfer et al. 2019	Comparative - Retrospective	3	30	HS auto or allo	57%	29 ± 7.6	HS Auto, allo or hybrid	Fibertape	Button	Button	29 ± 4.8	20
Parkes et al. 2021	Comparative - Retrospective	3	36	HS auto	31%	25 ± 8.6	HS auto	Fibertape	Button	Button	26 ± 2.5	19
Hamido et al. 2015	Comparative - Retrospective	3	27	HS auto	0%	24 ± NR	HS auto	LARS	Cross pin	Screw	59 ± NR	16
Santi et al. 1994	Comparative - Retrospective	3	30	HS auto	25%	27 ± 7.0	HS auto	Kennedy	Screw post	Staple	31 ± NR	15
Marumo et al. 2000	Comparative - Retrospective	3	60	PT auto	90%	29 ± 9.9	HS auto	Kennedy	Staple	NR	109 ± NR	8
Sgaglione et al. 1992	Comparative - Retrospective	3	16	HS auto	40%	27 ± 8.2	HS auto	Kennedy	Variety	Staples	31 ± 6.7	16
Ebert et al. 2019	Case series	4	65		36%	26 ± 9.3	HS auto	LARS	Button	Screw	24 ± NR	11
Nakayama et al. 1999	Case series	4	38		55%	22 ± NR	PT auto	Leeds Keio	Staple	Screw	14 ± NR	8
Puddu et al. 1993	Case series	4	587			NR	HS auto	PDS	Staple	Staple	NR	2
Kdolsky et al. 1997	Case series	4	152			28 ± NR	PT auto	Kennedy	Burri plate	Burri plate	89 ± NR	8
Struewer et al. 2013	Case series	4	126		40%	32 ± NR	PT auto	Trevira	Plate	Staple	29 ± NR	9
Hamido et al. 2011	Case series	4	112			26 ± NR	HS auto	LARS	Variety	Variety	45 ± NR	11
Falconer et al. 2015	Case series	4	111		34%	34 ± NR	HS auto	LARS	Button	Screw	29 ± NR	11
Viola et al. 1993	Case series	4	62		18%	21 ± NR	PT auto	Dacron	Screw post	Screw post	44 ± NR	8
Asahina et al. 1995	Case series	4	50		56%	24 ± NR	Quads auto or HS auto	Kennedy	Staple	NR	18 ± NR	6
Nakayama et al. 1996	Case series	4	66		59%	24 ± NR	PT auto	Leeds Keio	Staple	Screw	72 ± NR	8
Muneta et al. 2000	Case series	4	12		65%	23 ± 9	HS auto	Kennedy	NR	NR	89 ± 12	13

Auto = Autograft.
Allo = Allograft.
Hybrid = Hybrid graft.
HS = Hamstrings.
PT = Patella tendon.
NR = Not reported.

Table 2
Outcomes of studies comparing non-reinforced to reinforced grafts.

