

Hamstring autograft versus patellar tendon autograft for anterior cruciate ligament reconstruction, which graft has a higher contralateral anterior cruciate ligament injury rate?

A meta-analysis of 5561 patients following the PRISMA guidelines

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Abstract

Background: Contralateral anterior cruciate ligament (CACL) injury is one of the devastating complications after anterior cruciate ligament (ACL) reconstruction. Whether the risk of CACL tear is related to graft selection remains controversial due to contradictory results in studies. There are no meta-analyses to compare which graft has a higher CACL injury rate. Hence, this meta-analysis was conducted to compare the incidence of the CACL injury after ACL reconstruction with bone-patellar tendon-bone (BPTB) autografts compared with hamstring (HT) autografts.

Methods: A comprehensive search of literature published between 1980 and January 2020 was performed using MEDLINE, EMBASE, Web of Science, and the Cochrane Library databases. RevMan 5.3 software was used for meta-analysis. The overall risk ratio (RR) was calculated using a fixed- or random-effects. The heterogeneity among the included results was analyzed by chi-square test with significance set at $P < .10$, and the heterogeneity was quantitatively detected by I-square tests.

Results: Fifteen prospective comparative studies met inclusion criteria. In the BPTB group, the CACL rupture rate ranged from 1.8% to 30%, with a pooled percentage of 8.5%. In the HT group, the CACL rupture rate ranged from 0% to 14.4%, with a pooled percentage of 3.3%. The overall CACL rupture rate was 3.1% and ranged from 1.1% to 27.1%, with a pooled percentage of 4.9%. The pooled results indicate that there was a statistical significant difference in CACL rupture risk rate between BPTB and HT autograft. (RR, 1.53; 95% CL, 1.21–1.91; $P = .0004$).

Conclusion: This review showed that patients undergoing primary ACL reconstruction with BPTB autograft were more likely to have CACL rupture than patients treated with HT autograft.

Abbreviations: ACL = anterior cruciate ligament, BPTB = bone-patellar tendon-bone, CACL = contralateral anterior cruciate ligament, CI = confidence interval, HT = hamstring tendon, RCTs = randomized controlled trials, RR = risk ratio.

Keywords: anterior cruciate ligament, autograft, contralateral, hamstring tendon, patellar tendon

Editor: Jose Muyor.

PZ, J-CL, and X-TD have contributed equally to this article and should be listed as co-first author.

This research is supported by Cooperation program between Sichuan university and Luzhou municipal people's government (No. 2019cdlz-17).

Availability of supporting data: The present study was a review of previous published literatures.

Ethics approval and consent to participate: Not applicable. This paper does not involve research on humans. The datasets generated during and/or analyzed during the current study are publicly available.

The authors have not conflicts of interest to disclose.

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

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How to cite this article: Zhou P, Liu JC, Deng XT, Li Z. Hamstring autograft versus patellar tendon autograft for anterior cruciate ligament reconstruction, which graft has a higher contralateral anterior cruciate ligament injury rate? A meta-analysis of 5561 patients following the PRISMA guidelines. *Medicine* 2020;99:31(e21540).

Received: 31 January 2020 / Received in final form: 25 June 2020 / Accepted: 2 July 2020

<http://dx.doi.org/10.1097/MD.00000000000021540>

1. Introduction

Anterior cruciate ligament (ACL) tears are quite common injuries in sports and represent >50% of knee injuries,^[1] leading to episodic instability, meniscal and articular cartilage damage, and early joint degeneration.^[2–4] The prevalence of ACL injuries continues to rise as gradually increasing sports injuries and traffic accident injuries. At present, ACL reconstruction has become one of the most common orthopedic surgeries.

Either a subsequent rupture of the contralateral ACL (CACL) or graft is unacceptable to individuals who have undergone ACL reconstruction. Understanding the risk factors for rupture of the CACL or graft is important for us to provide preoperative counseling and appropriate postoperative rehabilitation for our patient. Some studies reported that age,^[4–7] sex,^[8–10] time to surgery,^[6,7,11] and activity level^[11] were increased risk for contralateral ACL reconstruction. Although previous studies have reported that the risk of tear on the contralateral side was significantly greater than the risk of graft rupture at long-term,^[12,13] however, compared with the number of studies related to the risk factors for graft rupture, the risk factors for CACL injury after ACL reconstruction are less reported.

