Systematic Review

Systemic Review of Anatomic Single- Versus Double-Bundle Anterior Cruciate Ligament Reconstruction: Does Femoral Tunnel Drilling Technique Matter?

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Purpose: To provide an up-to-date assessment of the difference between anatomic double-bundle anterior cruciate ligament (ACL) reconstruction (DB-ACLR) and anatomic single-bundle ACL reconstruction (SB-ACLR). We hypothesized that anatomic SB-ACLR using independent femoral drilling technique would be able to achieve kinematic stability as with anatomic DB-ACLR. **Methods:** A comprehensive Internet search was performed to identify all therapeutic trials of anatomic DB-ACLR versus anatomic SB-ACLR. Only clinical studies of Level I and II evidence were included. The comparative outcomes were instrument-measured anterior laxity, Lachman test, pivot shift, clinical outcomes including objective/subjective International Knee Documentation Committee (IKDC) score, Lysholm score, Tegner activity scale and complication rates of extension/flexion deficits, graft failure, and early osteoarthritis. Subgroup analyses were performed for femoral tunnel drilling techniques including independent drilling and transtibial (TT) drilling. **Results:** Twenty-two clinical trials of 2,261 anatomically ACL-reconstructed patients were included in the meta-analysis. Via TT drilling technique, anatomic DB-ACLR led to improved instrument-measured anterior laxity with a standard mean difference (SMD) of −0.42 (95% confidence interval [CI] = −0.81 to −0.02), less rotational instability measured by pivot shift (SMD = 2.76, 95% CI = 1.24 to 6.16), and higher objective IKDC score with odds ratio (OR) of 2.28 (95% CI = 1.19 to 4.36). Via independent drilling technique, anatomic DB-ACLR yielded better pivot shift (SMD = 2.04, 95% CI = 1.36 to 3.05). Anatomic DB-ACLR also revealed statistical significance in subjective IKDC score compared with anatomic SB-ACLR (SMD = 0.27, 95% CI = 0.05 to 0.49). **Conclusions:** Anatomic DB-ACLR showed better anterior and rotational stability and higher objective IKDC score than anatomic SB-ACLR via TT drilling technique. Via independent drilling technique, however, anatomic DB-ACLR only showed superiority of rotational stability. All clinical function outcomes except subjective IKDC score were not significantly different between anatomic DB-ACLR and SB-ACLR. **Level of Evidence:** Level II, meta-analysis of Level I and II studies.

Anterior cruciate ligament (ACL) rupture often needs reconstruction to restore its original functions, otherwise long-term knee instability poses great risk of secondary injuries.[1] Single-bundle ACL reconstruction (SB-ACLR) has long been the gold standard of ACL treatment, but in recent years, biomechanical and clinical studies have shown suboptimal outcomes of SB-ACLR, especially rotational instability and progress of degenerative joint disease.[2] Today, it is widely accepted that native ACL consists of 2 main bundles, anteromedial (AM) and posterolateral (PL), and they function independently in that the AM bundle controls anteroposterior (AP) laxity whereas the PL bundle ensures rotational stability.[3,4] So surgeons manage to reconstruct ACL with double bundles and replicate anatomic footprints of ACL. However, anatomic

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reconstruction and double-bundle ACL reconstruction (DB-ACLR) are not the same. Anatomic reconstruction refers to the functional restoration of the ACL to its native insertion sites. DB-ACLR means that AM and PL bundles are replaced without regard to the precision of graft tunnel positions.

