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Iliotibial band autograft is a suitable alternative graft for anterior cruciate ligament reconstruction: a systematic review and meta-analysis of outcomes

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Abstract

Purpose Despite encouraging clinical, biomechanical and histological results, ACL reconstruction using the ITB was slowly abandoned. The hypothesis was that the current literature supports the use of ITB as the graft of choice for ACL reconstruction because of its good outcomes.

Methods A systematic search of the literature was performed in the PubMed, MEDLINE, Cochrane, and Ovid databases to identify published clinical studies relevant to ACL reconstruction with ITB autograft and studies comparing ITB autograft with bone–patellar tendon–bone (BPTB) and hamstring (HT) autografts (none were found). The results of the eligible studies were analyzed in terms of graft failure, instrumented knee laxity measurements, Lachman test, pivot-shift test, Lysholm score, objective and subjective International Knee Documentation committee (IKDC) scores, Tegner activity score, return to sports rate, return to sports at pre-injury level and complications.

Results Nineteen clinical studies including 1,210 patients with ACL reconstruction met the inclusion criteria. Graft failure occurred after ITB autograft in 4.2% of patients. Postoperative mean side-to-side laxity was 1.41 mm with 21% of patients having greater than 3 mm side-to-side difference. Lachman test and pivot-shift test were negative (grade 0) in 57% and 85%, respectively, and were grade 0 or 1 in 95% and 97%, respectively. Functional outcomes were satisfactory in 84% of patients with good to excellent results (Lysholm score > 84). Mean postoperative Lysholm score was 93.3 and 84% of patients had an objective IKDC grade of A or B. Mean postoperative Tegner score was 6.8. The return to sports rate was 89% and 61% of patients returned to their pre-injury level. A comparison of 89 ITB versus 80 BPTB autografts revealed no significant differences in graft failure (n.s.), instrumented mean side-to-side knee laxity difference (n.s.) or Tegner score (n.s.).

Conclusion The graft survival rate and clinical and functional outcomes for ITB autograft are satisfactory. By allowing ACL reconstruction and lateral tenodesis to be done with a single, continuous, pedicled graft through an outside-in femoral tunnel, this technique may become the preferred alternative for primary or secondary ACL surgery.

Level of evidence Level IV

Keywords Anterior cruciate ligament · Fascia lata · Iliotibial band · MacIntosh

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Abbreviations

ACL	Anterior cruciate ligament
BPTB	Bone–patellar tendon–bone
CI	Confidence intervals
CMS	Coleman methodological score
HT	Hamstring
IKDC	International knee documentation committee
ITB	Iliotibial band
LCL	Lateral collateral ligament
MCMS	Modified Coleman methodological score
n.s.	Non-significant
OCEBM	Oxford centre for evidence-based medicine

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PRISMA	Preferred reporting items for systematic reviews and meta-analyses
QT	Quadriceps tendon
ROM	Range of motion
SD	Standard deviation

Introduction

Anterior cruciate ligament reconstruction using the iliotibial band (ITB) was slowly abandoned and relegated to the ranks of "old techniques" due to the invasive open harvesting of the graft [6]**.** Indeed, the first description of ACL reconstruction with the ITB was published in 1917 by Hey-Groves et al. [22] and popularized by MacIntosh et al. in 1974 using an over-the-top technique [36]. Several authors have substantially modified this technique and improved it further [2, 14, 26, 38]. The introduction of arthroscopy sparked the development of new minimally invasive techniques [30, 35, 37]. There has been renewed interest in the ITB autograft due to its potential use in the context of ACL revision surgery, multiligament surgery or as an alternative during primary ACL surgery.

Currently, the ITB is commonly used for ACL reconstruction in the pediatric population, as it spares the growth plates [1, 31] in the context of traumatic ACL tears and/or congenital ACL insufficiency [47]. ITB ACL reconstruction appears to restore normal, symmetric, physiologic kinetic and kinematic function in the growing knee [53]**.**

The biomechanical properties of the ITB allow its use for ACL reconstruction. Tensile strength and stress relaxation properties are close to those of the native ACL [11, 43]. The elastic modulus of the ITB is better than that of the patellar tendon (610 vs 417 MPa) [49], which is considered the gold standard for ACL reconstruction [7]. And according to Chan et al., the mean ultimate load to failure (3266 N vs 1494 N) and stiffness (414 N/mm vs 224 N/mm) were significantly higher for the ITB compared with bone–patellar tendon–bone, respectively [8]. MRI studies and histological analysis have shown that the ITB is viable when it replaces the ACL [11, 29, 50].

The intra/extra-articular technique with the ITB allows an ACL reconstruction and lateral tenodesis to be done from a single harvest site, which will reduce the stresses on the intra-articular portion of the graft [15], while keeping the knee's flexor and extensor mechanisms intact [19, 58].

Despite these encouraging clinical, biomechanical and histological results, it is important to determine clinical relevance of using the ITB in ACL reconstruction. The aim of this study was to carry out a meta-analysis based on the available data regarding ITB autograft outcomes and on clinical studies comparing ITB autograft versus bone–patellar tendon–bone (BPTB) and hamstring (HT) autografts in ACL reconstruction in terms of graft failure, stability, functional outcomes and complications. It was hypothesized that the current literature supports the use of ITB as the graft of choice for ACL reconstruction because of its good outcomes.

Materials and methods

A comprehensive search of the published literature in the PubMed, MEDLINE, Cochrane, and Ovid databases was performed based on PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [40]. References from primary and review articles and major orthopedic texts were cross-referenced to identify any additional articles that met the inclusion criteria and were not identified in the original search. The following terms were used as keywords: "iliotibial band", "fascia lata" and "MacIntosh" in combination with the terms "anterior cruciate ligament" or "ACL". All articles published up to February 1, 2020, were included, including articles published online.