It is well known that the selection of graft is an important factor affecting ACL reconstruction. During the past decades, hamstring tendon (HT) and bone-patellar tendon (middle 1/3)-bone (BPTB) autografts are the most used grafts for ACL reconstruction.^[14–16] Reconstructed ACL graft rupture more commonly occurred in the hamstring autograft than in the patellar tendon autograft.^[17–19] However, whether the risk of CACL tear is related to graft selection remains controversial due to contradictory results^[6,9,14,20–22] in previous studies. Therefore, the purpose of this meta-analysis was to evaluate which graft type (BPTB versus HT autografts) yields the higher odds of CACL injury after ACL reconstruction.

2. Methods

2.1. Literature search

A systematic review was performed according to the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).^[23] A comprehensive search of literature published between 1980 and January 2020 was performed using PubMed, EMBASE, Web Of Science, and the Cochrane Library databases. Two independent reviewers (PZ and X-TD) searched each database using the following search terms: (anterior cruciate ligament reconstruction or ACL reconstruction) and (bone patellar tendon bone grafts or patellar or bone tendon bone or BPTB) and (hamstring tendon OR semitendinosus OR gracilis). In addition, we also reviewed reference lists cited in these articles to ensure that no eligible literature was omitted. Any discrepancies were resolved by a third reviewer (J-CL).

2.2. Study selection

Inclusion criteria are as follows: English language; randomized controlled trials (RCTs), prospective comparative studies, and large national registries with prospective data collection; I or II level of evidence; clinical studies; minimum 2-year follow-up. Information about CACL injury rates was reported in the studies.

Studies failed to meet these inclusion criteria will be excluded. In addition, if different studies come from the same center and the same patient, but only with different follow-up intervals, we will include only 1 study with the longest follow-up time and relatively complete results. The flowchart of the literature search process can be seen in Fig. 1.

2.2.1. Data extraction and risk of bias assessment. Two reviewers (PZ and X-TD) extracted relevant data from each included study. Where required, the corresponding authors were

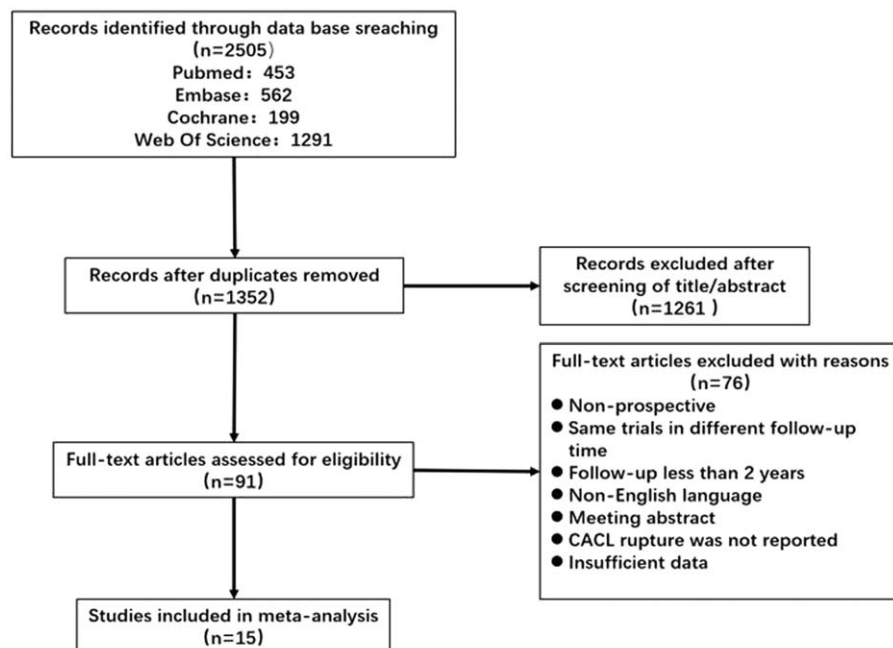


Figure 1. Preferred reporting items for systematic reviews and meta-analyses (PRISMA) flow diagram. CACL=contralateral anterior cruciate ligament.

Table 1
Overview of studies.