The non-unified information of surgical procedure in published papers claimed as anatomic ACL reconstruction confuses readers and jeopardizes further valid analysis. It is noteworthy that in 2013, the Anatomic ACL Reconstruction Checklist, experts' consensus of standardized criteria for what constitutes anatomic ACL reconstruction, was crafted to support the interpretation of anatomic ACL reconstruction so that papers on the topic can be compared.[5]

The position of femoral bone tunnels is considered key to successful anatomic ACL reconstructions. The TT technique is a widely used technique for arthroscopic SB-ACLR. But recent studies have discussed the inability of TT drilling technique to accurately position femoral tunnels within the native ACL insertion sites,[6,7] and independent drilling techniques, such as transportal (TP) and outside-in (OI) techniques, have been developed to achieve more accurate femoral tunnels independently from the tibial tunnels. More horizontally oriented grafts created using an independent drilling technique would further optimize rotational stability.[8-10] However, some studies stated that the TT drilling technique can lead to equally anatomic femoral tunnels and similar clinical outcomes as an independent drilling technique.[11-13] In addition, the overt disadvantages of independent drilling should not be overlooked, including extra skin lesions, prolonged surgical duration, and deep flexion of knees for locating and drilling tunnels.[14]

In the last decade, a number of meta-analyses have discussed the pros and cons of single- and double-bundle procedures, but confounding factors such as tunnel positions and techniques of tunnel creation implicate their comparisons.[15-18] Only a few reviews performed subgroup analysis of anatomic single- versus double-bundle reconstructions.[15,18] van Eck et al.[18] pointed out that KT arthrometer and the pivot-shift test results were in favor of anatomic DB-ACLR compared with anatomic SB-ACLR. Desai et al.[15] focused on kinematic variables, and anatomic DB-ACLR revealed less anterior laxity using KT arthrometer and less anteroposterior laxity measured by navigation compared with anatomic SB-ACLR. In spite of marvelous works previously done, there is still a controversy regarding the best technique for ACL reconstruction.

In conducting this meta-analysis, we explored a wider scope of evaluation indices, including both kinematic and patient-reported outcomes; and most importantly, we intended to refrain from inappropriate pooling of data by including only anatomic SB-ACLR and DB-ACLR and performing subgroup analysis for femoral tunnel via TT drilling versus independent drilling.

The purposes of the review were to provide an up-to-date assessment of the difference between anatomic DB-ACLR and anatomic SB-ACLR and to apply the Anatomic ACL Reconstruction Checklist in reviewing surgical methods of the included literature. We hypothesized that anatomic SB-ACLR using an independent femoral drilling technique would be able to achieve kinematic stability similar to that with anatomic DB-ACLR.

Methods

Search Strategy and Study Selection

PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses, www.prisma-statement.org) were used to design our systematic review and meta-analysis. The online databases PubMed (www.ncbi.nlm.nih.gov/pubmed), EMBASE (www.elsevier.com/online-tools/embase), and Cochrane (www.cochrane.org) were reviewed for all English-language studies published before January 25, 2016. Two authors (Y.Z. and C.X.) separately searched each database using the key terms "anterior cruciate ligament" OR "ACL" AND "surgery" OR "reconstruction" AND "anatomical."

Eligibility criteria for inclusion of the review were as follows: (1) clinical studies comparing anatomic SB and DB primary arthroscopic ACL reconstruction regardless of graft type or fixation method; (2) ACL rupture of human adults without additional knee ligament injuries; (3) authors stating that grafts were placed in the native ACL footprints on both the tibial and femoral sides in both SB and DB reconstructions for the technique to be regarded as anatomic; (4) full reporting of both postoperative kinematic and clinical function outcomes; (5) concomitant meniscus and minor cartilage injuries were not grounds for exclusion; (6) comparative clinical studies (Level III evidence), reviews, case series, expert opinions, and editorial comments (Level IV and V studies) were excluded; (7) studies that reported only nonclinical outcomes or in vitro and animal studies were excluded.

Data Extraction and Analysis

On the basis of the titles and abstracts, 2 reviewers (Y.Z. and P.S.) selected relevant studies for full review. For inclusion in the analysis, 2 reviewers analyzed the full articles using the previously mentioned criteria independently. The reviewers were not blinded to the author, year, and journal of publication. The study was analyzed in full text if the abstract did not provide enough data to make a decision. Disagreement between reviewers was consulted with a senior author (J.Z.).