Journal of
Experimental Orthopaedics

REVIEW PAPER Open Access

A comprehensive scoping review of tibial cysts after anterior cruciate ligament reconstruction

Nuno Camelo Barbosa[1*], João Pedro Campos[1], Vânia Capelão[2], Vikram Kandhari[3], Thais Dutra Vieira[4] and Bertrand Sonnery-Cottet[4]

Abstract

Purpose: The purpose of this study was to perform a scoping review of published literature reporting on surgical management of tibial cysts which developed after ACLR.

Methods: A scoping review was conducted following the Arksey and O'Malley framework for scoping studies and Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) extension for scoping reviews (PRISMA-ScR) guidelines. A search strategy using the terms ["Tibial Cyst" AND "ACL"], ["Pretibial Cyst" AND "ACL"] was applied to the PUBMED database.

Results: Thirty-seven studies published between 1990 and 2019 were a part of this scoping review. Non-absorbable implants for tibial graft fixation were used in 10 studies (comprising a total 21 patients), while bio-absorbable implants were used in 27 studies (comprising a total 115 patients). Incidence of tibial cyst was reported in 3 studies (434 primary ACLRs) from whom 3.9% ($n = 17$) developed tibial cyst. Tibial cyst development in relation to use of bio-absorbable screws for tibial ACL graft fixation was reported in 16 studies (42.1%). Use of bio-absorbable screws with another factor was found to be related to tibial cyst development in another 1 study (2.6%). Most common symptoms were presence of mass or swelling, pain, tenderness, drainage, instability and effusion.

Conclusion: This scoping review demonstrated that tibial cysts is more frequently related to bioabsorbable screws, however it can also occur due to other causes. Current literature on tibial cyst after ACLR is of low-quality evidence. Future research is required to better understand aetiology, risk factors for cyst formation and the best possible mode of management.

Level of evidence: IV

Keywords: ACL, Tibial cyst, Pretibial cyst, Interference screw

Background

Anterior Cruciate Ligament Reconstruction (ACLR) has been associated with significantly improved patient reported outcomes with respect to quality of life, knee symptoms and sports function when compared to non-operative treatment for patients with anterior cruciate ligament (ACL) tears [5]. Development of tibial cyst following ACLR is a rare but known complication of ACLR. To our knowledge Sgaglione was the first to report a tibial cyst related to ACLR [57].

Tibial graft fixation in ACLR was initially attained with staples, screws, washer posts and sutures tied directly to bone. Significant improvements have been witnessed in the make and design of implants for tibial graft fixation. Bio-absorbable screws have been developed and their use

*Correspondence: ncamelobarbosa@gmail.com
[1] Hospital Pedro Hispano, Hospital Pedro Hispano Rua Dr. Eduardo Torres, Matosinhos, Portugal
Full list of author information is available at the end of the article

has facilitated surgeons to overcome some complications related to non-absorbable implants [50]. Bio-absorbable materials are a popular method of tibial fixation due to advantages like the absence of artefacts on postoperative magnetic resonance imaging (MRI), simpler revision surgery and less graft damage compared to metallic implants [2, 16, 30, 44]. Unfortunately, bio-absorbable screws aren't exempt of complications, and several authors have related them to tibial cyst development after ACLR and ghost screws formation [16, 25, 53].

Furthermore, available literature about surgical treatment of tibial cysts following.

ACLR is scarce. For these reasons, a scoping review, was conducted in order to map the extent, range and quality of literature associated with development of tibial cysts after ACLR, giving an overview that further helps clinicians. A scoping review methodology was selected because this approach is considered to be superior when addressing an exploratory research question [27, 47].

Review

Study selection

A scoping review of the literature was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) extension for scoping reviews (PRISMA-ScR) guidelines [63] and the methodological framework of Arksey and O´Malley [6]. The study protocol was registered with the open science framework study registry prior to commencing data collection – OSF [73] database (reference blinded for review). The five-stage methodological framework in a scoping review of Arksey and O'Malley [6] were followed: as (1) the identification of a research question; (2) identifying the relevant studies; (3) the selection of studies to be included in the review; (4) data extraction from the included studies; and (5) collating, summarizing, and reporting the results of the review.

1. **Identification of research questions**
   The research question was "What is known from the existing literature regarding development and management of tibial cyst after ACLR?".

2. **Identifying Relevant Studies**
   Studies were identified by applying the search strategy to the PubMed database. The following keywords were included ["Tibial Cyst" AND "Anterior Cruciate Ligament"], ["Pretibial Cyst" AND Anterior Cruciate Ligament"] with automatic mapping to Medical Subject Headings terms. The search was conducted on May 16, 2020 (search date last executed), by 2 independent investigators (XX. and YY) (Table 1). Limits were applied to retrieve English-language, Spanish-Language and Portuguese-Language articles published. Both investigators reviewed the titles and abstracts of all identified records and potentially eligible studies were retrieved for full-text review. Reference lists of these articles were also reviewed, and any further potentially eligible studies were identified.

Table 1 Literature search sequence on Pubmed—Tibial cysts after ACLR (last performed on March 27, 2020)

1	Tibial Cyst ACL	94 items
2	Tibial Cyst	1218 items
3	Pretibial cyst ACL	24 items
4	Pretibial Cyst	32 items

3. **Study selection**
   All identified studies reporting clinical outcomes of tibial cyst surgery after ACLR were included. The following article types were excluded: non-clinical studies such as cadaveric and animal studies. The senior author resolved any disagreements between investigators regarding whether a study met the eligibility criteria.
4. **Data Extraction**

The included studies were analysed in details and data from each was recorded in Excel 2013 (Microsoft Corp., Redmond, WA) and then subjected to a stepwise analysis. The recorded data from each study included patients' demographic and clinical information, imaging findings and peri-operative findings. With demographics, patients' clinical information consisted of the symptoms at presentation, their duration and their effect on activities of daily living. The imaging findings recorded from the pre-operative MRI were presence of tibial tunnel enlargement and presence of tibial communication with the knee joint. Recorded peri-operative findings included details of surgical technique for managing tibial cyst, status of bio-absorbable screws, and intra operative testing of joint communication with tibial cyst. Findings of tissue sample screening by a microbiologist, and histopathologist were recorded. Complications including failure (defined as recurrence of tibial cyst after surgical excision) were recorded and evaluated.

Collating, summarizing and reporting the results

Due to a small number of published studies and heterogeneity between them, no statistical analyses were performed. Instead, the findings were summarized through a narrative analysis of the included published literature. The risk of bias in included case series was assessed using the Methodological Index for Non-Randomized Studies (MINORS) [60]. Overall quality of evidence for

each of the potential risk factors studied was assessed using the GRADE (Grading of Recommendations Assessment, Development and Evaluation) working group criteria [28].

Results

Application of the search strategy identified 1368 records from the searched databases. With title and abstract screening, 98 potentially relevant studies were isolated. 65 studies were removed as they were duplicates, 9 additional records identified from another source (33 studies references review) and 5 papers were excluded on full text examination. Thirty-seven studies were eligible for inclusion in the systematic review. The flow-chart of studies is represented in Fig. 1. The publication dates of the included studies ranged from 1999 to 2019. Using the adjusted Oxford Center For Evidence-Based Medicine criteria [74, 75] for the level of evidence we found that 1 study was Level I [11], 1 Level II [25], 1 Level III [57] and 34 studies were level IV [1, 3, 10, 12–17, 19–21, 23, 29, 33, 36, 42, 43, 46, 49, 51, 53, 54, 56, 58, 59, 62, 64–66, 69, 71, 72] case series or case reports.

