Rehabilitation Guidelines for ACL Reconstruction in the Older Adolescent Athlete (Hamstrings with No Hardware Across Growth Plates)

Anterior cruciate ligament (ACL) injuries affect men and women across a wide age range and at all levels of athletics. The number of ACL tears in kids 6-16 years old has increased a lot over the last 20 years. Overall, girls seem to be at higher risk of ACL tears than boys.

About the Anterior Cruciate Ligament (ACL)

There are four main ligaments that stabilize the knee. The ACL is located in the center of the knee along with the posterior cruciate ligament (PCL). The ACL is responsible for stabilizing knee rotation that occurs during cutting and pivoting activities. The ACL is also a secondary restraint to knee hyperextension.

The ACL stabilizes the knee joint in two ways. First, the ligament acts as a passive restraint to excessive movement through its connection to the shin bone (tibia) and thigh bone (femur). Second, the ACL has mechanically sensitive nerve receptors, called proprioceptors, which sense the position of a joint. When a joint starts to exceed its normal range or speed of movement these proprioceptors will send a signal to the brain and spinal cord, which in turn stimulates the appropriate musculature to assist with stabilizing the joint.

Mechanism of Injury

An ACL injury usually occurs without contact from another player. The most common form of non-contact injury is a deceleration injury. An athlete often plants their foot on the ground to cut or change directions, and the ACL cannot withstand the force placed on it, so it tears. This causes the knee to buckle or give out. The ACL also can be torn if the knee is forcefully hyperextended while landing from a jump. An ACL injury causes pain and a lot of swelling in the knee. Sometimes people say they felt or heard a "pop" in the knee. It is often hard to walk after an ACL tear. It is also usually hard to bend and straighten the knee all the way after the injury. Even once swelling goes down, people may feel like the knee "gives out" or feels unstable.

Although less common, contact ACL injuries occur. A common contact injury occurs when an athlete is hit from the side at the knee with the foot planted on the ground. These injuries often involve more than one ligament.

Research studies have attempted to determine what factors contribute to an increased injury risk, but ACL injuries are multi-factorial and cannot be isolated to a single cause.

Diagnosis of an ACL Injury

There are several ways to diagnose an ACL injury. A thorough history of how the injury occurred is important to know, but the physical examination is often the most reliable and least expensive method of diagnosis. A sports medicine physician, physical therapist or athletic trainer will assess the knee's laxity, compared to the uninjured knee, using a Lachman's test and an anterior drawer test. They will also test the rotational stability component with a test called the pivot shift test. This test attempts to reproduce the athlete's sensation of buckling or giving out.

A magnetic resonance imaging (MRI) scan can visualize soft tissue and is an accurate test for diagnosing an ACL tear (see Figure 1).

A KT-1000 is a device that measures the laxity or looseness in the uninjured knee compared to the injured knee. In a diagnostic arthroscopy, a surgeon looks inside the knee with a camera to determine an injury. This is the most definitive test but also the most expensive and invasive.

Consequences of an ACL Injury

When treating an ACL injury, the key is controlling the instability of the knee. Repeated instability not only hinders athletic performance, but more importantly increases the risk of further injury to the cartilage and other ligaments of the

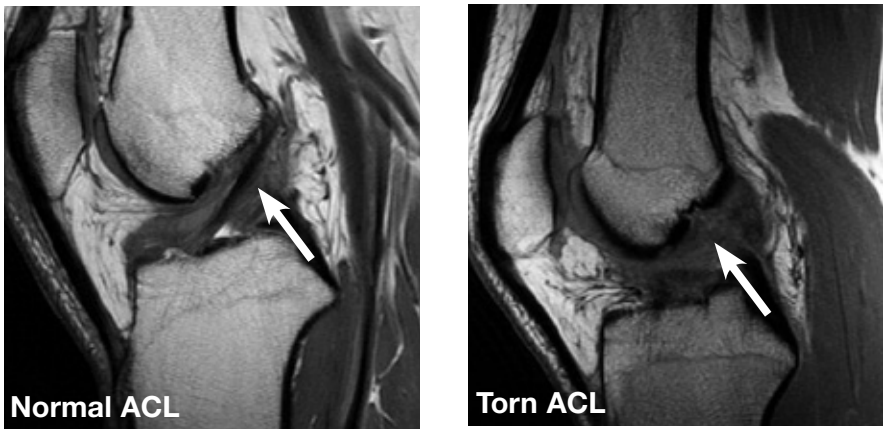

Figure 1: *MRI images of the ACL of the knee*

knee. Cutting and pivoting activities (common in sports like football, soccer, basketball and volleyball) are the most stressful for the ACL and are the activities most likely to reproduce the instability in an athlete with a torn ACL.