	Non-reinforced	Reinforced	*p*
Graft rupture			
Elveos et al. 2018	25%	16%	*0.40*
Peterson et al. 2014	4%	6%	*NR*
Barrett et al. 1993	0%	8%	*NR*
Bodendorfer et al. 2019	7%	7%	*NR*
Parkes et al. 2021	6%	3%	*0.66*
Hamido et al. 2015	0%	0%	*NR*
Marumo et al. 2000	5%	0%	*NR*
Sgaglione et al. 1992	4%	7%	*NR*
Objective stability assessment			
Lachman's (Grade 0–1)			
Elveos et al. 2018	100%	95%	*>0.99*
Peterson et al. 2014	85%	86%	*0.65*
Barrett et al. 1993	100%	92%	*NR*
Parkes et al. 2021	99%	98%	*0.70*
Santi et al. 1994	92%	88%	*>0.05*
Sgaglione et al. 1992	82%	73%	*NR*
Pivot shift (grade 0)			
Elveos et al. 2018	NR	NR	*0.49*
Peterson et al. 2014	81%	82%	*1.0*
Barrett et al. 1993	100%	92%	*NR*
Parkes et al. 2021	97%	100%	*0.55*
Santi et al. 1994	79%	67%	*>0.05*
Marumo et al. 2000	45%	36%	*NR*
Sgaglione et al. 1992	82%	80%	*NR*
KT-1000 <3 mm side–side difference			
Elveos et al. 2018	73%	86%	*0.46*
Peterson et al. 2014	72%	72%	*1.0*
Barrett et al. 1993	NR	NR	*>0.05*
Hamido et al. 2015	71%	89%	*0.01*
Santi et al. 1994	NR	NR	*>0.05*
Marumo et al. 2000	NR	NR	*NR*
Sgaglione et al. 1992	61%	64%	*>0.05*
Patient-reported outcomes			
Lysholm score			
Elveos et al. 2018	85 ± 5	83 ± 4	*0.40*
Barrett et al. 1993	93 ± NR	88 ± NR	*>0.05*
Parkes et al. 2021	94 ± 1.8	96 ± 2.1	*0.17*
Hamido et al. 2015	90 ± 6.9	95 ± 7.3	*0.24*
Santi et al. 1994	92 ± 6.9	90 ± 10	*>0.05*
Sgaglione et al. 1992	87 ± 16	92 ± 13	*NR*
Tegner score			
Elveos et al. 2018	3 ± NR	3 ± NR	*0.82*
Peterson et al. 2014	5 ± NR	6 ± NR	*NR*
Barrett et al. 1993	4.5 ± NR	4.3 ± NR	*>0.05*
Parkes et al. 2021	6.4 ± 0.4	7.1 ± 0.6	*0.03*
Hamido et al. 2015	6.7 ± 1.5	7.4 1.8	*0.37*
Santi et al. 1994	NR	NR	*>0.05*
Sgaglione et al. 1992	5.3 ± 1.9	5.9 ± 2.2	*NR*
Numerical pain score			
Bodendorfer et al. 2019	1.7 ± 1.9	0.6 ± 1.3	*0.02*
Barrett et al. 1993	1.3 ± NR	2.7 ± NR	*0.01*
KOOS – pain			
Elveos et al. 2018	91 ± NR	88 ± NR	*0.18*
Bodendorfer et al. 2019	90 ± 8.3	95 ± 9.5	*0.05*
Hamido et al. 2015	81 ± NR	85 ± NR	*>0.05*
KOOS – symptoms			
Elveos et al. 2018	85 ± NR	86 ± NR	*0.72*
Bodendorfer et al. 2019	83 ± 13	89 ± 12	*0.10*
Hamido et al. 2015	78 ± NR	86 ± NR	*>0.05*
KOOS – ADL			
Elveos et al. 2018	93 ± NR	95 ± NR	*0.60*
Bodendorfer et al. 2019	95 ± 8.1	98 ± 4.8	*0.07*
Hamido et al. 2015	92 ± NR	94 ± NR	*>0.05*
KOOS – sport/recreation			
Elveos et al. 2018	78 ± NR	73 ± NR	*0.29*
Bodendorfer et al. 2019	75 ± 22	88 ± 18	*0.04*
KOOS – QOL			
Elveos et al. 2018	77 ± NR	73 ± NR	*0.47*
Bodendorfer et al. 2019	60 ± 26	77 ± 19	*0.01*
IKDC (Normal or nearly normal)			
Peterson et al. 2014	77%	65%	*0.16*
Bodendorfer et al. 2019	NR	NR	*0.01*
Parkes et al. 2021	NR	NR	*0.44*
Hamido et al. 2015	71%	96%	*0.05*
Complications			
Effusions			
Peterson et al. 2014	5%	13%	*NR*
Barrett et al. 1993	0%	8%	*NR*
Parkes et al. 2021	0%	0%	*>0.99*
Santi et al. 1994	0%	17%	*NR*
Marumo et al. 2000	10%	10%	*NR*
Sgaglione et al. 1992	0%	0%	*NR*
Arthrofibrosis			
Elveos et al. 2018	7%	25%	*0.25*
Bodendorfer et al. 2019	3%	7%	*NR*
Parkes et al. 2021	4%	6%	*NR*
Hamido et al., 2015	2%	0%	*NR*
Santi et al. 1994	4%	7%	*NR*
Marumo et al. 2000	0	3%	*NR*
Sgaglione et al. 1992	11%	13%	*NR*

NR = Not reported.

difference in radiographic changes of osteoarthritis between reinforced and non-reinforced grafts [39,42,44,46,49].

Complications

The most frequently reported complications were effusions and arthrofibrosis. Effusions were reported in six studies. Santi et al. reported a 0% incidence of effusions in knees with non-reinforced hamstrings grafts versus 17% in knees with polypropylene-reinforced hamstrings grafts (p = NR) [49]. These patients subsequently underwent arthroscopic resection of the synthetic reinforcement with resultant improvement in their symptoms. Peterson et al. reported a 5% incidence of effusions in knees with non-reinforced grafts versus 13% in those with polyurethane urea reinforced grafts (p = NR) [43]. Two studies reported comparable rates of effusion with and without polypropylene reinforcement, and one study reported no effusions in knees with hamstrings grafts with and without Fibertape reinforcement [46–48].

Arthrofibrosis was reported in seven studies. No study reported a significant difference in arthrofibrosis rates between reinforced and non-reinforced grafts [39,45–49].

