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Comparison of The Clinical Results of Anterior Cruciate Ligament Reconstruction with Autologous Versus Allogeneic Grafts: A Meta-Analysis

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Abstract

Objective: To compare the clinical results of anterior cruciate ligament (ACL) reconstruction using autologous versus allogeneic grafts, by means of a systematic review with meta-analysis. Methodology: The review was conducted according to the PRISMA guidelines, with searches in PubMed/MEDLINE, Embase, Cochrane Library and Scopus. Randomized clinical trials published between 2011 and 2025 involving adult patients undergoing primary ACL reconstruction were included. The outcomes assessed were function (subjective and objective IKDC, Lysholm, Tegner, Cincinnati), joint stability (clinical tests and arthrometer) and complications, including graft failure. Methodological quality was assessed using the Cochrane Risk of Bias tool. Results: After initial screening of 14 articles, 5 studies met the inclusion criteria, totaling 471 patients (238 autogenous and 233 allogenous). Both groups showed significant improvement in joint function and stability at follow-up ≥ 24 months, with no statistically significant differences in functional scores. However, the failure rate was higher in allografts (up to 26% in some

studies). Conclusion: ACL reconstruction with autografts and allografts results in significant clinical improvement, but autografts have a lower risk of failure and greater stability, making them the preferred option in high-demand individuals.

Keywords: Anterior cruciate ligament reconstruction; anterior cruciate ligament; allograft and autograft.

Introduction

Anterior cruciate ligament (ACL) reconstruction is a common practice in athletes and aims to restore joint stability and allow a return to functional and sporting activities. Despite technical advances, there is still debate about the ideal choice of graft, which can influence healing, stability, complications and functional prognosis, especially in a load-bearing joint.[1,2]

Autologous grafts, obtained from flexor tendons or the patellar tendon, are traditionally considered the gold standard due to their biocompatibility and lower risk of disease transmission. However, they have disadvantages such as morbidity at the donor site and residual pain. On the other hand, allogeneic grafts offer benefits such as shorter surgical times and no morbidity at the donor site, but raise concerns about the time taken for biological incorporation, risk of failure and possible transmission of infectious diseases.[1,2,4,5]

The different grafts show divergent results. Bottoni et al. showed that the use of autologous grafts resulted in a lower failure rate after 10 years of follow-up, while other studies, such as those by Sun et al. and Lawhorn et al. suggest similar clinical results between the groups. Furthermore, the impact of factors such as the type of processing of allogeneic grafts, especially gamma irradiation, remains an important issue in the literature.[1,3,5]

A systematic and quantitative synthesis to evaluate the clinical outcomes of ACL reconstruction with autologous versus allogeneic grafts will be carried out in this proposed study, which aims to carry out a systematic review with meta-analysis to compare the clinical results of anterior cruciate ligament reconstruction using autologous grafts compared to allogeneic grafts.

Methodology

The review was carried out in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Systematic searches were carried out in the PubMed/MEDLINE, Embase, Cochrane Library and Scopus databases, using combinations of the terms: "anterior cruciate ligament reconstruction", "ACL reconstruction", "autograft", "allograft", "clinical outcomes".

Inclusion criteria: Randomized clinical trials, adult patients undergoing primary ACL reconstruction surgery. Studies that reported clinical outcomes such as failure rate, joint stability, function or complications. articles in Portuguese, English or Spanish. Articles from 2011 to 2025.

Exclusion criteria: Observational studies, case series or narrative reviews. Revision ACL reconstructions. Use of hybrid grafts (autologous + allogeneic) without isolated analysis of the groups. Articles that are not randomized clinical trials.

Data extraction and quality assessment. Two independent reviewers will screen the titles, abstracts and full texts. The data extracted will include patient characteristics, type of graft, surgical technique, follow-up time and clinical outcomes. Methodological quality will be assessed using the Cochrane Risk of Bias tool.