Treatment Options for an ACL Injury

The choices for treatment should be individualized and should take into account the age, activity level and the desire to return to sports which require significant amounts of cutting and pivoting or other high-speed movements. One form of conservative treatment is to modify the athlete's sports participation. This involves discontinuing sports involving cutting and pivoting, such as soccer and basketball. These sports could be replaced by sports that do not involve cutting and pivoting, such as swimming or running. Another form of conservative treatment is rehabilitation. Rehabilitation for an ACL injury focuses on improving an athlete's proprioception and reactive muscular stabilization. For sports such as basketball, soccer and football, rehabilitation alone may not be enough to prevent instability. If instability persists, the athlete must undergo surgical reconstruction of the ligament to return to these sports.

Surgical reconstruction involves replacing the torn ACL with a graft. The surgical procedure used to do this will depend on the skeletal maturity of the patient. In patients who are completely or near completely done growing the ACL is replaced with hamstring tendons, a portion of the patellar tendon or a portion of the quad tendon by drill holes (tunnels) in the thigh (femur) bone and shin (tibia) bone. In kids that are skeletally immature the surgical procedure needs to be altered to prevent growth arrest. Pre-pubescent (see chart) kids with growth plates that are completely open and significant growth is remaining, it is necessary to prevent drilling holes (tunnels) through the open growth plates near the knee. This approach is called an "all extraphyseal" surgery. As kids enter adolescence (see Figure 2) and approach skeletal maturity (usually age 12-14) the growth plates near the knee begin to close, with the tibial growth plate closing before the femoral growth plate but still have some growth remaining. In these situations a more anatomic reconstruction can be achieved through a procedure called "an over the top ACL reconstruction". In this procedure the normal tunnel in the tibia is drilled but no tunnel is drilled in the femur. One end of the hamstring graft is then placed in the tibial tunnel, while the other end is brought through the center of the knee and then attached over the top of the outside of the thigh bone (lateral condyle of the femur). Further in to adolescence (usually age 13-15) some kids may be very close to reaching skeletal maturity but the growth plates have not fully closed yet. In these situations kids can be provided a true anatomic reconstruction, similar to the adult surgery. The slight difference is that when using an all soft tissue graft (hamstrings), the surgeon will drill tunnels in both the tibia and femur, but will not using any hardware in these tunnels. Hardware, such as screws, has shown to accelerate the closure of open growth plates. This surgery is a very good option because it allows the graft to be placed in the anatomic (naturally occurring/normal) position while at the same time preserving the capability of remaining leg length growth.

All three of these surgical procedures will require different post-operative precautions in order to protect healing time. Yet all of these athletes will undergo six to twelve months of physical therapy.

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The post-operative physical therapy can be divided into five phases. During the first phase, the rehabilitative goals include protecting the healing graft, gradually improving range of motion, decreasing swelling, and regaining leg muscle control. In the "no hardware" technique the fixation is not quite as strong as an adult surgery. The graft is also slightly smaller. This requires a longer period of crutch and brace use, with slower initial physical therapy. In phase two, the goal is to focus on restoring proper body alignment and control with basic movements, such as walking, squats, and balance. This phase continues to build lower extremity and core (trunk) strength. In phase three, the focus shifts to developing good movement control with impact activities and more complex movements, such as a lunge with a rotational component. Developing movement control and eliminating apprehension while cutting and pivoting is the primary goal of phase four. At this time there is also more focus on single leg impact and push off with change of direction. The final phase transitions the athlete from performing intense cutting and pivoting activities in a controlled environment to an environment that more closely replicates their sport, including return to team practices with progressive decrease in limitations.