Basic characteristics of included studies

From all the included studies, 136 patients were evaluated with mean age of 31.0 (14 – 57) years. Main symptoms

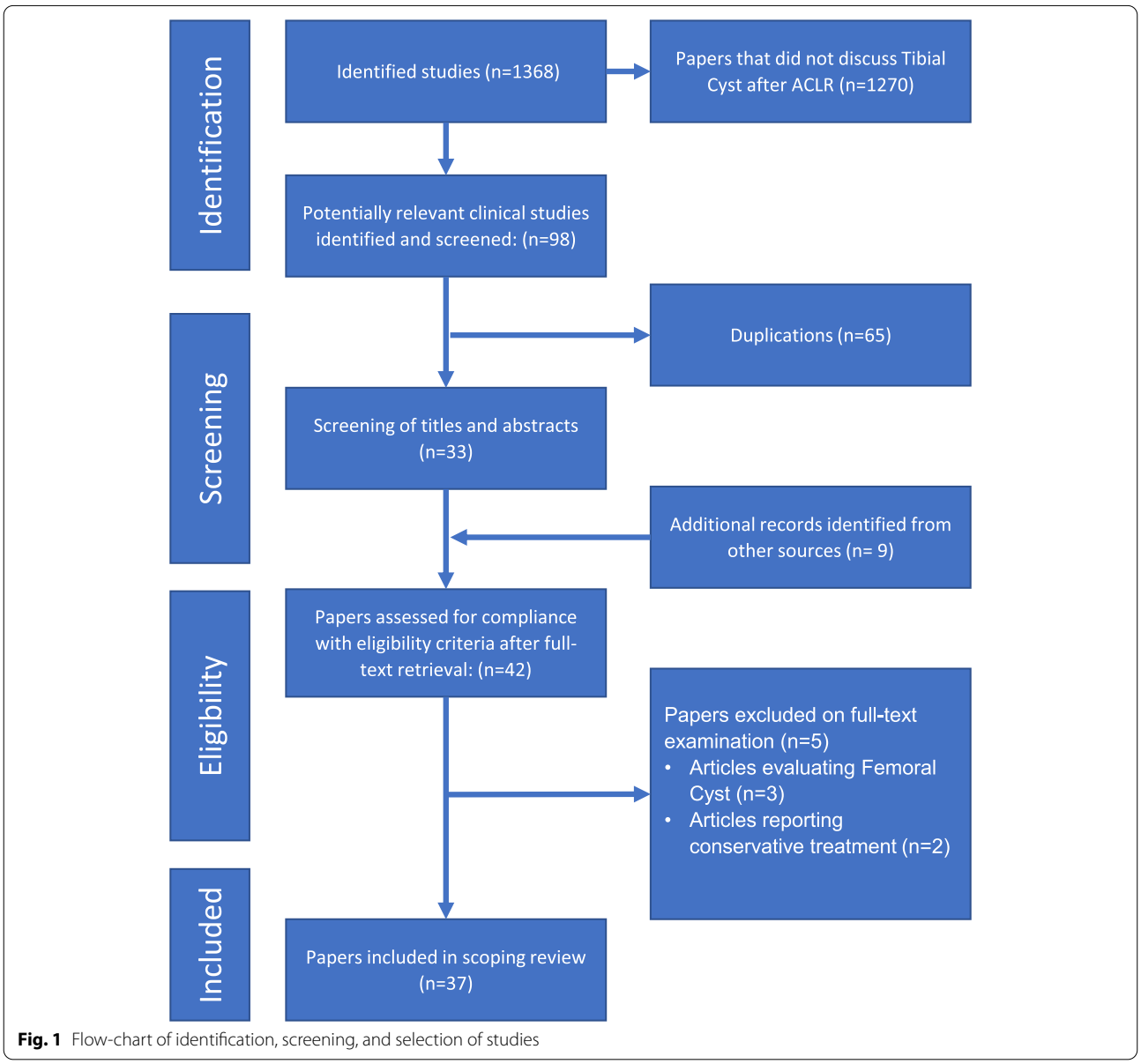

Fig. 1 Flow-chart of identification, screening, and selection of studies

following tibial cyst development after ACLR were mass or swelling in the area of tibial tunnel, pain, instability, and fluid discharge from the earlier surgical incision. Mean time to surgery was 40.2 (0.2 – 240) months. Incidence was calculated in 3 studies comprising a total 434 patients from whom 3.9% ($n=17$) developed tibial cyst. Follow-up after the surgery for tibial cysts was reported in 28 studies comprising a total 122 patients. The mean duration of reported follow-up was 37.7 (2 – 70) months. All the data of interest from the included studies have been illustrated in Table 2.

Non-absorbable implants for tibial graft fixation were used in 10 studies (comprising a total 21 patients), while bio-absorbable implants were used in 27 studies (comprising a total 115 patients). Composition of bio-absorbable screws and frequency of development of tibial ACL cysts with their use are described in Table 3.

The methodological quality of included case series evaluated by the MINORS tool varied between 5 and 8 indicating a high risk of bias (Additional file 1).

The overall strength of the evidence available in the scoping review using GRADE recommendations (Table 4) was very low.

Tibial cyst development

Tibial cyst development in relation to use of bio-absorbable screws for tibial ACL graft fixation was reported in 16 studies (42.1%). Use of bio-absorbable screws and reaction to suture material was found to be related to tibial cyst development in one study (2.6%) [64]. Development of tibial cyst was also related to communication between the tibial tunnel and knee joint in 8 studies (21.1%), other causes were appointed in 9 articles (21.1%): increased synovial fluid production [13], tendon necrosis [19], suture fragments reaction [56], allograft tendon [10], graft micro-motion [36], infection [46, 49, 69] and multifactorial aetiology [72]. Also, 3 studies did not provide any information on the reason for development of tibial cysts.

Imaging findings

Tibial tunnel enlargement was assessed in 25 studies comprising of 53 patients. Thirty-eight (71.7%) of them were found to have ACL tibial tunnel enlargement in either pre-operative x-ray or MRI scan done before the surgery for tibial cyst.

Communication of the ACL tibial tunnel with the knee joint was evaluated in preoperative MRI scans in 23 studies (comprising a total 91 patients).

Communication could be identified in 14 patients and was not present in 85.4% ($n=80$) patients.

Surgical findings

Surgical procedure technique was reported in 37 articles (comprising a total 136 patients) in 55.9% ($n=76$) of them, cyst excision was associated with curettage and bone (allo or auto) grafting. Also, in 12,5% ($n=17$) isolated cyst excision was performed and in 31.6% ($n=43$) curettage and excision were performed.

Screw absorption status at time of surgery was reported in 24 articles comprising a total 97 patients, 21.6% ($n=21$) of them reported an intact screw implant, 60.8% ($n=59$) presented a partially resorbed screw and in 17.9% ($n=17$) screw was completely resorbed at the time of tibial cyst surgery.

In 90% of patients autograft was used ($n=122$, 106 hamstring, 14 patellar tendon, 2 iliotibial band). The remaining used allograft (n = 14, 6 Achilles tendon, 4 tibialis anterior tendon, 4 NR).

Tissue processing

Samples from the cyst were sent for processing either to the microbiologist and/or to the histopathologist. Presence of infection was reported in 3 patients from 16 studies (comprising a total 102 patients) in which the tissue sample was sent to the microbiologist for evaluation. Organism isolated in these 3 patients was different in each. *Staphylococcus epidermidis*, *Propionibacterium acnes and Mycobacterium fortuitum* were the organisms isolated in the three patients.