Inclusion and exclusion criteria

This study included all original articles reporting on (1) clinical studies of ACL reconstruction using ITB autograft, (2) studies directly comparing the outcomes of ITB versus BPTB; and (3) studies directly comparing the outcomes of ITB versus HT, using either the semitendinosus-gracilis tendon or semitendinosus alone (three or four strands). All procedures were primary ligament reconstructions performed for symptomatic acute or chronic ACL deficiency, with or without meniscal injury, except for the Mirouse and al [39] study, which reported ITB autograft outcomes in revision ACL reconstructions.

Studies that failed to meet the inclusion criteria, such as reviews, studies with less than 12 months of follow-up, studies investigating outcomes after reconstruction of other ligaments, studies of lateral tenodesis with the ITB alone or in combination with intra-articular reconstruction using another graft were excluded.

Quality assessment

In accordance with the guidelines of the Oxford Centre for Evidence-Based Medicine (OCEBM) [44], the level of evidence was used to evaluate the quality of each study and summarized in Table 1. The Modified Coleman Methodological Score (MCMS) was used to evaluate the methodological quality; each study was assessed on ten criteria, resulting in a final score ranging from 0 to 100 (Table 1).

Table. 1 Summary of the main characteristics of the included studies

Adult patients	Year	Type of study	Level of evidence (OCEBM)	MCMS	Surgical technique	ITB length (cm)	Femoral tunnel (mm when available)	Tibial tunnel (mm when available)	Total number of knees	Lost to follow-up	Excluded	Number of knees evaluated	Mean follow-up (months)	SD (M)	Range (M)	Mean Age (Y)	SD (Y)	Range (Y)
Bertoia [6]	1985	CS	4	58	MacIntosh lateral substitution over the top	25	No	6.4	38	3	1 (died)	34	37	NA	24–59	21	NA	16–32
Ekstrand [14]	1989	CS	4	57	Hey-Grooves modified	16	5	5	60	NA	NA	45	NA	NA	12–36	22.9	3.9	NA
Dempsey [12]	1993	CS	4	47	MacIntosh lateral substitution over the top	25	No	6.4	35	10	0	25	99.6	NA	NA	26.2	NA	NA
Natri [42]	1996	CS	4	60	Marshall's method modified by Andersson	14–20	Yes	Yes	90	18	2	70	42	NA	24–60	34	12	NA
Dodelin [13]	1998	CS	4	53	MacIntosh modified par Jaeger	NA	Yes	Yes	89	49	0	50	92.4	NA	24–168	47	6	NA
Bak [4]	1999	CS	4	65	Hey-Grooves modified	20	Yes	Yes	40	0	6	34	37 *	NA	24–87	22 *	NA	16–39
Bak [5]	2001	CS	4	72	Hey-Grooves modified	20	Yes	Yes	132	14	0	118	47 *	NA	24–92	23 *	NA	16–39
Jorgensen [28]	2001	CS	4	77	Hey-Grooves modified	18	Yes	Yes	169	15	0	154	39 *	NA	24–92	24 *	NA	16–51
Johnston [27]	2003	CS	4	69	MacIntosh lateral substitution over the top	NA	No	8	140	57	1 (died)	82	117.6	38.4	45.6–181.2	27.5	5.9	17.6–44.1

Table. 1 (continued)

Adult patients	Year	Type of study	Level of evidence (OCEBM)	MCMS	Surgical technique	ITB length (cm)	Femoral tunnel (mm when available)	Tibial tunnel (mm when available)	Total number of knees	Lost to follow-up	Excluded	Number of knees evaluated	Mean follow-up (months)	SD (M)	Range (M)	Mean Age (Y)	SD (Y)	Range (Y)
Yamaguchi [59]	2006	CS	4	67	NA	22	7.5	7.5	45	18	1	26	72, 156, 288	NA	NA	24.8	NA	16—42
Schlatterer [48]	2006	CS	4	67	MacIntosh modified by Jaeger	18–20	Yes	6	62	8	4	50	62.4	NA	54.4–86.4	24	NA	15—42
Mirouse [39]	2016	CS	4	60	MacIntosh modified by Khiami	18–20	9	Yes	30	0	0	30	55.2	19.2	NA	NA	NA	18–50
Haillotte [19]	2017	CS	4	44	MacIntosh modified by Khiami	18–20	9	Yes	53	21	0	32	12	NA	NA	26.7	9.7	15–51
Jorgensen [54]	1998	PR	2	77	ITB NA	NA	NA	NA	30	0	0	30	26 *	NA	12–51	27 *	NA	16–44
					BPTB				30	0	0	30	26 *	NA	12–51	27 *	NA	16–44
Poulsen [46]	2003	RCS	3	55	ITB NA	18	Yes	Yes	55	NA	NA	34	24	NA	NA	26 *	NA	18–47
					BPTB				40	NA	NA	26	40.8	NA	24–48	27 *	NA	19–38
Stensbirk [52]	2013	PR	2	89	ITB Hey-Grooves modified	18	Yes	Yes	30	NA	NA	25	180	NA	NA	26	NA	14–37
					BPTB				30	NA	NA	24	180	NA	NA	30	NA	18–44
Pediatric patients	Year		Level of evidence (OCEBM)	MCMS	Surgical technique				Total number of knees	Lost to follow-up	Excluded	Number of knees evaluated	Mean follow-up (months)	SD (M)	Range (M)	Mean Age (Y)	SD (Y)	Range (Y)
Kocher [32]	2005	CS	4	65	Physeal sparing (over the top, over the front)	NA	No	No	50	6	0	44	63.6	NA	24—181.2	10.3	NA	3.6.14

Table. 1 (continued)

Adult patients	Year	Type of study	Level of evidence (OCEBM)	MCMS	Surgical technique	ITB length (cm)	Femoral tunnel (mm when available)	Tibial tunnel (mm when available)	Total number of knees	Lost to follow-up	Excluded	Number of knees evaluated	Mean follow-up (months)	SD (M)	Range (M)	Mean Age (Y)	SD (Y)	Range (Y)
Willimon [57]	2015	CS	4	66	Physeal sparing (over the top, over the front)	18	No	No	22	0	0	22	36	NA	12—79.2	11.8	NA	9.9—14.0
Kocher [33]	2018	CS	4	67	Physeal sparing (over the top, over the front)	NA	No	No	240	15, 103	0	225, 137	25.8, 74.4	NA, NA	NA, 25.2–298.8	11.2	1.7	NA

