Rehabilitation Guidelines for ACL Reconstruction in the Skeletally Mature Athlete

Anterior cruciate ligament (ACL) injuries occur in both men and women with varying activity levels and athletic participation.

About the Anterior Cruciate Ligament (ACL)

The knee is stabilized by 4 major ligaments: the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial collateral ligament (MCL), and lateral collateral ligament (LCL). The ACL is located inside the knee joint along with the PCL. The ACL helps stabilize against knee rotation, which occurs with pivoting and cutting motions. The ACL also acts as a restraint against hyperextension. This ligament works to stabilize the knee in two ways: (1) it acts as a passive restraint to knee joint mobility; and (2) it directly functions to limit excess mobility at the knee joint during functional movements. The ACL contains both proprioceptors and mechanical nerve receptors, which function to sense the position of the knee joint. When normal range of a joint is exceeded, proprioceptors send a signal to the brain and spinal cord to activate the appropriate muscles to stabilize the knee joint.

Mechanism of Injury

An ACL injury is commonly a non-contact injury, meaning there was no contact from another person/athlete to cause the injury. ACL injuries often occur as an athlete is decelerating, typically when an athlete plants his/her foot on the ground to cut and/or change directions. This mechanism can lead to a force that is greater than what the ACL can control, thus resulting in injury to the ACL. This injury is typically associated with a feeling of knee "buckling" or "giving out." The ACL can also be injured with forceful knee hyperextension, as with landing from a jump on a straight knee.

An ACL injury commonly results in pain and swelling in the knee joint. Athletes may feel or hear a "pop" at the time of injury. After an ACL injury it can be difficult and painful to bend / straighten the knee. People may feel the knee is unstable when moving around, like it "gives out".

Causes of ACL injuries are multi-factorial, and research is ongoing to determine which factors are most relevant in predicting an increased injury risk.

Diagnosis of an ACL Injury

There are different methods used to diagnose ACL injuries. Clinically, a sports medicine physician, physical therapist or athletic trainer will assess the knee through a physical exam. They will use evidence-based exam techniques to examine knee joint laxity (how much it moves compared the uninjured side) and assess any functional knee asymmetry that may exist as a result of injury. Diagnostic tests and imaging studies are also uses to assess the integrity of the ACL. A magnetic resonance image (MRI) will be ordered to visualize the soft tissue (muscles, tendons, and ligaments) and is relatively accurate at identifying an ACL tear (figure 1). A diagnostic arthroscopy is the most definitive and minimally invasive method to determine an ACL injury. During a diagnostic arthroscopy, an orthopedic surgeon can confirm injury to the ACL using an arthroscopic camera to assess the inside of the knee joint.

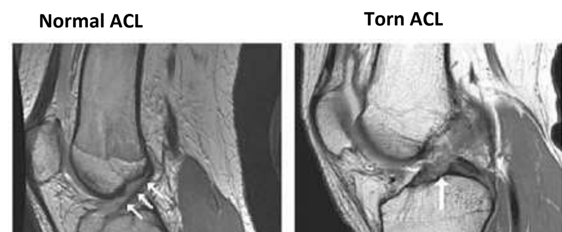

Figure 1: MRI of ACL in the knee.

Rehabilitation Guidelines for ACL Reconstruction

Treatment options for an ACL Injury

Treatment choices are specific and individualized to each patient with considerations for patient age, activity level, and desire to return to sports that require pivoting, cutting and high-speed movements. Non-operative treatment may be appropriate in patients who do not desire to participate in high demand athletic activities, and can consist of certain activity modifications - Ex: discontinuing participation in sports requiring pivoting and cutting (basketball, soccer) and replacing these activities with more linear sports (running, swimming, weight training). Non-operative treatment typically includes a course of physical therapy / rehabilitation. Rehabilitation for an athlete with an ACL injury aims to improve overall knee function in the presence of inherent knee instability following disruption of the ACL. Repeated episodes of knee instability can hinder sports performance and can also cause injury to the cartilage, meniscus, and other structures stabilizing the knee, which may increase risk of future arthritis. If instability persists, the athlete and surgeon may decide to perform an ACL reconstruction surgery to return these athletes to sport and activity.

