

Review Article

Functional Outcome Comparison Between Single Bundle Versus Double Bundle in ACL Reconstruction: A Meta-Analysis

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Abstract

Introduction:

Anterior Cruciate Ligament (ACL) tears are a common and debilitating sports-related injury, often necessitating surgical intervention for effective recovery. Two primary surgical techniques employed for ACL reconstruction are the Single Bundle (SB) and Double Bundle (DB) approaches. This meta-analysis aims to quantitatively assess and compare the outcomes of these two surgical methods in ACL tear patients, with a focus on functional outcome measures, specifically the Lysholm Score and the International Knee Documentation Committee (IKDC) Score.

Methods:

A thorough search of pertinent databases was executed to identify studies directly comparing SB and DB ACL reconstruction and reporting outcomes based on either the Lysholm Score or the IKDC Score. A total of eight studies met the inclusion criteria for Lysholm Score analysis, while seven studies were suitable for IKDC Score analysis, collectively involving 614 patients. The meta-analysis employed a random-effects model, and forest plots were utilized to visualize effect sizes and their associated confidence intervals.

Results:

The meta-analysis findings demonstrated a statistically significant difference favoring the Double Bundle approach concerning Lysholm Score outcomes ($p < 0.05$). Patients undergoing Double Bundle ACL reconstruction exhibited superior Lysholm Scores compared to those undergoing the Single Bundle technique. In contrast, the difference in IKDC Score outcomes between the two approaches was not statistically significant ($p > 0.05$). This implies that when using the IKDC Score as the functional outcome measure, there is no substantial divergence in patient outcomes between single-bundle and double-bundle ACL reconstruction.

Conclusion:

In summary, this meta-analysis provides evidence that double-bundle ACL reconstruction leads to improved outcomes in terms of the Lysholm Score when compared to single-bundle reconstruction. However, no significant disparities were observed between the two techniques when the IKDC Score was used to evaluate functional outcomes. Consequently, both Single Bundle and Double Bundle ACL reconstruction can be considered viable treatment options for ACL tears. The selection between these approaches should be based on patient-specific factors and the expertise of the surgeon. Further research, particularly randomized controlled trials, may offer more nuanced insights into the optimal surgical approach for distinct subsets of ACL tear patients.

Introduction

The management of injuries to the Anterior Cruciate Ligament (ACL) is evolving alongside advancements in surgical techniques, protocols for rehabilitation, and an increasingly deep understanding of the biomechanics of the knee. Within the spectrum of surgical options available for ACL reconstruction, a significant area of debate and investigation lies in the choice between the Single Bundle (SB) and Double Bundle (DB) techniques. Both methods share the common goal of restoring knee stability and functional outcomes for patients recovering from ACL injuries, yet they diverge in terms of their fidelity to the anatomical structure and biomechanical principles.

The single-bundle approach involves using a single graft to replicate the function of the original ACL, whereas the double-bundle technique employs two grafts to imitate the anteromedial and posterolateral bundles of the native ligament. Advocates of the Double Bundle technique contend that it more faithfully restores typical knee kinematics and stability, potentially resulting in better clinical results. However, some surgeons prefer the Single Bundle technique due to its simplicity and shorter surgical duration, which could reduce the chances of complications associated with a more intricate procedure.

Over time, numerous clinical studies have explored the effectiveness of these two techniques, but the outcomes have been inconsistent and frequently contradictory. Elements such as patient selection, graft selection, fixation methods, and surgical proficiency can all impact the consequences of ACL reconstruction surgeries. As a result, consolidating the existing body of evidence via a comprehensive meta-analysis can yield valuable insights into the relative efficacy of the single-bundle and double-bundle approaches.

This meta-analysis seeks to methodically assess and evaluate the available literature to address critical inquiries regarding the clinical outcomes of ACL reconstruction using both single-bundle and Double Bundle techniques. The findings of this meta-analysis can carry substantial implications for clinical practice, aiding in the refinement of surgical strategies and the enhancement of patient outcomes in ACL reconstruction procedures. Ultimately, a thorough comparison of single-bundle and Double Bundle techniques can contribute to an evidence-driven strategy that optimizes both short-term recovery and long-term knee function for individuals recuperating from ACL injuries.

