Predicting Success in ACL Reconstruction

ROBERT M. SHALVOY, MD

ABSTRACT

Anterior Cruciate Ligament (ACL) injury and ACL reconstruction is common in the United States. However, when compared to the standards of other orthopedics procedures today, ACL reconstruction is NOT predictably successful in restoring patients to their pre-injury state. Only 60–70% of reconstructed patients resume their previous level of activity and many patients experience some degree of osteoarthritis.

The reasons for such limitations of success are many. A recent renewal of interest in the many variables affecting ACL reconstruction and the understanding of the varying needs of patients with ACL injury holds promise for improving success even today as well as ultimately providing a normal knee for patients after ACL reconstruction.

KEYWORDS: anterior cruciate ligament reconstruction, knee kinematics, computer-assisted surgery

INTRODUCTION

ACL reconstruction is performed on 150,000 to 200,000 patients in the US yearly, a number that has been steadily growing for the past 25 years.[1] Despite this popularity, the long-term outcome has been surprisingly disappointing with regards to restoring the anatomy, returning patients to their previous level of activity and maintaining a healthy joint, free from the symptoms of osteoarthritis.[2] This is in part the result of a perception that ACL reconstruction is a routine surgical procedure for the general orthopedic community and supported by the fact that the majority of these reconstructions are performed by orthopedic surgeons performing less than 10 such procedures in a year. Additionally, after surgery the parameters of healing and rehabilitation needed to successfully return patients to pre-injury levels of function and performance remain poorly defined.[3]

The problem lies in approaching ACL reconstruction as a routine, generic or "one size fits all" procedure. In this paradigm, graft failures have been reported as high as 25% in athletes under the age of 25, even in the best of hands.[4] Likewise, the ability to return to previous levels of function among the most dedicated and elite athletes has been a disappointing 60%.[8] The solution is likely to lie in a better understanding of the injury and an individualization of the surgery to meet each patient's needs. With the appropriate focus on the subtleties and variations of the ACL-injured knee, ACL reconstruction, rehabilitation and functional assessment, we can move towards recreating normalcy in the knee while at the same time indentify the limitations or short-comings of each reconstructed knee and reasonably predict success in terms of function and joint health. As we move in this direction, it is important that patients have a realistic expectation of ACL reconstruction and receive the appropriate counseling for making their best decision.

Knee Function and ACL Injury

The knee is one of the more complex joints in the body requiring great mobility and stability to function properly. This is accomplished in part by the various ligaments, both intra-articular and extrarticular. The ACL predominately controls against excessive anterior movement or translation of the tibia along with internal rotation of the tibia with respect to the femur and the rest of the body above it. The ACL is a major stabilizer of the knee in pivoting activities and in positions of knee flexion ranging from 15–30 degrees.[5] This range comprises the majority of athletic functions as well as many activities of work and daily living. Given the ACL's limited blood supply and the effects of the synovial fluid environment that surrounds it, torn ACLs have no ability to heal after injury leading to altered mechanical function in the knee. It is important to note that the knee joint has a variable if not unique balance of mobility that suits one's own neuromuscular system of control resulting in a likewise unique functional starting point. The ACL injury alters knee function at this balance point creating a new "pathologic" balance point. The effect on function can vary from minimal effect to greatly disabling. To further complicate this picture, the ACL is rarely injured in a vacuum, meaning that even without frank tearing of other ligaments or the menisci, the surrounding soft tissue structures can be strained or stretched in a variety of patterns corresponding to the forces of injury that further alter the stability in both subtle and overt ways that leads to what is arguably a unique instability from ACL injury.

Recent work using computer navigation technology to measure knee kinematics during ACL reconstruction has confirmed variable patterns and magnitudes of instability resulting from what has been considered an "isolated ACL tear."[6] Clearly, a mindset of treating a variable pattern of

injury with a fixed solution paradigm is likely to successfully address only some patterns of injury while allowing others to fall through the cracks due to this variability and result in a limited correction or incompletely addressed pathology. This incomplete correction can itself result in poor function of the knee as well as allow abnormal stresses on the joint contributing to the eventual failure of the components that were corrected such as the ACL. (**Figures 1 and 2**)

Figure 1. Left knee with optical trackers applied for computer-assisted ACL reconstruction

Acute Care

From the patient's perspective, an ACL tear is a situation of acute pain, swelling and stiffness. The concept of instability is not always perceived or understood at the time of injury as the core of the problem. Knowing that surgery is typically prescribed and wanting to return to sports as quickly as possible, most athletes, young and not so young, proceed with surgical reconstruction before the acute phase resolves. When that happens, the patient goes without pre-surgical rehabilitation that can define for the patient his or her true impairment as well as allow time to address the neuromuscular and psychological components of the injury that can impact the ultimate outcome of surgery. Our own work has shown that these psychological elements have as much impact ultimately on function – positively or negatively – as knee kinematics.[7] Therefore, it is important that this is addressed prior to surgery.

