Systematic Review

Suture Tape Augmentation of Anterior Cruciate Ligament Reconstruction Increases Biomechanical Stability: A Scoping Review of Biomechanical, Animal, and Clinical Studies

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Purpose: To (1) assess the available literature reporting on suture tape augmentation in anterior cruciate ligament (ACL) reconstruction and (2) determine what evidence exists to support and oppose the technique in clinical practice. **Methods:** Five databases were systematically searched on November 24, 2021, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Technical, animal, biomechanical, and clinical studies were included. Quality appraisal was conducted according to study type. Data were extracted and reported in tabular and narrative form according to the study design. **Results:** In total, 1276 studies were appraised, with 22 studies including 6 biomechanical, 3 animal, 10 technical, and 3 clinical studies. Biomechanical studies reported tape-augmented grafts to withstand 12.2% to 73.0% greater load to failure and 17.0% to 60.2% reduced elongation compared with standard ACL reconstruction. Evidence of load sharing started at 200 N (7-mm graft) and 300 N (9-mm graft), with suture tape augments taking 31% and 20% of the final load (400 N), respectively, in one study. Among animal studies, no significant differences in complications, rates of ligamentization, histologic findings, or evidence of stress shielding were reported. Technical studies differed primarily in the method of fixation of the proximal end of the tape. Clinically, patient-reported outcome measures were mixed among significant and nonsignificant improvements in International Knee Documentation Committee scores and return to sport among tape-augmented groups, with no difference in complications. **Conclusions:** Biomechanically, suture tape augmentation of ACL reconstruction increased the strength of the graft complex and reduced elongation, with early evidence of the “safety belt” effect with load-sharing properties at greater loads established. In animal studies, graft maturation and 4-zone bone healing, and equivalent rates of intra-articular complications were detected in ACL reconstruction with suture tape augmentation. In clinical studies, patient-reported outcomes were mixed between improved and equivalent outcomes with and without suture tape augmentation, whereas graft failure was not adequately powered to be assessed. **Clinical Relevance:** Suture tape augmentation of ACL reconstruction offers a low-cost method of improving initial biomechanical stability of the ACL graft. Animal and clinical data suggest the complication profile associated with synthetic grafts may not be apparent in tape augmentation. Independent suture tape augmentation may be considered with aims to increase the initial stability of the native ACL graft.

Anterior cruciate ligament (ACL) rupture is a major sports-associated knee injury, with an incidence in the order of 30 to 52 per 100,000 person years.[1] Reconstructive surgery has been the gold standard treatment in achieving a return to sport or pivoting activity owing to the role of the ACL in knee joint

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stability.[2] Recently, there has been an increase in rates of primary and revision reconstructions performed, particularly in high-risk groups such as those aged younger than 20 years.[3] Although overall failure rates are approximately 3%,[4] certain subcohorts have been identified to be at much greater risk of graft failure. Groups with increased risk includeing those of younger age, return to pivoting sports, of smaller graft size, and increased tibial slope.[5-8] Successful restoration of function after surgery is subject to the ability of the ACL graft to withstand the appropriate loads during rehabilitation and upon return to sport. Furthermore, preceding ligamentization and during early maturation, grafts are particularly vulnerable to reinjury,[9] necessitating that rehabilitation is closely monitored, with strict protocols to reduce the risk of graft failure. As such, surgical methods to increase the strength of the graft construct and protect the graft during the early phases of integration/ligamentization are of substantial interest.

Synthetic devices to augment or replace the ACL graft have been in circulation since the 1980s; however, high failure rates and complications, such as joint effusion and synovitis, have led to a gradual decline in their use.[10-13] Most recently, there has been an interest in augmentation, rather than en bloc substitution of the native graft, with suture tape, a broad, artificial, nonabsorbable, braided polyethylene/polyester suture. Unlike other synthetic devices, which take the place of a biological graft, suture tape has been proposed for use as an augmentation device acting as a “safety belt” or “seat belt” to protect the in situ autograft/allograft from excessive stress, especially during the remodeling period, while avoiding stress shielding.[14] Encouraged by successful use in ligament repair within lateral ankle instability,[15] ulnar collateral ligament repair,[16] and ACL repair,[17] suture tape has been proposed as an augment in ACL reconstruction. The purpose of this scoping review was to (1) assess the available literature reporting on suture tape augmentation in ACL reconstruction and (2) determine what evidence exists to support and oppose the technique in clinical practice. A scoping review format was utilised due to the heterogeneity of the small body of literature that currently exists on this relatively new technique. It was hypothesized that suture tape augmentation of ACL reconstruction would be associated with improved biomechanical performance of the construct and improved surgical complication profile and functional outcome measures compared with standard ACL reconstruction.

Methods

This scoping review was performed according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta- Analyses) guidelines.[18] Synthesis was conducted by adopting principles provided by JBI Manuel for Evidence Synthesis for Scoping Reviews.[19]

Search Strategy and Data Sources

A systematic search of electronic databases was conducted on November 24, 2021, of the following databases: MEDLINE, EMBASE, CINAHL, and Cochrane Database. A manual search of Google Scholar was performed to identify articles not indexed by Web of Science. The search strategy was divided into 2 themes: “ACL reconstruction” and “Suture tape augmentation.” Examples of key search terms included the following: “anterior cruciate ligament reconstruction,” “ACLR,” “ACL-R,” “ACL reconstruction,” “augment,*” “reinforce*,” “suture tape,” “fibretape,” and “internal brace*.” Search strategies can be referred to in Appendix Table 1, available at www.arthroscopyjournal.org. To supplement electronic searches, the reference list of relevant studies was also crosschecked for any additional references. The results of the search were imported into EndNote X9 (Thomson Reuters) and duplicates removed.

Screening and Selection

This study aimed to select studies that reported outcomes after and the technique of suture tape augmentation of ACL reconstruction. The following inclusion criteria were applied to the search yield: studies that reported the use of suture tape augmentation of ACL reconstruction using autograft (all types) and allograft. Included study designs were clinical studies, biomechanical studies, animal models, and technical papers. Technical papers have been included, given this is a broad review of an emerging surgical technique. The exclusion criteria were as follows: review papers, conference papers, study protocols, editorial commentaries, papers reporting on ACL repair or partial ACL tears, studies reporting on other synthetic device constructs, papers reporting on multiligament injuries, and papers not accessible in English. Two authors (C.M. and L.H.) independently assessed all articles for inclusion by reviewing titles and abstracts based on eligibility criteria. After initial screening, full texts were retrieved for further selection based on the inclusion and exclusion criteria. Any discrepancies were resolved by discussion with a third reviewer involved if consensus could not be achieved (S.T.).

Data Extraction

Data were extracted concurrently by 2 reviewers (C.M., L.H.) using a spreadsheet database custom designed for this review (Excel; Microsoft, Inc., Redmond, WA). In studies reporting clinical, biomechanical, and animal data, details relating to patient demographics, investigation type, comparison group, outcome measures, and key results were presented in tabulated form, with numerical and raw data extracted where available. For the technical papers, key points relating to the technique described and presented in tabulated form.