OCEBM oxford centre for evidence-based medicine; *MCMS* modified Coleman methodology score; *SD* standard deviation; *M* month; *Y* years; *CS* case series; *PR* prospective randomized; *RCS* retrospective comparative studies; *NA* not available; *ACL* anterior cruciate ligament; *ITB* iliotibial band; *BPTB* bone–patellar tendon–bone; *median

Data extraction and analysis

The articles identified in the searches were reviewed by two authors. Data extraction was performed independently, and any conflict was resolved before the final analysis. In clinical and comparative studies, the outcome measures were collected. When the data were not provided, the authors were contacted by email. Statistical analysis was feasible after summarizing homogeneous and comparable outcomes between the studies. Parameters analyzed in this meta-analysis were (1) graft failure rate; (2) knee stability, including mean side-to-side difference and percentage with greater than 3 mm side-to-side difference (using KT-1000/2000 or Rolimeter arthrometer), Lachman test grade 0 and grade 0 or 1, and pivot-shift test grade 0 and grade 0 or 1; (3) functional outcomes, including mean Lysholm score, percentage of Lysholm scores greater than 84 (corresponding with good to excellent results), percentage of objective International Knee Documentation Committee (IKDC) grade A or B (corresponding to normal or nearly normal knee), mean IKDC subjective score, mean Tegner score, return to sports rate, percentage of return to sport at pre-injury level; and (4) complications, including reoperations for any cause, fixation device removal, meniscus-related reoperations, reoperations for other reasons and non-operative muscle hernia at the graft harvesting site.

Statistical analysis

The study results were tabulated with the number of events and total number of subjects in the ITB versus BPTB groups (for graft failure, KT1000/2000 > 3 mm, Lachman = 0, Lachman = 0 or 1, pivot shift = 0, pivot shift = 0 or 1, Lysholm > 84, return to sport, IKDC = A or B, reoperations and non-operative muscle hernia at graft harvesting site). Study results were tabulated with mean and standard deviation (SD) together with total number of subjects in ITB versus BPTB groups for continuous endpoints (KT1000/2000, Lysholm, Tegner and IKDC). Missing mean and SD were assessed from the median, range, and sample size [24]. Missing SD (without median and range) was assessed based on the sample size and mean value from reported P values [16]. For the description of ITB results, the event frequency or the weighted mean (continuous endpoint) were calculated together with 95% confidence intervals (95%CI). The risk ratio of an event for ITB versus BPTB based on the inverse variance approach with their 95%CI was calculated. The mean differences between ITB versus BPTB for continuous endpoints according to the inverse variance approach with their 95% CI were estimated. To assess heterogeneity across studies, forest plots as well as Cochran's heterogeneity statistic and Higgins I^2coefficients were used [23]. A p value < 0.1 or $I^2 > 50\%$ was considered suggestive of statistical heterogeneity, prompting random effects modeling. To assess small-study effects Funnel plots were generated [45]. None showed evidence of small-study bias. The Review Manager 5.2 analysis software (The Cochrane Collaboration, Copenhagen, Denmark) was used throughout.

Results

Literature search, study selection, characteristics and methodological quality

The literature search of the various databases identified 344 articles. A total of 324 articles were evaluated after duplicates were excluded. After screening the titles and abstracts, 44 articles were included, and full texts were assessed for eligibility. A total of 19 articles met our eligibility criteria: 13 articles reporting on outcomes of ACL reconstruction with ITB autograft [4–6, 12–14, 19, 27, 28, 39, 42, 48, 59], 3 articles comparing the outcomes of ITB autograft versus those of BPTB autograft [46, 52, 54], 0 articles comparing the outcomes of ITB autograft versus those of HT and 3 articles reporting on outcomes of ACL reconstruction with ITB autograft in a pediatric population [32, 33, 57]. A total of 1,210 patients were included in this meta-analysis. Descriptive study characteristics are shown in Table 1. A flowchart of the literature search is provided in Fig. 1. Most of the studies included in this review were retrospective case series. The levels of evidence assigned to the included studies were level 2 for two studies, level 3 for one study, and level 4 for 16 studies. The average MCMS of the articles was 64.5 ± 11.7, with the majority falling in the ''fair'' range (Table 1).

ITB outcomes

In total, 1,130 ITB autografts used in ACL reconstruction were analyzed, including 750 from articles reporting on adult ITB outcomes, 291 from articles reporting on child ITB outcomes, and 89 from articles comparing ITB versus BPTB autografts. Outcome measures are summarized in Table 2.

ITB versus BTBP outcomes

In all, the outcomes of 89 ITB versus 80 BPTB autografts were analyzed statistically. The results of this analysis are provided in Table 3. No significant difference was found between the ITB and BPTB groups in term of graft survival (Fig. 2), laxity (Fig. 3) and functional scores.

