

Outcomes of Ipsilateral Versus Contralateral Bone–Patellar Tendon–Bone (BPTB) Autografts in Anterior Cruciate Ligament Reconstruction: A Systematic Review and Meta-Analysis

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Abstract

Background

The bone–patellar tendon–bone (BPTB) autograft is considered the preferred graft choice for primary anterior cruciate ligament reconstruction (ACLR) in high-demand athletes, because of its favourable rotational stability and lower graft failure rates. Although contralateral BPTB harvest has been proposed to facilitate rehabilitation by distributing donor-site morbidity between limbs, evidence comparing outcomes between ipsilateral and contralateral BPTB autograft ACLR remains limited. The purpose of this study is to systematically review and meta-analyze postoperative clinical outcomes, time-to-return-to-sport, strength recovery, and complication rates following ipsilateral versus contralateral BPTB autograft primary ACLR.

Methods

A comprehensive search of PubMed, the Cochrane Central Register of Controlled Trials (CENTRAL), Embase, Scopus, and Web of Science was conducted from inception through May 2026 to identify eligible studies evaluating outcomes of ipsilateral versus contralateral BPTB autograft use in primary ACLR. Statistical analysis was performed using Stata SE version 19.5, employing a random-effects model. Heterogeneity was assessed using the I^2 statistic, and publication bias was evaluated using Doi plots and LFK indices. Primary outcomes included postoperative subjective, objective, strength and complication outcomes, as well as time-to-return-to-sport. This meta-analysis followed PRISMA guidelines for systematic reviews.

Results

Seven BPTB studies representing 6,631 participants were analyzed. Contralateral BPTB autografts were associated with significantly earlier time-to-return-to-sport (mean difference = 0.99 months [95% CI, 0.37–1.60]). Postoperative extension strength in the reconstructed knee favored the contralateral group in 3 of 4 studies, but did not reach statistical significance. Clinical outcomes including subjective scores, objective grades, postoperative reconstructed-knee and donor-site morbidity did not differ significantly between the two groups.

Conclusion

Primary ACLR using contralateral BPTB autograft confers earlier return-to-sport in the reconstructed knee without significant differences in clinical, strength or morbidity outcomes. It represents a viable, evidence-supported alternative to ipsilateral BPTB harvesting in appropriately selected patients.

Registration:

The study protocol was prospectively registered with the International Prospective Register of Systematic Reviews (PROSPERO) (Registration ID: CRD 420261391938).

Study Design: Systematic review and meta-analysis

Key points

Although the use of contralateral BPTB autografts in primary ACLR has been theorized to provide superior rehabilitation outcomes, its use has been controversial due to added donor-site morbidity. In this systematic review and meta-analysis, we show that contralateral BPTB autografts provided earlier return to sport times without compromising postoperative morbidity outcomes.

1. Background

Anterior cruciate ligament (ACL) injury is the most common ligamentous knee injury in athletes, with complete tear being the most common pattern of injury [1, 2]. The incidence of ACL injury continues to rise, with female athletes representing the population at greatest risk [3]. Indeed, the incidence of ACL injury increased by 2.3% annually among children and adolescents between 1994 and 2013.[4]. Management of ACL injuries in athletes is predominantly operative, with ACL reconstruction (ACLR) being more common than repair and its use increasing in parallel with injury incidence [5]. Paudel et al. reported that age-standardized annual incidence of primary ACLR increased from 40.6 to 51.2 per 100,000 population aged 10 years and older in 2023 [6].

A vital component of ACLR is graft selection, as this decision significantly influences donor-site morbidity, risk of graft failure, rehabilitation trajectory, and time-to-return-to-sport [7, 8]. The most commonly used graft choices are the hamstring tendon (HT) followed by bone-patellar-tendon-bone (BPTB) autografts [9]. Nevertheless, BPTB autografts remain a preferred graft choice particularly for young, high-demand athletes, owing to its robust cortical bone plugs, reliable bone-to-bone healing, and lower rupture rates compared with the HT autograft [7, 8, 10–12]. However, BPTB harvest is associated with notable donor-site sequelae including anterior knee pain, kneeling discomfort, and quadriceps weakness that can transiently impede rehabilitation [13, 14].

In current surgical practice, BPTB autografts are almost universally harvested from the ipsilateral (injured) knee [9]. This approach is intuitive in that it limits surgical insult to a single limb. However, the simultaneous demands of reconstruction recovery and donor-site healing on the same knee may constrain early rehabilitation, particularly quadriceps strengthening, during the critical first postoperative months [15]. An alternative strategy, harvesting the BPTB graft from the contralateral uninjured knee, has been proposed to address this limitation by distributing morbidity between two limbs, the reconstructed knee can focus rehabilitation efforts on range of motion and neuromuscular recovery, while the donor knee undergoes its own isolated recovery without the additional burden of ACL healing [13–16].

Despite this theoretical advantage, contralateral BPTB autograft harvest is infrequently adopted in clinical practice, due to concerns including bilateral lower extremity morbidity, the psychological burden of operating on the uninjured limb, a perceived risk of sensitizing the contralateral knee to future injury, and an absence of sufficiently powered, high-quality evidence [10]. Existing literature on this technique is fragmented, with most evidence drawn from single-center studies and heterogeneous surgical populations that mix BPTB and HT autografts, diluting the evidence specific to BPTB [9, 17].

A recent systematic review by Soeder et al. (2025) [9] examined clinical outcomes after ipsilateral versus contralateral autograft harvest across 11 study cohorts (n = 1,638 patients). However, that review included both BPTB and HT autograft studies. These two graft types differ substantially in donor site physiology, rehabilitation demands, and postoperative strength trajectories, potentially introducing heterogeneity and confounding the estimated effect of contralateral harvest.

This systematic review and meta-analysis addresses this gap by restricting analysis exclusively to studies using BPTB autografts, thereby providing graft-specific evidence to guide clinical decision-making. Our primary hypothesis was that contralateral BPTB autograft would be associated with earlier return-to-sport in the reconstructed knee, with comparable clinical outcome scores, donor-site morbidity, and complication rates relative to conventional ipsilateral BPTB primary ACLR.

2. Methods

2.1 Study design

This systematic review and meta-analysis was performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Table S1) [18]. The study protocol was prospectively registered with the International Prospective Register of Systematic Reviews (PROSPERO) (Registration ID: CRD 420261391938).

2.2 Data Sources and Search Terms

A comprehensive search was conducted on May 20th, 2026. The search included 5 electronic databases: PubMed, Cochrane Central Register of Controlled Trials (CENTRAL), Embase, Scopus and Web of Science for peer-reviewed articles. No date or language restrictions were applied. Reference lists of all included studies were screened for additional eligible publications. Full details of the search strategies are provided in Supplementary Materials.

2.3. Screening of Studies

All retrieved reports were imported into EndNote (Version 21) for deduplication and then uploaded to Rayyan for a second round of deduplication [19]. This was followed by title and abstract screening, which was carried out independently by two reviewers. Discrepancies were resolved by a third reviewer. Full texts of potentially eligible studies were independently retrieved and assessed by the same blinded reviewers according to predefined eligibility criteria. Disagreements were also reviewed and resolved by a third reviewer.

2.4 Eligibility Criteria

Studies were included if they met all of the following criteria: (1) enrolled skeletally mature human participants (2) involved primary ACLR only; (3) exclusively utilized a BPTB autograft as the donor tissue; (4) directly compared contralateral versus ipsilateral donor harvest within the same study; (5) reported at least one postoperative clinical or functional outcome; and (6) were original, peer-reviewed research articles published in English, employing either a randomized controlled trial or observational study design with full-text availability. Studies were excluded if they met any of the following criteria: (1) included mixed or multiple graft types within a comparison arm (e.g., BPTB versus HT autografts); (2) were non-original publications (e.g. narrative reviews or conference abstracts) case reports, or case series; (3) lacked reported postoperative outcomes; (4) involved duplicate patient populations; or (5) did not have full-text availability.