For the analysis of anterior cruciate ligament reconstruction, studies using autologous grafts and allografts, both irradiated and non-irradiated, were included. Although allograft irradiation may influence some variables, all eligible studies presented comparable clinical data, allowing for joint inclusion in the meta-analysis. Potential differences related to irradiation were explored in the discussion and, where possible, assessed in sensitivity analyses.

This systematic review is registered with PROSPERO under the ID CRD420251150282.

Results

A total of 14 articles were selected during the search process; after excluding those published more than 15 years ago, 12 remained. Analysis of the title and abstract allowed the exclusion of 6 articles that did not correspond to the objective of this study. Six articles were read in full, one of which was excluded because it did not meet the inclusion criteria, and five of which were selected for this article (Figure 1).

The 5 articles selected featured patients undergoing anterior cruciate ligament reconstruction using

autograft and allograft. Functional assessment was carried out using the subjective and objective IKDC (International Knee Documentation Committee), Tegner Activity Scale and Lysholm scores, Cincinnati score, as well as joint stability and clinical tests (Lachman, pivot-shift and anterior drawer). A total of 471 patients were included, of whom 238 underwent autograft reconstruction and 233 allograft reconstruction.

Table 1 - Results obtained by the selected studies

Study	Approach	Mean Age	Patients (M/F)	Results
Bottoni et al., 2015	Autograft / Allograft	28.9 years	84 / 13	Functional evaluation; subjective and objective IKDC; Tegner Activity Scale and Lysholm scores; joint stability and complications.
Li et al., 2011	Autograft / Gamma-irradiated allograft	30.2 years	32 / 32	Mechanism of injury; mean surgical time; ischemia time; postoperative inflammatory markers; knee stability evaluated by KT-1000; functional evaluation by subjective IKDC; Tegner activity score and Lysholm score; complications.
Sun et al., 2011	Hamstring autograft / Fresh-frozen allograft	30.4 years	149 / 37	Mean age; interval between injury and surgery; trauma mechanism; surgical time; functional evaluation; Lysholm and Tegner scores; subjective IKDC; Cincinnati score; joint stability (Lachman, pivot-shift, and anterior drawer tests); complications.
Yoo et al., 2017	Hamstring autograft / Tibial allograft	27.1 years	120 / 12	Mean age; predominant injury mechanism; functional evaluation; objective IKDC; Lysholm and Tegner scores; knee stability evaluated by Lachman and pivot-shift tests; relationship with osteoarthritis progression.
Lawhorn et al., 2012	Hamstring autograft / Fresh and frozen anterior tibial allograft	32.6 years	70 / 32	Mean age; subjective IKDC scores; stability assessed by Lachman and pivot-shift tests; functional scores; Lysholm and Tegner activity scores; final radiographic evaluation and complications.

Table 2 - Subjective IKDC (International Knee Documentation Committee) score after surgery in long-term follow-up (≥ 24 months), in patients undergoing autograft and allograft surgery

Study	Follow-up (months)	N (Autograft and Allograft)	IKDC Average (Autograft and Allograft)	DP (Autograft and Allograft)
Bottoni et al., 2015	126	48 / 49	77.2 / 73.7	25.4 / 25.9
Li et al., 2011	70.8 ± 7,2	32 / 32	87.5 / 83.8	3.2 / 6.9
Sun et al., 2011	94,8 (72-120)	104 / 104	89.0 / 90.0	12.0 / 14.0
Lawhorn et a., 2012	24	54 / 48	91.0 / 90.9	-

Figure 2 - Forest plot of the subjective IKDC analysis, using autograft and allograft in the long-term follow-up (≥ 24 months)

