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Sports Health: A Multidisciplinary Approach published online 17 January 2014
DOI: 10.1177/1941738113517855

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Anterior Cruciate Ligament Reconstruction Rehabilitation: MOON Guidelines

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Context: Anterior cruciate ligament (ACL) reconstruction rehabilitation has evolved over the past 20 years. This evolution has been driven by a variety of level 1 and level 2 studies.

Evidence Acquisition: The MOON Group is a collection of orthopaedic surgeons who have developed a prospective longitudinal cohort of the ACL reconstruction patients. To standardize the management of these patients, we developed, in conjunction with our physical therapy committee, an evidence-based rehabilitation guideline.

Study Design: Clinical review.

Level of Evidence: Level 2.

Results: This review was based on 2 systematic reviews of level 1 and level 2 studies. Recently, the guideline was updated by a new review. Continuous passive motion did not improve ultimate motion. Early weightbearing decreases patellofemoral pain. Postoperative rehabilitative bracing did not improve swelling, pain range of motion, or safety. Open chain quadriceps activity can begin at 6 weeks.

Conclusion: High-level evidence exists to determine appropriate ACL rehabilitation guidelines. Utilizing this protocol follows the best available evidence.

Keywords: anterior cruciate ligament; ACL reconstruction; rehabilitation

Anterior cruciate ligament (ACL) reconstruction is a frequently performed procedure in this country. While surgical aspects are critical to the success of the patient, rehabilitation following surgery is just as crucial. The best surgically reconstructed ACL can be ruined by inappropriate or ineffective rehabilitation. Our goal with this publication is to present the Multicenter Orthopaedic Outcomes Network (MOON) ACL rehabilitation guidelines (see Appendix, available at <http://sph.sagepub.com/content/suppl>) and the clinical evidence used to formulate the guidelines.

The MOON group began in 2001 as a 10-member group of orthopaedic sports medicine specialists at 7 sites that

assembled to study outcomes of lower extremity injuries and surgeries.^{14,15,39,66,72} It is now a National Institutes of Health-funded group of greater than 20 clinicians who have developed a longitudinal prospective cohort of more than 3000 ACL reconstructions. Shortly following formation of the group, it was acknowledged that standardized rehabilitation guidelines were important for analyzing and reporting our reconstruction outcomes. We undertook a groupwide systematic review to determine the best evidence to guide the formation of an ACL reconstruction rehabilitation protocol.^{74,75} Following a review of the evidence and an agreement on important milestones and approaches to rehabilitation, we engaged the physical

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The following authors declared potential conflicts of interest: Rick W. Wright, MD, received research grants from Smith & Nephew and the National Institute of Arthritis and Musculoskeletal and Skin Diseases of the National Institutes of Health (NIH) and receives royalties from Wolters Kluwer and Lippincott Williams & Wilkins; and Timothy Hewett, PhD, is employed by The Ohio State University and received a grant from the NIH.

DOI: 10.1177/1941738113517855

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therapists at our sites to develop practical ACL reconstruction rehabilitation guidelines. The guidelines have been developed to service the spectrum of ACL-injured people, from the nonathlete to the elite athlete. For this reason, sample exercises are provided instead of a highly structured rehabilitation guideline. Therefore, we recommend that attending rehabilitation specialists tailor the guidelines to each patient's specific needs.

The multicenter nature of the MOON group necessitates that the MOON ACL rehabilitation guidelines include only treatment methods that can be employed at all sites without purchasing expensive equipment. Consequently, some treatment methods with supporting evidence (eg, high-intensity electric stimulation, aquatic therapy) are not included in the guidelines because the expert panel believes that it is unreasonable to expect all sites to carry out such treatments.

Progression from one phase to the next is based on readiness by achieving functional criteria rather than the time elapsed since surgery. The time frames identified in parentheses after each phase are approximate times for the average patient, not guidelines for progression. Some patients will be ready to progress sooner than the time frame identified, whereas others will take longer.

This has now been in use for 10 years with high success. More than 3000 patients enrolled in MOON studies have utilized it, and most MOON surgeons use it for all their ACL reconstructions.

Recently, an update of this systematic review of level 1 and level 2 studies regarding ACL reconstruction rehabilitation was performed.³⁷ On the basis of this update, the physical therapist committee reconvened to address potential updates of the protocol. Minor changes were made to the protocol to reflect incremental progress in our understanding of ACL reconstruction rehabilitation that would influence the protocol for our patients. The goal of this report is to briefly review the available scientific evidence and to provide the guidelines in their current form.

REHABILITATION EVIDENCE

The initial systematic reviews covered level 1 and level 2 evidence, predominantly randomized controlled trials found through 2005.^{74,75} The updated systematic review covers the period from 2005 to 2011.³⁷ For many aspects of ACL rehabilitation, either there are no studies that qualify as "best evidence," or the number of studies is too few for conclusions to be drawn with confidence. These circumstances are identified.

CONTINUOUS PASSIVE MOTION

Six randomized trials evaluated continuous passive motion for the rehabilitation of the ACL-reconstructed knee.^{17,41,42,54,58,76} No long-term benefits were determined for continuous passive motion. There was no long-term improved range of

motion. These machines are frequently difficult to approve for insurance reasons, and thus, cost becomes an issue.