Surgical reconstruction involves replacing the torn ACL with a graft. The surgical procedure involves drilling sockets in the femur (thigh bone) and tibia (shin bone). Graft choices include: (1) a tendon from your own body (autograft) such as: hamstring tendon, patellar tendon, or quadriceps tendon (figure 2); or (2) a donor graft (allograft) such as: anterior tibialis tendon, Achilles tendon, or patellar tendon. The graft is placed through the tunnels drilled in the bone (figure 3) and then secured. Consult with your surgeon to determine best graft choice for your case. This choice is individualized to best suit each patient. Factors contributing to this decision can include: (1) concurrent injuries to knee (meniscal involvement, cartilage involvement or injury to other collateral ligaments), (2) pre-existing injuries, (3) sport/work requirements, and (4) age.

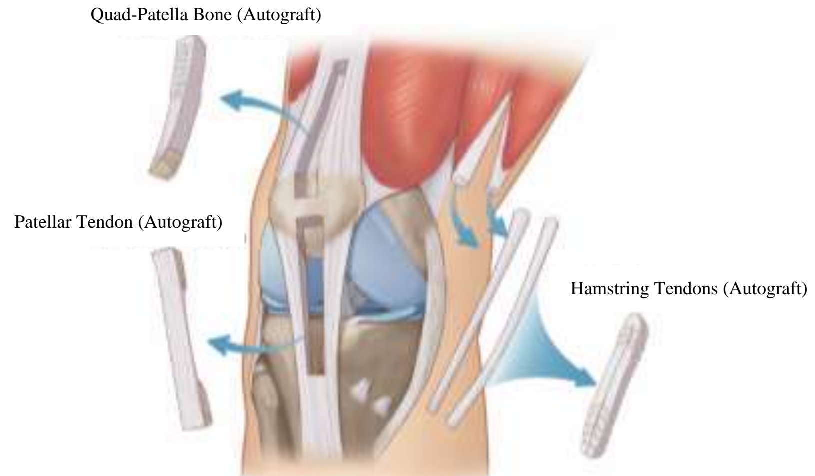

Figure 2: Donor sites for quad-patella bone, patellar tendon, and hamstring tendon grafts.

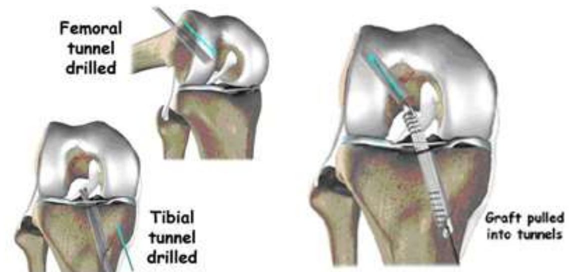

Figure 3: Example of graft placement

Rehabilitation Following Surgical Intervention

Your rehabilitation for this surgical procedure will ideally start with at least 1 pre-operative physical therapy visit to assess your strength and function prior to surgery. This baseline will be re-tested over the course of your rehabilitation plan of care.

Following ACL reconstruction, all athletes will participate in 9-12 months of physical therapy, commonly divided into 5+ phases beginning that start within 1 week post-operatively. **Phase I** consists of decreasing swelling, achieving full knee extension (straightening) and increasing knee flexion (bending). It is important to achieve full knee extension early post-operatively to promote functional mobility required for normal walking, and to prevent more permanent scar tissue formation. **Phase II** will focus on maintaining normal knee motion and management of joint swelling. The athlete will

begin to focus on overall leg strength and stability in this phase, and work to normalize walking. **Phase III** goals include achieving control of the knee and leg with more dynamic activities, while working towards the ability to jump. In **phase IV** the athlete will work to improve confidence in single leg activities, and demonstrate appropriate running mechanics to transition to phase V. During **phases V and VI**, the athlete will work towards confidence in cutting, pivoting, sprinting, and sport specific drills in a controlled environment, progressing towards more reactive and unpredictable sport specific environments at the end of these phases.