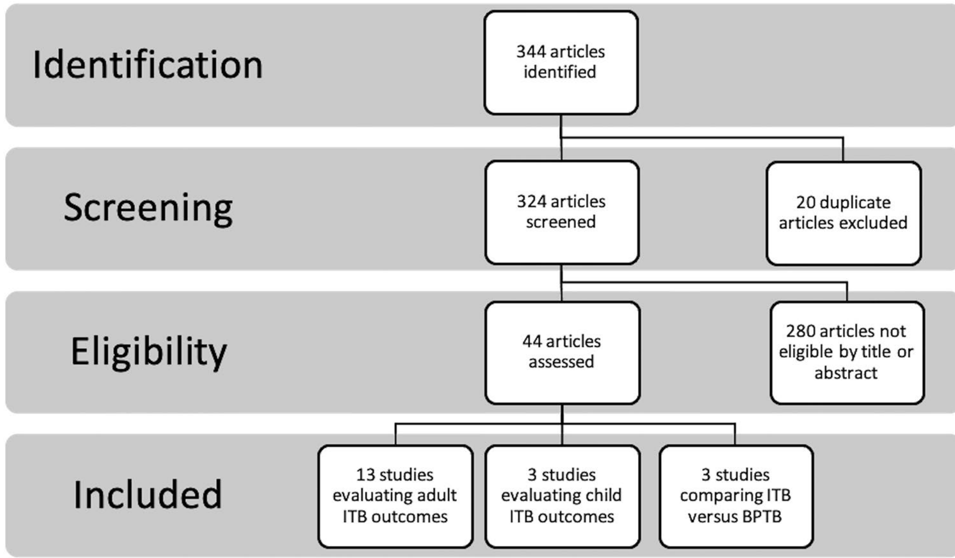

Fig. 1 PRISMA (Preferred Reporting Items for Systematic Meta-Analyses) study selection flow diagram. ITB: iliotibial band; BPTB: bone–patellar tendon–bone autograft

Discussion

The most important finding of the present study was that ITB provides satisfactory outcomes for ACL reconstruction, yielding a stable and functional knee with low graft failure rates. The analysis of comparative studies revealed that the outcomes and graft survival rates were comparable with BPTB autografts, which are considered as the gold standard for ACL reconstruction [7]. This meta-analysis shows that ITB is a suitable graft and supports its use as an alternative graft for ACL reconstruction, confirming our hypothesis.

Overall, this meta-analysis of 839 adults treated with an ITB autograft was in line with a meta-analysis of outcomes after ACL reconstruction with an BPTP or HT autograft [17] and with another meta-analysis of outcomes with quadriceps tendon (QT) autograft [41] (Table 4).

In terms of knee laxity in adults, in the present meta-analysis, the postoperative mean side-to-side laxity was 1.41 mm with 21% of patients having more than 3 mm side-to-side difference. Similarly, in the meta-analysis by Freedman et al., 21% of 1,153 BPTB graft patients and 26% of 562 HT graft patients were reported to have more than 3 mm side-to-side laxity. Moreover, in the meta-analysis by Mouarbes et al., 24% of 1,277 QT graft patients were reported to have more than 3 mm side-to-side laxity and the postoperative mean side-to-side laxity was 1.72 mm.

The knee laxity, rotational stability (pivot shift) and rupture results are similar to those found by Mouarbes et al. for the QT and by Freedman et al. for the BTBP and the HT (Table 4). The return to sports rate at pre-injury levels (61%) was similar to the one reported by Freedman for the BTBP (67%) and the HT (66%) or by Ardern et al. in another meta-analysis where all the graft types were pooled together (63%) [3]. The overall return to sports rate for the ITB is higher than the one found by Ardern et al.: 89% versus 82%, respectively [3].

In terms of complications, a high number of reoperations were needed to remove the surgical fixation devices (19%). Most patients who required a reoperation had gotten one staple for the femoral fixation and two staples at the tibia [4, 5, 14, 28]. This high rate of reoperations for device removal is not found with over-the-top techniques [6] or in pediatric studies [32, 33, 57] that use suture fixation, nor in techniques where an interference screw is used at the tibia and/or a single staple without femoral fixation [13, 39, 48]. Similarly, the rate of non-surgical muscle hernia at the harvest site was 11%. This complication mainly occurred in studies where the fascia lata was not closed after harvesting the graft [4–6, 14, 28]. Since Jaeger et al and Khiami et al [26, 30] described how to slide and laterally translate the intermuscular septum to make it easier to close the harvest site, this complication is now insignificant [39, 48].

Three articles directly comparing ITB and BPTB autografts were found in the literature. Comparable outcomes with no significant difference were found for stability outcomes (mean side-to-side difference), functional outcomes (Tegner score), and rate of graft failure. This meta-analysis was limited by the number of comparative studies involving the ITB and by the relatively small number of patients.

The technique featured here makes it possible to carry out ACL reconstruction and lateral tenodesis with a single continuous graft. Lateral tenodesis increases rotational stability and minimizes the risk of retears [10, 21, 25, 51, 55, 56]. Adding a lateral tenodesis procedure yields better results in patients with chronic instability or in those undergoing revision surgery [20, 34, 55]. The technique featured here provides a continuous graft that is left attached to Gerdy's tubercle. This anatomical attachment helps to preserve the

Table. 2 Outcomes measures analyzed for iliotibial band autografts

	Adults n/N or N	Studies N	Mean follow-up (M)	SD (M)	% or weighted mean (95% CI)	Children n/N or N	Studies N	Mean follow-up (M)	SD (M)	% or weighted mean (95% CI)
Graft failure	26/625	11	40.9	9.6	4.2 (2.6–5.7)	14/203	3	67.9	41.2	6.9 (3.4–10.4)
Side-to-side difference, mm	495	9	50.2	13.8	1.4 (1.3–1.5)	0				
Side-to-side difference > 3 mm	80/384	6	42.0	10.6	20.8 (16.8–24.9)	0				
Lachman grade 0	308/540	9	61.3	17.9	57.0 (52.9–61.2)	260/288	3	55.3	32.7	90.3 (86.9–93.7)
Lachman grade 0 or 1	433/456	7	63.2	18.7	95.0 (93.0–97.0)	42/44	1	63.6	39.6	95.5 (89.3–100)
Pivot-shift grade 0	474/559	9	59.8	17.3	84.8 (81.8–87.8)	272/288	3	70.2	42.8	94.4 (91.8–97.1)
Pivot-shift grade 0 or 1	464/477	8	49.3	13.0	97.3 (95.8–98.7)	42/44	1	63.6	39.6	95.5 (89.3–100)
Lysholm score	413	6	58.7	10.0	93.3 (92.4–94.2)	189	3	68.1	41.4	94.1 (92.8–95.3)
Lysholm score > 84	485/575	9	59.7	12.1	84.4 (81.4–87.3)	0				
Objective IKDC A or B	327/390	6	49.6	14.3	83.9 (80.2–87.5)	0				
Subjective IKDC	0					189	3	68.1	41.4	94.4 (93.1–95.7)
Tegner score	417	7	49.3	15.3	6.8 (6.6–6.9)	147	2	69.4	41.9	7.8 (7.6–8.0)
Return to sport	610/684	12	55.7	16.5	89.2 (86.9–91.5)	179/191	3	68.1	41.4	93.7 (90.3–97.2)
Return to sport at pre-injury level	330/539	10	57.8	17.4	61.2 (57.1–65.3)	0				
Reoperation for any cause	133/573	10	46.3	12.3	23.2 (19.8–26.7)	7/66	2	55.2	32.0	10.6 (3.2–18.0)
Device removal reoperations	111/573	10	46.3	12.3	19.4 (16.1–22.6)	0/66	2	55.2	32.0	0
Meniscus reoperations	18/573	10	46.3	12.3	3.1 (1.7–4.6)	7/66	2	55.2	32.0	10.6 (3.2–18.0)
Reoperations for other reasons	4/573	10	46.3	12.3	0.7 (0–1.4)	0/66	2	55.2	32.0	0
Non-operative muscle hernia at graft harvesting site	56/502	8	40.5	11.1	11.2 (8.4–13.9)	0/66	2	55.2	32.0	0