Quality Appraisal

Methodologic quality appraisal was performed using a tool specific to each study design. Animal model studies were assessed using the Systematic Review Centre for Laboratory Animal Experimentation (SYRACLE) Risk of Bias tool.[20] Biomechanical models were assessed using the Quality Appraisal for Cadaveric Studies (QUACS) scale.[21] Clinical studies were assessed using the Scottish Intercollegiate Guidelines Network (SIGN) checklist for cohort studies.[22] Each assessment was undertaken independently by 2 reviewers (C.M., L.H.). Disagreements were resolved by discussion or failing this, a third reviewer (S.T.). Quality appraisal scores are in the tabulated results adjacent to their respective studies.

Analysis

Data was analyzed in a narrative form only. Meta-analysis was not possible due to study heterogeneity. Data were presented descriptively and where possible in tabular form.

Results

Literature Identification

The electronic database search yielded 1997 results, which was reduced to 1275 results after removal of

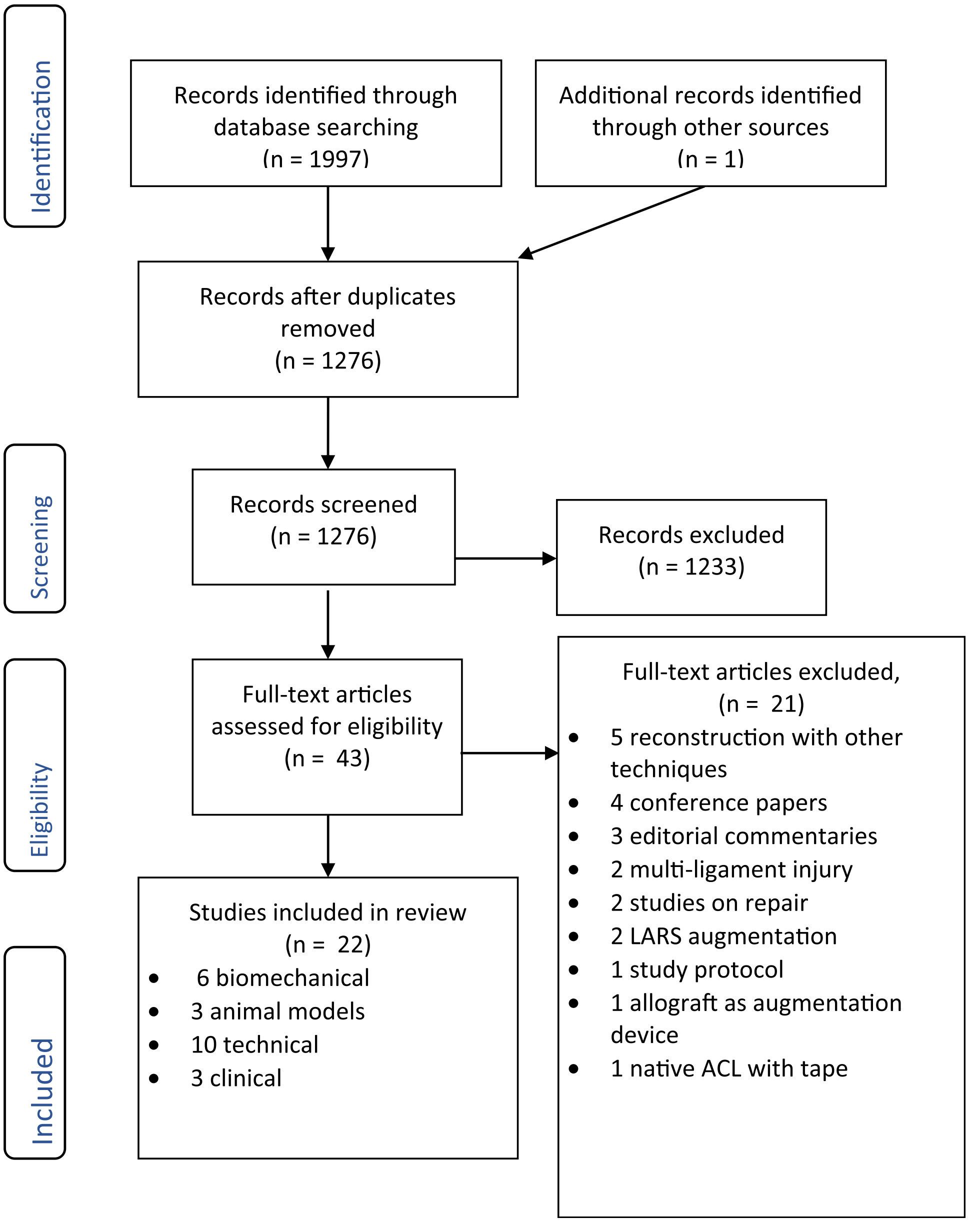

Fig 1. PRISMA flowchart.

duplicates, with 1 reference added from a Google Scholar search, due to the journal not being indexed by the Web of Science,[23] resulting in a total of 1276 studies. After review of titles and abstract, 43 studies remained for full-text review (Fig 1). A further 21 studies were excluded on review of full text, leaving a final yield of 22 studies. Of these, there were 6 biomechanical studies, 3 animal model studies, 10 technical papers, and 3 clinical studies.

Results by Study Methodology

Biomechanical

A summary of the studies and key results are available in Appendix Table 2, available at www.arthroscopyjournal.org. Four of the 6 biomechanical studies were noted to be performed by the same group of authors.[14,24-26] Four studies used quadrupled bovine tendon graft models, with a porcine tibia and either acrylic blocks or porcine femur.[14,24,26,27] The other 2 used human bone—tendon—bone (BTB) graft within porcine tibial and femoral bone fixations.[25,28] All studies measured total graft elongation after cyclic loading, and subsequent load to failure and stiffness after pull-out testing. Two studies measured yield strength,[27,28] and 1 measured load sharing between the graft construct and augmentation device.[26] Three studies compared small diameter (7- or 8-mm) tripled grafts and larger (9-mm) quadrupled grafts, each with and without suture tape.[14,24,26] One study compared 2 different types of quadrupled construct, a single suspensory construct and a double suspensory construct.[27] Each construct had 4 groups, consisting of a standard graft ± augmentation and an 80% resected graft ± augmentation.

