DANISH MEDICAL JOURNAL

Systematic Review

Return to sports after anterior cruciate ligament surgery with hamstring or patella tendon autograft – a systematic review

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Dan Med J 2024;71(7):A09230599. doi: 10.61409/A09230599

ABSTRACT

INTRODUCTION. In orthopaedics, anterior cruciate ligament (ACL) reconstructions are among the most common surgical interventions. Two methods are preferably used: autografts from the hamstring tendon (HT) or patella tendon (PT). The purpose of this meta-analysis was to compare these two methods when returning to sports.

METHODS. Eleven studies were included based on a literature search conducted in PubMed. The primary outcome was return to preinjury sport level in athletes. Post-operative results such as the Lysholm score, the International Knee Documentation Committee (IKDC) subjective score, the Tegner Activity Score and KT-1000 arthrometry and autograft re-rupture rates were analysed as secondary outcomes.

RESULTS. The analysis showed no significant difference in return to preinjury sports level at a two-year follow-up between patients operated with hamstring or patella autograft. Considering the secondary outcomes, no significant differences were recorded in Lysholm score, IKDC score or re-rupture rate. The Tegner Activity Scale demonstrated a significantly higher activity level in the PT group than in the HT group (OR 0.79, p = 0.003). At the two-year follow-up, the KT-1000 arthrometer analysis also showed a significant difference in laxity, which was higher for the HT autografts (OR –0.31, p = 0.02).

CONCLUSION. This study showed no significant differences between hamstring and patella autografts. Even so, the choice of method when operated for ACL rupture remains crucial for the individual and should be a weighted decision made jointly by the patient and the physician.

KEY POINTS

- No significant difference was found in return to preinjury sports after ACL reconstruction with either hamstring or patella autografts at a two-year follow-up.
- More evidence is warranted in the form of randomised control trials to increase the level of evidence.
- The fear of reinjury and the higher laxity in the HT group explained the lower activity level and return to sport in this group.

In orthopaedics, anterior cruciate ligament (ACL) reconstructions are one of the most common surgical interventions, with more than 130,000 reconstructions performed annually in the US alone. ACL ruptures are responsible for 20% of knee injuries in sports [1]. The mechanism behind ACL injuries may be explained by the combined loading application and torquing on the ligament [2], which often occurs in non-contact and contact sports alike. Therefore, it is highly relevant to study the incidence and effect of ACL injuries and their subsequent reconstruction in athletes.

For athletes who request a quick return to their sport after an ACL rupture, surgical treatment is recommended to regain articulation stability and reduce knee laxity, especially if ACL rupture is associated with a repairable meniscal tear or multiple torn ligaments [3]. Nowadays, two methods are preferably used [4]: autografts from the hamstring tendon (HT) or from the patella tendon (PT). Using these methods correlates with a reduction in graft rupture compared with allografts [5], and it was shown that reconstruction has a subsequent protective effect on osteoarthritis [6] in patients with meniscal injury.

Several studies have compared the outcomes of patella versus hamstring autograft, investigating graft re-rupture, patient-reported knee function, clinical tests, etc. However, these outcomes have not been thoroughly examined in comparative studies involving both graft types in high-level or competing athletes. For these individuals, it is of great importance to return to sports at the same level, and post-surgery outcomes should be continually improved.

This systematic review aims to analyse the return to preinjury sports in competing and high-level athletes by comparing patella tendon to hamstring tendon autografts.

METHODS

The PubMed database was searched in October 2022. The following search string was used: *("back to sport" OR "return to sport" OR "return to play" OR "athlete recovery" OR "athletes recovery" OR "athletes" OR "athlete" OR "sports participation" OR ”return” OR ”sport”) AND ("acl injuries" OR "acl injury" OR "anterior cruciate ligament injuries" OR "anterior cruciate ligament injury" OR "anterior cruciate ligament tear" OR "anterior cruciate ligament tears" OR "anterior cruciate ligament ruptures" OR "anterior cruciate ligament rupture" OR "ACL rupture" OR "ACL ruptures" OR "ACL reconstruction" OR "Anterior cruciate ligament reconstruction" OR "ACL surgery" OR "anterior cruciate ligament surgery") AND ("semitendinosus tendon" OR “semitendinosus” OR ”semitendinosus autograft” OR ”HT” OR "hamstring tendon autograft" OR "HT autograft" OR "hamstring autograft" OR ”hamstring tendon”) AND (”patellar tendon” OR ”patella tendon” OR "BPTB autograft" OR "patella tendon autograft" OR "bone patellar tendon bone grafts" OR "BPTB" OR "patella tendon autograft”) NOT ("allograft")*

A total of 167 studies were identified and assessed for eligibility using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) strategy [7]. One duplicate study was removed, and the remaining 166 articles were screened by title and abstract. A total of 137 studies were removed by title and abstract screening only, leaving 29 articles to go through a full-text eligibility assessment. Among the 29 studies, three articles only represented one of the two methods; one article did not characterise the patients as athletes, and 14 failed to present results for the primary outcome of interest. Finally, 11 studies, including three RCTs (n = 2,489 patients), matched the inclusion criteria and were included in this systematic review.