Material & Methods

Study design

The research was carried out following the Preferred Reporting Items for Systematic Reviews and Meta-

analyses guidelines statement.

Review question

The review sought to answer the following questions using the population, intervention, comparison, and outcome approach: among patients with ACL rupture, who undergo either Single Bundle or Double Bundle ACL Reconstruction, which option yields the most clinical improvements. The researchers screened multiple medical databases including PubMed, Embase, and Scopus for relevant scientific reports, using a combination of keywords such as "ACL Rupture or Injury," "single bundle," "double bundle" and "ACL Reconstruction" (MeSH). The search was last conducted in August 2023, and two reviewers independently screened the abstracts and reference lists, with any discrepancies resolved through consultation with a third author

Inclusion criteria & outcomes measurement

The following were the criteria for including studies: 1) prospective or retrospective comparative English studies comparing "single bundle" vs. "double bundle" reconstruction technique in patients with anterior cruciate ligament tear, and 2) reporting outcomes measurements such as the International Knee Documentation Committee (IKDC) score, and Lysholm Score.

International Knee Documentation Committee (IKDC) score subjective Knee Form, an 18-item, region-specific instrument designed to measure symptoms, function, and sports activity.^{33,34} The instrument contains 18 selected items designed to measure symptoms assess pain, stiffness, swelling, joint locking, and joint instability, while other items designed to measure knee function assess the ability to perform activities of daily living. Items purported to measure the respondent's activity levels such as the ability to run, stop, jump, and start quickly, ascend and descend stairs, stand, kneel, squat, sit and rise from a chair.

The IKDC Subjective Knee Evaluation Form is assessed by adding the results of each item's scores and then converting the result to a scale from 0 to 100. IKDC Score Calculation: (sum of all items/maximum score (87)) and multiplied by 100. Higher scores indicate higher levels of function, when there are responses to at least 90% of the items, the IKDC Subjective Knee Form score can be determined.

The Lysholm Scoring Scale is an assessment for the patient used to evaluate the functional status of the knee joint. The Lysholm Scoring Scale consists of eight questions that measure pain, swelling, locking, limping, and the ability to ascend and descend stairs, squatting, and weight bearing. Each question is scored on a scale from 0 to 10, with a total possible score of 100. A score of 95-100 points is excellent knee function, 84-94 points is good knee function, 65-83 points is fair knee function, < 65 points is poor knee function. In addition, a change of at least 10-15 points is considered to be

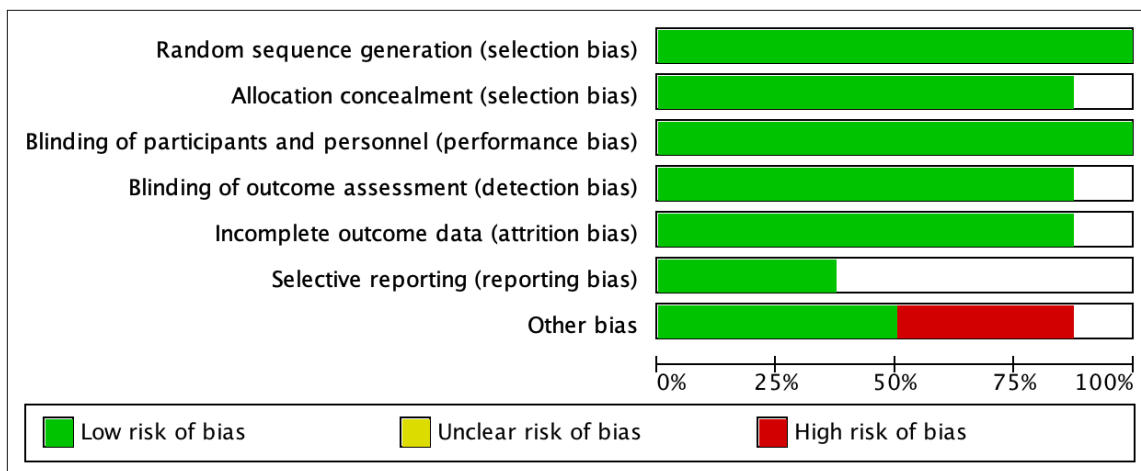


Figure 1. Risk of Bias Graph

clinically significant, indicating a meaningful improvement or deterioration in knee function. Scores above 84 points are considered good to excellent, whereas scores below 65 points indicate a need for further evaluation and intervention.