CI confidence interval; *IKDC* international knee documentation committee; *SD* standard deviation; *M* months

Table. 3 Outcomes measures analyzed from iliotibial band versus bone–patellar tendon–bone autograft studies

	Number ITB/BPTB	Studies N	Mean difference (95% CI) ITB – BPTB	Risk ratio (95% CI) ITB:BPTB	*P* value
Graft failure	55/54	2		1.47 (0.41 to 5.24)	n.s
Side-to-side difference	45/38	2	0.76 (– 0.04 to 1.56)		n.s
Tegner	52/46	2	– 0.04 (– 1.22 to 1.14)		n.s

ITB iliotibial band; *BPTB* bone–patellar tendon–bone; *CI* confidence interval; *n.s* non-significant

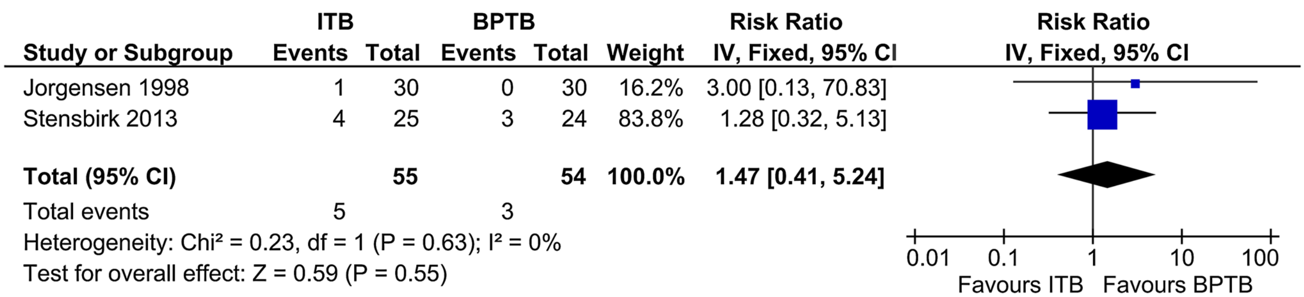

Fig. 2 Graft failure forest plot. Forest plot showing the risk ratio of graft failure for the iliotibial band (ITB) versus bone–patellar tendon–bone (BPTB) autograft

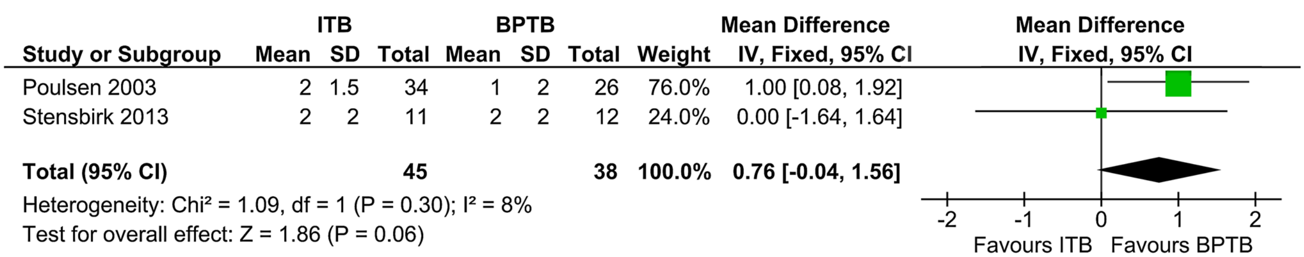

Fig. 3 Mean side-to-side difference forest plot. Forest plot showing the mean side-to-side difference in anterior tibial translation between the operated and contralateral knees between patients receiving iliotibial band (ITB) or bone–patellar tendon–bone (BPTB) autografts

Table. 4 Outcome measures analyzed from 4 different autografts in 3 meta-analysis studies

Graft	ITB (Our study data in adults)	QT (Mouarbes et al.)	BPTB (Freedman et al.)	HT (Freedman et al.)
Graft failure, % (95% CI)	4.2 (2.6–5.7)	2.1 (1.4–2.8)	1.9	4.9
Side-to-side difference, weighted mean, mm (95% CI)	1.41 (1.35–1.47)	1.72 (1.69–1.75)		
Side-to-side difference > 3 mm, %	20.8	23.7	21	26.2
Lachman grade 0, %	57.0	81.2		
Lachman grade 0 or 1, %	95.0	96.1		
Pivot-shift grade 0, %	84.8	84.8	82.2	81.8
Pivot-shift grade 0 or 1, %	97.3	97.7	96.7	95.5
Lysholm score, weighted mean	93.3	90.7		
Lysholm score > 84, %	84.4	87.9		
Objective IKDC A or B, %	83.9	87.1		
Tegner score, weighted mean	6.8			
Return to sport, %	89.2			
Return to sport at pre-injury level, %	61.2		67.2	65.6

ITB iliotibial band; *QT* quadriceps tendon; *BPTB* bone–patellar tendon–bone; *HT* hamstring tendon; *CI* confidence interval; *IKDC* international knee documentation committee vascular network vital to the graft's ligamentization [9]. Furthermore, this anatomical attachment allows surgeons to carry out lateral tenodesis without having to drill a tibial tunnel for fixation, which reduces for the risk of tunnel convergence and proximal tibial weakening.