EARLY WEIGHTBEARING AND MOTION

Immediate weightbearing following ACL reconstruction was investigated by 1 study.⁶⁹ A significant decrease in patellofemoral pain from 35% to 8% was demonstrated by this study. Thus, immediate full weightbearing is initiated following ACL reconstruction in the MOON protocol. Immediate range of motion has not been studied by randomized trial but reflects a fundamental principle that most therapists ascribe to as important in modern ACL reconstruction rehabilitation and is also immediately begun during rehabilitation.

POSTOPERATIVE BRACING

The use of postoperative bracing utilizing rehabilitative braces has been evaluated by a variety of studies.⁷³ This is exclusive of the question of functional bracing for return to sport but involves the use of knee immobilizers or hinged knee braces in the immediate postoperative time frame. Eleven studies in the initial review evaluated this question, and no study demonstrated a clinically significant or relevant improvement in safety, range of motion including extension, or other outcome measures.^{7,15,19,25,27,31,36,43,47,50,57,67} Given these studies and the expense of postoperative bracing, we do not include bracing following ACL reconstruction as part of our protocol. This was reinforced by an additional 6 studies published since 2005.^{5,26,32,34,35,40} None of these demonstrated an advantage from bracing.

HOME-BASED REHABILITATION

Four studies evaluated home-based ACL rehabilitation.^{2,20,24,60} Each featured minimal official visits with a physical therapist. Two additional studies have been performed since 2005.^{23,53} Although many of these studies have biases and limitations, none have indicated that home-based ACL rehabilitation was deleterious when prescribed with motivated patients.

OPEN VERSUS CLOSED CHAIN EXERCISES

Few studies have adequately evaluated this question.^{9,33,45,48,49} Based on the available evidence, it appears that open chain activities after 6 weeks may improve strength without adversely affecting the graft and/or increasing graft laxity.^{22,30} There is currently insufficient evidence on the safety of open chain knee exercises before 6 weeks postsurgery. With this lack of evidence and a concern raised by strain values that have been demonstrated in the ACL graft with open chain activities, we have limited the open chain activities in the first 6 weeks to light-load, short-arc quadriceps exercises.^{22,30} Additional studies need to be performed in this area to provide more appropriate evidence regarding the safety of initiating open chain exercise sooner.

NEUROMUSCULAR ELECTRICAL STIMULATION

Many studies have evaluated neuromuscular electrical stimulation in the ACL-reconstructed population.^{1,11,13,18,21,38,51,52,59,62-65,71} The evidence suffers from a lack of standardization and homogeneity among the studies to allow comparison. Some handheld devices are too weak to provide stimulation that will result in improved outcomes. Rehabilitation specialists should ensure that portable stimulators are capable of adequately recruiting the target muscle, or they should use a clinical stimulator in an outpatient setting. Some patients who are lagging in muscle recruitment and redevelopment following surgery will benefit from this adjunctive treatment.^{11,12} The electrical parameters that best stimulate the muscle for improved outcome are uncertain and require further analysis. Given this, we do not make neuromuscular electrical stimulation a requirement for the MOON ACL reconstruction rehabilitation protocol, and we leave it to the discretion of the individual physical therapist.

ACCELERATED REHABILITATION

Two randomized trials have evaluated accelerated rehabilitation.^{4,16} Neither study had a group that dramatically lessened the rehabilitation below 6 months. The question remains whether patients can rehabilitate from this surgery and be ready to return to sports at less than 4 months. There is minimal or no scientific evidence to support this earlier return. The guidelines are based on a functional criterion that typically has patients ready at 5 to 6 months. Additional research will be necessary to prove that shorter time frames are safe for the graft, menisci, articular cartilage, and the patient in general.

NEUROMUSCULAR TRAINING

Since 2005, 9 randomized trials evaluated neuromuscular training—including “proprioceptive” and balance training, perturbation training, and vibratory stimulation as part of ACL reconstruction rehabilitation—and demonstrated safety with some efficacy in their use.^{3,8,10,28,29,46,55,56,70} Neuromuscular training has been suggested in most phases of the MOON ACL rehabilitation guidelines since inception and continues to be included.

MISCELLANEOUS

A variety of randomized trials evaluated several miscellaneous topics. These included the safety of aquatic training,⁶⁸ slide board safety,⁶ and stair-climber versus cycle exercise efficacy.⁴⁴ Aquatic training was deemed to be safe and may decrease effusions. Slide board work was safe and may improve quadriceps strength. The stair-climber was as efficacious and safe as stationary cycling. Early quadriceps strengthening with straight-leg raises has been evaluated and improved strength has been noted with no untoward effects.⁶¹

CONCLUSION

The MOON ACL reconstruction rehabilitation guidelines have been in use for 10 years. Rehabilitation effectiveness is largely based on exercise selection and dosing. Accordingly, it is important that exercise dosing is scientifically based as well.

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ACKNOWLEDGMENT

This project was partially funded by grant 5R01 AR053684 from the National Institutes of Health/National Institute of Arthritis and Musculoskeletal and Skin Diseases.

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