Quality assessment

Two reviewers independently reviewed each article. Any noticed discrepancies are resolved by consensus and comprehensive discussion. Included RCTs will be assessed in terms of quality by the same two independent reviewers based on 7-item of Cochrane’s criteria for judging the risk of bias in the ‘Risk of bias’ assessment tool, including selection bias, performance bias, detection bias, attrition bias, reporting bias and other bias.

Statistical analysis

Data extraction was collected under basic characteristics and outcomes using designated tables in Microsoft Excel (Microsoft Corp., Redmond, WA, USA) for all identified and included studies. When the data were available, quantitative analysis was performed using Review Manager (RevMan computer program ver. 5.4). Outcomes were presented in the form of forest plots. In each study, the mean difference for continuous outcome and odds ratio for dichotomous outcome with a 95% confidence interval (CI) was calculated. A fixed-effects model was used when the heterogeneity <50%, whereas a random-effects model was used when the heterogeneity >50%.

Result

The present investigation involved reviewing 774 articles (as shown in Figure 3) and ultimately selecting 5 studies for inclusion (as outlined in Table 2 and Table 3).

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Aga 2018	+	+	+	+	+		⊖
Bevas 2017	+		+				+
Jarvela 2017	+	+	+	+	+		+
Kang 2015	+	+	+	+	+		+
Karlık 2016	+	+	+	+	+		+
Komzak 2018	+	+	+	+	+	+	⊖
Mohtadi 2019	+	+	+	+	+	+	
Sun 2014	+	+	+	+	+	+	⊖