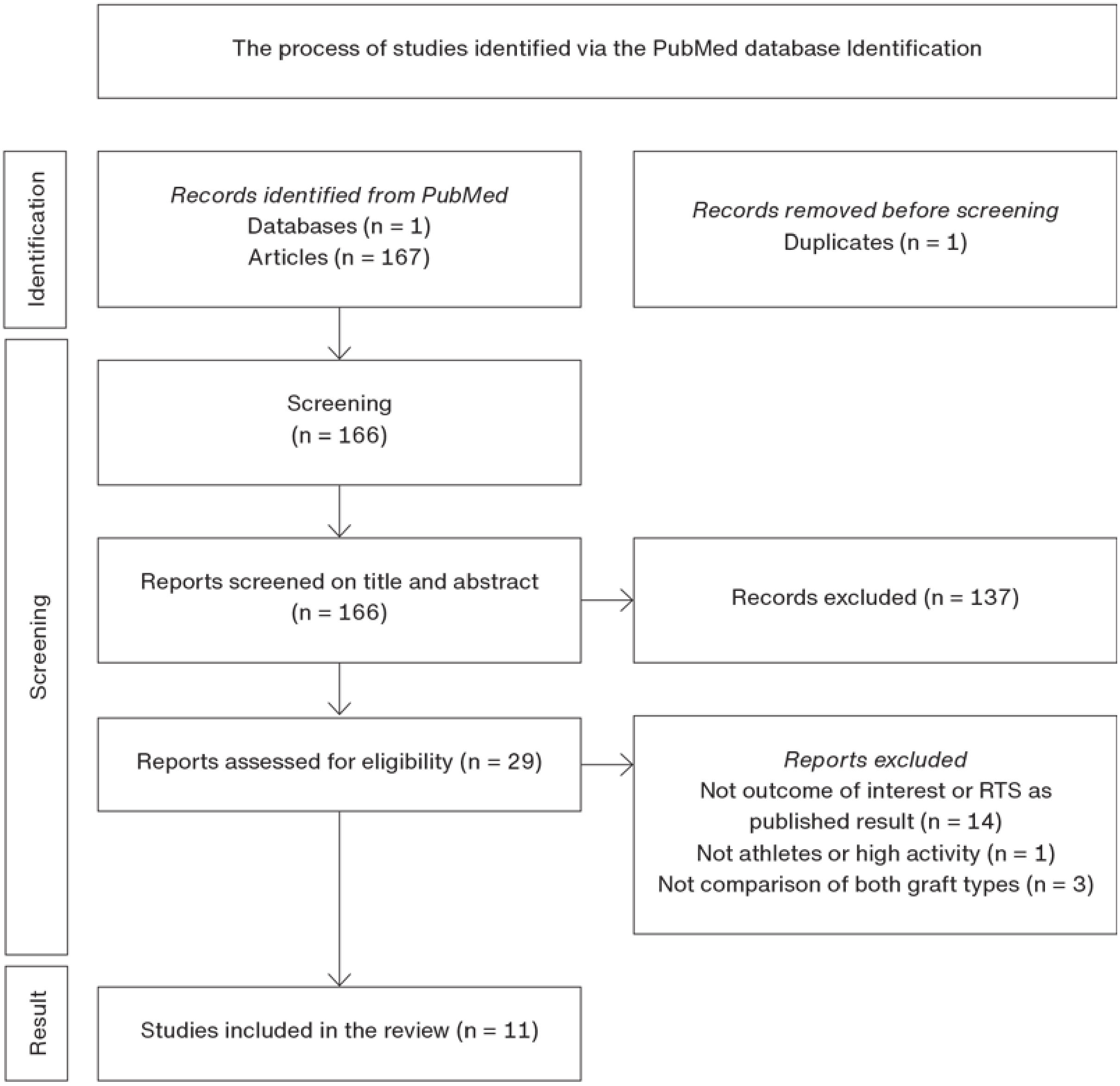
The inclusion criteria were 1) patients with ACL reconstruction with either HT or PT autografts, 2) competitive or high-level athletes, 3) extractable primary outcome and 4) comparative studies with both graft types, regardless of the number of strands.

The exclusion criteria were 1) allografts, 2) added ligament and 3) nonathletic population.

The data for the level of sport and return to sport were identified and collected from the papers. The athletic population was defined as a professional, elite or recreational athlete enrolled in competitive sports or strenuous high-risk sports such as soccer or skiing. Nonathletic populations were excluded. The primary outcome was mostly presented in the papers based on return to sport (RTS) questionnaires, or the athletes were followed clinically to assess whether they returned to sports.

The flow diagram in **Figure 1** outlines the study selection process.

FIGURE 1 Flow diagram of included studies from the literature search.



RTS = return to sport.

