

# Systematic Review of Single-Bundle Anterior Cruciate Ligament Reconstruction Outcomes

## A Baseline Assessment for Consideration of Double-Bundle Techniques

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**Background:** There is increasing interest in comparing the efficacy of single-bundle versus double-bundle anterior cruciate ligament reconstruction. Challenging this comparison, however, has been the lack of an established consensus on the success of single-bundle reconstruction.

**Hypothesis:** The current outcomes of single-bundle reconstruction can be clarified from a large unbiased body of evidence for future comparisons with double-bundle reconstructions.

**Study Design:** Systematic review.

**Methods:** A systematic review of 11 randomized, controlled trials comparing patellar tendon and hamstring tendon grafting is reported. The respective outcomes of each group were combined to assist the orthopaedic surgeon in assessing the current success of single-bundle reconstruction. The primary factors assessed were tibial subluxation and side-to-side differences in laxity. Secondary outcomes included concomitant injuries and treatments, complications, graft failure, range of motion, and radiographic evidence of degenerative changes.

**Results:** In this review of 1024 single-bundle anterior cruciate ligament reconstructions, 495 concomitant meniscal tears, 95 chondral injuries, and 2 posterior cruciate ligament tears were noted. The complication rate was 6%, and graft failure 4%. Reported pivot-shift test results were negative in 81% of cases; reported Lachman tests were negative in 59% cases; and KT-1000 arthrometer side-to-side differences were  $\leq 5$  mm in 86% of cases. Flexion and extension deficits were reported in 9 of 11 studies through mean range of motion or deficit ranges. Radiographic changes of articular surface abnormalities were observed in 7% of the knees at follow-up investigation.

**Conclusion:** Systematic review of a significant body of unbiased outcome data on single-bundle anterior cruciate ligament reconstruction demonstrates it to be a safe, consistent surgical procedure affording reliable results.

**Clinical Relevance:** These results may be used to assist orthopaedic surgeons in evaluating the benefit and practicality of pursuing new anterior cruciate ligament reconstruction techniques over standard single-bundle anterior cruciate ligament reconstruction.

**Keywords:** anterior cruciate ligament (ACL); single-bundle; double-bundle; outcomes; systematic review; ACL reconstruction

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An estimated 100 000 anterior cruciate ligament (ACL) reconstructions are performed annually.<sup>28</sup> Intraoperative technical decisions during ACL reconstruction have been a long-standing concentration of orthopaedic sports medicine research. There is increasing focus on the technical decision of whether to perform a single-bundle (SB) versus double-bundle (DB) ACL reconstruction. This controversy has evolved out of observations that a transtibial endoscopic procedure may preferentially reproduce the anteromedial bundle of the ACL, thus creating a vertically oriented graft. In doing so, the patient may demonstrate a normal Lachman test but have clinical complaints of instability and clinically demonstrate a low-grade pivot-shift phenomenon. The popularization of the DB technique has occurred in part because of these clinical failures while also focusing on an attempt to more thoroughly reconstruct the entire ACL footprint. The decision to perform either the SB- or DB-ACL reconstruction calls for a balanced evaluation of each technique's clinical outcomes, technical demands, and potential complications.

While a recent prospective study<sup>2</sup> reported encouraging clinical outcomes of DB reconstruction, there are reports that the clinical outcomes of DB reconstruction are not always significantly different than the outcomes of SB reconstruction.<sup>1,4</sup> The technical challenges and complications of DB reconstruction are greater,<sup>4,7,18,24,26,27</sup> given the standard training and practice of SB reconstruction. There are concerns expressed about the creation of 4 rather than 2 tunnels, the use of grafts that may require extracortical fixation, the potential for postoperative tunnel expansion, the potential for different challenges in failures that may occur with DB reconstruction, and whether the basic science demonstration of "significantly" improved rotational control is mirrored in improved clinical outcomes. The focus on a potentially superior outcome and an underappreciation of the technical demands can lead to a rise in the rate of complications as surgeons start to embark upon DB reconstruction.

This study was conducted to assist the practicing orthopaedic surgeon in making this very important decision by evaluating the current success of SB reconstruction using an evidence-based approach. The primary research objective was to define the knee stability of SB reconstruction through pivot-shift results, Lachman test results, and instrument-measured, anterior-posterior laxity at a minimum 2-year follow-up. The purpose of our research in this study is not to systematically review and compare both SB and DB reconstruction but rather to establish a baseline assessment of SB reconstruction outcomes to be compared with future data. By combining the conclusions of this study with one's own experience, practicing orthopaedic surgeons will have a more comprehensive profile of outcomes of standard SB-ACL reconstruction technique to compare with current and forthcoming data on alternative techniques.

## MATERIALS AND METHODS

The primary and secondary objectives of this study are listed in Table 1 and define the metrics of our clinical assessment. To minimize bias in this systematic review,

TABLE 1  
Research Objectives Established in the Study Protocol<sup>a</sup>

Primary
Knee stability
Pivot-shift test results, Lachman test results, anteroposterior laxity
Secondary
Concurrent injuries in the study population
Operative complications and concomitant procedures
Postoperative complications and surgical procedures
Clinically determined graft failures and traumatic graft ruptures
Range of motion
Prevalence of anterior knee pain
Quadriceps and hamstring strength testing
Functional outcome through single-legged hop testing
Anterior knee pain, IKDC grade, Lysholm score, Tegner activity level
Radiographic signs of degradative changes

<sup>a</sup>IKDC, International Knee Documentation Committee.

the research protocol was designed a priori and defined the methods for searching the literature, including and excluding articles, and extracting and analyzing the data. Our intent was to include only the most valid SB-ACL reconstruction studies comparing the use of bone-patellar tendon-bone autografts (BTB) versus the use of hamstring tendon autografts (HS).

The literature search was performed by 2 independent researchers and spanned from January 1966 to May 2007 for eligible articles in the Medline database. Relevant articles were identified using keywords related to this study's purpose, including *anterior cruciate ligament*, *hamstring*, *semitendinosus*, *gracilis*, *patellar tendon*, *allograft*, *autograft*, *single-bundle ACL*, and *ACL reconstruction*. These keywords were used separately and in combination. Fifty-one articles were selected from our search of the existing database.

Each study was evaluated for the inclusive criteria stated in the research protocol. Our goal to provide the most valid data in this study was accomplished by including only studies that were prospective, randomized clinical trials. Additional inclusive criteria included a minimum follow-up interval of 24 months, reporting of reliable and valid outcome measurements, and a minimum follow-up of 75% of treated patients. The patient allocation technique was required to be either concealed or by date of birth. Studies with randomization through the use of an alternating list, consecutive grouping, and surgeon or patient selection were excluded. The studies retained from this evaluation were then independently confirmed to be appropriate by 3 separate reviewers.

Data extraction from each study was performed with a worksheet established within the research protocol. Data were stratified into 4 domains: demographics, operative, complications, and outcomes. Demographic data were collected to define the population treated by SB-ACL reconstruction and the characteristics of their preoperative course. Operative data were examined to document the surgical conditions, attendant injuries, and concomitant