2.5 Outcomes

2.5.1 Postoperative Subjective Clinical Outcomes

Subjective clinical outcomes were assessed using validated patient-reported outcome measures, including:

- (1) International Knee Documentation Committee (IKDC) Subjective Score,
- (2) Lysholm Score,
- (3) Tegner Activity Level, and
- (4) Cincinnati Knee Rating System (KRS).

2.5.2 Postoperative Objective Clinical Outcomes

Objective clinical outcomes were evaluated using clinical examination and instrumented measures, including:

- (1) Lachman test grade,
- (2) Pivot-shift test grade,
- (3) Side-to-side anterior translation difference measured using KT-1000 or KT-2000 arthrometers.

2.5.3 Postoperative Rehabilitation Outcomes

Rehabilitation outcomes were assessed using the following parameters:

- (1) Postoperative knee flexion and extension strength, expressed as a percentage of preoperative or contralateral limb baseline,

(2) Time-to-return-to-sport.

2.5.4 Postoperative Complications Postoperative complications were assessed across two domains:

(1) Reconstructed-knee morbidity, including graft rupture, infection and patellar fractures,

(2) Donor-site morbidity, including pain scores and symptom-based assessments.

2.5.5 Operative Time

2.6 Data Extraction

Data was extracted independently by two reviewers using a standardized Microsoft Excel sheet. Each reviewer extracted data from included studies and then cross-verified each other's entries. Disagreements were resolved through consensus or consultation with a third reviewer. Study characteristics, participant demographics, and reported outcomes were extracted from article manuscripts. Additionally, supplementary materials and appendices of the published articles were thoroughly examined to identify any further relevant data.

2.7 Quality Assessment

The quality of the included studies was assessed by the same blinded data extraction reviewers and any discrepancies were resolved by a third reviewer. The methodological quality of non-randomized studies was assessed using the Newcastle-Ottawa Scale (NOS), which assesses eight methodological criteria across three domains: selection, comparability, and outcome assessment [20]. Randomized controlled trials (RCTs) were assessed using the Cochrane Risk-of-Bias 2 (RoB 2) tool [21]. This tool consists of five domains that assess potential sources of bias in RCTs: bias arising from the randomization process, bias due to deviations from intended interventions, bias due to missing outcome data, bias in the measurement of outcomes, and bias in the selection of the reported result. Judgements across these domains are used to generate an overall risk-of-bias assessment for each study, classified as low risk of bias, some concerns and high risk of bias.

2.8 Statistical Analysis

Characteristics of the included studies were presented in tables and narratively described. For side-to-side anterior translation difference and time-to-return-to-sport, pooled mean differences (MDs) with 95% confidence intervals (CIs) comparing primary ACLR using ipsilateral versus contralateral BPTB autografts were meta-analysed using a random-effects model with DerSimonian–Laird (DL) estimation [22]. Subjective outcomes were measured using different scales across studies; therefore, pooled effect estimates were expressed as standardised mean differences (SMDs) with their 95% CIs. SMDs were calculated using Hedges' g to account for small sample bias and were pooled using the random-effects model with DL estimation. When standard deviations (SDs) were not reported, they were estimated from available summary statistics, including interquartile ranges (IQRs), ranges, and other reported measures of dispersion, using the method proposed by Wan et al. (2014) [23]. Heterogeneity was assessed using the I^2 statistic, Cochrane's Q test, and τ^2 with I^2 cutoff values of 25%, 50% and 75% interpreted as low, moderate and high heterogeneity, respectively. Publication bias was assessed using Doi plots and Luis Furuya-Kanamori (LFK) indices [24]. Statistical analyses were conducted using Stata SE version 19.5 (College station, TX, USA) utilising the *metan* package. Planned subgroup and sensitivity analyses were not feasible due to the limited number of studies.

3. Results

3.1 Description of the Search and Selection of Studies

A systematic search of five electronic databases identified 1,834 records. After removal of 1,037 duplicates, 797 unique records underwent title and abstract screening. At this stage, 786 records were excluded as they did not meet the eligibility criteria, including lack of exclusive use of BPTB grafts, absence of comparison between ipsilateral and contralateral graft harvest, or failure to report outcomes of interest. The remaining 11 studies were advanced to full-text screening. Ultimately, seven studies which assessed BPTB autografts met the eligibility criteria for the present meta-analysis, comprising a total of 6,631 participants. The PRISMA flowchart is presented in Fig. 1.

3.2 Study Characteristics

The characteristics of the seven studies comparing the use of ipsilateral versus contralateral BPTB autografts for primary ACLR are summarized in Table 1. Among the included studies, only one was a RCT. The remaining studies were cohort studies, evenly divided between prospective and retrospective designs. All studies were published in English-language, peer-reviewed journals between 2000 and 2022. Sample sizes of included studies ranged between 30 and 5,364 reaching a total of 6,631 participants (Ipsilateral: 2,975; Contralateral: 3,656). Study follow-up durations ranged between 4 to 120 months. Geographically, all included reports were single-country studies. Three studies originated from the United States, whereas the remaining studies were conducted in Brazil, Germany, and Japan. Regarding demographic characteristics, mean age was reported in five of the seven included studies, with reported group means averaging approximately 27 years. Similarly, sex distribution was only reported in six of the seven included studies. Among the 1,267 participants for whom sex data were available, 785 (61.9%) were male. All 7 studies evaluated primary ACLR. Two studies used an arthroscopic approach, whereas three used a mini-arthrotomy; two studies did not specify the surgical technique.

Table 1
Characteristics of Included Studies (n = 7)

Study Lead Author (Year)	Design & LoE	Country	Patients, N (I / C)	Mean Age (yr) or Mean $\pm$ SD	Female (%)	Follow up	Approach	Risk of Bias Score
de Souza Borges et al. (2022) [25]	RCT, I	Brazil	44 / 44	I: 26.3 $\pm$ 6.2 C: 27.9 $\pm$ 8.9	0.0% both groups	4 mo	Arthroscopic	ROB-2: Some concerns
Sanada et al. (2021) [26]	Retrospective matched cohort, III	Japan	15 / 15	I: 19.7 C: 20.2	I: 20.0 C: 26.7	17.9 mo	NR	NOS: 6/9
de Souza Borges et al. (2020) [12]	Retrospective cohort, III	Brazil	25 / 25	I: 36 $\pm$ 7.53 C: 42 $\pm$ 7.36	I: 20.0 C: 12.0	120 mo	Arthroscopic	NOS: 5/9
Shelbourne et al. (2015) [16]	Prospective cohort, III	USA	58 / 279	I: 24.8 $\pm$ 9.5 C: 23.2 $\pm$ 8.9	I: 65.5 C: 50.9	48 mo	NR	NOS: 9/9
Benner et al. (2011) [27]	Prospective cohort, III	USA	2553 / 2811	NR	NR	Minimum 1 year	Mini-arthrotomy	NOS: 9/9
Mastrokalos et al. (2005) [14]	Retrospective cohort, III	Germany	52 / 48	NR	I: 38.5 C: 25.0	39.2 mo	Mini-arthrotomy	NOS: 7/9
Shelbourne & Urch (2000) [13]	Prospective cohort, III	USA	228 / 434*	I: 25.96 $\pm$ 9.0 C: 23.96 $\pm$ 8.7	I: 38.6 C: 38.5	48 mo	Mini-arthrotomy	NOS: 7/9

I = Ipsilateral; C = contralateral; RCT = randomized controlled trial; NR = not reported, LoE = level of Evidence; NOS = Newcastle-Ottawa Scale; RoB 2 = Version 2 of Cochrane risk-of-bias tool for RCT; * = analyzed: 208 / 275.