The present study was the first meta-analysis to assess the outcomes of ITB clinical studies statistically and it featured a large number of ACL reconstructions using an ITB autograft.

Several limitations of this analysis warrant mention. First, the MCMS of the studies included in this review limits our ability to draw definitive conclusions. Indeed, the majority of studies identified did not meet the recommended quality criteria [18], as, for the most part, they were case series analyzed retrospectively. Moreover, the studies featured substantially different surgical techniques (MacIntosh lateral substitution over the top, modified Hey-Grooves, Marshall's method modified by Andersson, MacIntosh modified by Jaeger, MacIntosh modified by Khiami, physeal sparing in a pediatric population), different fixation methods (interference screw, 1 or 2 staples, suture) and different rehabilitation protocols.

Furthermore, the oldest study was published in 1985, at which point the reconstruction was done through a medial arthrotomy, the graft was passed under the lateral collateral ligament (LCL), the fascia lata was not reclosed and both the tibial and femoral fixations were done with sutures. The most recent study was published in 2017; in that study, the ligament reconstruction was done arthroscopically, the graft was passed over the LCL, the fascia lata was reclosed and dual tibial fixation was done with an interference screw and a staple. This large variation over time may have contributed to underestimating the quality of the current technique. In fact, complications such as hematomas and postoperative muscle hernias [28] have been virtually eliminated through careful closure of the fascia lata and meticulous hemostasis after releasing the tourniquet [30, 35]. Second, the follow-up time varied between studies and thus may have impacted our findings. Third, the comparative component of the meta-analysis had only three articles and relatively few patients. This is a limitation of the literature itself, although we felt it was necessary to highlight the lack of data on this issue and the non-significant results on the risk of retear in comparison with BPTB grafts. Prospective and randomized trials are needed to adequately determine the non-inferiority of these two techniques.

The present study revealed that ITB ACL reconstruction has satisfactory outcomes, yielding a stable and functional knee with low graft failure rates. Despite these limitations, the findings of this meta-analysis highlight the possibility of using the ITB in the context of ACL revision surgery, multiligament surgery or as an alternative during primary ACL surgery.

Conclusion

The clinical and functional outcomes and the graft survival rate for ACL reconstruction with an ITB autograft are satisfactory. By allowing ACL reconstruction and lateral tenodesis to be done with a single, continuous, pedicled graft through an outside-in femoral tunnel while being associated with low donor site morbidity, this technique may become the preferred alternative for primary or secondary ACL surgery.

Author contribution TL participated in the design of the study, performed data collection and drafted the manuscript. VM helped to draft the manuscript. LC helped to performed data collection. CL performed a critical review of manuscript. EB performed the statistical analysis. NR performed a critical review of manuscript. EC devised the study and participated in its design and coordination. All authors read and approved the final manuscript.

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Declarations

Conflict of interest The author(s) declare that they have no competing interests.

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References

1. Abreu FG, Pioger C, Franck F, Freychet B, Vieira TD, Sonnery-Cottet B (2020) Femoral physeal-sparing anterior cruciate ligament reconstruction using the iliotibial band: over-the-top technique. Arthrosc Tech 9:e691–e695
2. Anderson AF, Snyder RB, Lipscomb AB (1994) Anterior cruciate ligament reconstruction using the semitendinosus and gracilis tendons augmented by the losee iliotibial band tenodesis. A long-term study. Am J Sports Med 22:620–626
3. Ardern CL, Webster KE, Taylor NF, Feller JA (2011) Return to sport following anterior cruciate ligament reconstruction surgery: a systematic review and meta-analysis of the state of play. Br J Sports Med 45:596–606
4. Bak K, Jørgensen U, Ekstrand J, Scavenius M (1999) Results of reconstruction of acute ruptures of the anterior cruciate ligament with an iliotibial band autograft. Knee Surg Sports Traumatol Arthrosc 7:111–117
5. Bak K, Jørgensen U, Ekstrand J, Scavenius M (2001) Reconstruction of anterior cruciate ligament deficient knees in soccer players with an iliotibial band autograft. A prospective study of 132 reconstructed knees followed for 4 (2–7) years. Scand J Med Sci Sports 11:16–22
6. Bertoia JT, Urovitz EP, Richards RR, Gross AE (1985) Anterior cruciate reconstruction using the MacIntosh lateral-substitution over-the-top repair. J Bone Joint Surg Am 67:1183–1188