Figure 2. Risk of Bias Summary

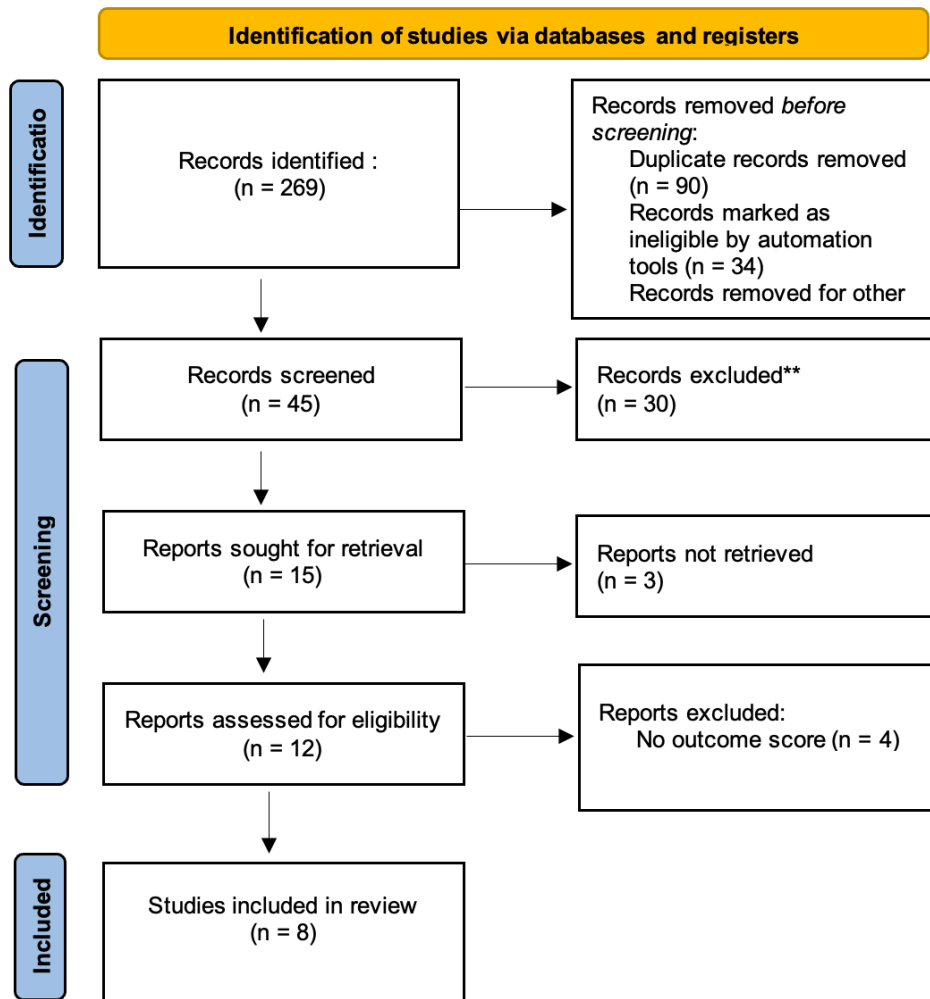


Figure 3. PRISMA for the flowchart of study selection (n = 5)

	Inclusion	Exclusion
Population	Patients with ACL rupture or injury	Patient ACL rupture with other soft tissue problems
Intervention	Patients treated with single bundle ACL Reconstruction.	Patients treated with conservative and primary ACL repair
Control	Patients treated with double bundle ACL Reconstruction.	Patients treated with conservative and primary ACL repair
Outcome	Lysholm Score IKDC Score	Outcomes not mentioned The outcome with other parameters than our inclusion criteria.

Table 1. Table of PICO

No.	Studies	Subject	Age (year)	Male	Female	Follow Up
1.	Sun, et al (2014)	SB: 142 DB: 154	SB: 28+8.25 DB: 27+8.25	SB: 101 DB: 41	SB: 41 DB: 48	SB: 3yr DB: 3yr
2	Kang, et al (2015)	SB: 43 DB: 41	SB: 30±5 DB: 28±5	SB+DB: 41	SB+DB:43	SB: 3yr DB: 3yr
3	Karikis, et al (2016)	SB: 50 DB: 53	SB: 25+8.5 DB: 29+8.5	SB+DB:71	SB+DB:33	SB: 5yr DB: 5yr
4	Beyaz, et al (2017)	SB: 16 DB: 15	SB:31.06± 5.48 DB:33.53±5.47	SB+DB:31	SB+DB:0	SB: 8yr DB: 8yr
5	Jarvela et al (2017)	SB: 30 DB: 30	SB: 30 DB: 34	SB: 21 DB: 21	SB: 9 DB: 9	SB: 10yr DB: 10yr
6	Aga, et al (2018)	SB: 62 DB: 54	SB: 27.1± 5.5 DB: 27.4± 6.3	SB+DB:88	SB+DB:28	SB: 2yr DB: 2yr
7	Komzak, etl al (2018)	SB: 20 DB: 20	SB: 27,5+6.25 DB: 27,5+6.25	SB+DB:23	SB+DB:17	SB: 2yr DB: 2yr
8	Mohtadi, et al (2019)	SB: 110 DB: 110	SB: 28.5± 9.9 DB: 28.3± 9.8	SB+DB:120	SB+DB:100	SB: 5yr DB: 5yr

Table 2. Characteristic of studies

No	Reference	Outcome Measure	
		Lysholm Score	IKDC Score
1	Sun, et al (2014)	SB:91.2+4.8 DB: 91.7 ± 4.2	SB: 92.7 ± 4.3 DB: 92.9 ± 4.3
2	Kang, et al (2015)	SB: 49.0 ± 10.1 DB: 51.2 ± 13.2	SB: 89.9 ± 4.7 DB: 91.1 ± 5.6
3	Karikis, et al (2016)	SB: 84.3+21.2 DB: 90.1+69.1	NA
4	Beyaz, et al (2017)	SB: 81.94 ± 7.15 DB: 81.43 ± 6.45	SB: 71.29 ± 9.14 DB: 70.71 ± 9.44
5	Jarvela et al (2017)	SB: 141 ± 7.5 DB: 94 67	SB: 9 ± 1.5 DB: 9 + 2
6	Aga, et al (2018)	NA	SB: 64.3 (61.0+67.6) DB: 69.5 (66.0+73.1)
7	Komzak, etl al (2018)	SB:89.3+13.3 DB:97.5+7.2	SB: 72.8+13.2 DB: +11.9
8	Mohtadi, et al (2019)	NA	SB: 83.9 ± 12.9 DB: 84.3 ± 13.4