Tissue sample was sent for analyses to a histopathologist in 29 studies, comprising a total 112 patients. Foreign body reaction was found to be present in 10 patients (9%).

Complications

The only reported complications of Tibial cyst excision after ACLR were recurrences of tibial cyst after surgical management reported in 4 patients in 4 different studies.

Discussion

The most important finding of this study is that tibial cyst in ACLR, is more frequently related to bio-absorbable implants, however it also has been related to other causes.

Clinical presentation and aetiology

Our scope identified tibial cysts occurring with several types of fixation methods, screw composition and auxiliar fixation methods as described in Table 3. Typically, tibial cyst after ACLR presents with mass or tenderness over the distal tibial aperture within 40.2 months after

Table 2 Demographic, radiological and surgical data from included studies

Authors	*Date*	*Patients*	*Age*	*ACL surgery*	*Fixation method*	*Bioabsorbable interference screw*
Sgaglione NA	1990	1 (NA)	NA	repair + —semitendinous augmentation	NR	
Brettler D	1995	1 (M)	41	autograft bptb	metal interference screw	
Victoroff BN	1995	4 (3 M)	31 (17–47)	allograft achilles	staples / screw washer	
Simonian PT	1998	3 (M)	29,3 (25–35)	2 autograft hamstring 1 autograft iliotibial band	2 staple; 1 in situ	
Martinek V	1999	1 (M)	32	autograft bptb	PDLLA interference screw	Sysorb, Sulzer Orthopedics
Deie M	2000	2 (F)	26,3 (20, 33)	autograft hamstring	2 staples	
Brager MA	2002	3 (2 M)	39,7 (36–47)	autograft hamstring	1 screw washer 2 in situ	
Malhan K	2002	1 (F)	22	autograft hamstring	PLLA + β-TCP interference screw	BioLok, Atlantech
Ilahi OA	2003	1 (F)	26	autograft bptb	metal interference screw	
Sekiya JK	2004	1 (F)	16	autograft hamstring	over a post Ethibond	
Tsuda E	2006	1 (M)	18	autograft hamstring	PLLA interference screw + over a post Ethibond	Fixsorb, Depuy Mitek
Busfield BT	2007	2 (F)	34 (28, 39)	1 allograft achilles 1 autograft hamstring	1 PLLA interference screw + screw washer; 1 PLLA interference screw + over a post	1 PLLA Delta, Arthrex 1 Bioscrew, Arthrex
Thaunat M	2007	1 (F)	47	autograft hamstring	PLLA interference screw	Phusiline, Phusis
Dujardin J	2008	1 (M)	32	autograft hamstring	PDLG + CA interference screw	Calaxo, Smith and Nephew
Gaweda K	2009	2 (NA)	NA	autograft hamstring	PLLA interference screw	NR, Arthrex
Umar M	2009	1 (M)	28	autograft hamstring	PLLA + β-TCP interference screw	BiLok, Arthocare
Sadat-Ali M	2010	1 (M)	23	autograft hamstring	PLLA interference screw	NR, Bionix Implants
Oh HL	2010	1 (F)	15	autograft hamstring	PLLA + β-TCP interference screw	Bio-INTRAFIX, Depuy Mitek
Gonzalez-Lomas G	2011	7 (NA)	39,3 (22–57)	4 autograft hamstring 3 allograft	PLLA interference screw	PLLA Delta, Arthrex
Quatman CE	2011	1 (F)	28	allograft tibialis anterior	PLLA + HA interference screw + staple	BioRCI, Smith and Nephew
Apostolopoulos A	2012	1 (M)	26	autograft hamstring	PLLA interference screw	NR
Bernard JA	2013	3 (2 M)	28 (25–32)	2 autograft hamstring 1 allograft tibialis anterior	2 PDLLA + β-TCP interference screw + PLLA SwiveLock 1 PLLA interference screw	2 BioComposite, Arthrex 1 Bio-Interference, Arthrex
Bourke HE	2013	1 (NA)	NA	autograft hamstring	PDLG + CA interference screw	Calaxo, Smith and Nephew
Shen MX	2013	1 (M)	21	autograft hamstring	PLLA interference screw	Bio-Interference, Arthrex
Bulisani LEP	2014	1 (M)	40	autograft hamstring	PLLA + HA interference screw	NR
Díaz Heredia J	2014	3 (1 M)	25 (23–27)	autograft hamstring	PLLA + HA interference screw	Biosure, Smith and Nephew
Ramsingh V	2014	14 (9 M)	27,1 (14–39)	12 autograft hamstring 1 autograft bptb 1 allograft achilles	PLLA + β-TCP interference screw	BiLok, Arthocare
Zabala IL	2014	1 (M)	29	autograft hamstring	PLLA interference screw	NR
Haragus H	2015	1 (M)	20	autograft hamstring	PLLA interference screw	NR
Joshi YV	2015	1 (M)	27	autograft bptb	metal interference screw	
Metcalf K	2015	2 (1 M)	39,5 (25–54)	allograft tibialis anterior	PDLLA + β-TCP interference screw	Bio-INTRAFIX, Depuy Mitek
Alonso B	2016	1 (M)	17	autograft bptb	PDLLA + β-TCP interference screw	Megafix C, Karl Storz

Table 2 (continued)

Zicaro JP	2017	13 (9 M)	35,6 (NA)	autograft hamstring	6 bioabsorbable interference screw 3 bioabsorbable interference screw + staple 4 in situ + Ethibond	NR
Weiss KS	2017	1 (F)	20	autograft hamstring	PDLLA + β-TCP interference screw	ComposiTCP; Biomet
Christodoulidis A	2018	2 (1 M)	50,5 (49, 52)	autograft hamstring	PLLA interference screw + PLLA cross pin	Bio-Interference, Arthrex
Chevallier R	2019	53 (20 M)	30,8 (NA)	44 autograft hamstring 8 autograft bptb 1 autograft iliotibial band	28 PLLA + HA 10 PLLA + β-TCP 7 PLLA 5 bioabsorbable interference screw 2 PDLG + CA 1 PLGA	21 BioRCI, Smith and Nephew 7 Biosure, Smith and Nephew 6 Bio-INTRAFIX, Depuy Mitek 3 Milagro, Depuy Synthes 1 TLS, FH orthopedics 7 GTS, Smith and Nephew 5 NR 2 Calaxo, Smith and Nephew 1 CentraLoc, Biomet
Dockry A	2019	1 (M)	33	allograft NR	bioabsorbable interference screw	NR
Authors	**Time to diagnosis/surgery**		**Presentation**	**Tunnel enlargment**	**MRI joint communication**	**Surgery joint communication**
Sgaglione NA	44		NR	NR	NR	no
Brettler D	22		mass tenderness	yes	NR	yes
Victoroff BN	15,8 (7–29)		2 mass 2 mass tenderness	NR	NR	3 yes 1 NR
Simonian PT	46,3 (25–72)		mass tenderness	no	1 yes 2 NR	yes
Martinek V	8		mass tenderness	yes	no	NR
Deie M	16 (15–17)		Mass	yes	NR	no
Brager MA	46,3 (21–76)		mass tenderness	1 yes 2 NR	1 yes 2 NR	1 yes 1 no 1 NR
Malhan K	12		mass tenderness	yes	no	NR
Ilahi OA	12		mass tenderness	NR	NR	yes
Sekiya JK	60		mass tenderness	yes	no	no
Tsuda E	24		mass tenderness	yes	yes	yes
Busfield BT	27 (18–36)		mass tenderness	NR	NR	no
Thaunat M	60		mass tenderness	yes	no	NR
Dujardin J	8		effusion	yes	no	no
Gaweda K	18 (16–20)		1 drainage 1 mass tenderness	NR	NR	NR
Umar M	30		mass tenderness	NR	NR	no
Sadat-Ali M	36		mass tenderness	no	NR	no