Four studies reported a significant reduction in elongation among tape-augmented specimens compared with controls,[14,24-26] ranging from 17% to 60.2% reduced mean elongation versus unaugmented control for matched graft type. Lai et al.[27] reported no differences in cyclic elongation in tape augmented intact grafts; however, following resection of 80% of the graft, the addition of suture augmentation restored the construct stiffness and cyclic elongation compared with the intact unaugmented graft for both constructs. The mode of failure of an intact graft was graft slippage past the interference screw in 80% of cases; however, for the augmented intact graft, the mode of failure was the button breaking through the cortex in 80% of cases ($P = .023$).[27]

With respect to load to failure, 4 studies reported significantly increased mean ultimate failure loads, ranging from 12.2% to 73.0% in augmented groups compared with controls of matched construct type.[14,24,26,28] Four studies reported increased construct stiffness in tape-augmented groups compared with matched controls ranging from 40% to 103.9%.[14,24,26,28] The single study that assessed load sharing reported the onset of loading of the suture tape to occur at 200 N and 300 N for the 7-mm and 9-mm constructs respectively.[26] Load sharing was reported to increase gradually from onset with the suture tape augmentation sharing 31% (7-mm graft) and 20% (9-mm graft) of the final peak load (400 N).

Animal

A summary of the studies and key results are available in Appendix Tables 3 and 4, available at www.arthroscopyjournal.org. Two of the 3 studies were conducted using canine models (conducted by the same group of authors)[29,30] and one using a rabbit model.[31] The 2 canine studies involved performing ACL reconstructions with suture tape augmentation.[29,30] One of these comparing allograft quadriceps tendon with suture augmentation against a nonoperative control[29] and the other comparing allograft quadriceps tendon with suture augmentation against BTB autograft.[30] One study, a rabbit model, compared ACL reconstruction by suture tape alone as a synthetic ACL graft, suture tape-augmented hamstring autograft, and hamstring autograft alone.[31]

On arthroscopic assessment, no significant differences were observed between operative groups,[30] with mild synovitis reported in all operative groups across both canine studies.[29,30] Histologic measures across all 3 studies did not report any adverse findings from the inclusion of suture tape.[29-31] Zonal architecture of graft incorporation was reported in 2 studies.[29,30] Those with suture tape augmentation showed 4-zone architecture along with graft remodeling, comparable with standard surgery. Radiographic assessment was performed in 2 of the canine model studies with no evidence of socket widening demonstrated, and no degenerative changes reported for any of the knees with suture tape augmented grafts.[29,30]

Postmortem biomechanical assessment was performed by the rabbit study[31] and both canine studies.[29,30] The canine studies[29,30] were inappropriately designed, attributable to their lack of appropriately matched controls (discrepant graft types); therefore, conclusions regarding biomechanical performance or functional assessment should not be informed by this data. Their data have still been included in Appendix Table 4 for completeness. The study in the rabbit model[31] reported a statistically significant increase in median failure load (interquartile range) for the augmented autograft versus autograft-alone groups ($P = .025$). Energy absorption for the suture tape-alone group and the augmented autograft group were greater than the autograft-alone group. There was no significant difference in stiffness or elongation when we compared augmented versus unaugmented grafts.

Technical

All 10 technical papers outlined various techniques for augmenting ACL reconstruction grafts with the use of suture tape (Appendix Table 5, available at www.arthroscopyjournal.org).[32-41] Four technical papers described hamstring autograft, of which 3 described a quadrupled graft[32,33,41] and the other a tripled.[35] Four described BTB graft.[34,36,37,40] All 3 included autograft, with one also describing BTB allograft[37] and another also describing Achilles tendon allograft.[34] Only 1 paper described a quadriceps graft[38] and 1 an anterior tibialis allograft.[39] All but 2 studies[34,37] reported graft independent suture tape fixation by looping the tape through the femoral cortical button and being tied over a tibial cortical button or attached to the tibia by an interference anchor distal to the tibial tunnel. Of the aforementioned 2 studies not using a femoral cortical button, both used BTB grafts. One technique reported the proximal attachment of the suture tape tied over the proximal bone block of the BTB autograft,[34] whereas the other was passed through a hole predrilled in the proximal bone block.[37] This technique was also unique in that the suture tape was passed by a needle within the substance of the tendon bilaterally along the length of the soft tissue portion of the graft. All other studies reported the suture tape running within the folds of the bundles, or alongside the graft.

All but 2 papers described suture tape fixation in full extension, with one stating "avoiding full extension"[34] and the other not being described.[37] Only 2 papers described a strategy to avoid stress shielding.[38,39] Both of these papers used the same technique of a hemostat underneath the free end of the tape while it was fixated. All but one study[36] raised concern for the potential of stress shielding of the graft and extension blocks if the suture tape were overtensioned.

Clinical

All clinical studies were nonrandomized in design, and a summary of the studies and key results are available in Appendix Table 6, available at www.arthroscopyjournal.org. Bodendorfer et al.,[42] in a retrospective cohort design, reported statistically significant reductions in daily maximum and average pain levels for the augmentation group compared with standard reconstruction ($P = .004$ and $P = .021$, respectively). Statistically significant improvements in time to return to preinjury level of sport (3.7 months earlier, $P < .002$) and improved Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and International Knee Documentation Committee (IKDC) at 2 years ($P = .024$ and $P = .006$, respectively) were also reported. Parkes et al.,[43] contrarily, reported nonsignificant differences in IKDC and Lysholm scores at 2 years' minimum follow-up, however, did report increased Tegner activity scores in tape augmented versus nonaugmented grafts ($P = .026$).

Shantanu et al.[23] prospectively reported no difference in Lysholm scores, knee extension lag or overall Lachman; however, they did report increased improvement rates of >2 grades of subjective Lachman examinations in tape augmented patients at 6 months.

There were no statistically significant differences in complication rates, including graft failure, in any of the studies.

Discussion

The most important finding of this review was improved biomechanical performance in suture tape augmentation grafts compared with standard technique in the majority of biomechanical studies, with one study demonstrating the presence of the desired "safety belt" effect of suture tape. Second, animal models suggested that possible pitfalls such as adverse reaction and failure of ligamentization are not supported by the literature. However, clinical outcomes are mixed, with select studies reporting improved patient-reported outcomes and return to sport data in tape augmented ACL reconstructions, whereas others reported no difference in clinical outcomes.

The biomechanical studies in this review suggest that tape augmentation may provide biomechanical advantage over standard ACL reconstruction (as reported by 4 of the 6 included biomechanical studies), characterized by a reduction in cyclic graft elongation and increased load to failure. A key driver of the slow rehabilitation of ACL reconstruction is the vulnerability of the graft to biomechanical failure during the ligamentization period, where there is an established reduction in the biomechanical strength of the graft and increased knee laxity compared with immediately postoperative. The reinforcement offered by tape augments may protect the graft during the early and remodeling phases of graft ligamentization, during which time it is weaker secondary to early necrosis and later extracellular matrix remodeling.[9] Similarly, the function of suture tape as the "safety belt," established biomechanically by Bachmaier et al.,[26] may allow protection against rupture during high loads and may allow more accelerated rehab protocols to be performed safely.

