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Operative Techniques in

Sports Medicine

Postoperative Knee Bracing After Anterior Cruciate Ligament Reconstruction

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Bracing for anterior cruciate ligament (ACL) injury began in the 1970s and is widely used today for both nonoperative treatment and during the postoperative rehabilitation process. ACL braces are designed to shield the reconstructed ligament from increased stress or stabilize an ACL-deficient knee. The evidence to support routine functional ACL bracing for uncomplicated primary ACL injuries is limited. The decision to use a brace in ACL-deficient knees with collateral ligament injury is the individual physician's choice. There is some evidence to support the use of bracing in ski athletes. Further research looking at functional bracing in high-demand contact athletes should be conducted to establish its role in the future.
Oper Tech Sports Med 24:55-58

KEYWORDS ACL, bracing, postoperative

Introduction

Postoperative knee bracing after anterior cruciate ligament (ACL) reconstruction is widely used despite limited evidence supporting its efficacy.[1-5] A survey of the American Academy of Orthopaedic Surgeons in the early 2000s revealed that 62.9% of surgeons recommended a brace during sports participation after ACL reconstruction.[6] A separate survey of American Orthopaedic Society for Sports Medicine members revealed that 31% of surgeons recommend a brace to their patients after ACL reconstruction.[7] This discrepancy in brace usage highlights the uncertainty regarding the effectiveness of postoperative bracing in improving patient outcomes. With an estimated cost of $592 USD per brace, prescribing functional braces without clinically proven results imparts a tremendous burden on the health care system.[8] In this review, we cover the history, biomechanics, and clinical outcomes associated with routine postoperative ACL bracing for primary ACL reconstructions without collateral ligament injury and without meniscus repair. The use of bracing to protect varus or valgus or range of motion in multiligament injury is an individual decision by physician. The use of bracing after meniscus repair with routine primary ACL reconstruction is likewise individualized.

History of ACL Bracing

The use of bracing to prevent ACL injury first gained notice in the 1960s when the Lenox Hill Derotational Brace was fashioned by Jack Castiglia, Dr Stephen Nicholas, and the staff at the Lenox Hill Hospital Brace Shop.[9] The brace was worn by Jets quarterback Joe Namath and became so iconic that the "Namath Brace" is now on display at the Pro Football Hall of Fame. The 1970s saw the addition of new designs and new companies. George Anderson, the head trainer for the Oakland Raiders developed the Anderson Knee Stabler for quarterback Ken Stabler. In 1978, Philadelphia Eagles football player Mark Nordquist cofounded Don Joy Orthopedics that focused on functional bracing. The Ottawa Brace and Breg Brace were also developed during this time. Subsequently, ACL braces have evolved from neoprene sleeves to custom-molded carbon fiber.

Biomechanics of ACL Bracing

Theory

The purpose of functional ACL bracing is 2 fold, either to shield the reconstructed ligament from increased stress or to stabilize the ACL-deficient knee. This is done primarily by

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http://dx.doi.org/10.1053/j.otsm.2015.10.001
1060-1872//

restraining the anterior translation of the tibia relative to the femur, with secondary constraints of internal-external rotation and varus-valgus angulation. The 4-point brace is a common "off-the-shelf" brace design and acts by shifting the tibia posterior relative to the femur by producing opposing moments on the 2 bones.[10]

Static Restraint

Several studies have focused on the ability of a functional brace to limit the anterior translation of the tibia relative to the femur. Beynnon et al[11] implanted a variable resistance transducer in 3 subjects with intact ACLs undergoing arthroscopic surgery for partial, medial, or lateral meniscectomy. The patients then underwent testing with and without an ACL functional brace. The results showed a statistically significant reduction in stress on the ACL with bracing during anterior translation as well as internal-external torque. This same group, however, later published a study with 11 subjects and found that bracing did not reduce strain values when the knee was subjected to isolated external torques or varus-valgus moments in weight-bearing and nonweight-bearing knees.[12]