ACL Reconstruction

Only once the exact pattern of instability has been identified and the distinct needs of the patient thoroughly addressed can ACL reconstruction be successfully performed with confidence. With this knowledge, the variables can be customized to address the needs of the patient. These variables include the timing of surgery (including the decision for

Figure 2. Computer graphics obtained during computer-assisted ACL reconstruction. Image documents precise tunnel placement in reference to intra-articular landmarks.

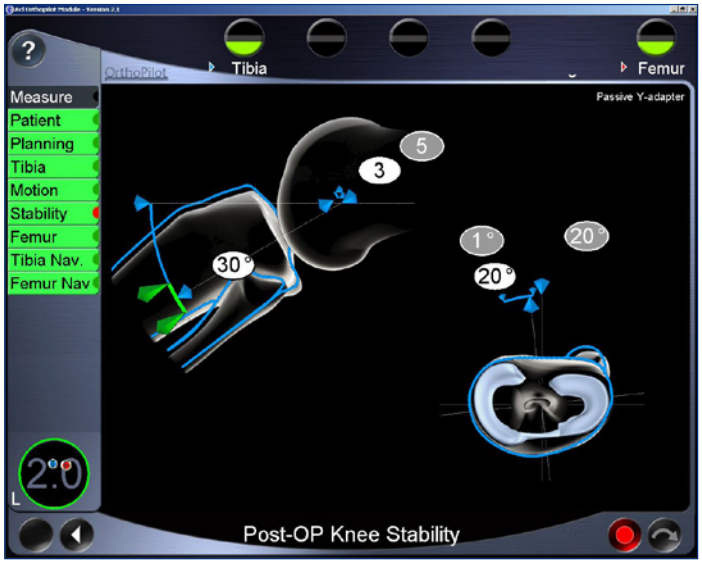

Figure 3. Knee kinematics obtained immediately after ligament fixation using computer navigation

nonoperative treatment), the type of graft material used, the number of grafts, graft fixation and additional extra-articular sugery when necessary. No single surgical technique can address all needs or situations successfully. With the use of intraoperative computer navigation, the direct effects of surgery on knee kinematics can be immediately assessed during surgery and the course of surgery modified to attain the desired outcome. Referred to as "on demand" ACL reconstruction, the result is a customized reconstruction with immediate documentation of the reestablished kinematics of the knee. **(Figure 3)** The expectation is that this will result in a better functioning knee and a greater likelihood of returning to previous functional activities.[10]

Post-op Healing and Rehabilitation

After surgery, a healing process is required for the grafted tendon material to remodel into a viable, dynamic ligament. While the acute phase requires 12 weeks, healing, complete or otherwise, is not guaranteed. Furthermore, no known graft tissue has the unique structure and mechanical function of the native ACL.[9] The goal of surgery therefore is to anatomically restore the ligament tissue in the best possible way and through remodeling attain the best functional equivalent. While the nuances of surgery as previously described can greatly affect this, establishing a nurturing intra-articular environment post operatively is equally important. Physical therapy is an important adjuvant that can help create such an environment.

Physical therapy is used to restore range of motion, reduce swelling and restore neuromuscular function. When done appropriately, this stimulates articular cartilage, helps normalize the synovial fluid environment and provides a positive stimulus for the healing ACL graft. Under stimulating or over stimulating the knee is thought to adversely affect graft healing and therefore knee function.[9] ACL rehabilitation is a subspecialty of physical therapy requiring close supervision and on-going feedback between patient, therapist and surgeon.

Function

While biological healing largely occurs during the first 12 weeks following surgery, no good determination of restored function exists.[12-14] While validated research instruments exist, these have been patient-reported outcomes and not true functional assessments. Single-leg hop and triple-hop testing through physical therapy have provided simple estimates of function but the need for better tools and methods of assessment is reflected in the alarmingly high incidence of reinjury in select groups of athletes returning to sport 6 or 7 months after surgery.[4] Similarly, the high incidence of injury to the contralateral ACL upon returning to sports implies an incomplete restoration of function in the recovering ACL patient.[11]

CONCLUSION

ACL injuries are common. They frequently have a devastating impact on knee function and can ultimately lead to joint degeneration. The traditional assumption has been that surgically restoring ligament anatomy will result in restored joint kinematics and thus joint function. Short- and long-term outcomes' research has failed to identify the limitations of current practice. As Lord Kelvin stated over a century ago, "if it cannot be measured, it cannot be improved." Currently available technologies, such as computer navigation, can be part of an increased effort to better assess and therefore better correct the pathology of ACL injury and ultimately measure the effect of surgical reconstruction on functional outcome. Patient selection, detailed, individualized surgical planning, in-depth patient education, precise intra-operative joint assessment and ligament reconstruction are all necessary now and are more likely to predict success in ACL reconstruction.

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Author

Robert M. Shalvoy, MD, is Assistant Professor of Orthopedic Surgery, The Warren Alpert Medical School of Brown University.

Correspondence

Robert M. Shalvoy, MD
University Orthopedics, Inc.
100 Butler Drive
Providence, RI 02906
401-330-1433
Fax 401-277-0795
robert_m_shalvoy@brown.edu

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