Statistics

The statistical analyses were performed using RevMan (The Nordic Cochrane Centre Copenhagen, Denmark) and Excel (Microsoft Redmond, WA, USA). Dichotomous results are expressed in risk ratios (RR) or odds ratios (OR) as appropriate. Continuous outcomes are expressed as mean differences (MD), and the results are presented with a 95% confidence interval (CI).

Potential heterogeneity was evaluated for the included studies through I^2 statistics and by screening funnel plots.

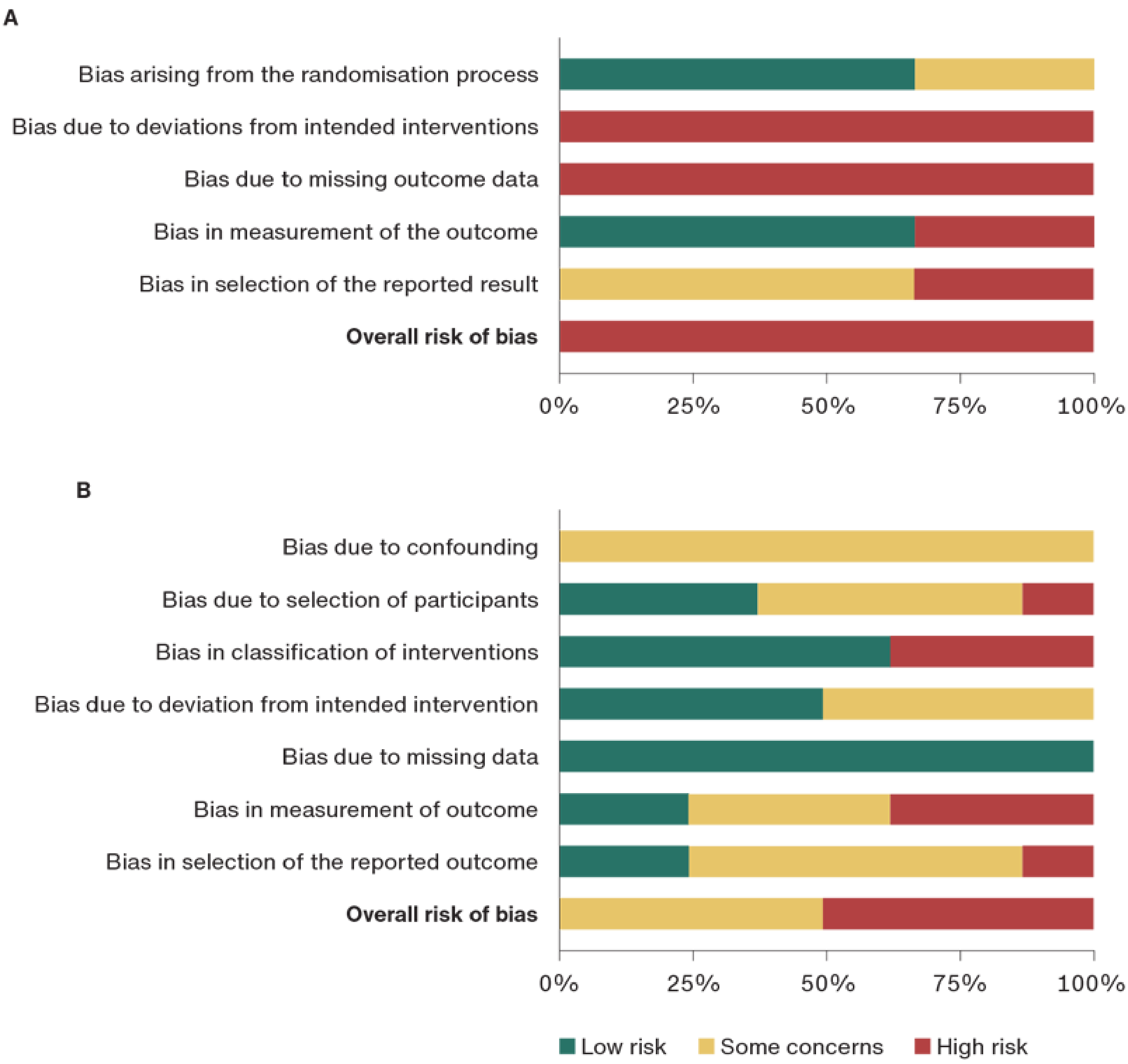
$I^2 > 50\%$ was defined as high heterogeneity. Forest plots are shown for each analysis. The random effects model was used globally to ensure that each study is weighted equally and to achieve high levels of dissimilarity between the studies [8].

If data were presented in the source studies as median (range), the results were converted into means and standard deviation using the method proposed by Hozo et al. [9]. Of note, the rates of return to sports for Smith et al. [10] were calculated from the percentages specified in the article. Furthermore, the study by Kilkenny et al. [11] is represented twice in the analysis because this study comprised two groups in the original article; “13-15-year olds” and “16-18-year olds”. The groups are shown in Supplementary Figure 1B in that order.