Table 3. Summary of outcomes

Lysholm Score

In 6 studies, including a total of 301 patients in the Single Bundle group and 313 patients in the Double Bundle group, Lysholm scores were analyzed. At the final follow-up, the mean Lysholm score difference in the Double Bundle group is higher than Single Bundle ACDF group is 2.64 points. Figure 4 demonstrates that there was a statistically significant difference between the two groups (CI = -1.68 to 3.59; P <0.00001). High heterogeneity was evident among these studies (I² = 95%; P < 0.00001).

IKDC

In 7 studies, including a total of 423 patients in the single bundle group and 411 patients in the double-bundle group, the IKDC score was analysed. Figure 5 demonstrates that there was no statistically significant difference between the two groups (CI = -0.76 to 0.96; P = 0.83). High heterogeneity was evident among these studies (I² = 89%; P < 0.00001).

(IKDC) Score as functional outcome measures.

In a systematic review conducted by Mascarenhas and colleagues, the findings indicated that the Double-Bundle (DB) technique yielded superior results concerning knee stability and functional outcomes when compared to the Single-Bundle (SB) technique. Additionally, several more recent reviews have corroborated these findings, demonstrating improved knee stability and functional outcomes with the DB approach during mid-term follow-up assessments. However, it is noteworthy that individuals who underwent either DB or SB procedures reported similar outcomes during long-term follow-up evaluations.¹

The Lysholm Score serves as a valuable metric for assessing the functional outcomes of ACL reconstruction surgery. In our analysis of six studies encompassing 301 patients in the Single Bundle group and 313 patients in the Double Bundle group, we observed a noteworthy difference in mean Lysholm scores at the final follow-up. The Lysholm scores in the Double Bundle group were, on average, 2.64 points higher than those in the Single Bundle group, indicating superior functional outcomes. Moreover, the forest plot analysis illustrated a statistically significant difference favoring the Double Bundle approach (P < 0.00001). While the other twelve studies reported on Lysholm score²⁻¹⁰. There was no significant difference between DB and SB in terms of overall Lysholm score¹¹⁻²³. However, it is essential to acknowledge the substantial heterogeneity among these studies (I² = 95%; P < 0.00001), suggesting variability in patient

Discussion

Anterior Cruciate Ligament (ACL) injuries are a common occurrence among athletes and individuals engaged in physical activities, necessitating surgical intervention for optimal recovery. This discussion focuses on the outcomes of Single Bundle (SB) and Double Bundle (DB) ACL reconstruction procedures, with a particular emphasis on the Lysholm Score and the International Knee Documentation Committee

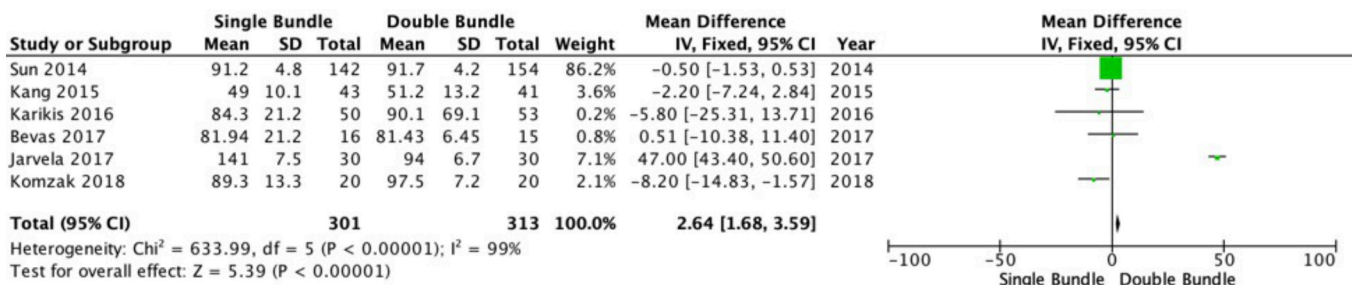


Figure 4. Forest plot illustrating the comparison of Lysholm score between Single Bundle and Double Bundle ACL Reconstruction