With the return to sports and higher-level activities, there is the risk of the new ACL graft tearing if there is a new injury to the knee. The risk of this happening in young athletes/individuals (< 18 years old) is at least twice as high as it is in older adults. It is reported to be as high as 15-30% in these younger individuals. Reasons for this are unclear but likely do to a few different things including the type of surgery, continued physical maturation and return to more years of high-level activity. Because of this high risk of re-injury, your physical therapist and doctor will put you through a series of progressive tests to determine when it is most safe to return to activity and sports. There is good evidence to show that the risk of re-injury goes down significantly by passing all return to sport testing and not going back too early.

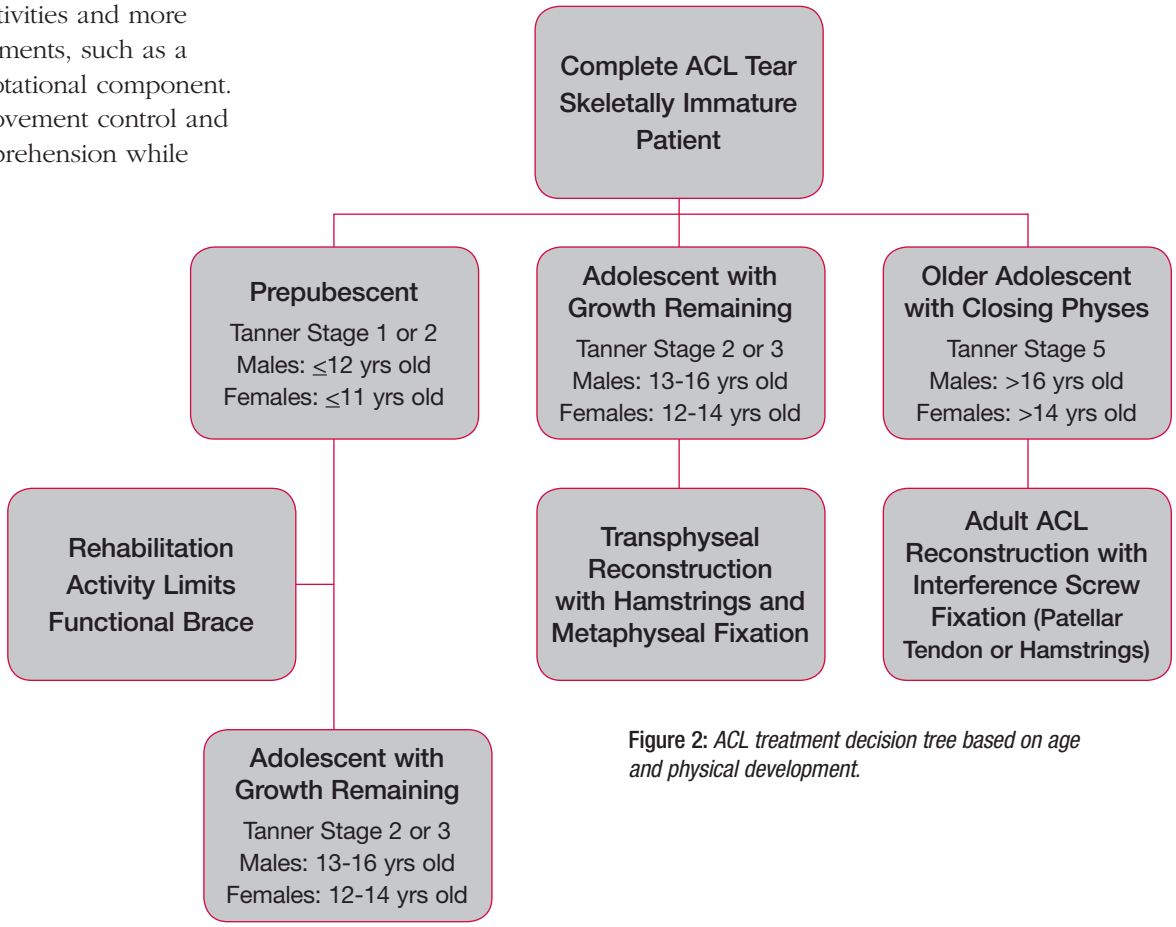

Figure 2: *ACL treatment decision tree based on age and physical development.*

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PHASE I (surgery to 6 weeks after surgery)