7. Carmichael JR, Cross MJ (2009) Why bone-patella tendon-bone grafts should still be considered the gold standard for anterior cruciate ligament reconstruction. Br J Sports Med 43:323–325
8. Chan DB, Temple HT, Latta LL, Mahure S, Dennis J, Kaplan LD (2010) A biomechanical comparison of fan-folded, single-looped fascia lata with other graft tissues as a suitable substitute for anterior cruciate ligament reconstruction. Arthroscopy 26:1641–1647
9. Claes S, Verdonk P, Forsyth R, Bellemans J (2011) The "ligamentization" process in anterior cruciate ligament reconstruction: what happens to the human graft? A systematic review of the literature. Am J Sports Med 39:2476–2483
10. Claes S, Vereecke E, Maes M, Victor J, Verdonk P, Bellemans J (2013) Anatomy of the anterolateral ligament of the knee. J Anat 223:321–328
11. Delcroix GJ-R, Kaimrajh DN, Baria D, Cooper S, Reiner T, Latta L, D'Ippolito G, Schiller PC, Temple HT (2013) Histologic, biomechanical, and biological evaluation of fan-folded iliotibial band allografts for anterior cruciate ligament reconstruction. Arthroscopy 29:756–765
12. Dempsey SM, Tregonning RJ (1993) Nine-year follow-up results of two methods of MacIntosh anterior cruciate ligament reconstructions. Clin Orthop Relat Res 294:216–222
13. Dodelin A, Baillet JM, Jaeger JH (2008) Ligamentoplastie mixte au fascia lata pour rupture du LCA chez les patients de plus de 40 ans. J Traumatol Sport 15:207–213
14. Ekstrand J (1989) Reconstruction of the anterior cruciate ligament in athletes, using a fascia lata graft: a review with preliminary results of a new concept. Int J Sports Med 10:225–232
15. Engebretsen L, Lew WD, Lewis JL, Hunter RE (1990) The effect of an iliotibial tenodesis on intraarticular graft forces and knee joint motion. Am J Sports Med 18:169–176
16. Follmann D, Elliott P, Suh I, Cutler J (1992) Variance imputation for overviews of clinical trials with continuous response. J Clin Epidemiol 45:769–773
17. Freedman KB, D'Amato MJ, Nedeff DD, Kaz A, Bach BR (2003) Arthroscopic anterior cruciate ligament reconstruction: a metaanalysis comparing patellar tendon and hamstring tendon autografts. Am J Sports Med 31:2–11
18. Guyatt GH, Oxman AD, Kunz R, Vist GE, Falck-Ytter Y, Schünemann HJ, GRADE Working Group (2008) What is "quality of evidence" and why is it important to clinicians? BMJ 336:995–998
19. Haillotte G, Hardy A, Granger B, Noailles T, Khiami F (2017) Early strength recovery after anterior cruciate ligament reconstruction using the fascia lata. Orthop Traumatol Surg Res 103:1021–1025
20. Helito CP, Camargo DB, Sobrado MF, Bonadio MB, Giglio PN, Pécora JR, Camanho GL, Demange MK (2018) Combined reconstruction of the anterolateral ligament in chronic ACL injuries leads to better clinical outcomes than isolated ACL reconstruction. Knee Surg Sports Traumatol Arthrosc 26:3652–3659
21. Hewison CE, Tran MN, Kaniki N, Remtulla A, Bryant D, Getgood AM (2015) Lateral extra-articular tenodesis reduces rotational laxity when combined with anterior cruciate ligament reconstruction: a systematic review of the literature. Arthroscopy 31:2022–2034
22. Hey-Groves EW (1917) Operation for the repair of the crucial ligaments. The Lancet 190:674–676
23. Higgins JPT, Thompson SG, Deeks JJ, Altman DG (2003) Measuring inconsistency in meta-analyses. BMJ 327:557–560
24. Hozo SP, Djulbegovic B, Hozo I (2005) Estimating the mean and variance from the median, range, and the size of a sample. BMC Med Res Methodol 5:13
25. Imbert P, Lustig S, Steltzlen C, Batailler C, Colombet P, Dalmay F, Bertiaux S, D'ingrado P, Ehkirch FP, Louis ML, Pailhé R, Panisset JC, Schlaterrer B, Sonnery-Cottet B, Sigwalt L, Saragaglia D, Lutz C, (2017) Résultats à moyen terme des plasties combinées intra- et extra-articulaires du ligament croisé antérieur : comparaison avec les plasties intra-articulaires isolées de la littérature. Étude multicentrique de la Société francophone d'arthroscopie (SFA). Rev Chir Orthopédique Traumatol 103:S204–S208
26. Jaeger JH, Van Hille W, Lutz C, Villeminot J (2003) La ligamentoplastie du ligament croisé antérieur au fascia lata selon la technique de Mac Intosh modifiée. Pathologie ligamentaire Genou. Springer, Paris, pp 399–409
27. Johnston DR, Baker A, Rose C, Scotland TR, Maffulli N (2003) Long-term outcome of MacIntosh reconstruction of chronic anterior cruciate ligament insufficiency using fascia lata. J Orthop Sci 8:789–795
28. Jørgensen U, Bak K, Ekstrand J, Scavenius M (2001) Reconstruction of the anterior cruciate ligament with the iliotibial band autograft in patients with chronic knee instability. Knee Surg Sports Traumatol Arthrosc 9:137–145
29. Jørgensen U, Thomsen HS (2000) Behavior of the graft within the bone tunnels following anterior cruciate ligament reconstruction, studied by cinematic magnetic resonance imaging. Knee Surg Sports Traumatol Arthrosc 8:32–35
30. Khiami F, Wajsfisz A, Meyer A, Rolland E, Catonné Y, Sariali E (2013) Anterior cruciate ligament reconstruction with fascia lata using a minimally invasive arthroscopic harvesting technique. Orthop Traumatol Surg Res 99:99–105
31. Kocher MS, Garg S, Micheli LJ (2006) Physeal sparing reconstruction of the anterior cruciate ligament in skeletally immature prepubescent children and adolescents. Surgical technique. J Bone Joint Surg Am. 88 Suppl 1 Pt 2:283–293
32. Kocher MS, Garg S, Micheli LJ (2005) Physeal sparing reconstruction of the anterior cruciate ligament in skeletally immature prepubescent children and adolescents. J Bone Joint Surg Am 87:2371–2379
33. Kocher MS, Heyworth BE, Fabricant PD, Tepolt FA, Micheli LJ (2018) Outcomes of physeal-sparing ACL reconstruction with iliotibial band autograft in skeletally immature prepubescent children. J Bone Joint Surg Am 100:1087–1094
34. Lee DW, Kim JG, Cho SI, Kim DH (2019) Clinical outcomes of isolated revision anterior cruciate ligament reconstruction or in combination with anatomic anterolateral ligament reconstruction. Am J Sports Med 47:324–333
35. Lutz C, Sonnery-Cottet B, Imbert P, Barbosa NC, Tuteja S, Jaeger J-H (2016) Combined anterior and anterolateral stabilization of the knee with the iliotibial band. Arthrosc Tech 5:e251-256
36. Macintosh DL (1976) Lateral substitution reconstruction. J Bone Jt Surg 58:142
37. Marot V, Valette A, Courtot L, Lucena T, Reina N, Cavaignac E (2021) Outside-in anterior cruciate ligament revision with lateral tenodesis and high-strength suture augmentation is easy to perform with the iliotibial band. Arthrosc Tech 10:e1321–e1326
38. Marshall JL, Warren RF, Wickiewicz TL, Reider B (1979) The anterior cruciate ligament: a technique of repair and reconstruction. Clin Orthop Relat Res 143:97–106
39. Mirouse G, Rousseau R, Casabianca L, Ettori MA, Granger B, Pascal-Moussellard H, Khiami F (2016) Return to sports and functional results after revision anterior cruciate ligament reconstruction by fascia lata autograft. Orthop Traumatol Surg Res 102:863–866
40. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group (2009) Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. BMJ 339:b2535
41. Mouarbes D, Menetrey J, Marot V, Courtot L, Berard E, Cavaignac E (2019) Anterior cruciate ligament reconstruction: a systematic review and meta-analysis of outcomes for quadriceps tendon autograft versus bone-patellar tendon-bone and hamstring-tendon autografts. Am J Sports Med 47:3531–3540