Table 2 (continued)

Oh HL	4	drainage	NR	no		no
Gonzalez-Lomas G	29,1 (24–36)	4 mass 2 mass tenderness 1 drainage	yes	4 yes 3 no		NR
Quatman CE	78	mass tenderness	yes	yes		no
Apostolopoulos A	48	Mass	yes	NR		no
Bernard JA	20,7 (16–24)	1 mass 2 mass tenderness	NR	NR		NR
Bourke HE	9	Mass	NR	no		NR
Shen MX	24	mass tenderness	no	no		no
Bulisani LEP	36	Mass	no	yes		yes
Díaz Heredia J	0,3 (0,2–0,5)	drainage	no	yes		2 yes 1 no
Ramsingh V	27,8 (11,5–38,5)	12 mass tenderness 2 mass tenderness effusion	NR	NR		2 yes 12 no
Zabala IL	24	mass tenderness	yes	no		no
Haragus H	42	mass tenderness	yes	no		no
Joshi YV	240	instability	no	no		no
Metcalf K	22 (8–36)	mass tenderness	no	1 no 1 NR		no
Alonso B	24	mass tenderness	NR	NR		no
Zicaro JP	29 (NA)	Mass	yes	no		NR
Weiss KS	15	Mass	no	no		no
Christodoulidis A	84 (84–84)	1 mass; 1 mass tenderness	no	no		no
Chevallier R	55,2 (3,1–228)	22 mass tenderness 31 tenderness	4 yes 49 NR	2 yes 51 no		4 yes 49 no
Dockry A	16	mass tenderness	NR	NR		NR
Authors	**Surgery**	**Screw degradation**	**Microbiology**	**Histology**	**Follow-up (M)**	**Recorrence**
Sgaglione NA	excision	NR	NR	NR	NR	NR
Brettler D	excision	NR	NR	NR	18	no
Victoroff BN	1 excision + curetage 3 excision + curetage + bone graft	NR	NR	1 no 3 yes	24,8 (22–29)	1
Simonian PT	1 excision + curetage; 2 excision + curetage + bone graft	NR	NR	1 no 2 yes	39,3 (24–70)	no
Martinek V	excision	breakdown	NR	yes	2	no
Deie M	excision	NR	NR	yes	10,5 (9–12)	no
Brager MA	2 excision + curetage 1 excision + curetage + bone graft	NR	NR	yes	30 (6–54)	no
Malhan K	excision + curetage	breakdown	negative	yes	3	no

Table 2 (continued)

Ilahi OA	excision + curetage + bone graft	intact	NR	yes	2	no
Sekiya JK	excision + curetage	NR	NR	no	NR	1
Tsuda E	excision + curetage + bone graft	breakdown	negative	yes	12	no
Busfield BT	excision + curetage	breakdown	negative	yes	6	no
Thaunat M	excision + curetage + bone graft	absorption	NR	yes	2	no
Dujardin J	excision + curetage + bone graft	breakdown	negative	yes	3	no
Gaweda K	excision + curetage	intact	NR	yes	NR	no
Umar M	excision + curetage	breakdown	NR	yes	NR	no
Sadat-Ali M	excision + curetage	breakdown	NR	yes	9	no
Oh HL	excision + curetage	intact	M. fortuitum	no	NR	no
Gonzalez-Lomas G	excision	NR	negative	yes	5,3 (5–6)	no
Quatman CE	excision + curetage + bone graft	NR	NR	no	NR	no
Apostolopoulos A	excision + curetage + bone graft	absorption	NR	yes	12	no
Bernard JA	2 excision 1 excision + curetage	breakdown	negative	no	4 (2–6)	no
Bourke HE	excision	NR	NR	no	NR	1
Shen MX	excision	absorption	negative	yes	NR	no
Bulisani LEP	excision + curetage + bone graft	absorption	NR	yes	6	no
Díaz Heredia J	excision + curetage	intact	negative	yes	24	no
Ramsingh V	excision + curetage	13 breakdown 11 absorption	negative	yes	12	no
Zabala IL	excision + curetage	breakdown	NR	yes	3	no
Haragus H	excision	intact	NR	yes	3	no
Joshi YV	excision + curetage + bone graft	NR	NR	yes	6	no
Metcalf K	excision + curetage	1 intact 1 breakdown	P. Acnes none	yes	12	no
Alonso B	excision + curetage	breakdown	negative	yes	2	no
Zicaro JP	6 excision + curetage 7 excision + curetage + bone graft	NR	negative	yes	35 (NR)	1
Weiss KS	excision + curetage + bone graft	absorption	S. epidermidis	yes	4	no
Christodoulidis A	excision + curetage	absorption	NR	yes	6, NR	no
Chevallier R	excision + curetage + bone graft	12 intact 32 breakdown 9 absorption	negative	12 no 41 yes	64,8 (7–146)	1
Dockry A	excision + curetage + bone graft	NR	negative	no	NR	no

Table 3 Method of fixation, interference screw composition and auxiliar fixation frequency

Fixation method	*Frequency*
NR	1 (0,7%)
None	3 (2,2%)
Screw washer	1 (0,7%)
Screw washer + metal interference screw	1 (0,7%)
Screw washer + staple (removed before cyst development)	1 (0,7%)
Screw washer + 2 staples (removed before cyst development)	1 (0,7%)
Screw washer + poly-L-lactide (PLLA) interference screw	1 (0,7%)
Staple	2 (1,5%)
Staples 2	3 (2,2%)
Staples 2 (removed before cyst development)	1 (0,7%)
Staple + not reported bioabsorbable interference screw	3 (2,2%)
Staple + poly-L-lactide (PLLA) + hydroxyapatite (HA) interference screw	1 (0,7%)
Ethibond	4 (2,9%)
Over a post Ethibond	1 (0,7%)
Over a post Ethibond + poly-L-lactide (PLLA) interference screw	1 (0,7%)
Over a post + poly-L-lactide (PLLA) interference screw	1 (0,7%)
Bioabsorbable cross pin in PLLA + poly-L-lactide (PLLA) interference screw	2 (1,5%)
PLLA SwiveLock + poly-D,L-lactide (PDLLA) + β-tricalcium phosphate (β-TCP) Interference screw	2 (1,5%)
Metal interference screw	2 (1,5%)
Not reported bioabsorbable interference screw	12 (8,8%)
Poly(lactic-co-glycolic) acid (PLGA) interference screw	1 (0,7%)
Poly-L-lactide (PLLA) + hydroxyapatite (HA) interference screw	32 (23,5%)
Poly-L-lactide (PLLA) + β-tricalcium phosphate (β-TCP) interference screw	27 (19,9%)
Poly-L-lactide (PLLA) interference screw	23 (16,9%)
Poly-D,L-lactide (PDLLA) + β-tricalcium phosphate (β-TCP) interference screw	4 (2,9%)
Poly-D,L-lactide (PDLLA) interference screw	1 (0,7%)
Poly(lactic-co-glycolic) acid (PLGA) interference screw	1 (0,7%)
Poly(D,L-lactideecoglycolide) (PDLG) + calcium carbonate interference screw	4 (2,9%)
Interference screw composition	Frequency
NR	1 (0,7%)
None	17 (12,5%)
Metal	3 (2,2%)
Not reported bioabsorbable	15 (11%)
Poly-L-lactide (PLLA)	28 (20,6%)
Poly-L-lactide (PLLA) + hydroxyapatite (HA)	33 (24,3%)
Poly-L-lactide (PLLA) + β-tricalcium phosphate (β-TCP)	27 (19,9%)
Poly-D,L-lactide (PDLLA)	1 (0,7%)
Poly-D,L-lactide (PDLLA) + β-tricalcium phosphate (β-TCP)	6 (4,4%)
Poly(lactic-co-glycolic) acid (PLGA)	1 (0,7%)
Poly(D,L-lactideecoglycolide) (PDLG) + calcium carbonate	4 (2,9%)
Auxiliar fixation	Frequency
NR	1 (0,7%)
None	109 (80,1%)
Removed before cyst	3 (2,2%)
Screw washer	3 (2,2%)
Staple	6 (4,4%)
Staples 2	3 (2,2%)
Ethibond	4 (2,9%)
over a post Ethibond	2 (1,5%)
over a post	1 (0,7%)
Bioabsorbable cross pin in PLLA	2 (1,5%)
PLLA SwiveLock	2 (1,5%)