A possible concern is the tape acting to overconstrain the knee, leading to stress shielding of the graft.[44] The presence of graft remodeling among animal studies,[29,30] however, suggests that stress shielding of the graft may be avoided with correct tensioning of the graft, where many authors fix the tape in hyperextension of the knee, before cycling the knee and subsequent graft fixation in extension. This is substantiated by the biomechanical study findings of Lai et al.,[27] who demonstrated no increased stiffness in the augmented constructs versus the intact grafts, and Bachmaier et al.,[14] whereby the suture tape augmented groups showed lower stiffness than suture tape alone but with increased loading capabilities. This suggests a load-sharing capability between the graft and suture tape, an important consideration in tape augmentation given the importance of load bearing in graft maturation.[45] Only one of the biomechanical studies monitored in situ intragraft force to determine how much load is being taken by the graft versus the suture tape, and thus at what point does the "safety belt" effect of the tape begin.[26] Ideal augmentation would have the suture tape take no load during physiological ranges, but when this is exceeded, the load absorbed by the tape would protect the graft from elongation and ultimately failure of the construct. This more recent investigation by Bachmaier et al.[26] suggests that lower loads are transferred by the graft only and the augmentation acts as a "safety belt" at greater strain. Whilst biomechanical studies exhibit improved load to failure, they are a time-zero assessment with no changes to bone or graft remodeling, and as such do not inform the impact of tape upon graft remodeling, and potential stress shielding, which may influence long term biomechanical performance.

Given the historic downfalls of synthetic ligament grafts, tolerance of the intra-articular synthetic material is a key consideration, as well as the impact of augmentation on the biological graft function. A systematic review by Batty et al.[10] reported rates of sterile effusion or synovitis of 6.3% to 27.5% of knees with earlier generation synthetic ACL ligaments, illustrating the possible outcome of intra-articular foreign material. Histologic findings of foreign body granulomatous and chronic inflammatory responses have also been reported in a case series on Ligament Augmentation and Reconstruction System (LARS) devices, which are constructed of terephthalic polyethylene polyester fibers.[12] The histologic findings within animal studies in this review did not reveal any adverse reactions to the presence of suture tape.[29-31] In addition, graft-to-bone healing has been demonstrated, with a 4-zone healing pattern and graft remodeling evident among animal models.[29,30] Importantly, the use of tape in ACL repair has been associated with acceptable long-term outcomes, with Hopper et al.[46] reporting no residual synovitis or complications at 5 years in ACL repair. However, the animal studies within this review are limited by their short assessment periods of 8 weeks[31] and 6 months.[29,30] Clinical studies, however, did not report clinical signs of synovitis or persistent effusion among tape-augmented reconstructions. To the authors' knowledge, there is no current evidence that suture tape augmented ACL reconstruction is associated with synovitis. Although it is reasonable to be cautious adopting tape augmentation of reconstructions, the preliminary animal and clinical findings in this study, in addition to the longer-term studies on ACL repair lends support to its acceptable levels of tolerance within the knee.

The most significant downstream question to be answered regarding the use of tape augmentation is its capacity to protect the graft from failure. The clinical studies found in this review are insufficient to yet make a conclusion for or against the use of suture tape in this respect. The included studies were not appropriately powered to detect differences in graft failure rate or complications, with a post hoc analysis by Parkes et al.[43] suggesting a total sample size of 1,290 patients, with 430 in the augmentation group, is needed to detect a difference in graft failure between groups. Nevertheless, Shantanu et al.,[23] Bodendorfer et al.,[42] and Parkes et al.[43] all reported no differences in graft failure, reinjury, or complication rates at final follow-up compared with nonaugmented groups. The animal models found in this review are also unsuitable for making an assessment on the ability of tape augmentation to reduce graft failure rates, owing to their short follow-up periods. They are all inadequately powered and have unsuitable designs for making such conclusions: Cook et al.[29] compares augmented graft to nonoperative control, Smith et al.[30] compares augmented quadriceps allograft to BTB autograft, and Soreide et al.[31] uses a rabbit model that is not a high failure rate model.

Bodendorfer et al.[42] reported improved pain scoring, time to return to preinjury activity, WOMAC and IKDC scores, suggesting that adding tape augmentation has a role in improving outcomes after ACL reconstruction. There are some differences in baseline characteristics between 2 of the clinical papers that may impact the lack of significant changes in PROMs shown by Parkes et al.[43] Parkes et al.[43] reported concomitant medial meniscal injury in 39% and 44% of augmented reconstructions and controls, respectively, and lateral meniscal injury in 47% and 44%, whereas Bodendorfer et al.[42] reports presence of any meniscal injury at 26.7% and 33.3% of augmented reconstructions and controls, respectively. It should be noted that the observed differences between patient-reported outcome measures may be subject to biases owing to the nonrandomized design of included clinical studies. Similarly, the 2-year follow-up limits conclusions drawn regarding the long-term effects of suture tape augmentation on ACL protection, and clinical outcomes.

It has been widely reported that certain cohorts of patients are at much greater risk of graft failure after primary reconstruction.[5-7,47,48] Webster et al.[6] reported a 6-fold increased risk of failure in patients younger than 20 years. Similar results were reported by Faunø et al.[47] with a risk ratio for revision of 6.7 and 4.9 in patients aged 13-15 years and 15-20 years, respectively, when compared with older than 20 years of age. Magnussen et al.[5] also reported the increased risk of age less than 20 years and additionally the risk of smaller graft size (≤8 mm). The advantage of tape augmentation is the addition of strength to the graft without adding significant graft diameter. The advantage of tape within smaller graft diameters may be more apparent, as illustrated by the biomechanical findings of Lai et al.,[27] where a weaker graft model saw improved biomechanical performance with tape, whereas standard graft models did not. Furthermore, evidenced in the technical papers is the simplicity of the suture tape augmentation procedure, where it has been reported to be reproducible and adds minimal operative time.[34,36,39]

Limitations

This study has limitations. As with all review studies, it is limited by the input literature, focally the lack of high-level clinical evidence. Due to the broad nature of this scoping review, there is a great deal of heterogeneity within the literature included, as such, a specific targeted question was not the aim of this study and thus the conclusions should be considered accordingly. Owing to the study design, and the heterogenous nature of the included studies, formal meta-analysis is therefore not possible, which limits the strength of our conclusions. Second, the majority of studies were either biomechanical, which are time zero, and animal in nature, with 6-month follow-up, and as such this limits the strength of conclusions regarding the long-term viability of suture tape in the knee. The biomechanical studies found in this review report only unidirectional loading and do not necessarily represent the range of multidirectional forces that may be applied to the graft in normal loading, which limits the strength of any conclusions.[14,24,25] Longer-term, adequately powered clinical studies in high-risk cohorts are required, therefore, to accurately determine the impact of graft rupture rates and the tolerance of suture by the joint. Furthermore, given the breadth of techniques of tape incorporation in technical papers, investigation into which method may optimize its function needs clarification biomechanically and clinically.