3.3 Postoperative Subjective Outcomes

A summary of postoperative subjective outcomes following primary ACLR using ipsilateral versus contralateral BPTB autografts is presented in Table 2. Four studies reported subjective clinical outcomes using a variety of validated instruments, including the Cincinnati KRS, Tegner Activity Scale, IKDC Subjective Score, Kujala Score, and SF-36 score [12, 14, 16, 26]. Mastrokalos et al. (2005) evaluated postoperative subjective outcomes using the Cincinnati KRS and Tegner Activity Scale [14]. No statistically significant differences were identified between the ipsilateral and contralateral groups for either outcome measure. Mean Cincinnati KRS scores were 82.0 (range, 41–100) and 83.7 (range, 43–100) in the ipsilateral and contralateral groups, respectively. Similarly, mean Tegner scores were 5.0 (range, 1–9) and 5.4 (range, 3–9), respectively. Shelbourne et al. (2015) assessed postoperative subjective knee function using the IKDC Subjective Score and, likewise, reported no significant difference between groups [16]. Mean IKDC scores were 88.9 $\pm$ 11.2 in the ipsilateral group and 88.8 $\pm$ 12.3 in the contralateral group. In contrast, de Souza Borges et al. (2020) reported significantly superior subjective outcomes in the contralateral BPTB group [12]. Median Kujala scores were 98 (IQR, 93–100) in the contralateral group compared with 92 (IQR, 83.5–98) in the ipsilateral group. Similarly, median SF-36 scores were higher in the contralateral group (131 [IQR, 122–133]) than in the ipsilateral group (124 [IQR, 106–132]), with both comparisons reaching statistical significance. Finally, Sanada et al. (2021) reported no significant difference in postoperative activity levels at

follow-up, with both groups demonstrating a median Tegner score of 9 (range, 6–10) [26]. Overall, the majority of included studies demonstrated comparable subjective outcomes following primary ACLR using ipsilateral and contralateral BPTB autografts. Although de Souza Borges et al. (2020) reported significantly better Kujala and SF-36 scores in the contralateral group, no significant differences were observed in the remaining subjective outcome measures [12].

Three of the reported postoperative subjective outcomes assess similar domains of knee function following primary ACLR including knee pain, symptoms, and stability [12, 14, 16]. These measures included the Cincinnati KRS, IKDC subjective score, and Kujala score. Accordingly, the results were standardized and pooled for meta-analysis. The pooled analysis demonstrated a non-significant trend favoring the ipsilateral FBPTB group. Moderate heterogeneity was observed across studies ($I^2 = 57.8\%$, $p = 0.093$). Assessment of publication bias using the Doi plot demonstrated major asymmetry (LFK index = -2.28), suggesting a high risk of publication bias (Figure S1).

Table 2
Summary of Postoperative Subjective Outcomes Following Primary ACLR Using Ipsilateral versus Contralateral BPTB Autografts

Study	n (I/C)	Instrument	Ipsilateral Score	Contralateral Score	Significance
Mastrokalos et al. (2005) [14]	52/48	Cincinnati KRS	82.0 (min-max 41–100)	83.7 (min-max 43–100)	NS
Mastrokalos et al. (2005) [14]	52/48	Tegner	5 (min-max 1–9)	5.4 (min-max 3–9)	NS
Shelbourne et al. (2015) [16]	58/279	IKDC	88.9 ± 11.2	88.8 ± 12.3	NS
de Souza Borges (2020) [12]	25/25	Kujala	92 (IQR 83.5–98)	98 (IQR 93–100)	S ($P < 0.01$)
de Souza Borges (2020) [12]	25/25	SF-36	124 (IQR 106–132)	131 (IQR 122–133)	S ($P = 0.036$)
Sanada et al. (2021) [26]	15/15	Tegner	9 (median) (min-max 6–10)	9 (median) (min-max 6–10)	NS
NS = not significant; IKDC = International Knee Documentation Committee; KRS = Knee Rating System; mo = months; I = ipsilateral; C = contralateral					

3.4 Postoperative Objective Clinical Outcomes

Five studies evaluated the effect of BPTB autograft type on postoperative side-to-side anterior translation difference, measured using KT-1000 or KT-2000 arthrometers (Fig. 2) [13, 14, 16, 26, 27]. The overall pooled MD calculated using the random effects model favored the use of contralateral BPTB autograft over ipsilateral BPTB autografts but did not reach statistical significance (MD = 0.12 [95% CI -0.11 to 0.35]). Interstudy heterogeneity was moderate ($I^2 = 49.3\%$, $P = 0.116$). Assessment of publication bias using the Doi plot revealed major asymmetry (LFK index = 3.38), suggesting a high risk of publication bias (Figure S2). Benner et al. (2011) also assessed side-to-side anterior tibial translation and found no statistically significant difference between the two groups, consistent with the findings of the other included studies evaluating this outcome [27]. Notably, this study was excluded from the meta-analysis because it did not report any measures of spread.

Beyond anterior translation, Sanada et al. (2021) also evaluated postoperative knee stability of the reconstructed knee using the Lachman and pivot-shift tests at final follow-up (Table 3) [26]. A negative Lachman test was achieved in 86.7% of both the ipsilateral and contralateral groups. Similarly, a negative Pivot-shift test was achieved in 80% of both ipsilateral and contralateral groups. No statistically significant differences were identified between groups for either outcome.

Table 3
Summary of Postoperative Objective Clinical Outcomes Following Primary ACLR Using Ipsilateral versus Contralateral BPTB Autografts

Study	n (I/C)	Outcome Measure	Ipsilateral	Contralateral		Significance
Mastrokalos et al. (2005) [14]	52/48	Anterior Translation Side-to-Side Difference (mm)*	0.6 (min-max 0.0–3.00)	0.6 (min-max 0.0–3.00)		NS
Shelbourne & Urch (2000) [13]	211/402	Anterior Translation Side-to-Side Difference (mm)†	2.2 ± 1.1	1.9 ± 1.3		P = .0361
Shelbourne et al. (2015) [16]	58/279	Anterior Translation Side-to-Side Difference (mm)†	1.7 ± 1.3	1.8 ± 1.2		NS
Sanada et al. (2021) [26]	15/15	Anterior Translation Side-to-Side Difference (mm)*	1.9 ± 1.9	1.3 ± 1.2		NS
Benner et al. (2011) [27]	2553 / 2811	Anterior Translation Side-to-Side Difference (mm)†	1.5	1.4		NS
Sanada et al. (2021) [26]	15/15	Lachman Test	Negative	86.7%	86.7%	NS
			Glide	13.3%	13.3%	
			Gross	0%	0%	
Sanada et al. (2021) [26]	15/15	Pivot-Shift Test	Negative	80%	80%	NS
			Glide	13.3%	13.3%	
			Gross	6.7%	6.7%	
NS = not significant; mm = millimetres; I = ipsilateral; C = contralateral; † = measured using KT-1000 arthrometers;						
* = measured using KT-2000 arthrometers						

3.5 Postoperative Rehabilitation Outcomes

3.5.1 Postoperative Strength Recovery

Table 4 summarizes postoperative extension and flexion strength in reconstructed and nonreconstructed knees across participants who underwent primary ACLR using ipsilateral versus contralateral BPTB autografts across a follow-up period ranging from 4–24 months. Postoperative knee strength was reported as percentage of the preoperative or contralateral limb baseline. Four studies evaluated postoperative knee quadriceps strength and one study additionally evaluated flexion strength [13, 16, 25, 26].