Table 4 Quality of evidence of literature on Tibial cyst development after ACLR

Risk Factor	Risk of Bias	Inconsistency	Indirectness	Imprecision	Grade
Bioabsorbable screw	likely	unexplained heterogeneity	indirect	imprecision	very low
Tibial Comunication	unlikely	unexplained heterogeneity	indirect	imprecision	very low
Graft Type	unlikely	unexplained heterogeneity	indirect	imprecision	very low
Infection	unlikely	unexplained heterogeneity	indirect	imprecision	very low

the primary procedure, although immediate or late-term presentations have also been reported.

This scoping review reveals that tibial cyst development after ACLR is a rather uncommon condition. Incidence of tibial cysts was reported by Ramsingh et al. being up to 5% at 2–3 years [53]. Overall in this review, incidence could be calculated in 3 articles totalling a total 434 patients, 3.9% of them (n = 17) developed tibial cyst after ACLR.

Bioabsorbable implants were used in 27 studies and non-absorbable implants for tibial graft fixation were used in 10 studies. The biggest frequencies of tibial cysts were associated to bioabsorbable screws – 23.5% were poly(L-lactic) acid (PLLA) + hydroxyapatite (HA), 19.9% were PLLA + B-tricalcium phosphate (B-TCP) and 16.9% were PLLA interference screws (Table 3).

Tibial cyst formation has been linked to several causes, such has foreign body reaction [53], leakage of joint fluid through the tunnel [62], intraosseous graft necrosis with incomplete graft incorporation [66] and graft micro-motion [59, 64, 66], among other causes. Development of tibial ACL cysts has also been controversially linked to the tibial graft fixation methods. [26, 59, 62, 64, 66]. In our scoping review, almost half (42.1%) of the studies related tibial cyst development to the use of bio-absorbable implants.

Bio-absorbable implants

Bio-absorbable implants were developed in order to address the limitations with the use of non-absorbable implant. Some of the concerns with the use of non-absorbable implants include screw breakage, artefact in MRI, and hardware interference in ACL Revision and subsequent need for hardware removal [44]. The natural history of the bio-absorbable implant is that it will be absorbed and replaced by bone in the tibial tunnel, however this isn´t consistently seen in vivo [7, 52, 67]. Through our review we found complete absorption of the screw evident in only 17 (17.9%) patients. Others either remain partially resorbed or un-resorbed. Also, though bio-absorbable address some of the limitations encountered with the use of non-bioabsorbable screws, their use is not without complications. Complications in ACLR, [38] related to the use of bio-absorbable tibial ACL screws include foreign body reaction [26], breakdown [64], migration and tibial cyst formation.

Degradation of bioabsorbable materials occurs over five stages: hydration, depolymerization, loss of mass integrity, absorption and elimination [52]. During hydrolysis, the screw may release acid products (resultant from screw composition degradation) harmful to surrounding tissues. As so, different materials result in different degradation products, with different effects on surrounding tissues, and different timings of degradation which may lead to fluid collection on the bone tunnel and progress to tibial cysts [68, 70].

Bone tunnel fluid collections are common in ACLR, however not all fluid collections in the bone tunnel mature into tibial cysts [67]. Moreover, fluid collection can resolve [55]. Chevallier et al. present the biggest series of reported tibial cysts after ACLR in a retrospective clinical study that included 53 patients with an average 4.6 years (+ -3.1 months) after primary ACLR. The authors found that bio-absorbable interference screws absorption can be symptomatic independent of screw composition and correlated tibial cysts to bio-absorbable screw absorption [16]. Unfortunately, the authors didn´t provide individual results database.

However, some prospective imaging studies following up bio-absorbable implants fail to report on tibial cysts. Tecklenburg et al. despite a short follow-up of 24 months after ACLR, reported no inflammatory response in the tibial tunnels in a prospective imaging study of patients with bio-absorbable and allograft screws [61]. Furthermore, Barber et al. in a long-term study of bio-absorbable screws degradation, demonstrated no tibial cysts and complete degradation with no screw remnant at 3 years after BPTB (Bone patella tendon bone) graft ACLR in 14 patients [8]. Also, Jonhston et al. in a computed tomography study of 65 patients after ACLR with bioabsorbable screw showed no tunnel enlargement, osteolysis or reported tibial cysts at long term [35]. Thus, other causes may also be related to tibial cyst development.

Non-absorbable implants and other tibial cyst causes

Tibial cysts development was already described in early ALCR articles with non-absorbable methods of fixation.

Our scoping review included 10 articles in which non-absorbable implants were used for graft fixation. These authors related tibial cysts with several causes such as drainage from the joint through the tibial tunnel, which could be caused by a tunnel with difference in diameter in relation to the graft, eccentric positioning of the tendon in the bone tunnel, intraosseous tendon necrosis during graft incorporation [19], incomplete allograft incorporation [15, 33, 59, 66], graft micro-motion [36, 59, 64, 66], synovitis [13] and foreign body reaction due to non-absorbable suture [56].

Victoroff et al. and Simonian et al. described tibial cyst after ACLR with non-absorbable implants, the authors associated incomplete graft tissue incorporation in the bone tunnel to tibial cysts. Accordingly, graft necrosis led to synovialization that allowed synovial fluid to be transmitted through the tibial tunnel [59, 66]. As so, hydrostatic pressure within the knee joint would drive synovial fluid allowing accumulation and development of tibial cyst [41, 64, 66].

Furthermore, prospective imaging studies have failed to show difference in tibial cyst formation between bio-absorbable and non-absorbable fixation implants.

In a systematic review by Debieux et al. [18] on bio-absorbable versus metallic screws for graft fixation in anterior cruciate ligament reconstruction, the authors chose to include 12 randomised controlled trial published between 1995 and 2015 [4, 9, 22, 24, 31, 32, 34, 37, 39, 40, 45, 48]. Of the included studies only Arama et al. reported tibial cyst formation, and according to the authors there were no differences between bio-absorbable (4 of 17 pts PLLA-HA) and non-bioabsorbable (3 of 19 pts Titanium) groups in cyst formation or graft integration [4].

