Editorial Commentary: Rehabilitation and Return-to-Sports Readiness, the "Black Box" of Anterior Cruciate Ligament Reconstruction Patient Recovery

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Abstract: When progressing patients who have undergone anterior cruciate ligament reconstruction through rehabilitation and deciding whether they are ready to safely return to sports, the health care team needs to consider what they know and what they do not know about each patient. Although increased postsurgical time without related functional improvement is of limited value, greater time postsurgery that leads to enhanced neuromuscular control and dynamic knee stability restoration may be of considerable value, particularly when soft tissue grafts are combined with extracortical suspensory devices or other forms of indirect fixation.

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Patients generally undergo anterior cruciate ligament (ACL) reconstruction to be able to safely return to sports participation without further injury. Time 0 studies suggest that soft tissue grafts with extracortical suspensory fixation may be prone to stretching effects, expressed as tunnel slippage or graft elongation, rather than outright failure.[1-3] The rehabilitation team needs to weigh the benefits of therapeutic exercise movements and loading tasks versus the risks of soft tissue graft stretching, particularly during early recovery. With this understanding, they are challenged to ensure that the patient regains sufficient neuromuscular knee control before undertaking therapeutic exercise or activity loading events that might adversely stretch the graft.

In the study by Shimizu, Cheng, Samaan, Tanaka, Souza, Li, and Ma,[4] entitled "Increases in Joint Laxity After Anterior Cruciate Ligament Reconstruction Are Associated With Sagittal Biomechanical Asymmetry," patients received anatomic ACL reconstruction using soft tissue grafts fixed in the femur with suspensory fixation and in the tibia with interference screws. The study provides important longitudinal information about lower-extremity landing mechanics, magnetic resonance imaging kinematics, and patient-reported outcome measures over a 3-year period. In addition to kinetic and kinematic data, they present subjective patient-reported outcome measurement information in the form of the Knee Injury and Osteoarthritis Outcome Score (KOOS) and Marx Activity Scale before surgery and at 6 months and 3 years after surgery. When tibiofemoral alignment was measured in knee extension using a 25% bodyweight compressive load, the force vector was sufficient to produce anterior tibial translation forces similar to those observed during full weightbearing.

The study findings are very important. Although patients displayed lower surgical-side peak vertical ground reaction forces, lower peak external knee flexion moments, and less knee flexion during a drop-landing task compared with the contralateral lower extremity at 6 months postsurgery, by 3 years postsurgery, bilateral equivalence was observed. As surgical-side vertical ground reaction forces or peak external knee flexion moments improved, so too did subjective KOOS pain, sports, and quality-of-life subscale scores. Not surprisingly, the capacity to generate increased surgical-side loading was related to patient perception of better knee function. The peak external knee flexion moments that occur during hopping and jumping tasks are

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largely indicative of quadriceps muscle group functional capacity. Thus, at 3 years after ACL reconstruction, it is good to know that bilateral equivalence was re-established.

Of concern, however, is that as patients approached the 6-month period for release to unrestricted sports participation decision-making, a moderate, inverse relationship was observed, with anterior tibial position tending to increase as peak external knee flexion moment magnitude tended to decrease. This suggests that returning to sports at 6 months might place the contralateral knee at increased injury risk. Although we cannot be sure that the mean 1- to 2-mm more anterior tibial position represented clinical anterior knee laxity, any combination of increasing anterior tibial translation (possible graft stretch) and decreasing quadriceps function would be of concern. At this key time point, possible graft slippage or elongation appeared to be related to decreased quadriceps function. Additionally, a moderate, direct relationship was observed between surgical-side peak knee flexion moment magnitude changes at the 6-month and 3-year data collection periods and increased surgical side anterior tibial positioning in the same time periods. This finding of increasing surgical-side peak external knee flexion moment magnitudes and greater anterior tibial positioning may suggest that despite the increased anterior tibial positioning that occurred over the initial 6 months, quadriceps neuromuscular function was recovering and perhaps compensating for residual anterior knee laxity. Correlational analyses can identify relationships, but they cannot prove causation. However, it is worrisome that the surgical-side biomechanical impairment observed at 6 months postsurgery appeared to relate to greater long-term surgical-side anterior tibial positioning.

These findings may suggest that clinical laxity also increased between the 6-month and 3-year data collection periods, as lower extremity neuromuscular function continued to improve. This supports the concept that more time may be needed to restore neuromuscular control and dynamic knee stability before performance of more intense functional tasks such as jump landings. Given the study model used, we do not know the premorbid anterior tibial position, nor do we have a matched control group with which to compare study findings.