At early follow-up, Shelbourne and Urch (2000) reported significantly superior extension strength at 4–6 months in the contralateral group ($93 \pm 23\%$ vs. $83 \pm 24\%$) ($p = 0.003$) [13]. In the same cohort, this difference was not sustained at long-term follow-up (24 months), where no significant difference was observed (122 ± 30 vs 113 ± 27 ; $p = 0.407$). Similar to the findings of Shelbourne and Urch (2000), de Souza Borges et al. (2022) demonstrated a statistically significant advantage favouring the contralateral reconstructed knee at 4 months postoperatively ($P < 0.0001$) [13, 25]. However, the longevity of this effect could not be assessed, as no follow-up beyond 4 months was reported. While neither Shelbourne and Urch (2000) nor de Souza Borges et al. (2022) provided evidence of long-term strength outcomes, Shelbourne et al. (2015) reported a significant difference at 24 months favouring the contralateral group (116 ± 25 vs 105 ± 29 ; $p < 0.01$), suggesting superior quadriceps recovery following contralateral graft harvest [13, 16, 25].

Sanada et al. (2021) was the only study to evaluate postoperative strength outcomes in both reconstructed and non-reconstructed (graft donor) knees [26]. At 4–6 months postoperatively, the non-reconstructed knees in the ipsilateral group demonstrated significantly greater quadriceps strength than the graft knees in the contralateral group (118.7 ± 27.4 vs 74.5 ± 14.4 ; $p < 0.01$). This difference persisted at the 12-month follow-up, with the ipsilateral non-reconstructed knees continuing to exhibit significantly higher quadriceps strength compared with the contralateral graft knees (134.2 ± 22.9 vs 103.4 ± 11.5 ; $p < 0.01$). In contrast, no statistically significant differences in quadriceps strength were observed between reconstructed knees of the ipsilateral and contralateral groups at either 4–6 months or 12 months postoperatively. Although Sanada et al. (2021) reported significant differences in quadriceps strength between non-reconstructed knees and graft knees, the same pattern was not observed for hamstring strength [26]. Postoperative hamstring strength did not differ significantly between groups at either 4–6 or 12 months of follow-up. Similarly, no significant differences were identified in postoperative flexion strength when reconstructed knees from the ipsilateral and contralateral groups were compared.

Table 4
Postoperative Strength Outcomes – BPTB Autograft Studies (% of Preoperative Baseline)

Study	Group	Limb	Ext. 4–6 mo	Ext. 12 mo	Ext. 24 mo
Shelbourne & Urch (2000) [13]	Ipsilateral	Reconstructed Quadriceps	83 ± 24	—	113 ± 27
	Contralateral	Reconstructed Quadriceps	93 ± 23	—	122 ± 30
	P value		< 0.01	—	NS
Shelbourne et al. (2015)[16]	Ipsilateral	Reconstructed Quadriceps	—	—	105 ± 29
	Contralateral	Reconstructed Quadriceps	—	—	116 ± 25
	P value		—	—	< 0.01
Sanada et al. (2021) [26]	Ipsilateral	Non-reconstructed Quadriceps	118.7 ± 27.4	134.2 ± 22.9	—
	Contralateral	Graft knee Quadriceps	74.5 ± 14.4	103.4 ± 11.5	—
	P value		< 0.01	< 0.01	
Sanada et al. (2021) [26]	Ipsilateral	Reconstructed Quadriceps	81.5 ± 19.1	109.7 ± 18.3	—
	Contralateral	Reconstructed Quadriceps	88.8 ± 19.5	97.4 ± 8.4	—
	P value		NS	NS	
Sanada et al. (2021) [26]	Ipsilateral	Non-reconstructed Hamstring	134.6 ± 26.3	133.8 ± 25.7	—
	Contralateral	Graft knee Hamstring	127.6 ± 20.4	121 ± 24.9	—
	P value		NS	NS	
Sanada et al. (2021) [26]	Ipsilateral	Reconstructed Hamstring	120.9 ± 24	122.7 ± 34.6	—
	Contralateral	Reconstructed Hamstring	124.9 ± 9.5	112.1 ± 12.8	—
	P value		NS	NS	
de Souza Borges (2022) [25]	Ipsilateral	Reconstructed Quadriceps	NR	—	—
NS = not significant; mo = months; Ext. = extension strength; C = contralateral; NR = not reported					

Study	Group	Limb	Ext. 4–6 mo	Ext. 12 mo	Ext. 24 mo
	Contralateral	Reconstructed Quadriceps	Favors C	—	—
P value			< .0001		
NS = not significant; mo = months; Ext. = extension strength; C = contralateral; NR = not reported					

3.5.2 Time-To-Return-To-Sport

Three studies evaluated the effect of BPTB autograft laterality on time-to-return-to-sport following primary ACLR (Table 5) [13, 14, 26]. Participants who underwent primary ACLR using contralateral BPTB autografts returned to sport significantly sooner than those who received ipsilateral BPTB autografts. The pooled analysis using a random-effects model demonstrated a statistically significant MD of 0.99 months (95% CI, 0.37–1.60) in favor of contralateral graft harvest (Fig. 4). Moderate heterogeneity was observed across studies ($I^2 = 50.7\%$, $p = 0.131$). Assessment of publication bias using the Doi plot demonstrated no evidence of asymmetry (LFK index = 0.35), suggesting a low risk of publication bias (Figure S3).

Table 5
Summary of the Effect of Ipsilateral Versus Contralateral BPTB autografts on Return to Sport After Primary ACLR

Study	Ipsilateral (months)	Contralateral (months)	Difference	P value
Mastrokalos et al. (2005) [14]	7.8	7.4	– 0.4 mo	NS
Shelbourne & Urch (2000) [13]	6.1 ± 2.2	4.9 ± 2.1	–1.2 mo	< .01
Sanada et al. (2021) [26]	8.0 (min-max 6–11)	6.5 (min-max 5–8.5)	–1.5 mo	.012

NS = not significant; mo = months; negative difference indicates earlier return in contralateral group. Data are reported as mean or mean ± SD.

3.6 Postoperative Complications

3.6.1 Reconstructed-Knee Morbidity

Table 6 illustrates a summary of postoperative reconstructed-knee morbidity following primary ACLR using ipsilateral versus contralateral BPTB autografts. Five studies reported graft rupture data. Overall, the ipsilateral group experienced 7 graft ruptures among 2,872 reconstructed knees (0.24%), whereas 8 graft ruptures occurred among 3,193 reconstructed knees (0.25%) in the contralateral group [13, 14, 25–27]. No study reported a statistically significant difference in graft rupture rates between groups. Infection data were reported by four studies [13, 14, 25–27]. Among 2,857 participants who underwent primary ACLR using an ipsilateral BPTB autograft, 9 infections were reported at follow-up (0.31%) in the reconstructed knee. In the contralateral group, 3 infections occurred in reconstructed knees among 3,178 participants (0.13%). No statistically significant differences in infection rates were identified between groups. Data on patellar fractures involving the reconstructed knee were reported by only two studies [13, 14]. No patellar fractures were observed at follow-up among participants for whom these data were available.