Ultimate clearance for an athlete to return to sport is based on several criteria, including both time from surgery and objective testing measures. **Full return to sport** can occur as early as 9-12 months post-operatively but can often take 12-24 months. Every surgically reconstructed ACL can retear. The retear risk can range anywhere from 4% to over 20%, and there is a 2x higher risk of re-injury in athletes younger than 18 years-old. Based on current research, reasons for ACL retears are multifactorial. Hypotheses include accelerated time to return to sport, impaired lower extremity muscle strength, athletes who are still growing, and athletes who return to sport participation at a high level.

It is **critical** to ***fully*** complete rehabilitation and training programs before resuming normal activity and sport, as this can reduce risk of repeat ACL tear by up to 40-60%. Evidence demonstrates that the risk of re-injury decreases significantly when athletes successfully passing return to sport testing and honor full ACL healing timelines by not returning to sport too early.

Your structured and individualized rehabilitation program will work to put you in the best position to return to sport with minimal risk for re-injury. Your physician, physical therapist, and athletic trainer will intentionally work you through a series of criterion based, progressive screens to determine safe return to sport recommendations. Even with satisfactory performance on these functional tests, athletes will benefit from continued strength and conditioning programs to ensure return to pre-injury performance levels and beyond. In conjunction with return to sport, a referral may be made to a strength and conditioning specialist to return athletes to high levels of sport performance.

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Rehabilitation Guidelines for ACL Reconstruction

Estimated Return to Sport Milestones
(Based on graft healing time **and** the passing of functional screening)

	Jumping / Impact	**Jogging**	**Linear Speed Work**	**Change of Direction / Agility**	**Return to Sport**
Bone-Patellar Tendon-Bone Autograft	4+ months ***(most commonly** 5+ months)*	4-5 months ***(most commonly** 5-6 months)*	5-6 months ***(most commonly** 6-7 months)*	7-8 months ***(most commonly** 8-9 months)*	9+ months ***(most commonly** 12+ months)*
Hamstring/Quad Tendon Autograft	4+ months ***(most commonly** 5+ months)*	4-5 months ***(most commonly** 5-6 months)*	5-6 months ***(most commonly** 6-7 months)*	7-8 months *(most commonly 8-9 months)*	9+ months *(most commonly 12+ months)*
Bone-Patellar Tendon-Bone Allograft	5+ months ***(most commonly** 6+ months)*	5-6 months ***(most commonly** 6-7 months)*	6-7 months ***(most commonly** 7-8 months)*	8-9 months *(most commonly 9-10 months)*	10+ months ***(most commonly** 13-14 months)*
Soft Tissue Allograft	5+ months ***(most commonly** 6+ months)*	5-6 months ***(most commonly** 6-7 months)*	6-7 months ***(most commonly** 7-8 months)*	8-9 months *(most commonly 9-10 months)*	10-12+ months *(most commonly 16+ months)*

***Modified from UPMC Reconstruction Functional Rehabilitation Protocol*
***These timelines are representative of expectations for **isolated** ACLR surgery*

These times are estimated based on the graft healing process and are dependent upon the patient passing functional testing in physical therapy aimed to assesses strength and neuromuscular control. These times may be **longer** if the patient also had a concomitant procedure such as a meniscal repair, microfracture/articular cartilage procedure or other ligament injury or procedure.

These rehabilitation guidelines were developed by Samaritan Athletic Medicine Physical Rehabilitation. Please be aware the information provided is not intended to replace the care or advice given by your physician or health care provider. It is neither intended or implied to be a substitute for professional advice. Call your health care provider immediately if you think you have a medical emergency. Always seek advice from your health care provider before starting any new treatment or with any questions you may have regarding a medical condition.

