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Operative and Nonoperative Rehabilitation of the ACL-injured Knee

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Summary: Rehabilitation of the anterior cruciate ligament-deficient knee seeks to return the individual to the highest possible level of function. No protocol will be universally successful for all patients, so the most appropriate rehabilitative program must be designed for each individual. We review the nonoperative and operative rehabilitation treatment options for patients with anterior cruciate ligament-deficient and reconstructed knees. **Key Words:** Cryotherapy—Kinetic chain—Continuous positive motion—Theraband.

The anterior cruciate ligament (ACL) serves as the primary passive restraint to anterior tibial translation on the femur. Loss of this restraint results in tibial subluxation or "giving way," as described by patients. The secondary restraints, if not damaged at the time of initial ACL injury, are at increased risk for injury as a result of the increased force placed on them. In addition to its function as a static restraint to anterior tibial translation, the ACL has mechano-receptors that send information through sensory pathways, resulting in a reflex contraction of the hamstrings, thereby providing protection as a form of dynamic stability to the knee (1–3). Loss of the ACL results in abnormal kinematics of the knee, which can lead to progressive instability, meniscal tears, recurrent pain, and eventual degenerative joint disease.

The goal of rehabilitation of the ACL-deficient knee, whether treated surgically or non-surgically, is to return the individual to the highest possible level of function. Each individual has his or her own personality, as does each ACL-injured knee. These two personalities must be matched to optimize treatment and outcome. Over the last 20 years, considerable attention has been focused on the ACL-deficient knee. Clinical and basic science research has contributed to an increase in our understanding of ACL functions, the natural history of the ACL-deficient knee, and the effects of various treatments in regard to function and outcome (4–9,9a–9d).

Rehabilitation programs continue to evolve as a result of these advances in our clinical and basic science knowledge. Initial rehabilitation programs that emphasized immobilization in an effort to maintain stability have progressed to early mobilization, and for most treating surgeons, full range of motion (10–46,46a).

Although guidelines for ACL rehabilitation have evolved, no single protocol will be universally successful for all patients. Factors such as age, sex, chronicity of injury, associated pathology, range of motion, patient activity level, attitude, and motivation must all be considered to develop the most appropriate rehabilitative program for each individual.

This article reviews nonoperative and operative rehabilitation treatment options for patients with ACL-deficient and reconstructed knees. With increasing attention to cost-containment, the efficacy of various treatment modalities as they relate to cost-effectiveness are discussed.

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COMMON COMPONENTS OF ACL REHABILITATION

Cryotherapy

Use of cryotherapy to reduce pain, inflammation, and swelling after trauma is a common modality. Activity or surgically induced trauma results in damage to tissues, with subsequent swelling and inflammation. Cell damage causes a release of cytokines, which results in vasodilatation and fluid extravasation (edema) (47). This edema causes stretching of the local tissues and nerves with pain as the byproduct. In part, cryotherapy's effectiveness results from a slowing of afferent nerve-conduction velocity, decrease in delta pain fiber transmission, impedance of transmission of sensory fibers, and a decrease in muscle spindle responsiveness to stretch, thereby decreasing painful muscle spasm (47–49). Additionally, cryotherapy decreases local cell metabolism, hypoxia, and cell death, thereby diminishing release of inflammation- and edema-producing chemical mediators (47,50). Cryotherapy also results in vasoconstriction to the cooled area, thereby counteracting trauma-induced vasodilatation and edema.

Ice, cold packs, cold baths, and continuous-flow cooling pads are a few of the more common forms of cryotherapy. Clinically, patients report less subjective pain postoperatively (51). Additionally, postoperative analgesic use is reduced with cryotherapy use.

A rare but reported complication of cryotherapy in neuropraxia and local skin damage (frostbite) (52). The peroneal nerve is the most commonly involved nerve. Fortunately, these injuries are usually transient. Direct prolonged application of ice directly to the skin or overlying superficial nerves should be avoided.

Contraindications to cryotherapy include hypersensitivity to cold (i.e., Raynaud's phenomenon), cryoglobulinemia, lupus erythematosus, rheumatoid arthritis, periarteritis nodosa, and paroxysmal cold hemoglobinuria (48). Testing for cold sensitivity is best done by limited local application of ice.

Knee braces

There are three types of braces: prophylactic, rehabilitative, and functional. Prophylactic braces are not generally used to protect ACL-reconstructed knees and have been designed to reduce the frequency and magnitude of medial collateral ligament (MCL) sprains. Rehabilitation braces are often used in the postoperative period to protect the knee. They are locked in extension to minimize knee-flexion contractures resulting from intercondylar notch scar formation during sleep and at night. They are unlocked or removed to allow daily range-of-motion exercises. Many cost-conscious surgeons are replacing these postoperative rehabilitation braces with knee immobilizers, as they serve the same function and cost considerably less. Functional braces, which have been used in ACL-deficient and ACL-reconstructed patients, are controversial, as new insights into the settings in which they are truly effective have unfolded (17,52,53–60). ACL-functional braces were originally designed to protect the ACL-deficient knee. They do not prevent instability but may reduce the severity and frequency of instability. Their application has been extended to the ACL-reconstructed knee. Several studies have noted that functional braces limit, at best, anterior translation at low forces. Most authors attribute the success of functional bracing to enhanced joint proprioception, although this concept has been challenged. Multiple centers are now investigating "brace free" rehabilitation after ACL reconstruction. Preliminary reports are encouraging.

Functional braces, whether used after knee reconstruction or in the ACL-deficient knee, are limited by the compliance of the soft tissues surrounding the femur and tibia. Empirically, braces in the thinner patient with a muscular extremity result in better fit and function. Patients with short obese thighs do poorly with a brace. Many patients complain about brace slippage, pistoning, and calf cramping (58). As a result, patients frequently will become noncompliant (61). Knee bracing does not appear to enhance proprioception (55). Biomechanical tests both in vivo and in vitro have demonstrated static and low force dynamic stability, but at higher forces (typical with sporting activities), dynamic stability is lost (17,54,57,59–65). Functional braces, therefore, are unable to prevent anterior tibial translation in the ACL-deficient knee or graft strain in the reconstructed knee. However, many patients report feeling more confident with a brace and are able to rehabilitate more effectively and perform at a higher functional level. Whether or not to use a functional brace depends more on the comfort level and desires of the patient than on the functional capabilities of the brace.