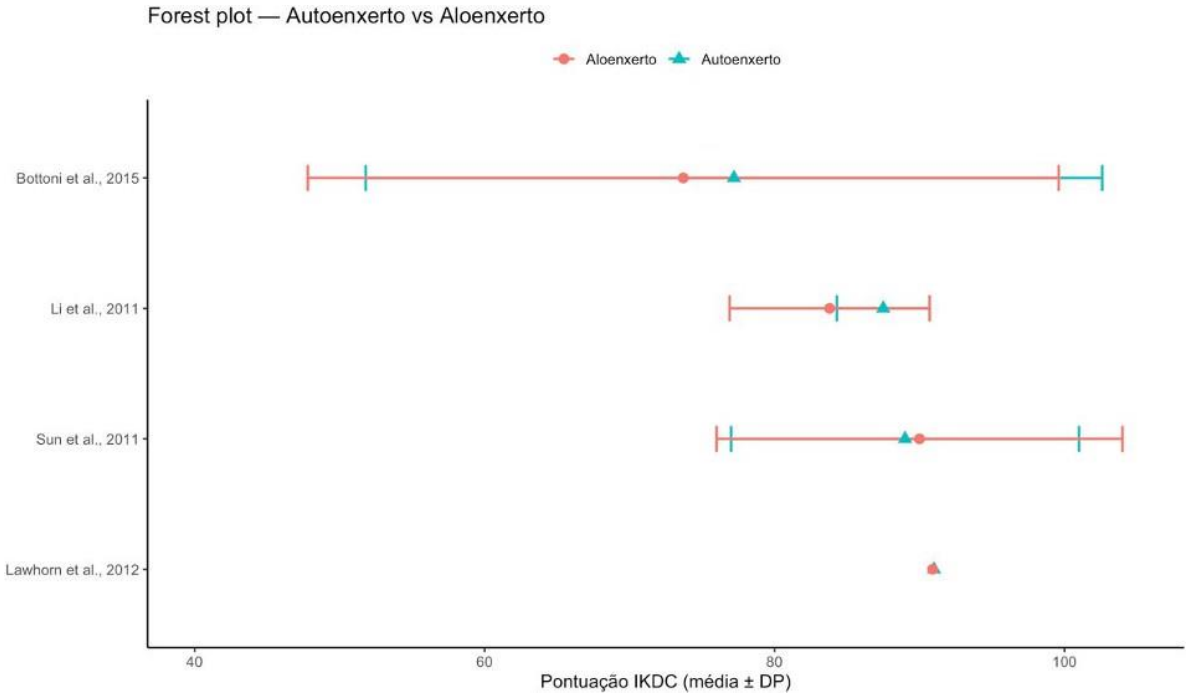

Figure 2 shows the analysis of the subjective IKDC with autograft and allograft at long-term follow-up (≥ 24 months).

In the study by Bottoni et al.[1], some patients did not complete the full follow-up due to loss to follow-up, including change of place of residence, dropouts or clinical complications that prevented the final assessment. For this reason, the authors presented two populations for analysis: the intention-to-treat (ITT) population, which included all 50 patients originally randomized in each group, and the "without failure" population, which excluded patients who had graft failure or did not complete follow-up. Thus, for this analysis, we chose to use the ITT population, to maintain the total number of randomized patients and avoid attrition bias.[1]

Thus, considering the ITT, 99 patients (100 knees) were randomized, with 50 in each group (autograft and allograft). All patients underwent anterior cruciate ligament (ACL) reconstruction with a standardized fixation technique, using semitendinosus tendon autograft in the autologous group and posterior tibial tendon allograft in the allograft group, without allograft irradiation. The average age was 28.9 for the autograft group and 29.2 for the allograft group. Most of the injuries occurred due to sports trauma and intense physical activity, typical of the military population studied.[1]

The functional assessment showed significant improvement in both groups. In the subjective IKDC (International Knee Documentation Committee), the mean scores were 77.2 ± 25.4 for the autograft and 73.7 ± 25.9 for the allograft, with no statistically significant difference. The IKDC objective showed a predominance of categories A (normal) and B (almost normal), indicating good joint stability and function in both groups. The Tegner Activity Scale and Lysholm scores also reflected satisfactory recovery of function and physical activity, with no clinically relevant differences between the groups.[1]

had adequate results, with no significant differences between the grafts. The complications observed were mostly related to graft failure, occurring in 4 patients (8%) in the autograft group and 13 (26%) in the allograft group, showing a higher failure rate in the allograft group.[1]