Rehabilitation Guidelines for ACL Reconstruction

<table>
<tr><th colspan="2">Phase I: 0-2 week post-operative</th></tr>
<tr><td>Appointments</td><td>Surgeon/Physician Assistant follow-up: 7-10 days post-op
Start Physical Therapy: 1-10 days post-op</td></tr>
<tr><td>Precautions</td><td><u>Post-op brace</u>: worn at all times until cleared by physical therapist
Unlocked (unless full extension is lacking then keep locked at 0°)
Okay to remove for performance of home program as directed by physical therapist
<u>Weightbearing</u>: crutches until cleared by therapist
<u>Modifications for concomitant procedures:</u>
Stable Meniscus Repair (simple vertical, horizontal repairs)
Non-weightbearing for weeks 0-2
50% weightbearing weeks 2-4
Weight-bearing as tolerated weeks 4-6
Unstable Meniscus Repair (root, radial, complex repairs), Cartilage Repair (MACI, osteochondral allograft/autograft), Collateral Ligament Repair
Non-weightbearing for 6 weeks
<u>Hamstring grafts & concomitant meniscal repairs and medial / lateral collateral ligament injuries</u>:
No active hamstring tasks, avoid aggressive stretching of hamstrings for 6 weeks</td></tr>
<tr><td>Rehabilitation Goals</td><td>Swelling at ≤ 2+ on sweep test
Restore range of motion to full, passive knee extension and knee flexion as tolerated
If SLR doesn't reach neutral extension (0°) by 2 weeks post-op, increase frequency of PT and notify surgeon
Achieve strong and steady quadriceps activation</td></tr>
<tr><td>Range of Motion</td><td>Emphasis on restoring knee extension to help normalize walking
<u>Modifications for concomitant procedures:</u>
Stable Meniscus Repair (simple vertical, horizontal repairs) & Collateral Ligament Repair
0-90° for weeks 0-4
Unstable Meniscus Repair (root, radial, complex repairs)
0-70° for weeks 0-4
0-90° for weeks 4-6
(Consult operative note for surgery specific, staged ROM progressions)</td></tr>
<tr><td>Therapeutic Exercises
(Examples, but not limited to…)

Consider implementing dual tasking throughout rehab program to minimize compensatory neurocognitive deficits</td><td>Focus on quad activation without gluteal co-activation / reduce quadriceps autogenic inhibition
Consider pre-treatment focal cooling and use of transcutaneous electrical nerve stimulation (TENS) - see Appendix A for ideal parameters
Restore patellar mobility
Exercise examples:
<u>Knee extension</u>: prone hangs, supine bag hangs, calf stretch
<u>Knee flexion</u>: wall slides, heel slides, seated heel slides
Quad sets (at varying speeds and hold durations)
Straight leg raises (all 4 planes)
Neuromuscular re-education using electrical stimulation (NMES) at 0° and 60° knee flexion (See Appendix A for ideal parameters)</td></tr>
</table>

Phase II: 2-6 weeks post-operative	
Appointments	Physical Therapy appointments: 1-2 times/week

Precautions	Post-operative brace: incorporate full-time until at least post-op **weeks 1-2**
	• Criteria to discharge from post-operative brace:
	    o No sooner than post-op **week 2**
	    o Able to comfortably wear ACL brace *(consider swelling, incision healing, etc.)*
	    o Able to perform strong, steady quadriceps activation and perform 2x10 SLR with no extensor lag
	Weightbearing: crutches as needed
	• **Modifications for concomitant procedures:**
	    o Stable Meniscus Repair (simple vertical, horizontal repairs)
	        ▪ Non-weightbearing for **weeks 0-4**
	        ▪ 50% weightbearing **weeks 4-6**
	    o Unstable Meniscus Repair (root, radial, complex repairs), Cartilage Repair (MACI, osteochondral allograft/autograft), Collateral Ligament Repair
	        ▪ Non-weightbearing for **6 weeks**