A critical study limitation is the vague description of the rehabilitation program as the patient progresses from early pain and effusion control to more intense therapeutic exercise and activity-based demands.[4] Locked, hinged knee brace use combined with partial weightbearing crutch ambulation was prescribed for 3 weeks. The initial 6 weeks of rehabilitation focused on knee range of motion and quadriceps neuromuscular control recovery.[4] What is not clear is what objective criteria or guidelines were followed to better ensure that patients were ready to safely progress to running at 4 months postsurgery (intensity, frequency, total volume) and release to sports participation by 6-8 months postsurgery. Although the authors mention core stability restoration, no details are provided regarding the therapeutic exercises, functional tasks, or objective or subjective clinical assessments that contributed to the decision-making process regarding safe rehabilitation program advancement. Essential clinical information such as the criteria for rehabilitation program and sport-specific training advancement and return to play decision-making are not presented.[5-9] The Modified Coleman Methodology score criteria suggest that an essential component of receiving a high grade for postsurgical rehabilitation is presenting a well-described protocol and >80% patient compliance.[10] Unfortunately, neither of these essential parameters are present in the research that we discuss.[4]

Interestingly, the patients who participated in this study were on average 31.3 years old, with a normal body mass index and a mean Marx Activity Scale score of 7.5 at 3 years postsurgery, similar to the postinjury, presurgical score (mean = 7.0). We do not know if patient surgical and rehabilitation expectations were met. Among this patient group, between the 6-month and 3-year data collection periods, each KOOS subscale score improved, either meeting or exceeding the minimal detectable change value. We agree that time postsurgery should not be the sole or primary determinant of return to sport readiness. However, longer postsurgical time in conjunction with improving neuromuscular control would be time well spent to avoid increased laxity and better ensure dynamic knee stability restoration. This may be particularly true when soft tissue grafts are used. Time postsurgery may continue to be given too much import in the realm of functional integrity; however, based on the findings of this study, one might argue that longer recovery time also provides a greater opportunity to collect all essential information needed to address rehabilitation and return-to-sports decision-making criteria or guidelines.[11,12] The consequence of early return to sports after poorly monitored ACL rehabilitation is all too often a poor patient outcome, revision knee surgery, or injury to the contralateral knee.

We see mainly what we look for.[13] In this case, the researchers paid particular attention to sagittal plane tibiofemoral alignment, knee joint kinetics and kinematics during drop jump landings, and perceived knee function and activity level changes from before surgery to 3 years after surgery.[4] The authors are to be commended for providing a comprehensive, longitudinal appraisal of important data beyond the requirement of an early patient outcome. We may only see what we know and understand.[14] The "black box" mentioned in the title does not refer to surgical methods (although hamstring autografts can vary considerably regarding

tendons used, diameter, strand number, and preparation method) or early rehabilitation interventions. The black box refers to missing patient information, such as the index ACL injury mechanism; expectations; psychobehaviors such as fear, self-efficacy or health locus of control; objective impairment level; trunk, quadriceps, hamstring, hip, or ankle strength or functional test information; instrumented laxity testing; the activities, sports, or vocations that patients return to; and whether functional braces are used. We do not know the patient rehabilitation program compliance or what criteria, milestones, or guidelines contributed to readiness for program advancement and return-to-sports decision-making. Based on the research study design, we cannot be sure whether the slightly increased surgical-side anterior tibial alignment is the cause of quadriceps muscle group impairment during the drop jump landing or whether it even relates to clinical knee laxity. Although evidence of sagittal plane knee laxity may not be associated with dynamic knee instability, a positive pivot shift test often suggests transverse plane dynamic rotatory instability. Unfortunately, no information is presented regarding either of these important factors. Because mean surgical-side anterior tibial repositioning replicated the presurgical location, it is reasonable to surmise that greater dynamic knee instabilities may exist during functional movements.

With our current understanding, the goal that surgeons should strive for is anatomic placement of a strong graft with sufficient fixation to create construct stiffness closely simulating the native ACL. Time 0 studies have suggested that anatomic soft tissue graft placement with tunnel aperture fixation may more effectively restore this important characteristic than other fixation methods.[1-3] Although contemporary ACL reconstruction simulates precision carpentry of the highest order, ACL graft neurosensory function is not restored even in a remotely similar way to the native healthy ACL.[15,16] Therefore, additional recovery time in conjunction with a more gradual criteria- or guideline-based rehabilitation and return-to-sports progression would be advantageous to more complete neuromuscular control and dynamic knee stability restoration.

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