Assessment of risk of bias

Risk of bias was evaluated for each study exclusively for the primary outcome level using the Cochrane tool for assessing risk of bias (RoB-2) for RCTs [12] and the Risk Of Bias In Non-randomized Studies of Interventions (ROBINS-I) tool [13] for the cohort and case studies. This analysis is presented in **Figure 2**, made using the Robvis visualisation tool [14].

FIGURE 2 Risk of bias analyses. **A**. Risk of bias - 2.
B. Risk of bias in non-randomised intervention studies - 1.



The overall risk of bias for non-randomised studies was graded according to the ROBINS-I tool as follows: "*low*" risk if the study was judged to carry a low risk of bias for all domains, "*moderate*" if the study was assessed to carry a low or moderate risk of bias for all domains and "*serious*" risk if serious risk was determined in at least one domain without critical risk of bias being assessed in any domain. Finally, the study was defined as "*critical*" if a critical risk of bias was found in at least one domain.

The following guidelines were used to grade the risk of RTCs: Studies with four "*low-risk*" domains were defined as having a "*low*" risk of bias. Studies with two "*moderate risk*" domains but no "*high-risk*" domains were labelled as carrying a "*moderate*" risk of bias. Studies with one or more "*serious risk*" domains or a minimum of three "*unclear*" risks were labelled as carrying a "*high risk of bias".*

For attrition bias, studies exceeding a 10% dropout at the final outcome evaluation were analysed as "high risk", as described in the Cochrane Handbook [12, 13]. This method was also used to decide the level of bias due to missing data for non-randomised studies. Funnel plots were used to evaluate potential publication bias.

RESULTS

Included studies

Table 1 shows the characteristics of the included studies: study design, minimum follow-up time, total number of patients included, mean age, graft type and level of sport.

TABLE 1 Characteristics of included studies.

				Patients at outcome evaluation			Graft type[a]				
Reference	Start date	Study type	Patients incl.	total analysed	PT	HT	PT	HT	Sport level	Mean age, yrs.	Min. follow-up, yrs.
Guglielmetti et al., 2023 [15]	2016	RCT	62	62	31	31	BPTB	4-strand STG	Prof./semi-prof. soccer	25,1	2
Gupta et al., 2020 [16]	2014	RCT	160	160	80	80	BPTB	Doubled loop STGI	Prof.: kabaddi, football	24,91	2
Smith et al., 2020 [10]		RCT	64	56	29	27	BPTB	AIST	High-risk athletic population: high school, college, recreational	17,7	2
Kilkenny et al., 2022 [11]	2014	Retrospective comparative cohort	378	358	253	105	BPTB	4- or 5- strand STG	Competitive Gaelic football, rugby, soccer...	< 18	2
Britt et al., 2020 [17]	2013	Case	90	71	41	30	BPTB	4- strand HT	Injured during soccer (college, high school, club)	15,4	2
Gupta et al., 2020 [18]	2014	Prospective cohort	116	116	58	58	BPTB	STGPI	Prof.	24,3	2
Laboute et al., 2018 [19]	2011	Cohort	2424	955	242	713	BPTB	Single bundle ST	Competitive, (non-competitive)[a]	26,3	2
Gupta et al., 2018 [20]	2005	Case	249	249[b]	80	85	BPTB	STGI	Elite + recreational: level 1-3 sports	27,5	2
Sonnery-Cottet et al., 2017 [21]	2012	Prospective cohort	541	502[b]	105	176	BPTB	STGPI	High-risk pivoting sports + prof.	22,4	2
Mascarenhas et al., 2012 [22]	2001	Match pair case control	46	46	23	23	BPTB	4 strand STG	Strenuous 4-7 times a week	18	2
Laboute et al., 2010 [23]	2003	Case	540	298	138	160	NS	STG	Competitive: regional or higher	25,5	4

AIST = all-inside quadrupled semitendinosus autograft; BPTB = bone patellar tendon-bone autograft; HT = hamstring tendon; min. = minimum; NS = not specified; prof. = professional;
PT = patella tendon; ST = semitendinosus; STG = semitendinosus gracilis; STGPI = STG graft with preserved tibial insertion.
a) Excluded in primary outcome analysis were non-competitive athletes (such as coach and monitor).
b) The total number does not equal sum of the two groups because these studies used three intervention groups, one of which was not included in this meta-analysis.

Risk of bias analysis

None of the included RCTs were classified as carrying an overall "*low*" or "*unclear*" risk of bias for the primary outcome. All three studies had some serious concerns regarding performance and detection bias since staff and participant blinding and outcome assessment blinding are not possible in this type of intervention. One study exceeded a 10% participant dropout and was therefore assessed to be of a "*high*" risk. Based on the funnel plots, the reporting bias was judged as "unclear" and "high" for the studies (Figure 2A).

Among the non-randomised studies, 50% were classified as having a "*moderate*" risk, whereas the other 50% had "*serious*" risk. None of the studies were judged as carrying "*critical*" risk. All studies presented some bias due to confounding, but these biases were controlled for. Bias due to intervention classification was mostly well defined, and none of the studies exceeded a 10% dropout rate at follow-up (Figure 2B).

