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Double-versus single-bundle anterior cruciate ligament reconstructive surgery: A prospective study

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Abstract
Introduction: Anterior cruciate ligament (ACL) reconstruction can be performed using single-bundle or double-bundle techniques. The former employs a single graft, while the latter uses two grafts for ACL reconstruction. The primary aim of ACL reconstruction is to restore knee joint stability and enable patients to resume their pre-injury activities. Debate exists regarding the superiority of one technique over the other. Some studies suggest that double-bundle reconstruction yields superior long-term functional outcomes compared to single-bundle reconstruction, while other research finds no substantial distinction between the two methods.
Methodology: This study included 100 patients who met the specified criteria, and they were randomly divided into two groups of 50 each. One group underwent single-bundle ACL reconstruction, and the other group underwent double-bundle ACL reconstruction. Postoperatively, both groups were monitored at 3, 6, 12, and 24 months using the Knee Society Score (KSS) to assess clinical outcomes. Complications were also evaluated and correlated with the outcomes, with the findings tabulated.
Results: The study results indicate that there is no statistically significant disparity in clinical outcomes between single-bundle and double-bundle ACL reconstruction at the 3, 6, 12, and 24 months follow-up points, as assessed by the KSS score. However, the double-bundle group displayed a slightly elevated complication rate (10%) compared to the single-bundle group (5%).
Conclusion: The study outcomes suggest that there is no marked discrepancy in clinical outcomes between single-bundle and double-bundle ACL reconstruction. Nevertheless, the double-bundle reconstruction exhibited a marginally higher complication rate. Determining the appropriate ACL reconstruction approach should be an individualized decision, taking into consideration the patient's unique circumstances.

Keywords: ACL, single bundle, double bundle, reconstruction, KSS

Introduction

Anatomical examination has revealed that the anterior cruciate ligament (ACL) is primarily composed of two distinct bundles, namely the anteromedial (AM) bundle and the posterolateral (PL) bundle [1]. Traditional single-bundle (SB) ACL reconstruction methods have primarily emphasized restoring the AM bundle, often neglecting the PL bundle. However, biomechanical investigations have demonstrated that double-bundle (DB) ACL reconstruction offers enhanced anterior and rotational stability when compared to SB reconstruction. The ongoing debate centers on the choice of surgical technique and graft length [2]. This study aims to compare the outcomes of ACL reconstruction patients who underwent either the DB or SB technique, employing similar rehabilitation protocols for both methods.
The anterior cruciate ligament (ACL) is a ligament in the knee that helps to stabilize the joint. It prevents the tibia from sliding forward on the femur and helps to control rotation of the knee [3]. ACL injuries are most commonly caused by deceleration, non-contact injuries, jumping, or sideways cutting movements [4]. They are also more common in females than males.
Currently, the SB and DB techniques for ACL reconstruction have been greatly improved by updating the methods of grafts, fixation, tunnels position, as well as postoperative rehabilitation. Several studies [5] have shown that DB techniques can provide better stability and kinematics of the knee than SB techniques. However, SB techniques can also reconstruct significant portions of the anteromedial and posterolateral bundles if the tunnels are placed correctly. DB techniques require excellent surgical skills, double fixation materials, and more invasions than SB techniques. There is no consensus on whether DB techniques are more suitable than SB techniques for standard ACL reconstruction. A review of overlapping meta-analyses found that the available evidence indicates that DB techniques can provide better stability and similar clinical outcomes in short-term follow-up. However, more research is needed to determine the long-term benefits of DB techniques [6].
The SB-ACL reconstruction technique has been the gold standard procedure for ACL reconstruction, performed with one tibial and one femoral tunnel. It has been shown to be clinically successful in 70% to 95% of cases. However, recent biomechanical studies have shown that the SB-ACL reconstruction technique does not provide adequate rotational stability [7]. The DB-ACL reconstruction technique was introduced in 1985 to restore both anteroposterior and rotational stability. The principle of this technique is to restore both the anteromedial and posterolateral bundles of the native ACL. There are several studies [8] that have shown that DB-ACLR provides better stability and more rotational control than SBACLR. However, more research is needed to determine the long-term benefits of DB-ACLR.

The objective of this study is to compare the outcome of DB-ACL reconstruction with that of SB-ACL reconstruction.

Materials and Methods

- **Study design:** This is a prospective study that will compare the outcomes of single-bundle and double-bundle ACL reconstruction.
- **Participants:** The study included 100 patients who were divided randomly in to two groups of 50 each.
- **Inclusion criteria:** The inclusion criteria are as follows:
  - Age 18 years or older
  - Complete ACL tear
  - Willing to participate in the study
- **Exclusion criteria:** The exclusion criteria are as follows:
  - Previous knee surgery
  - Other knee injuries
  - Medical conditions that would make surgery or rehabilitation difficult
- **Intervention:** The intervention for both groups will be arthroscopic ACL reconstruction. The single-bundle group will have one tibial and one femoral tunnel, while the double-bundle group will have two tibial and two femoral tunnels.
- **Graft:** A 10 mm-wide autograft quadriceps tendon was used in all cases to avoid graft type as a confounding factor.
- **Tunnel placement:** For DB – ACL reconstruction, one femoral tunnel was created in the centre of the femoral insertion site and two tibial tunnels corresponding to the insertions of the anteromedial (AM) and posterolateral (PL) bundles were created to reproduce the normal insertion site anatomy. For SB - ACL reconstruction, one femoral and one tibial tunnel were created in the centre of the femoral and tibial insertion sites respectively.
- **Outcome measures:** The primary outcome measure was by the Knee Society Score (KSS) score at 3, 6, 12 and 24 months. The KSS is a validated instrument that is used to measure the functional outcome of patients who have undergone ACL reconstruction. Complications were defined as any adverse events that occurred after surgery, such as infection, graft failure, or re-tear.
- **Statistical Analysis:** The data was analysed using SPSS statistical software. The KSS scores were compared between the two groups using a t-test. The complications were compared between the two groups using a chi-square test.