The randomized study by Li et al.2 evaluated 64 patients undergoing anterior cruciate ligament (ACL) reconstruction, divided into two groups: 32 patients received autograft and 32 received g-irradiated allograft, with a mean follow-up of 70.8 ± 7.2 months (approximately 5.9 ± 0.6 years). For this analysis, only the autograft and allograft groups were considered, excluding the hybrid arm, since the comparison focused exclusively on these two techniques.[2]

The predominant mechanism of injury was sports, mainly involving soccer, basketball and recreational activities, with no significant difference between the groups. The average surgery time was 63.2 ± 12.6 minutes for the autograft group and 58.5 ± 13.4 minutes

for the allograft group (P > 0.05), while the average tourniquet time was 51.6 ± 9.7 minutes and 47.2 ± 10.1 minutes, respectively (P > 0.05).[2]

In relation to post-operative inflammatory markers, both groups showed an increase in C-reactive protein (CRP) and erythrocyte sedimentation rate (ES) on the 1st post-operative day, CRP peaked on the 3rd day and returned almost to normal on the 14th day. The ESR peaked on the 7th day. As for knee stability, assessed by the KT-1000, it showed a mean side-to-side difference of 2.1 # 0.6 mm in the autograft group and 2.4 ‡ 0.7 mm in the allograft group, with no statistically significant difference (P > 0.05).[2]

The subjective IKDC functional assessment showed a mean of 87.5 ± 3.2 for autograft and 83.8 ± 6.9 for allograft (P = 0.353), while in the objective classification, 90.6% of patients in the autograft group and 87.5% in the allograft group were categorized as "normal" or "almost normal" (P > 0.05). Both the Tegner activity score and the Lysholm score showed significant improvement in both groups, with no relevant differences between them. No serious complications related to the procedure were reported in either group, indicating that both the autograft and the g-irradiated allograft showed similar functional results and comparable safety. [2]

The study by Sun et al.[3] initially included 208 randomized patients, but only 186 were included in the complete clinical evaluation, 91 with autologous grafts and 95 with allogeneic grafts. The mean age was approximately 30 years, with no statistical difference between the groups (29.6 ± 6.9 in the autologous group vs. 31.2 ± 8.3 in the allogeneic group). The interval between injury and surgery was similar, around 2 to 3 months.[3]

The predominant trauma mechanism was sports-related in both groups (approximately 90%), followed by work or traffic accidents to a lesser extent. Surgical time showed a significant difference between the groups: autograft procedures took an average of 78.5 minutes, while allograft procedures lasted 60.5 minutes (p = 0.013).[3]

In the functional assessment, both the subjective and objective scores showed significant progress compared to the preoperative period, with no significant differences between the groups. The mean Lysholm score was 89 in the autologous group and 90 in the allogeneic group, while the mean Tegner score was 7.7 and 7.6, respectively. The subjective IKDC was 89 ± 12 in the autologous group and 90 ± 14 points in the allogeneic group, and more than 90% of patients in both groups were classified as normal or almost normal by the objective IKDC. The Cincinnati score also showed high and comparable averages (90 vs. 91).[3]

In terms of joint stability, the clinical tests (Lachman, pivot-shift and anterior drawer) showed no differences between the groups. In the evaluation with the KT-2000 arthrometer, most patients had a lateral difference of less than 3 mm, and only a small proportion had a displacement of more than 5 mm (7.7% in the autologous group vs. 8.4% in the allogeneic group).[3]

As for complications, no serious events were reported in either group. In the autologous group, five patients had complaints related to the donor site, such as hypoesthesia in the saphenous nerve territory or local pain. In the allogeneic group, there were two cases of superficial wound infection, both of which resolved satisfactorily after antibiotic therapy. There were no cases of deep vein thrombosis, significant joint stiffness, fixation failure or major complications during follow-up.[3]