Table 6
Summary of Postoperative Reconstructed-Knee Morbidity Rates in ACL-Reconstructed Knees Following Primary ACLR Using Ipsilateral Versus Contralateral BPTB Autografts

Study Lead Author (Year)	Graft Rupture	Infection	Patellar fracture
Mastrokalos et al. (2005) [14]	I: 0	I: 0	I: 0
	C:0	C:0	C:0
	NS	NS	NS
Shelbourne & Urch (2000) [13]	I:0	I: 0	I: 0
	C: 0	C:0	C:0
	NS	NS	NS
de Souza Borges et al. (2020) [12]	NR	NR	NR
de Souza Borges et al. (2022) [25]	I: 0	I: 0	NR
	C: 0	C:0	
	NS	NS	
Sanada et al. (2021) [26]	I: 1/15	NR	NR
	C: 1/15		
	NS		
Shelbourne et al. (2015) [16]	NR	NR	NR
Benner et al. (2011) [27]	I:6/2553	I: 9/2553	NR
	C:7/2811	C: 3/2811	
	P = 0.92	P = 0.12	
I = ipsilateral; C = contralateral; NR = not reported; NS = not significant			

3.6.2 Donor Site Morbidity

Donor-site morbidity following BPTB harvest was assessed in four of the seven BPTB studies, across 6,035 participants [13, 14, 25, 27]. Mastrokalos et al. (2005) evaluated postoperative donor-site morbidity using two approaches: subjective patient-reported outcomes collected via questionnaires assessing tenderness, kneeling pain, and other donor-site symptoms, and objective donor-site complications. Subjectively, Mastrokalos et al. (2005) reported that in among 48 patients who underwent primary ACLR using contralateral BPTB autografts with a mean follow-up of 31.7 months, 85.4% of donor knees were symptomatic [14]. Specifically, 58.3% reported local tenderness, 70.9% reported kneeling pain, and 70.8% reported knee-walking pain [14]. Importantly, comparable rates of donor-site symptoms were observed in the ipsilateral BPTB group, suggesting that these symptoms reflect an intrinsic morbidity associated with patellar tendon harvest rather than being exacerbated by contralateral harvesting [14]. Objectively, Mastrokalos et al. (2005) reported one patellar tendon rupture in a contralateral donor knee in an athlete at 8 months postoperatively, which required patellar tendon repair using a semitendinosus autograft [14]. In addition, one participant developed chronic patellar tendinopathy in the contralateral donor knee. Similarly, Shelbourne and Urch (2000) reported one patient that was unable to return to full sporting activity at 6 months postoperatively due to donor-knee pain [13]. Benner et al. (2011) reported one donor-site infection among 2,811 contralateral donor knees, whereas de Souza Borges et al. (2022) reported no donor-site morbidity at follow-up [27].

3.7 Operative Time

Operative time was not evaluated in any of the included studies. This gap represents a limitation in the literature, as contralateral harvest may require repositioning and additional setup time.

3.8 Quality Assessment of Included Studies

The methodological quality of included studies was assessed using tools appropriate to each study design. Cohort studies were evaluated using the NOS, whereas the single RCT was assessed using the RoB-2 tool [20, 21]. Regarding cohort studies, NOS total quality scores ranged from 5 to 9 with an average of 7.2. Benner et al. (2011) and Shelbourne et al. (2015) each achieved a 9 which is the highest achievable score on the NOS scale, indicating excellent methodological quality with a minimal risk of bias [16, 27]. In contrast, de Souza Borges et al. (2020) achieved the lowest score of 5 out of 9, with points deducted due to lack of baseline outcome measurement, failure to control for important confounders beyond age and sex, and high attrition resulting in only 55% follow-up at 10 years [12]. As for the only RCT included, de Souza Borges et al. (2022) was judged to have 'some concerns' overall [25]. Points were primarily deducted due to the inability to blind participants and surgical personnel to the assigned graft technique, an inherent limitation of surgical trials. Nevertheless, no major concerns were identified regarding the randomization process, missing outcome data, outcome measurement, or selective reporting.

4. Discussion

This systematic review and meta-analysis comprehensively evaluated postoperative outcomes following primary ACLR using ipsilateral versus contralateral BPTB autografts. Across six cohort studies and one RCT, encompassing 6,631 participants, the use of contralateral BPTB autograft for primary ACLR demonstrated a statistically significant benefit in time-to-return-to-sport (MD = 0.99 months [95% CI, 0.37–1.60]). However, it showed no statistically significant improvement in postoperative subjective, objective, strength, or postoperative morbidity outcomes as compared to the use of ipsilateral BPTB autografts. These findings suggest that contralateral BPTB harvest may represent a viable alternative to the traditional ipsilateral approach without compromising postoperative outcomes. Nevertheless, these results should be interpreted with caution given the moderate-to-high heterogeneity across all included studies, stemming from the small number of studies included in the analysis, as well as differences in surgical technique, rehabilitation protocols, follow-up duration, and patient characteristics.

The rationale for using contralateral BPTB autografts over ipsilateral grafts has been the subject of considerable debate and controversy. Traditionally, contralateral BPTB autografts have been reserved for cases in which the ipsilateral patellar tendon is unsuitable for harvest, such as insufficient graft tissue or intraoperative graft contamination [9]. This practice likely reflects concerns regarding the potential for increased donor-site morbidity associated with operating on an otherwise healthy contralateral knee [16]. Nevertheless, several experts advocate for the routine use of contralateral BPTB autografts even in the absence of these indications. The rationale underlying this approach is that harvesting the BPTB autograft from the contralateral knee may facilitate postoperative rehabilitation by allowing competing rehabilitation objectives to be distributed between the two knees [16]. In this manner, the reconstructed knee can primarily focus on restoring joint function and stability, while the donor knee focuses on extensor mechanism and quadriceps strength recovery [16]. Owing to these theoretical advantages, several studies have evaluated whether contralateral BPTB autografts improve postoperative outcomes compared with the ipsilateral approach.

In the present study, comparison of subjective outcomes between the two groups was challenging, because included studies employed patient-reported outcomes measures that assess varying components of a patient's postoperative course. Nevertheless, scoring instruments evaluating similar domains, particularly knee pain and stability were standardized and pooled for meta-analysis, revealing no statistically significant difference in postoperative subjective outcomes between the two groups. Beyond the quantitative synthesis, additional patient-reported outcome measures that were not included in the standardization process, such as the SF-36 and Tegner activity scores assessed by de Souza Borges et al. (2022) and Mastrokalos et al. (2005), respectively, also showed no statistically significant differences

between groups [14, 25]. These findings suggest a consistent pattern across multiple assessment tools, indicating comparable subjective postoperative outcomes regardless of graft selection. Collectively, These findings are consistent with previous systematic reviews by Fan et al. (2023) and Soeder et al. (2025), both of which reported comparable subjective outcomes between ipsilateral and contralateral autografts [9, 17]. Notably, these studies were not limited to BPTB autografts and instead included a broader range of graft types, including HT autografts.

Similar findings were observed for postoperative objective outcomes, which were comparable between ipsilateral and contralateral BPTB autografts. The primary objective measure reported across studies was side-to-side anterior translation difference, assessed using KT arthrometers. A meta-analysis of four studies reporting this outcome demonstrated no significant difference in postoperative knee laxity between groups. This lack of difference is biologically plausible, as anterior knee stability is primarily determined by graft placement, fixation method, and biological incorporation rather than rehabilitation-related factors. Consistent with this, secondary clinical stability assessments, including the Lachman and pivot-shift tests assessed by Sanada et al. (2021) also demonstrated no meaningful differences between groups across the included studies [26].

The return-to-sport difference is one of the most clinically relevant findings of this meta-analysis and systematic review. Participants who underwent primary ACLR using contralateral BPTB autografts returned to sport significantly earlier (MD = 0.99 months; 95% CI, 0.37–1.60) compared with those who received ipsilateral BPTB autografts. This finding is consistent with Soeder et al. (2022), who also reported a significantly shorter time-to-return-to-sport following primary ACLR using contralateral BPTB autografts [9]. These findings are particularly important for athletes, especially given the absence of meaningful differences in subjective or objective outcomes between graft types.

Postoperative quadriceps and hamstring strength are central functional outcomes following ACLR, particularly when comparing ipsilateral and contralateral BPTB autografts due to potential differences in rehabilitation loading between limbs. In the present meta-analysis and systematic review, no consistent long-term differences in quadriceps or hamstring strength were observed between ipsilateral and contralateral reconstruction groups. Although some individual studies demonstrated an early advantage in quadriceps strength in the contralateral group at 4–6 months postoperatively, this effect was not consistently sustained at longer follow-up, with later timepoints showing convergence between groups. These findings are in agreement with the systematic review by Soeder et al. (2025), which similarly reported that most included studies demonstrated no significant differences in flexion or extension strength at any postoperative timepoint [9]. While that review identified isolated inconsistencies such as transient reductions in extension strength in contralateral donor limbs, the overall synthesis supported equivalence in strength recovery between graft strategies. Similarly, the systematic review by Fan et al. (2023) further reinforces these findings, reporting no significant differences in isometric quadriceps or hamstring strength, isokinetic torque, or flexion strength between contralateral and ipsilateral ACLR groups across multiple timepoints [17]. Taken together, the current evidence suggests that while contralateral BPTB grafts may facilitate earlier subjective or functional progression in some cohorts, likely due to distribution of rehabilitation load across both lower limbs, this does not translate into sustained differences in objective strength outcomes. Overall, both ipsilateral and contralateral BPTB techniques appear to achieve comparable medium- to long-term recovery of quadriceps and hamstring strength following primary ACLR.