42. Natri A, Järvinen M, Kannus P (1996) Primary repair plus intra-articular iliotibial band augmentation in the treatment of an acute anterior cruciate ligament rupture. A follow-up study of 70 patients. Arch Orthop Trauma Surg 115:22–27
43. Noyes FR, Butler DL, Grood ES, Zernicke RF, Hefzy MS (1984) Biomechanical analysis of human ligament grafts used in knee-ligament repairs and reconstructions. J Bone Joint Surg Am 66:344–352
44. OCEBM Levels of Evidence Working Group (2011) 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. Accessed 23 May 2021
45. Peters JL, Sutton AJ, Jones DR, Abrams KR, Rushton L (2008) Contour-enhanced meta-analysis funnel plots help distinguish publication bias from other causes of asymmetry. J Clin Epidemiol 61:991–996
46. Poulsen M, Fabrin J, Carstensen JP, Ulnits L, Lausten GS (2003) Reconstruction of anterior cruciate ligament using bone-patellar tendon-borne graft or fascia lata graft. A retrospective study of functional results. Ugeskr Laeger 165:682–685
47. Sachleben BC, Nasreddine AY, Nepple JJ, Tepolt FA, Kasser JR, Kocher MS (2019) Reconstruction of symptomatic congenital anterior cruciate ligament insufficiency. J Pediatr Orthop 39:59–64
48. Schlatterer B, Jund S, Delépine F, Razafindratsiva C, de Peretti F (2006) Acute anterior cruciate ligament repair with combined intra- and extra-articular reconstruction using an iliotibial band with the modified MacIntosh technique: a five-year follow-up study of 50 pivoting sport athletes. Rev Chir Orthop Reparatrice Appar Mot 92:778–787
49. Smeets K, Bellemans J, Scheys L, Eijnde BO, Slane J, Claes S (2017) Mechanical Analysis of Extra-Articular Knee Ligaments. Part two: Tendon grafts used for knee ligament reconstruction. Knee 24:957–964
50. Somer L, Vukadinović S, Somer T, Mikić Z, Milankov M (1990) Histologic changes in fascia lata transplants in the replacement of the anterior cruciate ligament of the knee in dogs. Acta Chir Iugosl 37(Suppl 1):51–55
51. Sonnery-Cottet B, Lutz C, Daggett M, Dalmay F, Freychet B, Niglis L, Imbert P (2016) The involvement of the anterolateral ligament in rotational control of the knee. Am J Sports Med 44:1209–1214
52. Stensbirk F, Thorborg K, Konradsen L, Jørgensen U, Hölmich P (2014) Iliotibial band autograft versus bone-patella-tendon-bone autograft, a possible alternative for ACL reconstruction: a 15-year prospective randomized controlled trial. Knee Surg Sports Traumatol Arthrosc 22:2094–2101
53. Sugimoto D, Whited AJ, Brodeur JJ, Liotta ES, Williams KA, Kocher MS, Micheli LJ, Heyworth BE (2020) Long-term follow-up of skeletally immature patients with physeal-sparing combined extra-/intra-articular iliotibial band anterior cruciate ligament reconstruction: a 3-dimensional motion analysis. Am J Sports Med 48:1900–1906
54. Tøndevold E (1998) Danish orthopedic society. Acta Orthop Scand 69:44–63
55. Trojani C, Beaufils P, Burdin G, Bussière C, Chassaing V, Djian P, Dubrana F, Ehkirch F-P, Franceschi J-P, Hulet C, Jouve F, Potel J-F, Sbihi A, Neyret P, Colombet P (2012) Revision ACL reconstruction: influence of a lateral tenodesis. Knee Surg Sports Traumatol Arthrosc 20:1565–1570
56. Weber AE, Zuke W, Mayer EN, Forsythe B, Getgood A, Verma NN, Bach BR, Bedi A, Cole BJ (2019) Lateral augmentation procedures in anterior cruciate ligament reconstruction: anatomic, biomechanical, imaging, and clinical evidence. Am J Sports Med 47:740–752
57. Willimon SC, Jones CR, Herzog MM, May KH, Leake MJ, Busch MT (2015) Micheli anterior cruciate ligament reconstruction in skeletally immature youths: a retrospective case series with a mean 3-year follow-up. Am J Sports Med 43:2974–2981
58. Wren TL, Beltran V, Katzel MJ, Conrad-Forrest AS, VandenBerg CD (2021) Iliotibial band autograft provides the fastest recovery of knee extensor mechanism function in pediatric anterior cruciate ligament reconstruction. Int J Environ Res Public Health 18:7492
59. Yamaguchi S, Sasho T, Tsuchiya A, Wada Y, Moriya H (2006) Long term results of anterior cruciate ligament reconstruction with iliotibial tract: 6-, 13-, and 24-year longitudinal follow-up. Knee Surg Sports Traumatol Arthrosc 14:1094–1100