In the prospective, randomized study by Yoo et al.[4] , 141 randomized patients were initially recruited, but after loss to follow-up, only 132 completed follow-up and were assessed for clinical outcomes, 68 of whom were treated with semitendinosus tendon autograft and 64 with tibial tendon allograft. The average age was 30 years (15-62) in the autograft group and 24 years (13-54) for allograft, but there were no significant differences between the groups. The predominant mechanism of injury was sports-related. The average follow-up was 24 months, during which time functional outcomes and knee stability were assessed.[4]

In the objective IKDC functional assessment, most patients had satisfactory results in both groups. In the autograft group, the majority were classified as A (normal) or B (almost normal), indicating good knee function and stability. In the allograft group, the findings were similar, with a predominance of A and B, with no statistically significant differences. The Lysholm score averaged 96 (range 67-100) points for autograft and 93 (range 73-100) points for allograft, while the Tegner score averaged 5 (range 2-9) and 5 (range 3-8), respectively, also with no significant differences between the groups.[4]

Knee stability, assessed by the Lachman and pivot-shift tests, showed comparable results between the groups, with no relevant statistical differences. Muscle strength of the quadriceps and hamstrings also showed no significant differences between the groups. Regarding the progression of osteoarthritis, five patients in the autograft group and four in the allograft group showed radiographic changes, with no significant difference. During revision arthroscopy, synovial coverage of the graft was observed to be better in the autograft group, but there was no difference in the rate of graft rupture between the groups.[4]

The study by Lawhorn et al.5 included 147 patients with isolated ACL injuries, divided into two groups: 74 who underwent reconstruction with a semitendinosus tendon autograft and 73 with a fresh tibialis anterior tendon allograft. After a minimum follow-up of 2 years, 102 patients completed the final assessment (54 in the autograft group and 48 in the allograft group). The mean age was 32.0 ± 8.5 years in the autograft group and 33.3 ± 9.2 years in the allograft group, with no statistically significant difference.[5]

The subjective IKDC scores were similar between the groups, with averages of 91.0 in the autograft group and 90.9 in the allograft group ($P > 0.05$). Among the patients in the group who underwent autograft reconstruction, 46 patients (85%) were classified as having normal function, 7 (13%) with almost normal function and 1 (2%) with severely abnormal function. In the allograft-treated group, 43 (90%) achieved a normal score and 5 (10%) almost normal. There was no statistically significant difference between the groups.[5]

As for stability, assessed by the Lachman and pivot shift clinical tests, 92% of the patients in the autograft group and 90% in the allograft group had stable knees, with no statistically significant difference between the groups. Functional scores also improved significantly: on the Lysholm, the average went from 63 ± 12 to 91 ± 8 in the autograft group and from 61 ± 11 to 90 ± 9 in the allograft group. The Tegner activity score increased from 3.1 ± 1.4 to 7.4 ± 1.6 in the autograft group and from 3.0 ± 1.5 to 7.2 ± 1.5 in the allograft group, with a $P < 0.05$ compared to the preoperative period, with no significant difference between the groups in the postoperative period.[5]

In the final radiographic evaluation (AP and lateral in full extension), most patients did not present arthrosis. In the medial compartment, 93% of the autograft group and 88% of the allograft group were free of alterations, while mild cases were rare in both groups ($P > 0.05$). In the lateral compartment, 96% of the autograft and 88% of the allograft showed no arthrosis, with 5 allograft patients showing mild narrowing ($P < 0.05$). There were no signs of femoral roof impingement or posterior cruciate ligament injury in any group. No complications related to the procedure were reported. However, 3 patients in the autograft group underwent reoperation and 4 in the allograft group, unrelated to knee instability.[5]

Discussion

In the studies analyzed, some methodological differences are worth highlighting. Li et al.[2] evaluated three arms (autograft, irradiated allograft and hybrid), but only the first two were included in this analysis. Although irradiating the allograft reduces the risk of infection, it can alter its biomechanical properties. Similarly, Sun et al.[3] compared autograft and irradiated allograft, providing complementary data on the clinical efficacy of these grafts.