The risk of postoperative reconstructed-knee and donor-site complications remains a theoretical concern, particularly given the evidence suggesting increased rates of contralateral ACL injury following primary ACLR. In this review, no statistically significant differences in reconstructed-knee morbidity including graft rupture, infection and patellar fracture were observed between groups. This is likely because these outcomes are primarily determined by surgical technique, sterility, fixation method, and biological healing capacity rather than graft harvest laterality. Because both groups utilise the same tendon source, intrinsic tissue characteristics are expected to be comparable, further supporting the absence of differences in reconstructed-knee morbidity. Regarding donor-site morbidity, only Mastrokalos et al. (2005) performed a formal comparative analysis using a questionnaire assessing local knee tenderness, kneeling pain, and knee-walking pain

[14]. Their findings demonstrated comparable donor-site morbidity between groups, suggesting that these symptoms are intrinsic consequences of BTPB harvest rather than being exacerbated by contralateral graft use. de Souza Borges et al. (2020) further supports this, demonstrating no significant differences at 10-year follow-up in patellofemoral symptoms or quality-of-life measures between groups [12]. Collectively, these findings suggest that donor-site morbidity alone should not preclude contralateral BPTB autograft use. Nevertheless, isolated cases of patellar tendon rupture, chronic patellar tendinopathy, and persistent donor-knee pain were reported exclusively in the contralateral groups by Mastrokalos et al. (2005) and Shelbourne and Urch (2000) [13, 14]. Notably, such chronic donor-site complications were not reported in ipsilateral groups, which may warrant further investigation into whether contralateral harvesting carries a distinct long-term donor-knee risk profile.

This is the first systematic review and meta-analysis specifically comparing ipsilateral and contralateral BPTB autografts in primary ACLR, addressing a previously underexplored clinical question. A key strength is the restriction to BPTB grafts only, unlike previous reviews that combined heterogeneous graft types such as hamstring autografts. This methodological focus reduces clinical heterogeneity and allows for a more precise comparison between the two BPTB approaches. The review also benefits from its comprehensive assessment of outcomes, including patient-reported subjective outcomes, objective knee function, strength measures, return-to-sport rates, and both reconstructed-knee and donor-site morbidity. This broad scope provides a more complete and clinically meaningful evaluation of postoperative recovery. Nevertheless, this study harbors several important limitations. First, included studies varied in surgical approaches, patient demographics, rehabilitation protocols, and outcome reporting intervals contributed to relatively high heterogeneity across several meta-analyses, with even the lowest estimates indicating moderate heterogeneity. Incomplete reporting of summary statistics also required the manual estimation of standard deviations from reported measure of spread in some studies. Although these estimates were derived using established methods, they may have introduced additional imprecision into the pooled analyses. Similarly, subjective outcomes were assessed using a variety of measurement instruments across studies. To facilitate quantitative synthesis, outcomes evaluating comparable constructs were standardized using the Hedges' g method; however, this process may have introduced further measurement uncertainty and should be considered when interpreting the pooled estimates. In addition, in a subset of studies, the timing of outcome assessment was not clearly reported and could not be reliably determined from the full text or supplementary materials. These studies were, nevertheless, included in the meta-analyses, which may have introduced additional clinical heterogeneity due to potential variation in follow-up time points across studies. Specifically, for the meta-analysis of side-to-side anterior translation difference, two studies reported outcomes at 1 year postoperatively, one study at 2 years, and one study did not specify the timing of assessment. Although objective measures of knee stability following ACLR are generally considered to stabilize after the first postoperative year, these differences in follow-up duration, particularly the inclusion of a study with an unspecified assessment time point, may have influenced the pooled estimates and reduce confidence in the comparability of this outcome across studies. A similar limitation applies to subjective outcomes, as follow-up ranged from 1 to 10 years and was not clearly reported in at least one study. Given that patient-reported outcomes may change substantially over time, these differences in follow-up duration may have introduced clinical heterogeneity and influenced the pooled estimates. None of the included studies stratified outcomes according to concomitant injuries, such as meniscal tears, or anterolateral ligament injuries, despite these factors having the potential to influence rehabilitation trajectories and return-to-sport timelines. Moreover, the predominance of cohorts originating from a limited number of surgeons and centres raises the possibility of centre-specific effects and may restrict the generalizability of the findings owing to differences in surgical technique and rehabilitation practices. Finally, none of the included studies investigated the effect of graft laterality on operative time, an important outcome that may have a significant impact on infection rates and overall morbidity. Collectively, these limitations highlight the need for future research to prioritise adequately powered multicentre RCTs incorporating standardised outcome definitions, graft-specific subgroup analyses, and long-term follow-up to address these gaps in the evidence.

5. Conclusion

This systematic review and meta-analysis demonstrates that primary ACLR using contralateral as compared to ipsilateral BPTB autografts may facilitate earlier return-to-sport without compromising knee stability or increasing donor-site morbidity. These findings support contralateral BPTB autografts as clinically viable alternatives to conventional ipsilateral harvest particularly in high-demand athletes for whom earlier return-to-sport is a priority. Surgeons may consider offering contralateral BPTB ACLR with appropriate patient counseling, recognizing that bilateral limb rehabilitation is required and long-term morbidity appears comparable to standard ipsilateral techniques. Large, multicenter RCTs with standardized outcome definitions and reporting are warranted to validate these findings and strengthen evidence-based recommendations regarding graft selection in primary ACLR.

Abbreviations

ACL
anterior cruciate ligament
ACLR
anterior cruciate ligament reconstruction
BPTB
bone-tendon pateller bone
HT
hamstring tendon
PRISMA
Preferred Reporting Items for Systematic Reviews and Meta-Analyses
IKDC
International Knee Documentation Committee Subjective Score
KRS
knee rating system
RCT
randomized controlled trial
NOS
Newcastle-Ottawa Scale
RoB-2
Risk-of-Bias 2
DL
DerSimonian–Laird
MD
mean differences
SMD
standardised mean difference
LFK
Luis Furuya-Kanamori index
CIs
confidence intervals
SD
standard deviations
IQR
interquartile range
RE
random effects.