The primary outcome of "Return to sports"

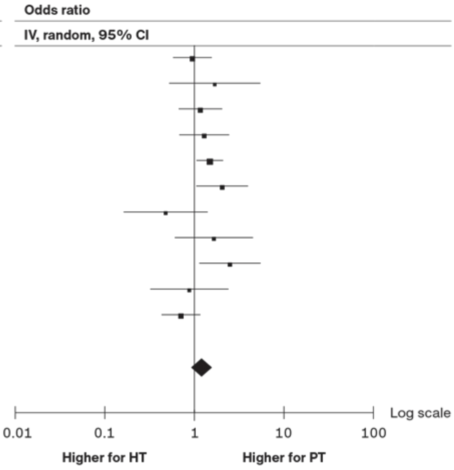
The 11 studies [10, 11, 15-23] included in this review (2,489 patients) presented the results for the primary outcome: returning to the preinjury level of physical activity at the time of the final evaluation. These studies are shown in the overall analysis in **Figure** 3A. In this analysis, an event was defined as a return to the baseline level of physical activity after ACL surgery. A trend was observed towards a higher return to preinjury sports in the PT group, but the analysis was not significant.

FIGURE 3 **A**. Overall analysis of returning to preinjury sports at two-year follow-up.
B. Metaanalysis of returning to preinjury level of sports at two-year follow-up.

A

Reference	PT, n events	PT, n total	HT, n events	HT, n total	Weight, %	Odds ratio IV, random, 95% CI
Laboute et al., 2010 [23]	84	129	102	154	12.9	0.95 (0.58-1.56)
Mascarenhas et al., 2012 [22]	13	23	10	23	4.0	1.69 (0.53-5.42)
Sonnery-Cottet et al., 2017 [21]	54	85	88	147	11.5	1.17 (0.67-2.03)
Gupta et al., 2018 [20]	32	80	29	85	9.8	1.29 (0.68-2.43)
Laboute et al., 2018 [19]	183	241	479	705	17.4	1.49 (1.06-2.08)
Gupta et al., 2020 [16]	53	77	40	77	9.3	2.04 (1.06-3.94)
Smith et al., 2020 [10]	13	29	17	27	4.6	0.48 (0.16-1.39)
Britt et al., 2020 [17]	17	41	9	30	5.1	1.65 (0.61-4.48)
Gupta et al., 2020 [18]	43	58	31	58	7.4	2.50 (1.14-5.46)
Guglielmetti et al., 2021 [15]	16	31	17	31	5.1	0.88 (0.32-2.38)
Kilkenny et al., 2022 [11]	159	253	74	105	12.9	0.71 (0.43-1.16)
Total (95% CI)	**667**	**1,047**	**896**	**1,442**	**100.0**	**1.22 (0.95-1.58)**

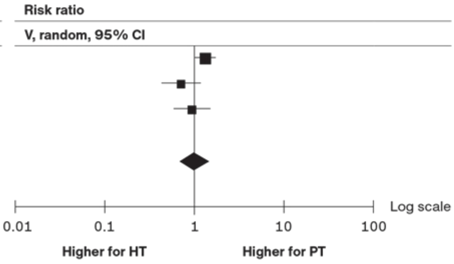
Heterogeneity: $tau^2 = 0.07$; $chi^2 = 16.68$, df = 10 (p = 0.08); $I^2 = 40\%$
Test for overall effect: Z = 1.56 (p = 0.12)



B

Study or Subgroup	PT, n events	PT, n total	HT, n events	HT, n total	Weight, %	Risk ratio IV, random, 95% CI
Gupta et al., 2020 [16]	53	77	40	77	42.7	1.32 (1.02-1.72)
Smith et al., 2020 [10]	13	29	17	27	27.8	0.71 (0.43-1.17)
Guglielmetti et al., 2021 [15]	16	31	17	31	29.5	0.94 (0.59-1.50)
Total (95% CI)	**82**	**137**	**74**	**135**	**100.0**	**1.01 (0.69-1.47)**

Heterogeneity: $tau^2 = 0.07$; $chi^2 = 5.30$, df = 2 (p = 0.07); $I^2 = 62\%$
Test for overall effect: Z = 0.04 (p = 0.97)



CI = confidence interval; HT = hamstring tendon; IV = inverse variance; PT = patella tendon.

Three included studies [10, 15, 16] were randomised control trials (n = 272). The results are presented in Figure 3B. No significant difference was observed between the two groups in this analysis.

Secondary outcomes "Post-operative outcomes"

Examining the return to sport from the athletes' and medical perspectives may be helpful and may be accomplished by studying the studies' subjective and objective outcomes.

Subjective outcomes

Lysholm score

Five studies [15-17, 20, 21] (n = 739 patients) presented subjective results based on the Lysholm Score (Supplementary Figure 1A). The result of the analysis was not significant.

IKDC subjective score

Five studies used the IKDC Subjective Score [11, 16, 17, 22, 23] presented in **Supplementary Figure 1B** (n = 811 patients). The mean difference of the IKDC subjective score was higher for the HT group but was nonsignificant.