Rehabilitation Goals	▪ Decrease swelling ≤ 2+ on sweep test ▪ Progress range of motion to symmetrical *active* knee extension mobility when compared to the non-operative leg ▪ Normalize gait

Range of Motion	No restrictions: full range of motion expected at **3-4 weeks**
	• **Modifications for concomitant procedures:**
	    o Stable Meniscus Repair (simple vertical, horizontal repairs) & Collateral Ligament Repair
	        ▪ 0-90° for **weeks 0-4**
	    o Unstable Meniscus Repair (root, radial, complex repairs)
	        ▪ 0-90° for **weeks 0-6**

Therapeutic Exercises ***(Examples, but not limited to…)*** ****Consider implementing dual tasking throughout rehab program to minimize compensatory neurocognitive deficits****	Emphasis on quad activation without glute co-activation • Continue *pre-treatment* focal cooling and use of transcutaneous electrical nerve stimulation (TENS) - see **Appendix A** for ideal parameters Functional gait training Exercise examples: • Bicycle without resistance • Prone knee flexion • Leg press • Heel raises • Isometric knee extension progressions at 90° and 60° knee flexion *Focus on quadriceps steadiness and rate of force development (RFD) components* • Terminal knee extension (standing, prone, marching) Continue use of neuromuscular re-education using electrical stimulation (NMES) with progressive CKC / functional LE tasks (see **Appendix A** for ideal parameters) Incorporate core stabilization exercises
Criteria for Discharging Crutches/Assistive Device and Progression to Next Rehabilitation Phase	✓ No sooner than **4 weeks** ✓ Full *active* knee extension range of motion ✓ Swelling: ≤1+ on sweep test ✓ Strength: able to perform strong quadriceps activation and perform 2x10 SLR with no extensor lag ✓ Tolerate full weight bearing ambulation with no visible gait deviations

If multiple concomitant procedures done, default to highest precautions for weightbearing and range of motion. Please consult surgeon for protocol.

Rehabilitation Guidelines for ACL Reconstruction

Phase III: 6-16 weeks post-operative	
Appointments	Surgeon: 6 weeks post-op Physical Therapy appointments: 1-2 times/week

Precautions	Avoid donor site pain / over-loading
	ACL brace use: ACL brace as directed by surgeon & therapist
	• **Modifications for concomitant procedures:**
	  ○ Unstable Meniscus Repair (root, radial, complex repairs)
	    ▪ Gradual progression to full ROM after **week 6**
	    ▪ Avoid loading in flexion beyond 90° for **16 weeks**

Rehabilitation Goals	• Maintain full, *active* knee extension range of motion symmetric to non-operative leg • Improve lower extremity strength • Progress balance and neuromuscular control

Therapeutic Exercises
(Examples, but not limited to…)
 	
****Consider implementing dual tasking throughout rehab program to minimize compensatory neurocognitive deficits****
	Early phase strengthening: consider utilization of blood flow restriction training once joint effusion is well controlled - if no contraindications are present *(appropriate for use with OKC and CKC strength task* - see **Appendix A** for ideal parameters*)*
	• Leg press (single leg)
	• Full range OKC knee extension with ankle cuff weights
	  ▪ Partial range with increased load
	    Weeks 6-8: progress load in 90-45° knee flexion (15-20 rep max)
	    Weeks 8-10: progress load in 90-30° knee flexion (15-20 rep max)
	• Step-ups *(limit compensatory hip / ankle strategies)*
	• Step-downs *(limit compensatory hip / ankle strategies)*
	• Bridges
	• Hip hinge / deadlift patterns
	• Hamstring curls
	• Wall slides
	Stretching exercises and manual therapy if knee flexion or extension AROM is still limited
	Cardio
	• Bike (if flexion ROM > 120° and joint effusion is well controlled)
	• Treadmill interval walking (speed and incline progressions)
	Late phase strengthening:
	• Loaded OKC knee extension
	  Weeks 10-12: progress load in full ROM (15-20 rep max)
	  Weeks 12-16: progress load in full ROM (10-12 rep max)
	  Week 16: progress to Biodex training if available
	• Single leg squats
	• Forward and reverse lunges
	  Quadriceps & patellar tendon graft: avoid significant early loading of rearfoot loading of operative LE in a lunge/split squat position
	• Frontal plane strength progressions (multi-direction band walking, lateral lunge progressions, etc.)
	• Deadlifts
	• Gradual rate of force development progressions