Appointments	• Rehabilitation appointments begin post-op day 1 and should be 1 to 2 times per week during this phase.
Rehabilitation Goals	• Protection of healing graft fixation • Restore quadriceps function and leg control • Adherence to home exercise program (HEP) and precautions

Precautions	• Weightbearing and Brace:
	  • weeks 0-2 = partial weight bearing (PWB) with crutches and locked brace
	  • weeks 3-4 = weight bearing as tolerated (WBAT) with 1-2 crutches and locked brace
	  • weeks 5-6 = WBAT with or without crutches and unlocked brace
	• Range of Motion (ROM): 0-90° for the first 4 weeks moving toward full flexion after the first 4 weeks. The goal in the first phase is to achieve hyperextension equal to the other side, unless excessive hypermobility exists. 5-7° of hyperextension should be a maximum. Generally these patients won't have difficulty achieving extension, so exercises and therapy to achieve it should be more gradual than in the adult to protect the graft and fixation.
	• Donor site: Avoid aggressive hamstring sets, heel slides and other hamstring activities that may aggravate the graft donor site. Slowly and progressively build in hamstring work.
	• Mensical Repair:
	  • For Drs. Baer, Walczak and Spiker = no weightbearing (NWB) flexion, respect and don't push through any compression type pain or discomfort when working on flexion range of motion
	  • Dr. Scerpella = no change in precautions
	• Mensical ROOT Repair:
	  • Touch-down weight bearing (TDWB)/NWB in locked extension brace for 6 weeks. NWB flexion for 6 weeks.
	  • ROM 0-90°, always in NWB position.

Suggested Therapeutic Exercise	• Assisted range of motion (AROM) seated knee flexion or supine wall slides (within above guidelines) • Knee extension ROM (avoid hyperextension past 5 degrees) • Ankle pumps progressing to resisted ankle ROM • Patellar mobilizations • Quad sets-10 second sustained and rapid activation 1 second sets • Straight leg raises
Cardiovascular Exercise	• None at this time
Progression Criteria	• 6+ weeks AND: 1. Good quad set and open chain leg control 2. Full knee extension 3. Near normal gait without crutches 4. Minimal knee effusion

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PHASE II (begin after meeting Phase I criteria, usually 6-8 weeks after surgery)

Appointments	• Rehabilitation appointments are 1-2 times per week
Rehabilitation Goals	• Normalize gait • Avoid overstressing the fixation site • Closed chain leg control for non-impact movement control • Adherence to HEP
Precautions	• Full weight bearing (FWB) • Avoid over-loading the fixation site by utilizing low amplitude low velocity movements. • No active inflammation or reactive swelling.
ROM Exercises	• Supine wall slides, heel slides and knee to chest to improve knee flexion as needed. Full extension should be gained by this point. • Stationary bike with low resistance • Aquatic therapy as needed
Suggested Therapeutic Exercise	• Gait drills - forward and backward march walk, soldier walk, side step, step overs, hurdle walk • Double leg balance drills - balance board, tandem balance, progressing to stationary single leg balance drills • Weight acceptance and control - shallow squat with lateral shifting, with sagittal shift, with shallow arc motions • Closed chain strengthening for quadriceps and glutes - double leg squat progressions, split squats, step backs, leg press • Begin to use external focus of attention drills for double leg strengthening • Double leg heel raises • Bridging • Hip and core strengthening
Cardiovascular Exercise	• Stationary bike with low resistance • Deep water running • Elliptical trainer
Progression Criteria	• Normal gait • Symmetric weight acceptance for squats to 60° • No reactive swelling after exercise or activity that lasts for more than 12 hours

PHASE III (begin after meeting Phase II criteria, usually 12-16 weeks after surgery)

Appointments	• Rehabilitation appointments as needed. Usually 1 time every 1-2 weeks
Rehabilitation Goals	• Normal running gait without side to side differences or compensations • Normal double leg landing control without side to side differences or compensations for sub-maximal squat jump • Adherence to HEP