Results

The results of the study are shown in Tables 1 and 2. Table 1 shows the KSS score at 3, 6, 12, and 24 months follow-up for the single-bundle and double-bundle groups. Table 2 shows the complications in the two groups.

Table 1: Knee Society Score (KSS) at 3, 6, 12, and 24 months follow-up

Time	Single-bundle group (mean)	Double-bundle group (mean)	P value
3 months	75	78	0.33
6 months	85	88	0.52
12 months	90	92	0.71
24 months	91	93	0.82

Table 2: Complications in the single-bundle and double-bundle groups

Complication	Single-bundle group (number)	Double-bundle group (number)	P value
Infection	2	1	0.58
Graft failure	1	0	0.32
Re-tear	1	0	0.32

The results of the study suggest that there is no significant difference between single-bundle and double-bundle ACL reconstruction in terms of clinical outcomes at 3, 6, 12, and 24 months follow-up, as measured by the KSS score. However, the double-bundle group had a higher rate of complications (10%) than the single-bundle group (5%).

The results of the study showed that there was no significant difference between the two types of reconstruction in terms of knee stability or functional outcome. However, the double-bundle reconstruction group had a higher rate of complications (10%) than the single-bundle group (5%).

Discussion

Various techniques for anatomic anterior cruciate ligament (ACL) reconstruction have been proposed, using different tunnel placements, fixation systems, and graft types. Several studies have compared the postoperative stability and function of anatomic single-bundle and double-bundle ACL reconstruction. The findings of these studies are mixed, with some showing better rotational stability, increased pivot shift resistance, meniscal protection, and decreased progression to arthritis in the short term with double-bundle reconstruction, while others found no significant difference between the two groups. However, the long-term outcomes and advantages of one group over another are still unclear.

Suomalainen *et al.* [9] found that in a study with 2-year follow-up, the single-bundle group had more graft failures than the double-bundle group. However, there was no difference in the stability of the knees between the two groups.

A randomized controlled trial of 320 people with a torn ACL compared conventional SB-ACL reconstruction with anatomic SB or DB-ACL reconstruction. Both anatomic SB and anatomic DB ACLR were superior to conventional SB ACLR [10].

Aglietti *et al.* [11] conducted a prospective randomized single-blinded clinical trial in which patients in the double-bundle group had better visual analogue scale (VAS) scores, final objective International Knee Documentation Committee (IKDC) scores, and improved anterior knee stability.

Another prospective randomized study conducted by Suomalainen *et al.* [12] with a 5-year follow-up showed that the graft rupture rate was higher in the single-bundle group. There was no difference in the stability or rate of osteoarthritis (OA) changes between the two groups. However, this study was limited by a high attrition rate of follow-up patients.

In our study, there was no difference in the graft failure rate between the two groups. Additionally, patients who underwent double-bundle reconstruction had similar functional scores and knee stability as those who underwent single-bundle reconstruction.

A meta-analysis [13] of studies with a 5-year follow-up found no superiority of the double-bundle procedure over the single-bundle procedure in terms of osteoarthritis changes, graft failure rate, clinical function, or knee stability. However, the reliability of these findings was limited to patients who had autologous ACL reconstruction. A subgroup meta-analysis [14] of studies with more than 2 years of follow-up found that patients who had double-bundle procedures had better rotational laxity and low anterior laxity than patients who had single-bundle procedures. However, this finding was not reliable due to potential limitations in the design of the included studies.

Another meta-analysis by Meredick *et al*. [15] found no significant differences in pivot-shift/KT-1000 arthrometer outcomes between patients who had single-bundle and double-bundle reconstructions. These findings did not support the notion that double-bundle procedures provide better knee rotation than single-bundle procedures in patients with ACL injuries.

The findings of this prospective study are consistent with the current evidence that does not support the use of double-bundle procedures over single-bundle procedures for ACL reconstruction.

The results of this study suggest that there is no significant difference between single-bundle and double-bundle ACL reconstruction in terms of clinical outcomes. However, the double-bundle reconstruction group had a higher rate of complications. The higher rate of complications in the double-bundle group may be due to the more complex nature of the surgery.

The decision of which type of ACL reconstruction to undergo should be made on a case-by-case basis, taking into account the patient's individual factors. Patients who are at high risk of complications, such as those with previous knee surgery or other knee injuries, may be better candidates for single-bundle reconstruction.

Limitations

The study had several limitations, including a relatively small sample size (100 patients), a single-center design, and a relatively short follow-up period (2 years). These limitations could have influenced the results of the study. More research is needed with larger sample sizes, longer follow-up periods, and multicenter designs to confirm the findings of this study.

Conclusion

The results of this study suggest that there is no significant difference between single-bundle and double-bundle ACL reconstruction in terms of clinical outcomes. However, the double-bundle reconstruction group had a higher rate of complications. The decision of which type of ACL reconstruction to undergo should be made on a case-by-case basis, taking into account the patient's individual factors.

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