Study	Study design	Level of evidence	Number of patients/ Lost to follow up	Age at surgery, y			Gender (F/M)		Jadad/NOS score
				BPBT	HT	Follow-up, yr	BPBT	HT	
Bjornsson et al (2016) ^[30]	RCT	I	164/29	NA	NA	14	34/35	44/21	3
Gifstad et al (2013) ^[31]	RCT	II	193/45	28	27	16	19/42	33/53	3
Harilainen et al (2006) ^[32]	RCT	I	114/37	27	27	7	NA	NA	3
Heijne et al (2015) ^[33]	RCT	I	99/20	NA	NA	5	NA	NA	1
Holm et al (2010) ^[34]	PCS	II	68/0	29	30	5	12/22	20/14	8
Laxdal et al (2005) ^[35]	RCT	I	72/15	25	27	12	10/18	14/15	3
Mohdadi and Chan (2019) ^[36]	RCT	I	79/0	28	26	2	11/29	11/28	3
Rahardja et al (2020) ^[37]	RCT	I	330/11	29	28	7	43/60	94/118	5
Sajovic et al (2018) ^[38]	PCS	II	3395/0	NA	NA	2	NA	NA	6
Shaieb et al (2002) ^[39]	RCT	II	64/16	27	25	17	9/15	11/13	1
Taylor et al (2009) ^[40]	RCT	I	82/12	32	30	2.7	7/26	16/21	1
Thompson et al (2016) ^[41]	PCS	II	839/69	17	17	6	231/261	138/140	7
Webster et al (2016) ^[42]	RCT	I	64/11	22	22	3	NA	NA	4
Spindler et al (2020) ^[43]	PCS	II	180/0	25	24	20	42/48	43/47	8
Wright et al (2007) ^[44]	RCT	I	65/18	27	26	15	6/16	5/20	5
Total			5808/283	26.3	26.1	9	1760	3801	

* BPBT = bone-patellar tendon-bone, HT = hamstring tendon, M/F = male/female, N/A = not available, PCS = prospective cohort study, RCT = randomized controlled trial.

contacted for additional data. Extracted data included first author; publication date; study design; country; level of evidence; number of patients; number of dropouts; sex ratio; follow-up period; CACL injury rates.

The Jadad scale^[24] was used to evaluate the quality of RCTs, and in the 5-point scale, the quality score ≥ 3 was considered to be relatively high quality. The Newcastle-Ottawa Scale (NOS)^[25] was used to evaluate the quality of prospective cohort studies, and the quality score of ≥ 7 on the 9-point NOS was considered to be relatively high-quality.^[26] Two reviewers independently graded the methodological quality of each included study, and any disagreements were resolved by arbitration and consensus. The characteristics and quality scores of each included trial are respectively were added to Table 1.

2.3. Statistical analysis

Statistical analysis was performed using Review Manager Version 5.3 (Copenhagen, The Nordic Cochrane Centre, The Cochrane Collaboration, 2014). Risk ratio (RR) was used as summary statistics for dichotomous variables. RR was reported with 95% confidence intervals, and the significance level was set at $P = .05$. The heterogeneity among the included results was analyzed by chi-square test with significance set at $P < .10$, and the heterogeneity was quantitatively detected by I-square tests. I-square values of 0% to 24.9%, 25% to 49.9%, 50% to 74%, and 75% to 100% were considered none, low, moderate, and high heterogeneity, respectively.^[27] Random-effects or fixed-effects models were used depending on heterogeneity of the study. The fixed effect model was utilized for I^2 values $\leq 25\%$.^[28]

3. Result

3.1. Study characteristics

Fifteen studies^[29–43] (11 RCTs, 3 prospective comparative studies, 1 national registry) that included a total of 7974 patients met inclusion criteria (Fig. 1). The final analysis included 5561 patients, of with 1760 patients using BPTB autografts and 3801

receiving hamstring autografts. The average follow-up duration was 9 years (range, 2–20 years). Based on jaded score or NOS score, 10 of these studies were considered to be of high quality. The patient demographics, characteristics, and quality scores of the included trials are respectively shown in Table 1.

3.2. Rupture of contralateral ACL

In the BPTB group, the CACL rupture rate ranged from 1.8% to 30%, with a pooled percentage of 8.5%. In the HT group, the CACL rupture rate ranged from 0% to 14.4%, with a pooled percentage of 3.3%. The overall CACL rupture rate was 3.1% and ranged from 1.1% to 27.1%, with a pooled percentage of 4.9%. The pooled results indicate that patients undergoing primary ACL reconstruction with BPTB autograft were more likely to have CACL rupture than patients treated with HT autograft. (RR, 1.53; 95% CL, 1.21–1.91; $P = .0004$). The heterogeneity was low ($I^2 = 0.0\%$, $P = .71$) (Fig. 2). A sensitivity analysis was conducted by omitting the study by Rahardja et al,^[37] who used large data prospectively captured by the New Zealand National ACL Register, and the pooled result were similar with and without exclusion of this study in the model.