Surgical preference

In our scoping review surgical resection and bone grafting was the most preferred surgical approach in 84 patients (61.76%). Tibial cyst recurrence was reported in only 4 patients [11, 56, 66, 72].

Communicating vs non-communicating tibial cyst

Distinguishing between communicating and non-communicating cysts might be helpful in further understanding the cause of tibial cyst development as described by Zicaro [72]. Communication between joint and tibial tunnel is in theory always possible after ACLR procedure. Depending on the amount of communication, hydrostatic pressure in the tibial tunnel may lead to tibial cyst formation at early, medium or long-term [66]. Thus more than one factor may be responsible for formation of tibial ACL cysts as pointed out by Zicaro [72] and other authors.

This review identified when using bio-absorbable implants (28 articles), 19 (67.8%) articles evaluated tibial communication with the joint with MRI and communication was found in 12 (13.6%) patients. During surgical procedure 19 (67.8%) articles evaluated tibial communication with the joint communication – it was found in 10 (11.2%) patients. However, probing the tibial tunnel with an arthroscopic probe may not be enough to rule out tibial tunnel communication. Noteworthy, in our review only one article performed a fistulogram with radiographic contrast dye in order to confirm communication of tibial tunnel with the joint [66].

Histopathology

In our scope we found 10 patients with histopathology report of foreign body reaction, overall, we encountered great variability among the reports (Table 2).

Study limitations and strengths

The limitation of this of this scoping review is the inclusion of mostly level IV studies. However, it is worthy to include them as the incidence of occurrence and reporting of ACL tibial cyst is low. Thus, every piece of information will contribute to better understanding of incidence, natural history, pathology, and best possible management of tibial cysts after ACLR.

The strength of this scoping review is that the authors have managed to create an up-to-date evidence-based resource on tibial cysts after ACLR. Though the level of evidence is low, all the evidence consolidated will certainly help the authors of future studies to better understand the patient characteristics, preoperative imaging findings, surgical findings and biopsy related to the tibial cysts after ACLR. The resource will also facilitate clinicians who encounter this complication to be equipped with evidence-based knowledge related to tibial cysts after ACLR.

Conclusions

In our understanding, the major finding of this scope is that tibial cyst in ACLR, is more frequently related to bio-absorbable implants, however it also has been related to other causes. The natural history behind the development of these cysts and their best possible management is still controversial. More standardised reporting on patients who develop tibial cysts is needed to further add to the existing knowledge and understanding related to the tibial cysts after ACLR in the published literature.

Abbreviations

ALCR: Anterior Cruciate Ligament Reconstruction; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-analyses; PRISMA-ScR: PRISMA

extension for scoping reviews; ACL: Anterior cruciate ligament; MRI: Magnetic resonance imaging; MINORS: Methodological Index for Non-Randomized Studies; GRADE: Grading of Recommendations Assessment, Development and Evaluation); PLLA: Poly(L-lactic) acid; HA: Hydroxyapatite; B-TCP: B-tricalcium phosphate.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40634-021-00356-9.

Additional file 1. Quality assessment of included articles using the Methodological Index for Non-Randomized Studies (MINORS).

Acknowledgements
No acknowledgments

Authors' contributions
Each authors' contributions to the manuscript is detailed using the criteria below: Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND Drafting the work or revising it critically for important intellectual content; AND Final approval of the version to be published; AND Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Funding
No funding sources.

Declarations

Competing interests
One or more of the authors has declared the following potential conflict of interest or source of funding: BSC is a paid consultant, receives royalties and research support, and has made presentations for Arthrex. NCB is a paid consultant and has made presentations for Arthrex.

Author details
[1]Hospital Pedro Hispano, Hospital Pedro Hispano Rua Dr. Eduardo Torres, Matosinhos, Portugal. [2]Centro Hospitalar Lisboa Norte, Lisboa, Portugal. [3]Sydney Orthopaedic Research Institute, Sydney, Australia. [4]Centre Orthopédique Santy, Hopital Privé Jean Mermoz, Ramsay-Générale de Santé, Lyon, France.

Received: 16 February 2021 Accepted: 19 May 2021
Published online: 21 June 2021

References

1. Alonso B, Sobrón FB, Vidal C, Vaquero J, Alonso B, Sobrón FB, Vidal C, Vaquero J (2016) Seudoquiste pretibial tras la reconstrucción del ligamento cruzado anterior con tornillo biocomposite. Acta Ortopédica Mex 30:150–153
2. Ambrose CG, Clanton TO (2004) Bioabsorbable implants: review of clinical experience in orthopedic surgery. Ann Biomed Eng 32:171–177
3. Apostolopoulos A, Nikolopoulos D, Polyzois I, Liarokapis S, Rossas C, Michos I (2012) Pretibial cyst formation after anterior cruciate ligament reconstruction with poly-L acid screw fixation: a case report presentation and review of the literature. J Surg Orthop Adv 21:151–156
4. Arama Y, Salmon LJ, Sri-Ram K, Linklater J, Roe JP, Pinczewski LA (2015) Bioabsorbable Versus Titanium Screws in Anterior Cruciate Ligament Reconstruction Using Hamstring Autograft: A Prospective, Blinded, Randomized Controlled Trial With 5-Year Follow-up. Am J Sports Med 43:1893–1901
5. Ardern CL, Kvist J (2016) What is the evidence to support a psychological component to rehabilitation programs after anterior cruciate ligament reconstruction?: Curr Orthop Pract. 27:263–268
6. Arksey H, O'Malley L (2005) Scoping studies: towards a methodological framework. Int J Soc Res Methodol 8:19–32
7. Bach FD, Carlier RY, Elis JB, Mompoint DM, Feydy A, Judet O, Beaufils P, Vallée C (2002) Anterior cruciate ligament reconstruction with bioabsorbable polyglycolic acid interference screws: MR imaging follow-up. Radiology 225:541–550
8. Barber FA, Dockery WD, Hrnack SA (2011) Long-term degradation of a poly-lactide co-glycolide/β-tricalcium phosphate biocomposite interference screw. Arthrosc J Arthrosc Relat Surg 27:637–643
9. Benedetto KP, Fellinger M, Lim TE, Passler JM, Schoen JL, Willems WJ (2000) A new bioabsorbable interference screw: preliminary results of a prospective, multicenter, randomized clinical trial. Arthrosc J Arthrosc Relat Surg 16:41–48
10. Bernard JA, Riguad J, Tan E, Naziri Q, Zikria B (2013) Sterile pretibial cyst formation following anterior cruciate ligament reconstruction with a bioabsorbable screw. J Long Term Eff Med Implants 23:61–65
11. Bourke HE, Salmon LJ, Waller A, Winalski CS, Williams HA, Linklater JM, Vasanji A, Roe JP, Pinczewski LA (2013) Randomized controlled trial of osteoconductive fixation screws for anterior cruciate ligament reconstruction: a comparison of the Calaxo and Milagro screws. Arthrosc J Arthrosc Relat Surg 29:74–82
12. Brager MA, Traina SM, Parker AW (2002) Pretibial cyst following anterior cruciate ligament reconstruction using hamstring autografts. Orthopedics 25:79–82
13. Brettler D, Soudry M (1995) Tibial bone plug resorption with extra-articular cyst: a rare complication of anterior cruciate ligament reconstruction. Arthrosc J Arthrosc Relat Surg 11:478–481
14. Bulisani LEP, Bulisani E (2014) Pre-tibial synovial cyst after reconstruction of the anterior cruciate ligament: case report. Rev Bras Ortop Engl Ed Elsevier BV 49:671–674
15. Busfield BT, Anderson LJ (2007) Sterile Pretibial Abscess After Anterior Cruciate Reconstruction From Bioabsorbable Interference Screws: A Report of 2 Cases. Arthroscopy Elsevier 23:911.e1-911.e4
16. Chevallier R, Klouche S, Gerometta A, Bohu Y, Herman S, Lefevre N (2019) Bioabsorbable screws, whatever the composition, can result in symptomatic intra-osseous tibial tunnel cysts after ACL reconstruction. Knee Surg Sports Traumatol Arthrosc 27:76–85
17. Christodoulidis A, Barbareschi M, Molinari M (2018) A Delayed Formation of Pretibial Pseudocyst After Anterior Cruciate Reconstruction from Bioabsorbable Interference Screws: A Report of Two Cases and Short Review of the Literature. J Long Term Eff Med Implants 28:215–221
18. Debieux P, Franciozi CES, Lenza M, Tamaoki MJ, Magnussen RA, Faloppa F, Belloti JC (2016) Bioabsorbable versus metallic interference screws for graft fixation in anterior cruciate ligament reconstruction. Cochrane Database Syst Rev 7:CD009772
19. Deie M, Sumen Y, Ochi M, Murakami Y, Fujimoto E, Ikuta Y (2000) Pretibial cyst formation after anterior cruciate ligament reconstruction using auto hamstring grafts: two case reports in a prospective study of 89 cases. Magn Reson Imaging 18:973–977
20. Díaz Heredia J, Ruiz Iban MA, Cuéllar Gutiérrez R, Ruiz Diaz R, Martinez C, del Val I, Turrion Merino L (2014) Early postoperative transtibial articular fistula formation after anterior cruciate ligament reconstruction: a review of three cases. Arch Orthop Trauma Surg 134:829–834
21. Dockry A, Magnussen RA, Baria MR (2020) Tibial Tunnel Cyst After Anterior Cruciate Ligament Reconstruction. Am J Phys Med Rehabil 99:e101–e102
22. Drogset JO, Grøntvedt T, Tegnander A (2005) Endoscopic reconstruction of the anterior cruciate ligament using bone-patellar tendon-bone grafts fixed with bioabsorbable or metal interference screws: a prospective randomized study of the clinical outcome. Am J Sports Med 33:1160–1165
23. Dujardin J, Vandenneucker H, Bellemans J (2008) Tibial cyst and intra-articular granuloma formation after anterior cruciate ligament reconstruction using polylactide carbonate osteoconductive interference screws. Arthrosc J Arthrosc Relat Surg 24:238–242
24. Fink C, Benedetto KP, Hackl W, Hoser C, Freund MC, Rieger M (2000) Bioabsorbable polyglyconate interference screw fixation in anterior cruciate ligament reconstruction: a prospective computed tomography-controlled study. Arthrosc J Arthrosc Relat Surg 16:491–498