Conclusions

Biomechanically, suture tape augmentation of ACL reconstruction increased the strength of the graft complex and reduced elongation, with early evidence of the “safety belt” effect with load-sharing properties at greater loads established. In animal studies, graft maturation and 4-zone bone healing, and equivalent rates of intra-articular complications were detected in ACL reconstruction with suture tape augmentation. In clinical studies, patient-reported outcomes were mixed between improved and equivalent outcomes with and without suture tape augmentation, whereas graft failure was not adequately powered to be assessed.

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Appendix Table 1. Search Strategies

Medline

ID	Search Terms
1	exp anterior cruciate ligament reconstruction
2	("anterior cruciate ligament reconstruction" or ACLR or ACL-R or "ACL reconstruction").mp.
3	1 or 2
4	(augment* or reinforc*).mp.
5	((suture or tape) and (augment* or brac* or reinforc*)).mp.
6	(fibertape or fibretape or fiber-tape or fibre-tape or "fiber tape" or "fibre tape").mp.
7	(suturetape or suture-tape or "suture tape" or "internal brac*").mp.
8	(tigertape or tiger-tape or ultratape or ultra-tape or ultra tape or xbraid or permatape or "force fiber" or hifi).mp.
9	4 or 5 or 6 or 7 or 8
10	3 and 9

EMBASE

ID	Search terms
1	exp anterior cruciate ligament reconstruction/
2	("anterior cruciate ligament reconstruction" or ACLR or ACL-R or "ACL reconstruction").mp.
3	1 or 2
4	(augment* or reinforc*).mp.
5	((suture or tape) and (augment* or brac* or reinforc*)).mp.
6	(fibertape or fibretape or fiber-tape or fibre-tape or "fiber tape" or "fibre tape").mp.
7	(suturetape or suture-tape or "suture tape" or "internal brac*").mp.
8	(tigertape or tiger-tape or ultratape or ultra-tape or ultra tape or xbraid or permatape or "force fiber" or hifi).mp.
9	4 or 5 or 6 or 7 or 8
10	3 and 9

CINAHL

ID	Search terms
S1	anterior cruciate ligament reconstruction or acl reconstruction or aclr
S2	augment* or reinforc*
S3	(suture or tape) and (augment* or brac* or reinforc*)
S4	fibertape or fibretape or fiber-tape or fibre-tape or "fiber tape" or "fibre tape"
S5	suturetape or suture-tape or "suture tape" or "internal brac*"
S6	tigertape or tiger-tape or ultratape or ultra-tape or ultra tape or xbraid or permatape or "force fiber" or hifi
S7	S2 OR S3 OR S4 OR S5 OR S6
S8	S1 AND S7

Cochrane

ID	Search
#1	anterior cruciate ligament reconstruction
#2	aclr or acl-r or "acl reconstruction"
#3	#1 or #2
#4	augment*
#5	suture and (augment* or brac*)
#6	fibertape or fiber-tape or "fiber tape"
#7	fibretape or fibre-tape or "fibre-tape"
#8	suturetape or suture-tape or "suture tape"
#9	internal brac*
#10	tigertape or tiger-tape
#11	#4 or #5 or #6 or #7 or #8 or #9 or #10
12	#1 and #3 and #11

Appendix Table 2. Biomechanical Studies

Author	Year	Journal	Quality (QUACS)	Model	Groups	Specimens	Outcomes	Methods			Results			
								Cyclic Loading Protocol	Load to Failure Protocol		Total Elongation (or Cyclic Displacement) (Mm ± SD)	Load to Failure (aka Ultimate Strength) (N ± SD)		Stiffness (N/mm ± SD)
Bachmaier et al.[14]	2018	*Arthroscopy*	11/13	Bovine flexor tendon graft fixated between porcine tibia and acrylic block, with and without suture tape. Suspensory fixation proximal and distal.	a. Tripled bovine graft (8 mm) b. Tripled bovine graft + suture tape (8 mm+ ST) c. Quadrupled bovine graft (9 mm) d. Quadrupled Bovine graft + suture tape (9 mm + ST) e. Suture tape only	n = 40 (8 per group)	-Dynamic and total elongation -Ultimate failure load -Stiffness	250 N for 1000cycles 400 N for 1000 cycles	50 mm /min		a. 5.91 ± 0.76 b. 2.44 ± 0.29 c. 3.91 ± 0.74 d. 2.39 ± 0.28 e. 4.67 ± 0.30	a. 968 ± 103 b. 1592 ± 105 c. 1131 ± 89 d. 1585 ± 265 e. 865 ± 81		Dynamic (400N) a. 129.4 ± 8.9 b. 219.7 ± 10.7 c. 156.9 ± 10.4 d. 231.2 ± 29.8 e. 329.4 ± 5.9
									P values	a vs b	**<.001**	**<.001**		**<.001**
										c vs d	**<.001**	**<.001**		**<.001**
Bachmaier et al.[26]	2021	*Arthroscopy*	11/13	Bovine flexor tendon fixated between porcine femur and tibia, with and without isolated suture tape. Suspensory fixation proximal and distal.	a. Tripled bovine graft (7 mm) b. Tripled bovine graft + suture tape (7 mm+ ST) c. Quadrupled bovine graft (9 mm) d. Quadrupled bovine graft + suture tape (9 mm + ST)	n= 56 (8 per group)	-Dynamic and total elongation -Ultimate failure load -Stiffness - Load sharing	100N for 1000 cycles 200 N for 1000 cycles 300 N for 1000 cycles 400 N for 1000 cycles	50 mm /min		a. 4.77 ± 1.08 b. 1.90 ± 0.27 c. 3.57 ± 0.54 d. 1.50 ± 0.35	a. 835 ± 92 b. 1435 ± 228 c. 1044 ± 49 d. 1806 ± 157	Load sharing at peak (400 N) a. − b. 31% c. − d. 20%	Dynamic (400 N) a. 113.4 ± 9.3 b. 195.9 ± 9.8 c. 151.9 ± 13.8 d. 208.9 ± 13.7
									P values	a vs b	**<.001**	**<.001**		**<.001**
										c vs d	**<.001**	**<.001**		**<.05**
Matava et al.[28]	2021	*Arthroscopy*	11/13	Human BTB graft fixated between porcine knees, with and without suture tape augmentation. Interference screw fixation.	a. BTB graft b. BTB graft + suture tape	n = 16 (8 per group)	-Cyclic and total displacement -Stiffness -Ultimate load failure -Yield load	50-250 N for 500 cycles	20 mm /min		a. 7.16 1.42 b. 5.87 ± 1.43	a. 473 ± 169 b. 744 ± 219	Yield strength (N ± SD) a. 503 ± 137 b. 601 ± 124	a. 128 ± 28 b. 261 ± 76
									P values		.118	**.015**	.189	**.002**
											Cyclic displacement (mm ± SD)		Yield strength (N ± SD)	