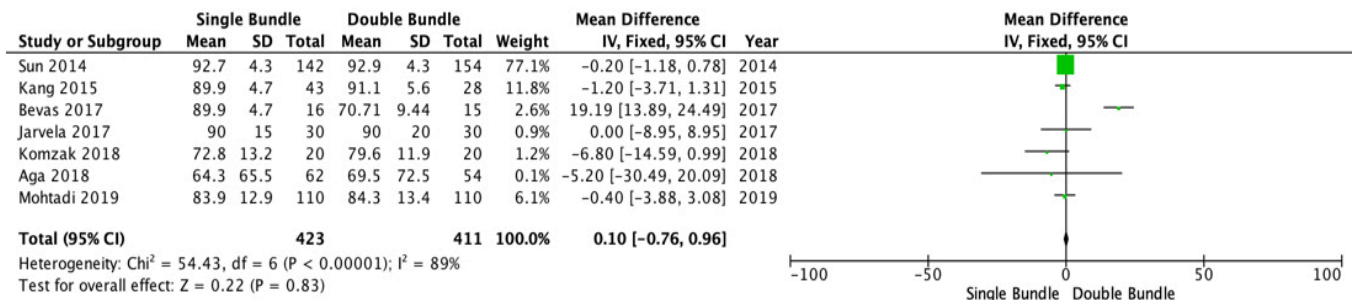


Figure 5. Forest plot illustrating the comparison of IKDC score between Single Bundle and Double Bundle ACL Reconstruction

populations, surgical techniques, and rehabilitation protocols. This heterogeneity underscores the importance of considering individual patient characteristics and the need for more standardized research in this field.

Conversely, the IKDC Score, another vital measure of functional outcomes following ACL reconstruction, yielded different findings. Our analysis of seven studies involving 423 patients in the Single Bundle group and 411 patients in the Double Bundle group revealed no statistically significant difference in IKDC scores between the two surgical approaches ($P = 0.83$). Despite this lack of statistical significance, it is crucial to note the high heterogeneity observed among these studies ($I^2 = 89\%$; $P < 0.00001$), mirroring the heterogeneity seen in the Lysholm Score analysis. The high heterogeneity in both Lysholm and IKDC Score analyses suggests that additional factors beyond surgical technique may influence functional outcomes, such as patient compliance with rehabilitation protocols and individual variations in recovery. Mayr et al evaluated the subjective and objective IKDC scores between the 2 techniques and also did not find any difference between the 2 groups²⁴. Only one analogous study found the superiority of subjective IKDC scores in the DB group compared to SB group⁷ while other studies did not detect a significant difference²⁵⁻²⁸. Statistic significances of IKDC grading were found in six previous meta-analyses in favor of DB ACL reconstruction²⁹⁻³² and Chen et al and Li et al did not detect a significant difference^{25,28}. About our outcomes of knee function scores, the IKDC grading deserved the primary disagreement with previous studies. It is noteworthy that these meta-analyses with controversy only include studies with short-term follow-up.

Conclusion

These findings collectively suggest that while the Double Bundle approach may offer advantages in terms of Lysholm Scores, it does not demonstrate a significant edge over the Single Bundle approach when considering IKDC Scores. Thus, the choice between these two surgical techniques should be tailored to individual patient needs and surgeon expertise. Furthermore, the high heterogeneity observed in our analysis underscores the need for standardized reporting of outcomes and more rigorous research protocols in future studies. Additional well-designed randomized controlled trials with larger patient cohorts and standardized rehabilitation protocols are necessary to provide further insights into the optimal surgical approach for ACL reconstruction in specific patient populations.

Conflict of Interest

The authors declare that, there is no conflict of interest regarding this study.

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