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Precautions	• No active reactive swelling or joint pain that lasts more than 12 hours
Suggested Therapeutic Exercise	• Low amplitude low velocity agility drills: forward and backward skipping, side shuffle, skater's quick stepping, carioca, cross overs, backward jog, forward jog • Closed chain strengthening for quadriceps and glutes - progressing from double leg strengthening to single leg strengthening: lunge progressions and single leg squat progressions • Single leg balance exercises and progressions, progressing from stationary to deceleration in to holding posture and position • At ~12-14 weeks initiate low amplitude landing mechanics: med ball squat catches, shallow jump landings, chop and drop stops, etc. • Hip strengthening - especially oriented at neuromuscular control in prevention of hip adduction at landing and stance • Core strength and stabilization - especially orientated at preventing frontal plane trunk lean during landing and single leg stance
Cardiovascular Exercise	• Stationary bike with moderate resistance • Deep water running and swimming • Elliptical trainer at moderate intensity
Progression Criteria	• Normal jogging gait • Good single leg balance • Less than 25% deficit on Biodex strength test • No reactive swelling after exercise or activity

PHASE IV (begin after meeting Phase III criteria, usually 18-22 weeks after surgery)

Appointments	• Rehabilitation appointments are once every 2-4 weeks
Rehabilitation Goals	• Normal multi-planar high vel without side to side differences or compensations. • Normal double leg landing control without side to side differences or compensations. • Adherence to HEP
Precautions	• No active reactive swelling or joint pain that lasts more than 12 hours.

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Suggested Therapeutic Exercise	• Progressive agility drills: forward and backward skipping, side shuffle, skater's quick stepping, carioca, cross overs, backward jog, forward jog • Landing mechanics - progressing from higher amplitude double leg to single leg landing drills. Start uni-planar and gradually progress to multi-planar • Movement control exercise beginning with low velocity, single plane activities and progressing to higher velocity, multi-plane activities • Unanticipated movement control drills, including cutting and pivoting • Agility ladder drills • Strength and control drills related to sport specific movements • Sport/work specific balance and proprioceptive drills • Hip strengthening - especially oriented at neuromuscular control in prevention of hip adduction at landing and stance • Core strength and stabilization - especially orientated at preventing frontal plane trunk lean during landing and single leg stance • Stretching for patient specific muscle imbalances
Cardiovascular Exercise	• Progressive running program. Design to use sport specific energy systems
Progression Criteria	• Patient may return to sport after receiving clearance from the orthopedic surgeon and the physical therapist/athletic trainer. Progressive testing will be completed. The patient should have less than 15% difference in Biodex strength test, force plate jump and vertical hop tests, and functional horizontal hop tests.

PHASE V (begin after meeting Phase IV criteria, usually 28-36 weeks after surgery)

This phase is individualized based on the athlete's sport and continued physical impairment/performance needs. During this phase athletes will be allowed to return to team practices with criteria and limitations from the physical therapist. This may include time, volume or specific activity.

Practice Continuum:

1. Movement Patterns: a. sprinting b. shuffle c. carioca d. zig-zag cutting and e. shuttle change of direction
2. Closed Drills – sport-specific drills without opposition in a controlled speed environment
3. 1 on 1 Drills (no-contact) – sport-specific drills/ activities where the athlete is expected to react to his/ her opponent without compensation
4. 1 on 1 Drills – full speed 1 on 1 drills with game necessary contact
5. Team Scrimmage (no-contact) – patients are asked to wear a different colored jersey to indicate their contact restrictions during team scrimmaging when appropriate
6. Team Scrimmage – full scrimmaging
7. Restricted Play – progressing time and situational play as appropriate.
8. Full return to play

Patient may return to sport after receiving clearance from the orthopedic surgeon and the physical therapist/athletic trainer. Progressive testing will be completed. Patient should have less than 15% difference in Biodex strength test, force plate jump and hop tests and functional hop tests.

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These rehabilitation guidelines were developed collaboratively by UW Health Sports Rehabilitation and the UW Health Sports Medicine physician group.

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