(continued)

Appendix Table 2. Continued

Author	Year	Journal	Quality (QUACS)	Model	Groups	Specimens	Outcomes	Methods			Results			
Lai et al.[27]	2020	*Arthroscopy, Sports Medicine, and Rehabilitation*	10/13	Bovine extensor tendon graft within porcine femur and tibia. Tested over 2 models: single suspensory construct (SSC) with femoral button and tibial interference screw; double suspensory construct (DSC) with bicortical button fixation.	SSC a. Standard graft b. Standard graft + suture tape c. 80% resected graft d. 80% resected graft + suture tape	n = 80 (all groups) 10 per group	-Cyclic displacement -Stiffness -Ultimate load failure -Yield load	50-250 N for 500 cycles	20 mm /min		a. 5.3 ± 1.1 b. 4.4 ± 0.7 c. 9.5 ± 1.6 d. 6.0 ± 1.0	a. 891 ± 116 b. 1000 ± 139 c. 263 ± 82 d. 655 ± 149	a. 826 ± 122 b. 820 ± 186 c. 263 ± 82 d. 623 ± 124	a. 146 ± 28 b. 139 ± 28 c. 85 ± 20 d. 121 ± 9
									P values	a vs b c vs d a vs d	0.111 **<.001** .117	0.57 **<.001** **<.001**	0.927 **<.001** **.005**	0.428 .148 .09
					DSC a. Standard graft b. Standard graft + suture tape c. 80% resected graft d. 80% resected graft + suture tape	10 per group	-Cyclic displacement -Stiffness -Ultimate load failure -Yield load	50-250 N for 500 cycles			a. 5.2 ± 1.9 b. 3.8 ± 0.8 c. 8.9 ± 0.8 d. 4.9 ± 1.2	a. 747 ± 86 b. 850 ± 216 c. 372 ± 139 d. 798 ± 116	a. 680 ± 147 b. 815 ± 212 c. 371 ± 139 d. 697 ± 115	a. 118 ± 14 b. 128 ± 22 c. 79 ± 18 d. 108 ± 29
									P values	a vs b c vs d a vs d	0.286 **.001** .735	0.327 **<.001** .441	0.181 **<.001** .810	0.237 **.022** .398
Noonan et al.[24]	2020	*Arthroscopy*	10/13	Bovine tendon with porcine tibia and acrylic femoral block. Suspensory fixation proximal, interference screw distal with further independent fixation of suture tape with another interference screw.	a. Tripled bovine graft (8 mm) b. Tripled bovine graft + suture tape (8 mm+ ST) c. Quadrupled bovine graft (9 mm) d. Quadrupled bovine graft + suture tape (9 mm + ST)	n = 32 (8 per group)	-Dynamic and total elongation -Ultimate failure load -Stiffness	250 N for 1000 cycles 400 N for 1000 cycles	50 mm /min		a. 4.54 ± 0.75 b. 2.01 ± 0.50 c. 3.25 ± 0.34 d. 1.98 ± 0.51	a. 829 ± 100 b. 1074 ± 149 c. 939 ± 76 d. 1125 ± 157		Dynamic (400 N) a. 176 ± 9 b. 272 ± 19 c. 200 ± 10 d. 280 ± 32
									P values	a vs b c vs d	**<.001** **<.001**	**.003** **.023**		**<.001** **<.001**
Smith et al.[25]	2019	*The Journal of Knee Surgery*	10/13	Human BTB graft within porcine femur and tibia.	a. Interference screw fixation femur and tibia b. Adjustable loop device (ALD) femur, screw tibia c. ALD femur, screw tibia + suture tape	n = 30 (10 per group)	- Cyclic displacement - Stiffness - Ultimate load failure	50-250 N for 250 cycles	20 mm /min		Cyclic displacement (mm ± SD) a. 4.3 ± 1.1 b. 4.2 ± 0.9 c. 2.9 ± 0.8	a. 416 ± 167 b. 628 ± 223 c. 758 ± 128		a. 104 ± 40 b. 122 ± 28 c. 156 ± 23
									P values	a vs b a vs c b vs c	.910 **.015** **.017**	**.025** **<.001** .111		**.042** **.003** .218

BTB, bone–tendon–bone; QUACS, Quality Appraisal for Cadaveric Studies; SD, standard deviation; ST, suture tape.
P values in bold are statistically significant.

Appendix Table 3. Animal Models (Study Overview)

Author	Year	Journal	Quality (SYRACLE)	Aim	Intervention	Suture Tape Fixation/ Incorporation	Assessment Period	Subjects	Outcome Measures
Cook et al.[29]	2017	*The Journal of Knee Surgery*	6/10	Describe and validate canine model for all-inside ACL reconstruction	Canine model 1. Allograft QTIB 2. Control - no surgery	Within graft, attached to adjustable loop	6 mo	n = 20 1. Intervention - 10, 2. Control - 10 (nonoperated knee)	Clinical/functional (lameness, function, pain, effusion, ROM, anterior draw, internal rotation), arthroscopic, radiographic, biomechanical, histologic
Smith et al.[30]	2019	*The Journal of Knee Surgery*	6/10	Compare quadriceps tendon allograft ACL reconstruction augmented with internal brace (QTIB) and PRP versus BTB graft	Canine model 1. Allograft QTIB and PRP 2. BTB autograft Contralateral knee in both groups used as non-operative control	Within graft, femoral end not stated, tibial free ends tied over cortical button	6 mo	n = 10 1. 5 2. 5	Clinical/functional (lameness, function, pain, effusion, ROM, anterior draw, internal rotation), arthroscopic, radiographic, biomechanical, histologic
Soreide et al.[31]	2019	*The Bone and Joint Journal*	8/10	Assessment of use of FiberTape within intra-articular ligament reconstruction	Rabbit model Bilateral ACL reconstruction by: 1. FiberTape alone (semitendinosus still harvested) 2. FiberTape augmented autograft (semitendinosus) 3. Autograft (semitendinosus)	FiberTape side-by-side with autograft Fixated with tenodesis screws proximally and distally for all procedures	8 wk	n = 18 (rabbits) 1: 6 2: 6 3: 6 Both knees underwent identical procedure within groups	Biomechanical, micro-CT, histologic, gene expression analysis

ACL, anterior cruciate ligament; BTB, bone−tendon−bone; CT, computed tomography; QTIB, quadriceps tendon with internal brace; ROM, range of motion; SYRACLE, Systematic Review Centre for Laboratory Animal Experimentation.