Tegner activity scale

Four studies [17, 18, 20, 21] used the Tegner Activity Scale to show the activity level of the patients at the final follow-up (n = 633 patients, Supplementary Figure 1C). The analysis showed a mean difference favouring the PT group, and the result was significant.

Objective outcomes

KT-1000 arthrometer

Four of the included studies [10, 16, 20, 22] (n = 421) illustrated the displacement between the injured and the uninjured knee by the KT-1000 arthrometer at a minimum two-year follow-up (Supplementary Figure 1D). This parameter showed a significant difference between the two graft types, which was higher for the HT group.

Graft failure rate

Autograft re-rupture rate is an important objective indicator of return to preinjury sport level (Supplementary Figure 1E, n = 2486). The result showed a more frequent re-rupture rate in the HT group, but the analysis was not significant.

DISCUSSION

The main finding of this review was that the two autografts are generally similar in outcome concerning return to preinjury sports. The overall analysis of all included studies showed no significant difference in return to preinjury sports level when operated with either a hamstring or a patella autograft. This finding is also applicable to the RCT analysis. The study by Gupta et al. [16] was the only randomised control trial to find a significant difference in return to preinjury sports level; the return occurred earlier and was higher in the PT group. Similarly, in another study, Gupta et al. [20] showed a significantly higher return to sports level for the PT group. This result was related to the inclusion of observational studies. Still, in a metanalysis by Bergeron et al. [24] conducted exclusively on RCTs, the authors failed to establish any significant correlation with return to sport activity.

Regarding the secondary outcomes, no significant difference was found in subjective opinion, as illustrated through the Lysholm or IKDC scores. As for the Tegner Activity Scale at the final follow-up, a significantly higher activity level was recorded in the PT than in the HT group. When exploring objective outcomes, the KT-1000 arthrometer was favourable for the PT autografts since the laxity was higher for the HT than for the PT group. As for autograft re-rupture rate, the result was nonsignificant. Some studies [10, 11, 15-23] included other measurement methods (e.g., anterior drawer test, the Short Form mental/physical components, Lachman Grade and pivot shift test) to illustrate potential differences between the two surgical techniques. These results are not included in this study as the included studies did not have enough published data on these tests. Nonetheless, most studies failed to demonstrate significant differences between the two groups in the mentioned outcomes.

In the study by Guglielmetti et al. [15], all the re-ruptures occurred after full return to sports activity. In another article by Salmon et al. [25], it was shown that a return to level 1-2 sports was correlated with ten-fold increased odds of contralateral rupture. However, this increase was nonsignificant when comparing the incidence in the two autograft types. The re-rupture rate of the autograft and the risk of contralateral rupture therefore remain relevant risks to account for in athletes as they may affect the ability of an athlete to return to the preinjury level of sports.

From a more psychological perspective, it may also be argued that athletes are more motivated for a quick and definitive return to sport than other populations. This may apply especially to professional athletes, who also have an economic incentive. In the article by Sonnery Cottet et al. [21], 28 out of 39 professional athletes returned to their preinjury level of sports if they had not endured a graft (n=5) or contralateral (n=6) rupture. The study by Britt et al. [17] studied the reasons why some athletes did not return to their preoperative levels and pinpointed fear of reinjury as the most common reason. In another study [26], kinesophobia was found to be related to knee function after surgery.

In the paper by Britt et al. [17], twice as many in the HT as in the PT group reported fear as the main reason, which aligns with our findings concerning the KT-1000 arthrometer measurements. A correlation may exist between higher displacement in the injured knee compared to the displacement in the uninjured knee, with kinesophobia. In support of this, the present study showed a significantly higher activity level for the PT group. The lower activity level in the HT group may be associated with significantly higher laxity, which may potentially lead to a feeling of instability in the injured knee, resulting in more fear of reinjury and, therefore, a lower return to sports in this group.

Surgeons may have preferences based on their surgical skills or which technique they were schooled in. A UK study from 2004 [27] showed that 58% of surgeons used bone patella tendon bone (BPTB) autografts, whereas 33% used semitendinosus gracilis (STG) autografts. In Italy, the most popular graft type is hamstring autograft, according to a web-based survey [28]. In 2011, a global study showed that the hamstring autograft was the preferred graft choice (53.1%), followed by the BPTB autograft (22.8%) [29].

A similar study from 2020, a systematic review by Defazio et al. [30], showed that the overall return to sports was higher for the PT than for the HT group. However, the study also showed that the PT and HT autograft groups had similar rates of preinjury return to sports and that less than half of the athletes (48.9%), regardless of graft type, were able to return to their preinjury level. Even though Defazio's analysis and this study found no significant differences between hamstring and patella autografts, the choice, when operated for ACL rupture, remains crucial for the individual and should be a weighted decision taken jointly by the patient and the physician.