25. Gaweda K, Walawski J, Węgłowski R, Drelich M, Mazurkiewicz T (2006) Early results of one-stage knee extensor realignment and autologous osteochondral grafting. Int Orthop 30:39–42
26. Gonzalez-Lomas G, Cassilly RT, Remotti F, Levine WN (2011) Is the etiology of pretibial cyst formation after absorbable interference screw use related to a foreign body reaction? Clin Orthop 469:1082–1088
27. Grant MJ, Booth A (2009) A typology of reviews: an analysis of 14 review types and associated methodologies. Health Inf Libr J 26:91–108
28. Guyatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello P, Schünemann HJ (2008) GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ 336:924–926
29. Haragus H, Lăzureanu VE, Prejbeanu R, Mioc L, Boscu A, Radu DA, Babeş V (2015) Painful Pretibial Cyst with Bioabsorbable Poly-L-lactic Acid Screw Migration 4 Years after Anterior Cruciate Ligament Reconstruction. REVCHIM 66:1655–1658
30. Harilainen A, Sandelin J (2009) A prospective comparison of 3 hamstring ACL fixation devices–Rigidfix, BioScrew, and Intrafix–randomized into 4 groups with 2 years of follow-up. Am J Sports Med 37:699–706
31. Hegde AS, Rai DK, Kannampilly AJ (2014) A Comparison of Functional Outcomes After Metallic and Bioabsorbable Interference Screw Fixations in Arthroscopic ACL Reconstructions. J Clin Diagn Res JCDR 8:LC01–LC03
32. Hofmann GO, Wagner FD, Beickert R, Gonschorek O, Bühren V (2001) Anterior Cruciate Ligament Reconstruction Using Patellar Tendon Autograft and Bioresorbable Interference Screws. Eur J Trauma 27:241–249
33. Ilahi OA, Younas SA, Sahni IK (2003) Pretibial cyst formation after arthroscopic anterior cruciate ligament reconstruction. Arthrosc J Arthrosc Relat Surg 19:1–3
34. Järvelä T, Moisala A-S, Paakkala T, Paakkala A (2008) Tunnel enlargement after double-bundle anterior cruciate ligament reconstruction: a prospective, randomized study. Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc 24:1349–1357
35. Johnston M, Morse A, Arrington J, Pliner M, Gasser S (2011) Resorption and remodeling of hydroxyapatite-poly-L-lactic acid composite anterior cruciate ligament interference screws. Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc 27:1671–1678
36. Joshi YV, Bhaskar D, Phaltankar PM, Charalambous CP (2015) Tibial Tunnel Cyst Formation after Anterior Cruciate Ligament Reconstruction Using a Non-Bioabsorbable Interference Screw. Knee Surg Relat Res 27:269–273
37. Kaeding C, Farr J, Kavanaugh T, Pedroza A (2005) A prospective randomized comparison of bioabsorbable and titanium anterior cruciate ligament interference screws. Arthrosc J Arthrosc Relat Surg 21:147–151
38. Konan S, Haddad FS (2009) A clinical review of bioabsorbable interference screws and their adverse effects in anterior cruciate ligament reconstruction surgery. Knee 16:6–13
39. Kotani A, Ishii Y (2001) Reconstruction of the anterior cruciate ligament using poly-L-lactide interference screws or titanium screws: a comparative study. Knee 8:311–315
40. Laxdal G, Kartus J, Eriksson BI, Faxén E, Sernert N, Karlsson J (2006) Biodegradable and metallic interference screws in anterior cruciate ligament reconstruction surgery using hamstring tendon grafts: prospective randomized study of radiographic results and clinical outcome. Am J Sports Med 34:1574–1580
41. Linn RM, Fischer DA, Smith JP, Burstein DB, Quick DC (1993) Achilles tendon allograft reconstruction of the anterior cruciate ligament-deficient knee. Am J Sports Med 21:825–831
42. Malhan K, Kumar A, Rees D (2002) Tibial cyst formation after anterior cruciate ligament reconstruction using a new bioabsorbable screw. Knee 9:73–75
43. Martinek V, Friederich NF (1999) Tibial and Pretibial Cyst Formation After Anterior Cruciate Ligament Reconstruction With Bioabsorbable Interference Screw Fixation. Arthroscopy Elsevier 15:317–320
44. Mascarenhas R, Saltzman BM, Sayegh ET, Verma NN, Cole BJ, Bush-Joseph C, Bach BR (2015) Bioabsorbable versus metallic interference screws in anterior cruciate ligament reconstruction: a systematic review of overlapping meta-analyses. Arthrosc J Arthrosc Relat Surg 31:561–568
45. McGuire DA, Barber FA, Elrod BF, Paulos LE (1999) Bioabsorbable Interference Screws for Graft Fixation in Anterior Cruciate Ligament Reconstruction. Arthrosc J Arthrosc Relat Surg 15:463–473
46. Metcalf K, Ko J-WK, Quilici S, Barnes P, Crawford DC (2015) Differentiating Occult Propionibacterium acnes Infection From Aseptic "Biologic" Interference Screw Hydrolysis After Anterior Cruciate Ligament Reconstruction: Introducing a Novel Culture Protocol for Detecting Low-Virulence Organisms. Orthop J Sports Med 3:2325967115611872
47. Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur A, Aromataris E (2018) Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. BMC Med Res Methodol 18:143
48. Myers P, Logan M, Stokes A, Boyd K, Watts M (2008) Bioabsorbable versus titanium interference screws with hamstring autograft in anterior cruciate ligament reconstruction: a prospective randomized trial with 2-year follow-up. Arthrosc J Arthrosc Relat Surg 24:817–823
49. Oh HL, Chen DB, Seeto BG, Macdessi SJ (2010) Mycobacterium fortuitum infection after anterior cruciate ligament reconstruction using a polylactic acid bioabsorbable screw: Case report. Knee 17:176–178
50. Papoutsidakis A, Drosos GI, Koukou OI, Piskopakis N, Verettas D-A (2010) Peroneal nerve damage by bicortical tibial screw in ACL reconstruction. Knee Surg Sports Traumatol Arthrosc 18:794–796
51. Quatman CE, Paterno MV, Wordeman SC, Kaeding CC (2011) Longitudinal Anterior Knee Laxity Related to Substantial Tibial Tunnel Enlargement after Anterior Cruciate Ligament Revision. Arthrosc J Arthrosc Relat Surg 27:1160–1163
52. Radford MJ, Noakes J, Read J, Wood DG (2005) The natural history of a bioabsorbable interference screw used for anterior cruciate ligament reconstruction with a 4-strand hamstring technique. Arthrosc J Arthrosc Relat Surg 21:707–710
53. Ramsingh V, Prasad N, Lewis M (2014) Pre-tibial reaction to biointerference screw in anterior cruciate ligament reconstruction. Knee 21:91–94
54. Sadat-Ali M, Azzam Q, Bluwi M, Al-Umran AS (2010) Case report: Fibroxanthoma: a complication of a biodegradable screw. Clin Orthop 468:2284–2287
55. Sanders TG, Tall MA, Mulloy JP, Leis HT (2002) Fluid collections in the osseous tunnel during the first year after anterior cruciate ligament repair using an autologous hamstring graft: natural history and clinical correlation. J Comput Assist Tomogr 26:617–621
56. Sekiya JK, Elkousy HA, Fu FH (2004) Recurrent pretibial ganglion cyst formation over 5 years after anterior cruciate ligament reconstruction. Arthrosc J Arthrosc Relat Surg 20:317–321
57. Sgaglione NA, Warren RF, Wickiewicz TL, Gold DA, Panariello RA (1990) Primary repair with semitendinosus tendon augmentation of acute anterior cruciate ligament injuries. Am J Sports Med 18:64–73
58. Shen MX, Sathappan SS (2013) Painful pretibial pseudocyst at bioabsorbable interference screw aperture two years after anterior cruciate ligament reconstruction. Singapore Med J 54:e211-214
59. Simonian PT, Wickiewicz TL, O'Brien SJ, Dines JS, Schatz JA, Warren RF (1998) Pretibial cyst formation after anterior cruciate ligament surgery with soft tissue autografts. Arthrosc J Arthrosc Relat Surg 14:215–220
60. Slim K, Nini E, Forestier D, Kwiatkowski F, Panis Y, Chipponi J (2003) Methodological index for non-randomized studies (minors): development and validation of a new instrument. ANZ J Surg 73:712–716
61. Tecklenburg K, Burkart P, Hoser C, Rieger M, Fink C (2006) Prospective evaluation of patellar tendon graft fixation in anterior cruciate ligament reconstruction comparing composite bioabsorbable and allograft interference screws. Arthrosc J Arthrosc Relat Surg 22:993–999
62. Thaunat M, Chambat P (2007) Pretibial ganglion-like cyst formation after anterior cruciate ligament reconstruction: a consequence of the incomplete bony integration of the graft? Knee Surg Sports Traumatol Arthrosc 15:522–524
63. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, Moher D, Peters MDJ, Horsley T, Weeks L, Hempel S, Akl EA, Chang C, McGowan J, Stewart L, Hartling L, Aldcroft A, Wilson MG, Garritty C, Lewin S, Godfrey CM, Macdonald MT, Langlois EV, Soares-Weiser K, Moriarty J, Clifford T, Tunçalp Ö, Straus SE (2018) PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Ann Intern Med 169:467–473
64. Tsuda E, Ishibashi Y, Tazawa K, Sato H, Kusumi T, Toh S (2006) Pretibial cyst formation after anterior cruciate ligament reconstruction with a hamstring tendon autograft. Arthrosc J Arthrosc Relat Surg 22:691.e1–6
65. Umar M, Baqai N, Peck C (2009) Foreign body reaction to a bioabsorbable interference screw after anterior cruciate ligament reconstruction. BMJ Case Rep. bcr0920081007
66. Victoroff BN, Paulos L, Beck C, Goodfellow DB (1995) Subcutaneous pretibial cyst formation associated with anterior cruciate ligament allografts:

a report of four cases and literature review. Arthrosc J Arthrosc Relat Surg 11:486–494
67. Warden WH, Chooljian D, Jackson DW (2008) Ten-year magnetic resonance imaging follow-up of bioabsorbable poly-L-lactic acid interference screws after anterior cruciate ligament reconstruction. Arthrosc J Arthrosc Relat Surg 24:370.e1–3
68. Weiler A, Hoffmann RF, Stähelin AC, Helling HJ, Südkamp NP (2000) Biodegradable implants in sports medicine: the biological base. Arthrosc J Arthrosc Relat Surg 16:305–321
69. Weiss KS, Weatherall JM, Eick J, Ross JR (2017) Delayed Tibial Osteomyelitis after Anterior Cruciate Ligament Reconstruction with Hamstrings Autograft and Bioabsorbable Interference Screw: A Case Report and Review of the Literature. Case Rep Orthop 2017:6383526
70. Williams R, Johnson D (eds) (2004) Controversies in Knee Surgery. Oxford University Press, Oxford, New York
71. Zabala IL, Solsona SS (2014) Tibial cyst formation following anterior cruciate ligament reconstruction. J Orthop Sports Phys Ther 44:839
72. Zicaro JP, Ranalletta M, Avila CG, Yacuzzi C, Costa-Paz M (2017) Pretibial Cyst Formation after ACL Reconstruction. A series of 14 cases with different etiologies. Orthop J Sports Med 5 (1 Suppl):2325967117S00034.
73. OSF. https://osf.io/
74. OCEBM Levels of Evidence Working Group*. The Oxford Levels of Evidence 2. Oxford Centre for Evidence-Based Medicine. https://www.cebm.ox.ac.uk/resources/levels-of-evidence/ocebm-levels-of-evidence
75. Howick J, Chalmers I, Glasziou P, Greenhalgh T, Heneghan C, Liberati A, Moschetti I, Phillips B, Thornton H. The 2011 Oxford CEBM Levels of Evidence (Introductory Document). Oxford Centre for Evidence-Based Medicine. https://www.cebm.ox.ac.uk/resources/levels-of-evidence/ocebm-levels-of-evidence

Publisher's Note