Appendix Table 4. Animal Model Data

Author		Key Functional and Clinical Results								Arthroscopic Assessment	Histologic	Radiographic	Biomechanical
	Group	Lameness ± SD	Function ± SD	%TPI ± SD	Pain ± SD	Effusion ± SD	CROM (°) ± SD	Ant. Draw (mm) ± SD	Int. Rot. (deg) ± SD				
Cook et al.[29]	Control	0 ± 0	10 ± 0	19.9 ± 1	0 ± 0	0 ± 0	108.4 ± 2	2.8 ± 0.1	14.7 ± 1				
	QTIB	0.7 ± 0.5	9.3 ± 0.6	18.4 ± 3	0.2 ± 0.5	1.2 ± 0.6	104.2 ± 5	2.9 ± 0.5	15 ± 2	No articular cartilage, meniscal pathology. Minimal focal synovitis in all knees	Graft-to-bone healing demonstrated in both sockets for all grafts. Four-zone healing demonstrated in all sockets. Ligamentous remodeling and neo-vascularization observed	No evidence socket widening, mild effusion in 8/10 knees, no degenerative changes	No difference between groups for load/ displacement testing
		$P > 0.1$ for all functional measures											$P > .2$
Smith et al.[30]	Normal (control)	0 ± 0a	10 ± 0a	21.5 ± 1a	0 ± 0a	0 ± 0a	108.6 ± 3a	2.9 ± 0.3	12.9 ± 1				
	QTIB (group 1)	0.4 ± 0.5a	9.2 ± 0.7a,b	20.5 ± 2a,b	0.3 ± 0.4a	0.6 ± 0.4a	105.0 ± 5a	2.9 ± 0.8	12.8 ± 1	All grafts intact No fibrillation or partial tearing Mild focal synovitis all knees No articular pathology	Graft-to-bone healing occurred. Four-zone architecture observed Remodeling of grafts observed—hypercellularity, altered collagen fiber organization	No difference vs BTB for sockets Mild effusion in 2 knees No degenerative or osteoarthritic changes	No difference between groups for load/ displacement testing
	BTB (group 2)	1.6 ± 0.9b	7.0 ± 1.9b	18.2 ± 4b	1.5 ± 1b	1.5 ± 0.6b	90.6 ± 5b	2.8 ± 0.8	13.0 ± 1	All grafts intact. Mild fibrillation in 4 grafts. Mild-to-moderate synovitis in all grafts. Patellofemoral cartilage pathology in 4 knees.	Bone-to-bone healing occurred. Remodeling of grafts observed. More prominent neovascularization and less inflammation.	Mild effusion in all 5 knees. More severe radiographic pathology scores compared with QTIB group ($P < .05$)	
		Where 2 groups differ in the letter (a or b) $P \leq .05$											p > 0.2
		Median Failure Load, N (IQR)		Median Stiffness, N/mm (IQR)		Median Elongation, mm (IQR)		Median Energy Absorption, Nmm (IQR)				Micro-CT	Gene expression analysis
Soreide et al.[31]		1: 60.3 (51.0 to 103.9) 2: 46.1 (35.0 to 64.3) 3: 26.4 (16.6 to 47.2)		1. 27.2 (17.6 to 51.6) 2. 21.4 (15.1 to 33.7) 3. 15.1 (11.4 to 26.1)		1: 5.3 (4.8 to 6.3) 2: 6.6 (6.1 to 10.0) 3: 9.2 (7.7 to 11.7)		1: 103.5 (69.3 to 196.5) 2: 82.7 (48.7 to 89.3) 3: 31.0 (17.1 to 55.9)		n/a	Limited signs of inflammation in all groups No collagen fiber regeneration seen along FiberTape	No adverse events observed No significant differences in bone mineral density between groups 2 and 3	No significant differences between gene expression between groups
	1 vs 3	***P* = .025**						***P* = .018**					
	2 vs 3	***P* = .025**						***P* = .037**					

BTB, bone−tendon−bone; CT, computed tomography; IQR, interquartile range; QTIB, quadriceps tendon with internal brace.
P values in bold are statistically significant.

Appendix Table 5. Technical Papers

Author	Year	Journal	Graft Type	Graft Fixation	Tape Details	Suture Tape Fixation	Questions Raised
Aboalata et al.[32]	2017	*Arthroscopy Techniques*	Modified all-inside hamstring autograft technique, quadruple bundle	Suspensory fixation proximal and distal with cortical buttons. Anatomical Fixed in 30° flexion	Within substance of graft by crossing 3 times within bundles of graft	Proximal: looped through cortical button Distal: Knotted over tibial button and ends fixed to tibia with Bio-SwiveLock anchor Fixed in full extension	Potential for stress shielding Potential for overtensioning and limiting extension range
Aboalata et al.[33]	2017	*Arthroscopy Techniques*	Quadruple bundle hamstring autograft	Proximal: suspensory fixation with cortical button Distal: interference screw Anatomical Fixed in 30° flexion	Within substance of graft by crossing 3 times within bundles of graft	Proximal: looped through cortical button Distal: interference screw of graft and threaded cancellous screw with washer outside tibial tunnel Fixed in full extension	Potential for stress shielding and unknown effect on ligamentization of graft
Anderson et al.[34]	2019	*Arthroscopy Techniques*	BTB autograft or Achilles allograft with bone block	Proximal and distal: interference screws Isometric Fixed in “near full extension”	Alongside graft	Proximal: tied to distal portion of proximal bone block and passed through to planed aspect of graft with a free needle Distal: passed through cannulation of interference screw, tied onto button over screw Fixed position described as “avoiding full extension”	Potential for stress shielding Potential for overtensioning and limiting extension range
Benson et al[40]	2021	*Arthroscopy Techniques*	BTB autograft Fixed	Proximal and distal: interference screws Fixed in full extension	Alongside graft	Proximal: looped through cortical button Distal: fixated distal to tibial tunnel with SwiveLock anchor secured into tibia Fixed in full extension before graft	nil
Daggett et al.[35]	2018	*Arthroscopy Techniques*	Triple bundle semitendinosus autograft, formed with preservation of insertion attachment of semitendinosus	Proximal: suspensory fixation with cortical button Distal: Interference screw Fixed in 30° flexion	Alongside graft	Proximal: looped through cortical button Distal: passed through cannula of interference screw, fixated distal to tibial tunnel with SwiveLock anchor secured into tibia Fixed in full extension	Potential for stress shielding Potential for overtensioning and limiting extension range

(continued)