3.3. Publication bias

A funnel plot was created to assess if there was bias in this study. The funnel plot appeared mild asymmetrical, suggesting publication bias in the data (Fig. 3).

4. Discussion

CACL injury is one of the postoperative complications of ACL reconstruction. The reported incidence of CACL injury varies between 0.6% and 22.7%.^[12] The wide range noted in the reported incidence can be attributed to different follow-up periods in individual trials. Previous articles have reported that the risk of CACL injury in the short term (within 2 years) is the same as the graft, but the risk in the long term (> 5 years) is nearly double that of the graft.^[13,44] In this study, the overall CACL

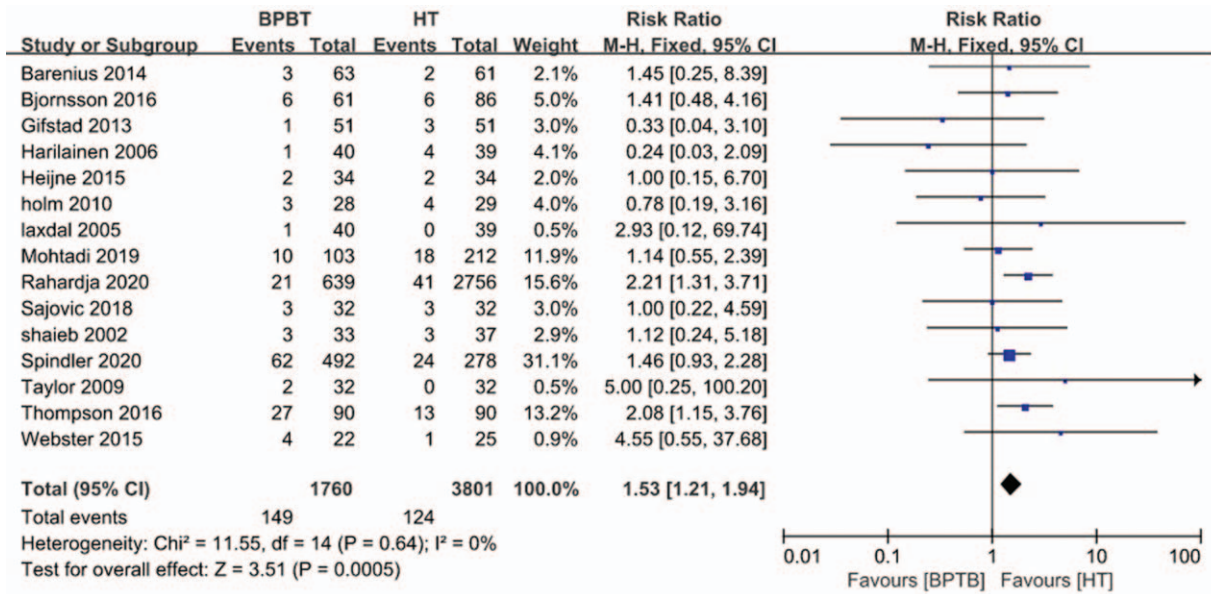


Figure 2. Forest plot of CACL rupture rate between BPTB and HT autograft. BPTB=bone-patellar tendon-bone, CACL=contralateral anterior cruciate ligament, HT=hamstring tendon.

rupture rate was 4.9%. This result mirrors 2 population-based studies reported rates of approximately 4%.^[7,43] Despite the low incidence of CACL rupture after ACL reconstruction, resulting subsequent repeat surgery and the long process of rehabilitation can be devastating to patients.

This meta-analysis systematic review included 15 Level-I and II studies and showed that there was a statistically significant difference in CACL rupture risk rate between BPTB and HT autograft. This finding is consistent with previous studies, indicating that patients undergoing primary ACL reconstruction were more likely to experience CACL rupture with BPTB versus

HT autograft.^[8,11,20,37,41] The explanation for this phenomenon is far from clear due to the sparse studies of such injuries.