Recreational Activities	Biking without use of clip pedals Low load, low volume weight training
Criteria for Progression to Next Rehabilitation Phase	✓ Full range of motion ✓ Swelling ≤ 2+ using sweep test ✓ Able to tolerate closed kinetic chain therapeutic exercise program without increased pain and swelling ≤ 2+ using sweep test ✓ Safely perform marching with 5 second balance

Rehabilitation Guidelines for ACL Reconstruction

Phase IV: 16-20 weeks post-operative	
Appointments	Surgeon: 16-20 week follow up after surgery Physical Therapy appointments: 1 time/week -> every other week
Rehabilitation Goals and Criteria for Return to Impact / Plyometrics & Running	See **Appendix B**

Therapeutic Exercises
(Examples, but not limited to…)
 	
****Consider implementing dual tasking throughout rehab program to minimize compensatory neurocognitive deficits****
	Progressive impact training: See **Appendix C** for LE plyometric principles
	○ Double leg impact drills
	  Floor based pogo drills
	  Jump rope
	○ Single leg impact drills
	  Floor based pogo drills
	  Jump rope
	Jogging/running progressions (sport-specific)
	• See **Appendix D**

Phase V: 5+ months post-operative	
Appointments	Surgeon: 6 month post-op visit Physical Therapy: 1 time/week -> every other week
Rehabilitation Goals and Criteria for Return to Change of Direction Tasks	See **Appendix B** ▪ *If patient is not planning on return to sport, discharge from PT once they are able to do agility training at sub-max speeds without new inflammation.*
Therapeutic Exercises ***(Examples, but not limited to…)*** ****Consider implementing dual tasking throughout rehab program to minimize compensatory neurocognitive deficits****	▪ Progressive strengthening (in sport team setting if applicable) ▪ Integrate sport-specific jumping, plyometric and linear running / speed tasks ○ Take into consideration demands of sport including energy systems, player position, and environment

Phase VI: 7+ months post-operative	
Appointments	Surgeon: 6 month post-op visit Physical Therapy appointments: 1 time /every other week -> 1/month
Rehabilitation Goals	▪ Progress jumping and plyometrics ▪ Progress to hopping and cutting ▪ Re-introduce sport-specific training based on objective criteria
Criteria for Return to Cutting and Agility	See **Appendix B**
Therapeutic Exercises ***(Examples, but not limited to…)*** ****Consider implementing dual tasking throughout rehab program to minimize compensatory neurocognitive deficits****	▪ Continue progressive strengthening (in team setting if applicable) ▪ Progress sport-specific jumping, plyometric and linear running / speed tasks ▪ Integrate sport-specific cutting and agility tasks with progressive contact drill preparation as relevant, with change of direction and agility training
Criteria for Return to Sport	✓ Surgeon clearance ✓ See **Appendix B**

***Important to continue participation in ongoing preventative strength, power and motor control exercises at return to sport**

All physical therapy appointment frequencies are recommendations only. Your physical therapy provider will work with you to select an appointment frequency that best fits your individual needs.

***Developed by**: Jennifer Neudorfer PT, DPT, SCS, ATC & Dr. Christopher McCrum*
***Edited/reviewed by**: Shanon Williams PT, DPT, SCS; Brie Herbst PT, DPT, OCS, SCS; Kaitlyn Schlueter PT, DPT, SCS*
(Most recent review: July, 2024)

SAMARITAN ATHLETIC MEDICINE
845 SW 30TH STREET • CORVALLIS, OR 97330