Appendix Table 5. Continued

Author	Year	Journal	Graft Type	Graft Fixation	Tape Details	Suture Tape Fixation	Questions Raised
Lavender et al.[36]	2018	*Arthroscopy Techniques*	Standard BTB autograft reconstruction with autogenous bone marrow aspirate	Proximal: suspensory fixation with cortical button Distal: Interference screw Fixed in 30° flexion	Alongside graft	Proximal: looped through cortical button Distal: passed through cannula of interference screw, fixated distal to tibial tunnel with SwiveLock anchor secured into tibia Fixed in 0° flexion	Increased risks and difficulty of technique due to bone marrow harvest, but benefits suggested to outweigh risks.
McGee et al.[37]	2019	*Arthroscopy Techniques*	BTB autograft or allograft	Proximal: suspensory fixation with cortical button Distal: interference screw Fixation position described as "posterior drawer tension"	Passed within tendon substance of along both sides, entering and exiting at bone/tendon junction	Proximal: looped through hole drilled within proximal bone segment Distal: SwiveLock anchor Fixation position not described	Potential for stress shielding Potential for overtensioning and limiting extension range Unknown joint or graft reaction to presence of suture tape
Saper et al.[38]	2018	*Arthroscopy Techniques*	All-inside quadriceps autograft	Suspensory fixation proximal and distal with cortical buttons Fixed in full extension with posterior drawer	Alongside graft	Proximal: looped through cortical button Distal: passed through cortical button, fixated with biocomposite SwiveLock distal to tibial tunnel with hemostat under tape at fixation to limit stress shielding Fixed in full hyperextension	Potential for stress shielding Potential for overtensioning and limiting extension range Limited clinical outcome data and long-term outcomes unknown
Smith et al.[39]	2016	*Arthroscopy Techniques*	All-inside reconstruction with quadrupled anterior tibialis allograft	Suspensory fixation proximal and distal with cortical buttons Fixed in full hyperextension	Within graft, tensioned after graft fixation	Proximal: Looped through femoral loop Distal: Composite SwiveLock anchor, fixed when hemostat under tape in full hyperextension	Potential for stress shielding Potential for overtensioning and limiting extension range
Waly et al[41]	2021	*Arthroscopy Techniques*	All-inside reconstruction with quadrupled semitendinosus autograft	Suspensory fixation proximal and distal with cortical buttons Fixed in 15-20° flexion with "reverse Lachman maneuver" applied	Crosses over once within substance of graft	Proximal: Looped through cortical button Distal: tied over cortical button Fixed in full extension after graft fixated	Potential for stress shielding Potential for overtensioning Potential for postoperative effusion or allergic reaction

BTB, bone–tendon–bone.

Appendix Table 6. Clinical Studies

Author	Year	Journal	Quality (SIGN)	Study Type	Intervention	Suture Tape Fixation	Subjects	Control Group	Follow-Up	Outcome Measures
Bodendorfer et al.[42]	2019	*Arthroscopy*	9/16	Retrospective comparative cohort study	1: ACL reconstruction using hamstring autograft or allograft with suture tape augmentation 2: Standard ACL reconstruction using hamstring autograft or allograft	Proximal: through adjustable loop device Distal: independent fixation with SwiveLock anchor	N = 60 (30 with suture tape and 30 matched controls)	Matched for age, sex, BMI, graft type and revision status	Minimum 2 y (29.54 ± 5.37 mo)	Clinical: ROM, pain, postoperative activity, time to return to sport, complications PROMs: KOOS, WOMAC, IKDC
Results				ROM (mean ± SD) 1. 128.50 ± 7.45 2. 127.33 ± 4.87 *P* = .457	Pain - NPRS (mean ± SD) Maximum daily 1. 1.57 ± 1.83 2. 3.35 ± 2.28 ***P* = .004** Average 1. 0.6 ± 1.25 2. 1.66 ± 1.90 ***P* = .021**	Time to return to preinjury activity (months ± SD) 1. 9.17 ± 2.06 2. 12.88 ± 3.94 ***P* = .002**	WOMAC (%, Mean ± SD at 12 mo) 1. 2.19 ± 4.62 2. 6.22 ± 7.72 ***P* = .024**	KOOS (postoperative) 1. 92.19 ± 8.89 2. 87.13 ± 10.54 *P* = .068	IKDC (postoperative, mean ± SD) 1. 87.55 ± 14.05 2. 73.24 ± 20.09 ***P* = .006**	Complications 1. 2 × cyclops, 2 x graft failure 2. 1 × cyclops, 2 x graft failure *P* > .05
Parkes et al.[43]	2020	*Arthroscopy*	9/16	Retrospective comparative cohort study	1: ACL reconstruction using hamstring autograft with suture tape augmentation 2: Standard ACL reconstruction using hamstring autograft	Proximal: through adjustable loop device Distal: Independent fixation with SwiveLock anchor	n = 108 (36 with suture tape and 72 matched without suture tape)	Matched for age, sex, BMI, preinjury Tegner (within 1 point), initial visit VAS at rest and with use, medial and lateral meniscus injury.	Minimum 2 y 1: 26.1 ± 2.5 mo 2: 31.3 ± 12.9 mo	Clinical: ROM, presence of effusion, Lachman examination, pivot shift, time to return to sport, complications PROMs: Tegner activity score, Lysholm scores, IKDC
Results				Arc ROM deg at final follow-up (mean ± SD) 1: 136 ± 6.1 2: 137 ± 7.0 *P* = .436		Time to return to preinjury activity, months (95% CI) 1: 11.9 (10.3-13.4) 2: 11.6 (10.5-12.7) *P* = .587	Postoperative Tegner activity score, mean (95% CI) 1:7.1 (6.5-7.6) 2: 6.4 (6.2-6.6) ***P* = .026**	Lysholm knee score, mean (95% CI) 1: 95.6 (93.5-97.7) 2: 94 (92.1-95.7) *P* = .165	IKDC, Postoperative, mean (95% CI) 1: 94.4 (91.7-97.1) 2: 93.8 (91.8-95.7) *P* = .436	Complications Arthrofibrosis 1: ×2 (6%) 2: ×3 (4%) *P* = .750 Infection 1: 0 (0%) 2: 1 (1%) *P* = .366
Shantanu et al.[23]	2019	*International Journal of Orthopaedics*	6/9	Prospective cohort study	1: ACL reconstruction with hamstring autograft 2: ACL reconstruction with hamstring autograft augmented by suture tape	Not described	n = 50 (25 per group, random allocation)		6 mo	Subjective Lachmanns (Grade 1 <5 mm of anterior tibial translation, Grade 2 5-10 mm, Grade 3 >10 mm), presence of knee extension lag, postoperative Lysholm knee score
Results					Lachmanns (6 mo) 1. Grade 1: 21, Grade 2: 4 2. Grade 1: 23, Grade 2: 2 *P* = .384	Change in Lachmanns (preoperative vs 6 mo) 1. 32% +2 grades, 60% + 1 grade, 8% no change 2. 68% +2 grades, 28% +1 grade, 4% no change. ***P* = .039**	Knee Ext lag (yes or no) 1. 25 - no lag 2. 25 - no lag	Lysholm Knee Score (6 mo) 1. 87.02 ± 4.77 2. 86.96 ± 4.98 *P* = .756		

ACL, anterior cruciate ligament; BMI, body mass index; CI, confidence interval; IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome Score; NPRS, Numeric Pain Rating Scale; PROMs, patient-reported outcome measures; ROM, range of motion; SD, standard deviation; SIGN, Scottish Intercollegiate Guidelines Network; VAS, visual analog scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

P values in bold are statistically significant.