Study design and risk of bias

Blinding is nearly impossible and randomisations are challenging in surgical intervention studies. This applies, in particular, to professional athletes who want to ensure that their participation in clinical studies does not compromise the best possible treatment. Thus, the study by Britt et al. [17] carried a serious risk of bias because soccer goalies preferentially received an HT autograft to minimise the impact and the pain that jumping on the knees might inflict. The risk of bias in measuring outcomes was also considerable in some studies because of subjective and self-describing outcomes. This could have been avoided if the outcome had been based exclusively on clinical, mechanical testing or on an objective rating tool. This study has a quite low risk of bias due to missing data since no studies exceeded a 10% dropout at the final follow-up.

However, this study still has a moderate or high risk of bias in relation to the included studies.

CONCLUSION

This study showed no significant difference in return to preinjury sports after ACL reconstruction with hamstring or patella autografts at a two-year follow-up. To increase the evidence level, further evidence is warranted in the form of randomised control trials comparing the two graft types. When operating for ACL rupture, the choice of method remains crucial for the individual and should be a weighted decision taken jointly by the patient and the physician.

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Accepted 27 March 2024

Conflicts of interest none. Disclosure forms provided by the authors are available with the article at ugeskriftet.dk/dmj

References can be found alongside the article at ugeskriftet.dk/dmj

Cite this as Dan Med J 2024;71(7):A09230599

doi 10.61409/A09230599

Supplementary material https://content.ugeskriftet.dk/sites/default/files/2024-03/a09230599-supplementary.pdf

REFERENCES

1. Kalawadia JV, Guenther D, Irarrázaval S et al. 1 - Anatomy and Biomechanics of the Anterior Cruciate Ligament. In: Prodromos CC, ed. The Anterior Cruciate Ligament (Second Edition). Elsevier; 2018:1-7.e2.
2. Berns GS, Hull ML, Patterson HA. Strain in the anteromedial bundle of the anterior cruciate ligament under combination loading. J Orthop Res. 1992;10(2):167-76. https://doi.org/10.1002/jor.1100100203
3. LaBella CR, Hennrikus W, Hewett TE. Anterior cruciate ligament injuries: diagnosis, treatment, and prevention. Pediatrics (Evanston). 2014;133(5):e1437-e1450. https://doi.org/10.1542/peds.2014-0623
4. Iriuchishima T, Goto B. Systematic review of surgical technique and tunnel target points and placement in anatomical single-bundle ACL reconstruction. J Knee Surg. 2021;34(14):1531-1538. https://doi.org/10.1055/s-0040-1710521
5. Kaeding CC, Aros B, Pedroza A et al. Allograft versus autograft anterior cruciate ligament reconstruction: predictors of failure From a MOON prospective longitudinal cohort. Sports Health. 2011;3(1):73-81. https://doi.org/10.1177/1941738110386185
6. Luc B, Gribble PA, Pietrosimone BG. Osteoarthritis prevalence following anterior cruciate ligament reconstruction: a systematic review and numbers-needed-to-treat analysis. J Athl Train. 2014;49(6):806-19. https://doi.org/10.4085/1062-6050-49.3.35
7. Moher D, Liberati A, Tetzlaff J et al. Reprint—Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. Phys Ther. 2009;89(9):873-80. https://doi.org/10.1093/ptj/89.9.873
8. Walker E, Hernandez AV, Kattan MW. Meta-analysis: Its strengths and limitations. Cleve Clin J Med. 2008;75(6):431-9. https://doi.org/10.3949/ccjm.75.6.431
9. Hozo SP, Djulbegovic B, Hozo I. Estimating the mean and variance from the median, range, and the size of a sample. BMC Med Res Methodol. 2005/04/20 2005;5(1):13. https://doi.org/10.1186/1471-2288-5-13
10. Smith PA, Cook CS, Bley JA. All-inside quadrupled semitendinosus autograft shows stability equivalent to patellar tendon autograft anterior cruciate ligament reconstruction: randomized controlled trial in athletes 24 years or younger. Arthroscopy. 2020;36(6):1629-46. https://doi.org/10.1016/j.arthro.2020.01.048
11. Kilkenny CJ, Hurley ET, Hogan RE et al. Return to play in paediatric & adolescent patients following anterior cruciate ligament reconstruction. Knee. 2022;37:87-94. https://doi.org/10.1016/j.knee.2022.05.013
12. Higgins JPT, Savovi&; J, Page MJ et al. Assessing risk of bias in a randomized trial. Cochrane Handbook for Systematic Reviews of Interventions. 2019:205-28.
13. Sterne JAC, Hernán MA, McAleenan A et al. Assessing risk of bias in a non-randomized study. Cochrane Handbook for Systematic Reviews of Interventions. 2019:621-41.
14. McGuinness LA, Higgins JPT. Risk-of-bias VISualization (robvis): An R package and Shiny web app for visualizing risk-of-bias assessments. John Wiley & Sons, Ltd. Updated 2020/04/26. Accessed 2022/12/28, n/a. https://doi.org/10.1002/jrsm.1411
15. Guglielmetti LGB, Salas VER, Jorge PB et al. Prospective and randomized clinical evaluation of hamstring versus patellar tendon autograft for anterior cruciate ligament reconstruction in soccer players. Orthop J Sports Med. 2021;9(9):23259671211028168. https://doi.org/10.1177/23259671211028168
16. Gupta R, Kapoor A, Soni A et al. No Difference in Outcome of Anterior Cruciate Ligament Reconstruction with "Bone-patellar Tendon-bone versus Semitendinosus-gracilis Graft with Preserved Insertion": A Randomized Clinical Trial. Indian J Orthop. 2020;54(5):665-71. https://doi.org/10.1007/s43465-020-00073-y
17. Britt E, Ouillette R, Edmonds E et al. The challenges of treating female soccer players with ACL injuries: hamstring versus bone-patellar tendon-bone autograft. Orthop J Sports Med. 2020;8(11):2325967120964884. https://doi.org/10.1177/2325967120964884
18. Gupta RK, Soni A., Khatri S, Masih GD. Anterior cruciate ligament reconstruction with bone-patellar tendon-bone graft is