Discussion

The most important finding of this systematic review was that synthetic reinforcement of autografts in ACL reconstruction has not been proven to reduce graft rupture rates [42–48,50]. Of the eight studies reporting graft rupture rates using synthetically reinforced patella tendon or hamstrings autografts, none found a significant reduction in rupture with the use of synthetic reinforcement. However, two studies demonstrated improved clinical stability [39,42] and one demonstrated improved patient-reported outcome measures with graft reinforcement [45].

ACL graft rupture remains an unsolved challenge in orthopaedics. Despite contemporary techniques, graft failure occurs in up to 28% of grafts [5]. Younger patients, those with smaller grafts, and those who return to pivoting sports are at increased risk [6–8] and could potentially benefit from a stronger graft construct. Recently reported success using Fibertape (Arthrex, Naples, FL) in an extra-articular fashion for ankle reconstruction has generated enthusiasm for its potential application to reinforce ACL grafts. Bodendorfer et al. undertook a matched comparative analysis of patients undergoing auto or allograft ACL reconstruction reinforced by a Fibertape construct [45]. The authors found lower mean pain scores (1.7 $\pm$ 1.9 vs 0.6 $\pm$ 1.7, $p = 0.02$), higher IKDC (73 $\pm$ 20 vs 88 $\pm$ 14), $p = 0.006$), and superior KOOS sport and quality of life sub-scores in reinforced grafts, at mean 29-month follow-up. It is noteworthy that the reported mean IKDC of non-reinforced grafts in the study is lower than that reported with contemporary graft techniques in other studies and below the reported threshold of 75 to achieve a patient acceptable symptom state [51–53].

Synthetic materials have a chequered past in ACL reconstruction. As a stand-alone graft, they have been largely abandoned due to high reported rates of graft failure, tunnel widening, synovitis and premature osteoarthritis [29,35]. Similarly, enthusiasm for synthetic materials as reinforcement in autograft ACL reconstructions has fluctuated with time. Potential advantages, such as greater graft strength, were outweighed by the perceived disadvantages of increased graft failure rates, inflammatory reactions to the synthetic materials and additional cost [39,43,44,46,47,49].

One proposed mechanism by which reinforced grafts failed was stress shielding [54,55]. In this process, the autograft tissue failed to ligamentize because inadequate forces were taken up by the tissue to allow collagen remodelling. Historical reinforcements were frequently sutured along the entirety of the graft's length. Modern "seat belt" reinforcement techniques, with independent tensioning of graft and reinforcement, may allow graft loading to assist maturation but prevent excessive elongation under higher loads [11,12]. Bachmaier et al. assessed the use of suture tape to reinforce ACL grafts in an animal model. The reinforcement was tensioned to have 1 mm of laxity compared to the graft. Biomechanical testing displayed reduced graft elongation and increased ultimate load to failure, without evidence of stress shielding [11]. Similarly, Lai et al. tested Fibertape reinforcement of partially transected ACL grafts in a porcine model, in order to replicate a weakened remodelling graft state. The authors found synthetic reinforcement significantly improved yield strength in weakened grafts but had a minimal biomechanical impact on intact grafts [56].

Reactions to synthetic materials are well recognised. This is particularly a problem after the failure of synthetic grafts, where rupture of the synthetic material leads to the release of fibres into the joint, which may contribute to synovitis, effusions and possibly premature degenerative changes [57]. Synovitis has been described with many previous synthetic fibers, including polytetrafluoroethylene (Proplast, Gore-Tex) [57], polyester (Leeds Keio, Dacron) [57–60], polypropylene (Kennedy LAD) [57,61], polyurethane urea (Artelon) [43] and polyethylene terephthalate (LARS, Trevira-Hochfest) [62–64]. The present review found a trend towards higher rates of effusion in reinforced grafts, but no study reported a significant difference [43,44,49]. Newer synthetics proposed for autograft augmentation have been tested in animal models and have not shown the reactivity of older synthetics [65]. However, at present, there is a lack of clinical data to confirm that this will not be an issue with these materials.

The present study has a number of limitations. First, most available studies were retrospective and thus prone to selection and intervention bias. Second, many studies experienced substantial loss to follow-up. Third, due to the relative infrequency of graft rupture, studies were often underpowered to detect significant differences in rupture rates. Parkes et al. undertook a sample size calculation and found that for a power of 0.8, a sample size of 1,290 patients would be required [48]. Such large patient cohorts are rarely practically feasible and highlight the limitations of graft rupture as an endpoint. Finally, heterogeneity between studies and outcome reporting prevented a meta-analysis from being undertaken.

Conclusion

In this systematic review, synthetic reinforcement of ACL autografts did not result in a reduced rate of graft rupture. A small number of studies have reported superior stability and patient-reported outcome measures with modern synthetic reinforcement techniques. Further clinical studies are required to establish the benefit of synthetic reinforcement of ACL autograft reconstruction.

Declaration of competing interest

None declared.

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Ethics approval statement

Ethics approval was not required for this study as it was a review of existing literature.

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None to declare.

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