In another study, Beynnon et al[13] studied the effects of ACL bracing on anterior tibial translation in subjects with chronic ACL tears. Anteroposterior shear and compressive loads were applied to the knee, and translation of the tibia relative to the femur was measured while subjects were nonweight bearing, during the transition to weight bearing, and then during weight bearing. The results stated that bracing the ACL-deficient knee resulted in a significant reduction of anteroposterior laxity to within normal limits of the normal knee during both nonweight-bearing and weight-bearing postures. However, when the ACL-deficient subjects transitioned from nonweight bearing to weight bearing, during the transition phase, the anterior translation of the tibia relative to the femur was 3.5 times greater than in the normal knee, and bracing did not reduce this to within normal limits. This suggests that the transition period is when the ACL is most at risk of injury, even with bracing.

Dynamic Restraint

Several groups have tried to recreate the dynamic actions found during cutting sports to evaluate ACL functional bracing during dynamic motion. It is thought that sagittal-plane biomechanical factors, such as small knee flexion angle, greater posterior ground reaction force, and greater quadriceps muscle force are major factors for noncontact ACL loading mechanisms.[14] A posterior ground reaction force creates a flexion moment relative to the knee, which needs to be balanced by a knee extension moment generated by quadriceps muscles, which is thought to stress the ACL.

Stanley et al studied 12 patients at 3.5-6.5 months post-ACL reconstruction. Three-dimensional video and force plate data were collected while patients performed level walking, jogging, and stair descent, wearing a knee extension constraint brace, wearing a nonconstraint brace, and not wearing a knee brace. Wearing a knee extension constraint brace increased the knee flexion angle at initial foot contact for each activity when compared with that without bracing. In addition, wearing the knee extension constraint brace also decreased peak posterior ground reaction force during walking but not during jogging and stair descent, suggesting that the ACL extension constraint brace can alter lower extremity movement patterns of patients during walking after ACL reconstruction, but not during jogging or stair descent.[15]

Cook et al studied how much ground reaction force 14 ACL-deficient athletes could generate during running and cutting maneuvers with and without their custom-fitted braces. Force plate data showed that while performing cutting maneuvers, braced limbs generated significantly increased shear forces compared with the same limb when unbraced, suggesting either a more stable kinetic chain or more confidence in the ability of the leg to push off. During straight line running, braced limbs appeared to promote a more stable kinetic chain vector by generating significantly less lateral and posterior forces compared with the same limb when unbraced. Running velocity increased while wearing a brace for most athletes, but this was not statistically significant. Interestingly, athletes who did not achieve 80% of the Cybex torque of the sound limb generated significantly more forces during cutting maneuvers while wearing their braces, suggesting the importance of the quadriceps for stabilization, even with bracing.[16] Wojtys et al[17] further showed that although braces can decrease anterior tibial translation by 33% without the stabilizing contractions of the hamstring, quadriceps, and gastrocnemius muscles, adding lower extremity muscle activation to bracing can reduce anterior tibial translation by 80%.

Clinical Outcomes

Functional ACL braces have been reported to improve outcomes through various mechanisms. Improved range of motion, decreased pain, decreased graft strain, and improved neuromuscular control have been mentioned as potential benefits. To date, these claims have not been supported clinically. In a systematic review of 54 Level 1 and Level II evidence studies, Wright et al[2] found that bracing did not protect against postoperative injury, decreased pain, altered range of knee motion, or improved knee stability. They concluded that postoperative bracing was not necessary following ACL reconstruction.

In 2012, Kruse et al followed up on Wright's study with a more recent systematic review of the literature and included 6 additional randomized trials in the analysis. These trials varied in methodology but focused on patient outcomes relating to knee immobilization and bracing in the postoperative period after ACL reconstruction. No trial demonstrated a clinically significant benefit to bracing or restricting knee range of motion. They concluded that bracing following ACL reconstruction was still not necessary or beneficial.[1]

In a randomized controlled trial, Birmingham et al compared the effectiveness of a neoprene knee sleeve to a functional brace after primary ACL reconstruction. Patients were assessed preoperatively and then 6 weeks and 6, 12, and 24 months