A neuromuscular theory is that after ACL rupture of the ipsilateral limb, the proprioception will be affected due to the loss of afferent signals, resulting in the interruption of the central protection mechanism that affects both limbs.^[11,46] Bourke et al^[20] suggest that harvesting BPTB autograft has a greater neuromuscular “cost” to the system than HT autograft. Postoperative activity levels may also be associated with a higher risk of CACL rupture with BPTB autograft.^[37] High level of activity is not only a risk factor for ipsilateral ACL rupture, but

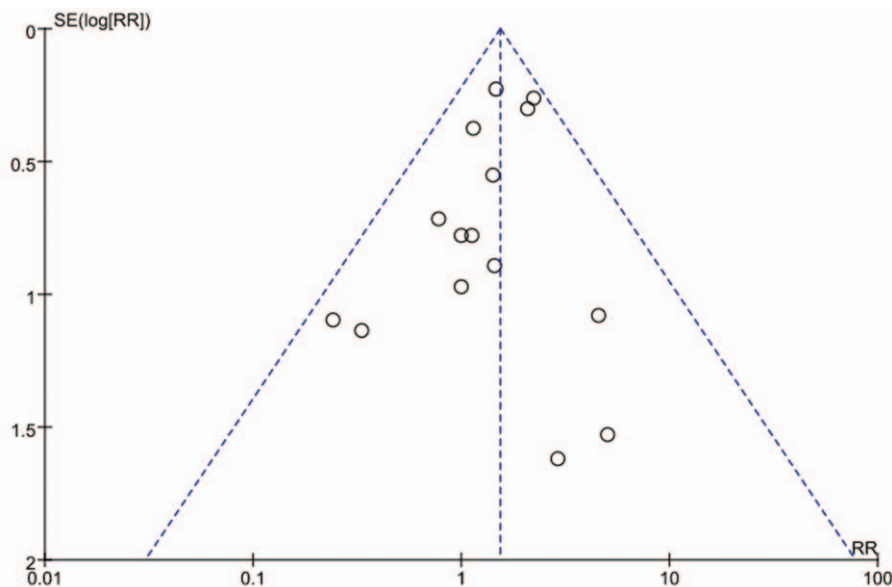


Figure 3. Funnel plot with 95% CL is showing mild publication bias for comparison of CACL rupture rate between BPTB and HT autograft. BPTB=bone-patellar tendon-bone, CACL=contralateral anterior cruciate ligament, HT=hamstring tendon.

also a risk factor for CACL.^[11,12] Pujol et al^[47] reported that the incidence of CACL injury among elite alpine skiers was 30.5%. Xie et al,^[48] in their meta-analysis, demonstrated that the BPTB autograft had a significantly higher percentages of patients returning to preinjury activity level and lower rate of positive pivot-shift test. Patients who received BPTB autograft return to higher level of activity and they may subconsciously protect the ipsilateral knee during exercise, making the CACL more vulnerable. This may explain the increased rate of injury to the contralateral ACL. However, in the Thompson et al study,^[41] there was no significant difference between the BPTB group and the HT group in the subjective results including IKDC subjective score, Lysholm knee score, and activity level, but there was a significant difference in the rate of CACL rupture between the 2 groups. Another potential factor influencing the difference in the rate of CACL rupture between BPTB and HT autograft is donor site morbidity. In a recent systematic review of overlapping Meta-analyses by Schuette et al,^[49] anterior knee pain and kneel pain are the most common donor complications and are more likely to occur in patients using BPTB autograft. The limitation of pain on the movement of the ipsilateral knee may increase the risk of injury to the CACL. Overall, further studies are required to test these hypotheses and investigate the etiology of the higher rate of CACL rupture seen in patients with BPTB graft.

There are some limitations of the present study. First, most of the patients included in this study came from prospective cohort studies. Although these studies with a high evidence level offer the strength of large population data and statistical power, there are still potential selection biases relative to rigorous RCTs. This might weaken the strength of the meta-analysis. Second, studies not published in English or unable to analyze the rate of CACL injury were excluded, thereby potentially leading to publication bias, as seen in the slightly mild asymmetrical funnel plot. In addition, the rehabilitation of patients has a great impact on the CACL, which was heterogeneous among the studies and might increase the likelihood of bias. Finally, the follow-up time for the studies included in this meta-analysis ranged from 2 to 20 years. The differences in follow-up time between the studies may also have influenced our results.

5. Conclusion

Patients undergoing primary ACL reconstruction were more likely to experience CACL rupture with BPTB versus HT autograft. Compared with patients who received the HT autograft, we should pay more attention to the opposite knee when making rehabilitation plans for patients who received the BPTB autograft. Further studies are required to investigate the causes of the differences in the risk of CACL injury between the 2 grafts.

Author contributions

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Resources: Peng Zhou, Xiang-Tian Deng, Zhong Li.

Software: Peng Zhou, Xiang-Tian Deng, Zhong Li.

Supervision: Peng Zhou, Jun-Cai Liu, Xiang-Tian Deng, Zhong Li.

Writing – original draft: Peng Zhou.

Writing – review & editing: Peng Zhou, Zhong Li.

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