

Editorial Commentary: Remember the Risk Factors During Individualized, Anatomic, Value-Based Anterior Cruciate Ligament Reconstruction



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Abstract: Understanding the etiology behind anterior cruciate ligament (ACL) reconstruction failure is a complex topic still being investigated heavily. The 3 classes of failure are technical, traumatic, and biologic. Technical errors are most common and most frequently reflect tunnel malposition. In addition, tibial slope has long been understood to be a risk factor for failed ACL reconstruction. Although not routinely performed at time of primary ACL reconstruction, osteotomy may be considered in the setting of failed ACL reconstruction. Relative quadriceps weakness is a risk factor, and we recommend sport-specific return-to-play testing as well as benchmarks for relative quadriceps strength before full return to activity. Revision ACL reconstruction is associated with both increased costs and worse patient outcomes, so every effort should be made to give patients the best chance of success after the index surgery. Whereas this begins with understanding the patient's history and risk factors for failure, it crescendos with careful attention to the individually variable factors that make each case unique, tailoring one's management to ensure that each patient receives an anatomic, individualized, and value-based ACL reconstruction.

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We commend the authors Ziegler, DePhillipo, Kennedy, Dekker, Dornan, and LaPrade on their recent study investigating risk factors for revision anterior cruciate ligament (ACL) reconstruction, titled, "Beighton Score, Tibial Slope, Tibial Subluxation, Quadriceps Circumference Difference and Family History Are Risk Factors for Anterior Cruciate Ligament Graft Failure: A Retrospective Comparison of Primary and Revision Anterior Cruciate Ligament Reconstructions." In their retrospective cross-sectional study, the authors identify several risk factors associated with revision, including factors that may be identified preoperatively as well as those pertaining to surgical technique. Family history of ACL injury, higher Beighton score, and increased lateral tibial slope were all associated with having revision ACL reconstruction. Additionally, anteromedial tibial subluxation and side-

to-side quadriceps circumference were greater in the revision group. Based on 3-dimensional computed tomography (3D CT) reformatted images, the femoral and tibial tunnel were more likely to be malpositioned in the revision group.¹

The etiology for failed ACL reconstructions is a complex, multifaceted issue, and understanding the associated risk factors may give us a better idea of the underlying mechanisms. In addition to increased financial burden, revision ACL reconstruction is also associated with worse outcomes and lower rates of return to play.²⁻⁴ Maximizing value for patients means giving them the best chance of success after primary ACL reconstruction, while avoiding treatments that are less likely to provide benefit. This begins with fully understanding what makes each patient's case unique, as well as identifying the risk factors for failure. We recommend tailoring surgical management to the patient's individually unique morphology, as well as the rehabilitation to their sport-specific need.^{5,6}

The Multicenter ACL Revision Study (MARS), which analyzed revision ACL reconstruction in 460 patients, broadly defined 3 classes of failure; technical, traumatic, and biologic.⁷ Technical error was found to be the most commonly cited etiology, reflecting the authors' reported frequency of tunnel malposition among the

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The authors report the following potential conflicts of interest or sources of funding: F.H.F. reports education support and hospitality payments, Smith & Nephew. Full ICMJE author disclosure forms are available for this article online, as [supplementary material](#).

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0749-8063/201807/\$36.00

<https://doi.org/10.1016/j.arthro.2020.11.008>

revision group.^{1,8} Using 3D CT reformatted images for all 90 revision patients, the authors found that all but 1 patient had tunnel malposition. Through our biomechanical studies, we have found that grafts placed within the anatomic footprint experience improved knee kinematics compared with grafts placed outside the anatomic footprint.^{9,10} Clinically, we have found similar results. In a prospective, randomized control trial comparing conventional single-bundle to anatomic single- and double-bundle ACL reconstruction, anatomic reconstruction resulted in improved kinematics.¹¹

In addition to placing tunnels within the native ACL insertion sites on both the femur and tibia, we believe that anatomic ACL reconstruction includes the functional restoration of the ACL to its native dimensions and collagen orientation.¹² The ACL is a dynamic structure that varies in shape along its length, as well as under different loading conditions.¹³ The cross-section of the native ACL is typically largest at the tibial insertion, narrowest in the midbody, and larger again at the femoral insertion site.^{13,14} Additionally, the relative size of the ACL varies considerably, with the area of the tibial insertion site varying as much as 3-fold between patients.^{15,16} In a prospective study, we have found that individualizing surgery with respect to the size of the ACL's tibial insertion site provides superior outcomes, irrespective of technique.⁵ Based on our experience, we recommend reconstructing 50% to 80% of the patient's individually unique tibial insertion area to best respect the patient's native anatomy.

Given that it is modifiable, surgical methodology remains an attractive risk factor for study. As other risk factors for failure are identified, the question remains how, or if, they should be addressed. As the authors identify, tibial slope has long been understood to be a risk factor for failed ACL reconstruction.^{1,17} Osteotomy is not routinely performed at time of primary ACL reconstruction but may be considered in the setting of multiple failed ACL reconstructions. Although some studies also recommend routine lateral sided extra-articular tenodesis for certain patients to reduce failure rates, we have found similarly low levels of failure following isolated individualized anatomic ACL reconstruction in our prospective randomized trials.^{5,11,18,19} In the postoperative setting, side-to-side differences in quadriceps size and strength can be addressed throughout the rehabilitation process. We recommend sport-specific return-to-play testing as well as benchmarks for relative quadriceps strength before full return to activity.⁶

In summary, every effort should be made to give patients the highest chance of success after primary ACL reconstruction. This involves being cognizant of the risk factors for failure and understanding when to intervene. In this study, Zeigler et al.¹⁰ identified

several risk factors associated with revision ACL reconstruction, with tunnel malposition being particularly common. In our experience, we can maximize the chance of success after primary surgery by giving every patient an individualized, anatomic, and value-based ACL reconstruction.

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