Declarations

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Availability of data and materials:

All data generated or analysed during this study are included in this published article and its supplementary information files]

References

1. Alsubaie, S.F., et al., *Anterior cruciate ligament injury patterns and their relationship to fatigue and physical fitness levels - a cross-sectional study*. Medicine (Baltimore), 2021. **100**(1): p. e24171.
2. Evans J, M.A., Nielson JI. , *Anterior Cruciate Ligament Knee Injury*. . 2023.
3. Bloom, D.A., et al., *ACL Injuries Aren't Just for Girls: The Role of Age in Predicting Pediatric ACL Injury*. Sports Health, 2020. **12**(6): p. 559-563.
4. Beck, N.A., et al., *ACL Tears in School-Aged Children and Adolescents Over 20 Years*. Pediatrics, 2017. **139**(3).
5. Vieider, R.P., et al., *Precision anterior cruciate ligament (ACL) reconstruction in high-level athletes*. Ann Jt, 2026. **11**: p. 10.
6. Paudel, Y.R., M. Sommerfeldt, and D. Voaklander, *Increasing incidence of anterior cruciate ligament reconstruction: a 17-year population-based study*. Knee Surg Sports Traumatol Arthrosc, 2023. **31**(1): p. 248-255.
7. Lin, K.M., et al., *Graft Selection in Anterior Cruciate Ligament Reconstruction*. Sports Med Arthrosc Rev, 2020. **28**(2): p. 41-48.
8. Lind, M., F. Menhert, and A.B. Pedersen, *The first results from the Danish ACL reconstruction registry: epidemiologic and 2 year follow-up results from 5,818 knee ligament reconstructions*. Knee Surg Sports Traumatol Arthrosc, 2009. **17**(2): p. 117-24.
9. Soeder, J.S., et al., *Clinical Outcomes After Ipsilateral Versus Contralateral Autograft Harvest for Anterior Cruciate Ligament Reconstruction: A Systematic Review*. Orthop J Sports Med, 2025. **13**(3): p. 23259671241310808.
10. Magnussen, R.A., et al., *ACL Graft and Contralateral ACL Tear Risk within Ten Years Following Reconstruction: A Systematic Review*. JBJS Rev, 2015. **3**(1).
11. Zhao, D., et al., *Risk Factors for Revision or Rerupture After Anterior Cruciate Ligament Reconstruction: A Systematic Review and Meta-analysis*. Am J Sports Med, 2023. **51**(11): p. 3053-3075.
12. de Souza Borges, B.d.M.P.M.a., Carlos Vitor Luz Nunes Lial, Anderson Freitas, Bruno Santos Leal Campos, Paulo Lobo Junior, *Patellofemoral disorders and quality of life after primary anterior cruciate ligament reconstruction – comparison between ipsilateral and contralateral techniques using bone-patellar tendon-bone graft after 10 years*. 2020.

13. Shelbourne, K.D. and S.E. Urch, *Primary anterior cruciate ligament reconstruction using the contralateral autogenous patellar tendon*. Am J Sports Med, 2000. **28**(5): p. 651-8.
14. Mastrokalos, D.S., et al., *Donor site morbidity and return to the preinjury activity level after anterior cruciate ligament reconstruction using ipsilateral and contralateral patellar tendon autograft: a retrospective, nonrandomized study*. Am J Sports Med, 2005. **33**(1): p. 85-93.
15. Shelbourne, K.D. and C. Klotz, *What I have learned about the ACL: utilizing a progressive rehabilitation scheme to achieve total knee symmetry after anterior cruciate ligament reconstruction*. J Orthop Sci, 2006. **11**(3): p. 318-25.
16. Shelbourne, K.D., M.B. Beck, and T. Gray, *Anterior cruciate ligament reconstruction with contralateral autogenous patellar tendon graft: evaluation of donor site strength and subjective results*. Am J Sports Med, 2015. **43**(3): p. 648-53.
17. Fan, D., J. Ma, and L. Zhang, *Contralateral grafts have comparable efficacy to ipsilateral grafts in anterior cruciate ligament reconstructions: a systematic review*. J Orthop Surg Res, 2023. **18**(1): p. 596.
18. Page, M.J., et al., *The PRISMA 2020 statement: an updated guideline for reporting systematic reviews*. BMJ, 2021. **372**: p. n71.
19. Ouzzani, M., et al., *Rayyan-a web and mobile app for systematic reviews*. Syst Rev, 2016. **5**(1): p. 210.
20. Wells, G.A., Brodsky, L., O'Connell, D., Shea, B., Henry, D., Mayank, S. and Tugwell, P, *An Evaluation of the Newcastle Ottawa Scale: An Assessment Tool for Evaluating the Quality of Non-Randomized Studies*. 2000.
21. Sterne, J.A.C., et al., *RoB 2: a revised tool for assessing risk of bias in randomised trials*. BMJ, 2019. **366**: p. l4898.
22. DerSimonian, R. and N. Laird, *Meta-analysis in clinical trials*. Control Clin Trials, 1986. **7**(3): p. 177-88.
23. Wan, X., et al., *Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range*. BMC Med Res Methodol, 2014. **14**: p. 135.
24. Furuya-Kanamori, L., J.J. Barendregt, and S.A.R. Doi, *A new improved graphical and quantitative method for detecting bias in meta-analysis*. Int J Evid Based Healthc, 2018. **16**(4): p. 195-203.
25. de Souza Borges, J.H., et al., *Is contralateral autogenous patellar tendon graft a better choice than ipsilateral for anterior cruciate ligament reconstruction in young sportsmen? A randomized controlled trial*. Knee, 2022. **36**: p. 33-43.
26. Sanada, T., et al., *Muscle strength after the anterior cruciate ligament reconstruction via contralateral bone-tendon-bone autograft*. J Exp Orthop, 2021. **8**(1): p. 86.
27. Benner, R.W., K.D. Shelbourne, and H. Freeman, *Infections and patellar tendon ruptures after anterior cruciate ligament reconstruction: a comparison of ipsilateral and contralateral patellar tendon autografts*. Am J Sports Med, 2011. **39**(3): p. 519-25.