associated with higher and earlier return to sports as compared to hamstring tendon graft. Knee Surg Sports Traumatol Arthrosc. 2020;28(11):3659-3665. https://doi.org/10.1007/s00167-020-06074-6

19. Laboute E, James-Belin E, Puig PL et al. Graft failure is more frequent after hamstring than patellar tendon autograft. Knee Surg Sports Traumatol Arthrosc. 2018;26(12):3537-46. https://doi.org/10.1007/s00167-018-4982-7
20. Gupta RS, M., Malhotra A, Masih GD, et al. Low re-rupture rate with BPTB autograft and semitendinosus gracilis autograft with preserved insertions in ACL reconstruction surgery in sports persons. Knee Surg Sports Traumatol Arthrosc. 2018;26(8):2381-8. https://doi.org/10.1007/s00167-017-4790-5
21. Sonnery-Cottet B, Saithna A, Cavalier M, et al. Anterolateral ligament reconstruction is associated with significantly reduced ACL graft rupture rates at a minimum follow-up of 2 years: a prospective comparative study of 502 patients from the SANTI study group. Am J Sports Med. 2017;45(7):1547-57. https://doi.org/10.1177/0363546516686057
22. Mascarenhas R, Tranovich MJ, Kropf EJ et al. Bone-patellar tendon-bone autograft versus hamstring autograft anterior cruciate ligament reconstruction in the young athlete: a retrospective matched analysis with 2-10 year follow-up. Knee Surg Sports Traumatol Arthrosc. 2012;20(8):1520-7. https://doi.org/10.1007/s00167-011-1735-2
23. Laboute E, Savalli L, Puig P et al. Analysis of return to competition and repeat rupture for 298 anterior cruciate ligament reconstructions with patellar or hamstring tendon autograft in sportspeople. Ann Phys Rehabil Med. 2010;53(10):598-614. https://doi.org/10.1016/j.rehab.2010.10.002
24. Bergeron JJ, Sercia QP, Drager J, et al. Return to baseline physical activity after bone–patellar tendon–bone versus hamstring tendon autografts for anterior cruciate ligament reconstruction: a systematic review and meta-analysis of randomized controlled trials. Am J Sports Med. 2022;50(8):2292-303. https://doi.org/10.1177/03635465211017522
25. Salmon L, Russell V, Musgrove T et al. incidence and risk factors for graft rupture and contralateral rupture after anterior cruciate ligament reconstruction. Arthroscopy. 2005;21(8):948-57. https://doi.org/10.1016/j.arthro.2005.04.110
26. Hartigan EH, Lynch AD, Logerstedt DS et al. Kinesiophobia after anterior cruciate ligament rupture and reconstruction: noncopers versus potential copers. J Orthop Sports Phys Ther. 2013;43(11):821-32. https://doi.org/10.2519/jospt.2013.4514
27. Kapoor B, Clement DJ, Kirkley A, Maffulli N. Current practice in the management of anterior cruciate ligament injuries in the United Kingdom. Br J Sports Med. 2004;38(5):542-4. https://doi.org/10.1136/bjsm.2002.002568
28. Vascellari A, Grassi A, Combi A et al. Web-based survey results: surgeon practice patterns in Italy regarding anterior cruciate ligament reconstruction and rehabilitation. Knee Surg Sports Traumatol Arthrosc. 2017;25(8):2520-7. https://doi.org/10.1007/s00167-016-4007-3
29. Middleton KK, Hamilton T, Irrgang JJ et al. Anatomic anterior cruciate ligament (ACL) reconstruction: a global perspective. Part 1. Knee Surg Sports Traumatol Arthrosc. 2014;22(7):1467-82. https://doi.org/10.1007/s00167-014-2846-3
30. DeFazio MW, Curry EJ, Gustin MJ et al. Return to sport after ACL reconstruction Wwth a BTB versus hamstring tendon autograft: a systematic review and meta-analysis. Orthop J Sports Med. 2020;8(12):2325967120964919. https://doi.org/10.1177/2325967120964919