In the study by Bottoni et al.[1], there was a high standard deviation in subjective IKDC scores, reflecting wide variation between patients, possibly related to long follow-up (≥10 years) and individual differences in functional evolution. These factors reinforce the need for caution when interpreting the results and may contribute to the heterogeneity observed in the meta-analysis findings, especially when comparing different types of graft and follow-up periods.[1]

The literature shows that both autologous and allogeneic grafts are viable options for ACL reconstruction, but differences in stability, risk of failure and biological integration must be considered. Randomized trials suggest that both techniques can offer good functional outcomes, but with greater consistency of autogenous grafts in measures of fine stability.[1,5]

In long-term follow-up, some studies have reported no significant differences between autogenous and allogenous grafts after 10 years, indicating comparable clinical durability when the grafts are well indicated.[1] However, other studies have highlighted the potential limitations of allogenous grafts. Li et al. observed greater laxity and failure in irradiated and hybrid grafts, while Sun et al. identified greater instability with fresh allografts.[2,3] Yoo et al., when associating clinical

evaluation with second-look arthroscopy, showed inferior integration in allografts, suggesting a delay in the ligamentization process.[4]

Systematic reviews confirm these findings. A meta-analysis of RCTs showed that autografts present a lower risk of graft failure and better objective stability than allografts, although self-reported function did not differ significantly.[6] Similar results were reported by Wang et al.[7], who reinforced the higher rate of residual laxity in allografts, even though the functional scores were comparable.7 More recently, Zhu et al.[8] updated the evidence and concluded that, although both provide clinical improvement, autogenous remains the safer option for young patients and athletes due to the lower risk of rerupture.[8]

In addition, the type of autograft has also been widely compared. Mouarbes et al.[9] showed that quadriceps tendon grafts have similar or better results than patellar and hamstring grafts, especially in terms of stability and less anterior knee pain. Hurley et al.[10] reinforced this evidence, showing a lower rate of re-injury with quadriceps compared to hamstring. In the context of hybrids, Chang et al.[11] identified a higher risk of failure when compared to autogenous isolates, raising concerns about the real benefit of this technique. Fan et al.[12] addressed artificial grafts, highlighting worse long-term results, with higher failure rates, limiting their routine clinical use.

From a clinical point of view, allografts still offer practical advantages - no morbidity in the donor area, shorter surgical time and usefulness in multiple reconstructions or revisions - but the greater biomechanical robustness and biological integration of autografts favors their use in young populations, athletes and in situations that require high functional demand. The findings of recent meta-analyses reinforce that the choice should be individualized, taking into account age, sporting level, the type of graft available and the method of processing the allogenous graft.[5-12]

Finally, the literature still shows significant methodological heterogeneity, especially in relation to the type of allograft processing (fresh, frozen, irradiated), fixation methods and evaluation criteria. Future studies should focus on multicentre, long-term trials with standardized clinical and radiographic outcomes in order to clarify the impact of the graft in preventing post-trauma joint degeneration.

Conclusion

ACL reconstruction with autografts and allografts results in significant clinical improvement, but autografts have a lower risk of failure and better stability, making them the preferred option in young patients and athletes. Allografts remain a viable alternative in specific cases, but the type of graft processing has an impact on their results. The choice must be individualized and new long-term studies are needed to define the role of each graft more precisely.

The results shown in the forest plot indicate that, in general, there are no clinically relevant differences between the use of autograft and allograft in the subjective IKDC score in long-term follow-up (≥ 24 months). In all the studies analyzed, the means were very close between the two types of graft, with small variations within the standard deviation intervals. Bottoni et al. (2015) showed a greater dispersion of scores, but still no evidence of a marked difference between the groups. On the other hand, the studies by Li et al. (2011), Sun et al. (2011) and Lawhorn et al. (2012) show high (above 83 points) and consistent averages for both grafts, reinforcing that, in the long term, both autograft and allograft offer similar functional results.

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