Figures

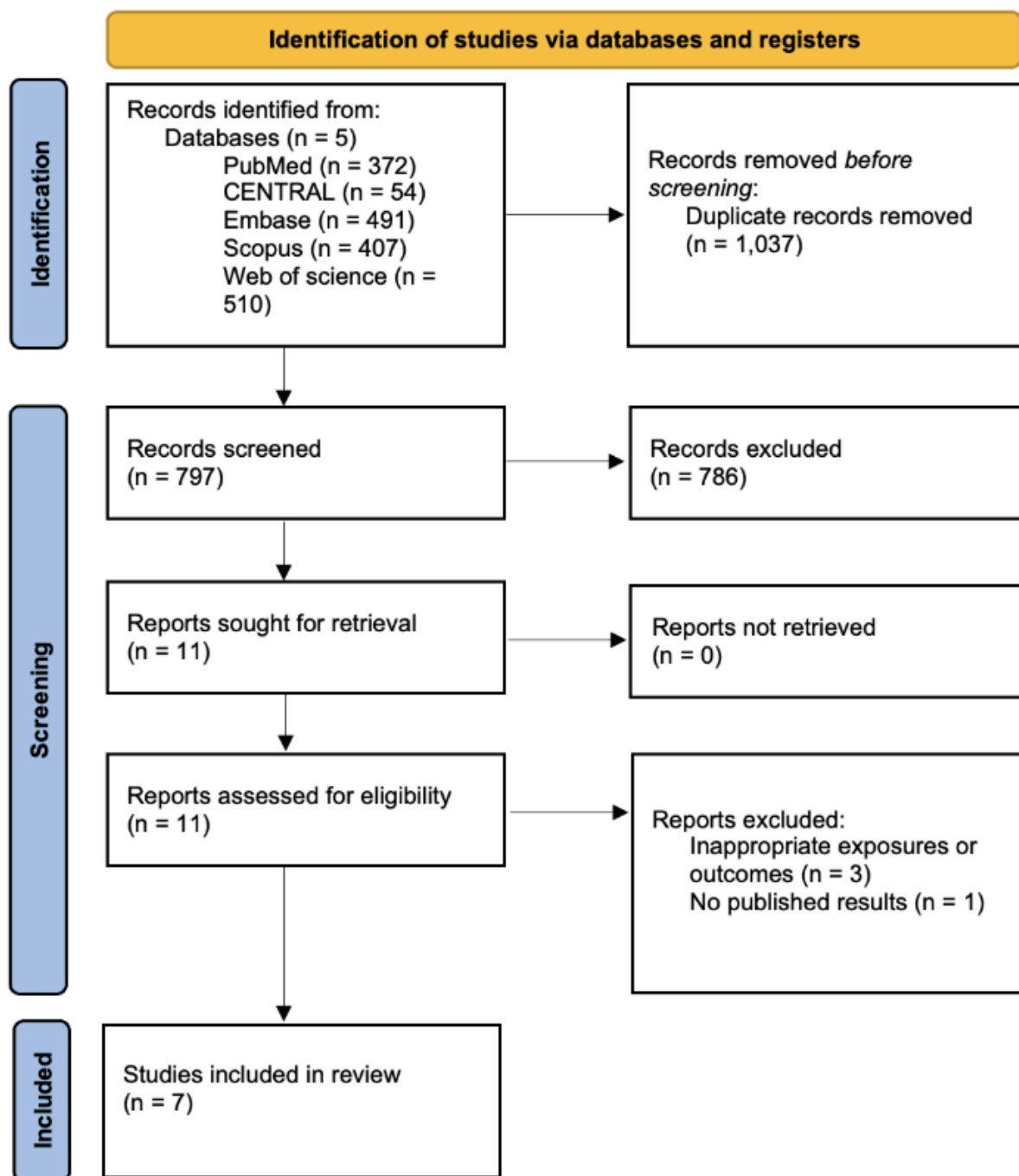


Figure 1

PRISMA flow chart illustrating the identification, screening, and inclusion of studies in the current systematic review and meta-analysis.

Meta-Analysis of Subjective Outcomes After ACL Reconstruction: Ipsilateral vs Contralateral Graft

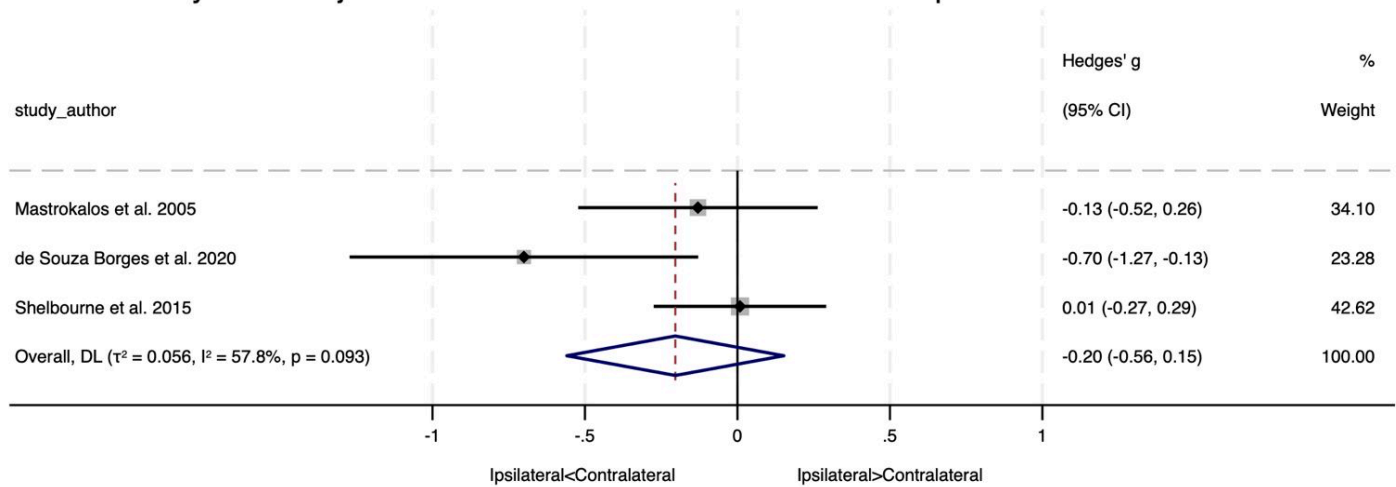


Figure 2

Forest plots demonstrating the standardized mean differences (Hedges' g) in postoperative subjective outcomes following primary ACLR using ipsilateral versus contralateral BPTB autografts. Horizontal lines represent 95% CIs, squares indicate the point estimate for each study with size proportional to the study weight, and diamonds represent the pooled effect size using the random effects model. The solid vertical line represents the line of no effect (mean difference of change = 0).

Meta-Analysis of Mean Difference of Anterior Translation After ACL Reconstruction: Ipsilateral vs Contralateral Graft

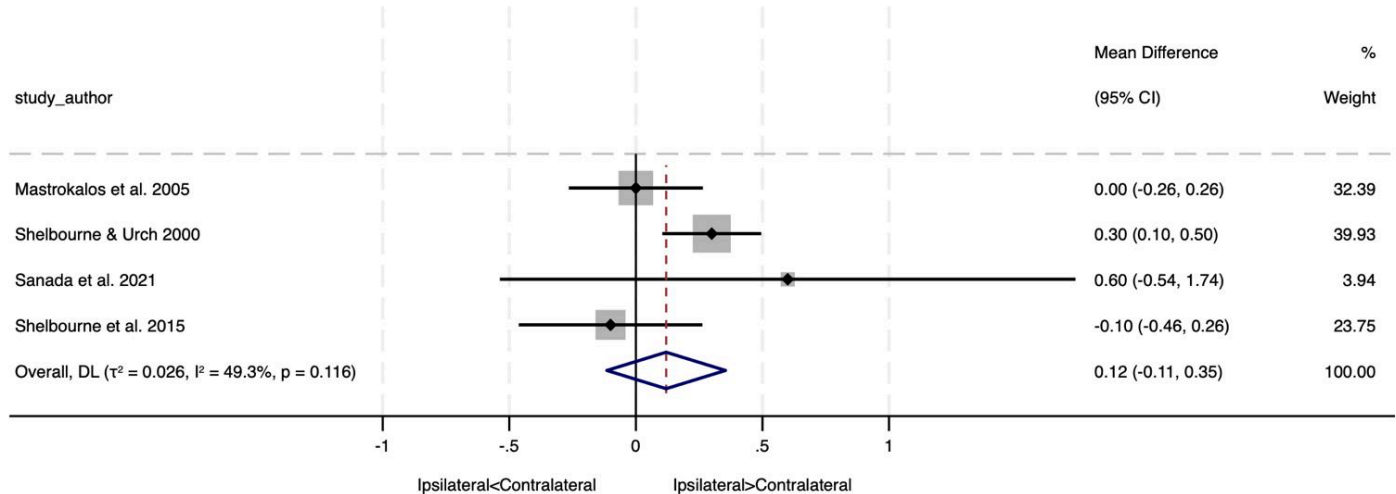


Figure 3

Forest plots demonstrating the pooled mean difference in postoperative side-to-side anterior translation difference following primary ACLR using ipsilateral versus contralateral BPTB autografts. Horizontal lines represent 95% CIs, squares indicate the point estimate for each study with size proportional to the study weight, and diamonds represent the pooled effect size using the random effects model. The solid vertical line represents the line of no effect (mean difference of change = 0).

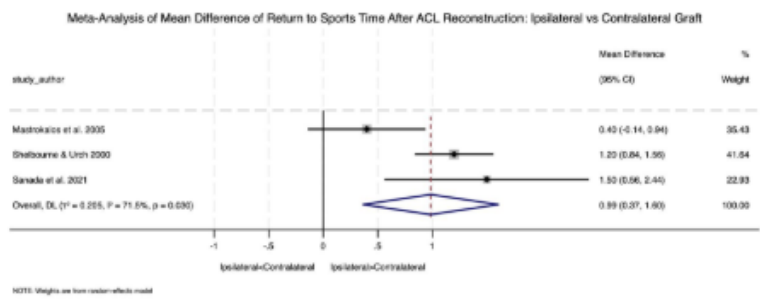


Figure 4

Forest plot demonstrating the pooled M in return to sport after primary ACLR using ipsilateral versus contralateral BPTB autografts. Horizontal lines represent 95% CIs, squares indicate the point estimate for each study with size proportional to the study weight, and diamonds represent the pooled effect size using the random effects model. The solid vertical line represents the line of no effect (MD of change = 0).

Supplementary Files

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