Pediatric Rehabilitation Protocol for Anterior Cruciate Ligament (ACL) Reconstruction

This protocol is intended to guide clinicians through the post-operative course for pediatric/adolescent ACL Reconstruction. This protocol is time based (dependent on tissue healing) as well as criterion based. Specific intervention should be based on the needs of the individual and should consider exam findings and clinical decision making. The timeframes for expected outcomes contained within this guideline may vary based on surgeon's preference, additional procedures performed, and/or complications. If a clinician requires assistance in the progression of a post-operative patient, they should consult with the referring surgeon.

The interventions included within this protocol are not intended to be an inclusive list of exercises. Therapeutic interventions should be included and modified based on the progress of the patient and under the discretion of the clinician.

Considerations for allograft, hamstring autograft, and varied surgical techniques for pediatric patients
Early weight bearing and early rehabilitation intervention vary for allograft and hamstring autograft. Please reference specific instructions below. Expectations are the early return to sport phase will be delayed and communication with surgical team will be important to understand implications of surgical procedure to rehab timeframes.

Pediatric patients with open epiphyseal plates may require surgical techniques that differ from adults, such as physeal sparing, partial epiphyseal, and transphyseal techniques. Variations in rehab timeframes based on these procedures should be confirmed with surgical team.

Considerations with concomitant injuries
Be sure to follow the more conservative protocol with regards to range of motion, weight bearing, and rehab progression when there are concomitant injuries (i.e. meniscus repair).

Post-operative considerations
If you develop a fever, intense calf pain, excessive drainage from the incision, uncontrolled pain or any other symptoms you have concerns about you should call your doctor.

Considerations for the Pediatric/Adolescent Patient:

Children are not small adults! Children have different psychological and physiological needs than adults. These needs should be considered when designing any rehabilitation program. Rehabilitation timeframes may be protracted by these factors and often will require modification/adaptation to the individual patient.

- **Biological Age:** Rates of growth and development are highly variable, making it important to consider that the patient in front of you may be very different than another patient of the same chronological age. Alterations in center of mass, muscle imbalances, and the relative tightening of the muscle–tendon units due to rapidly growing bones may cause difficulty with coordinated athletic movements or motor learning.
- **Training Age:** The length of time, if at all, a child has followed a structured and supervised resistance training or conditioning program. It is important to consider that some young athletes have never been trained in common functional or joint specific movements found in post operative rehabilitative programs. Extensive motor learning may need to take place prior to multi-joint or compound exercise progression.

- **Development of Strength:**
    - Prepubescent children gain strength primarily through neural adaptation, as they lack the necessary hormones for muscle hypertrophy. Once children reach puberty, strength development becomes primarily hormonal which stimulates hypertrophic changes in muscle.
    - Myelination of nerve fibers (motor neurons) is absent or incomplete in children, making fast reactions and skilled movements difficult to perform. Thus, high levels of strength and power will not be achieved as in an adult patient.
- **Epiphyseal Plates:** Prepubescent children's epiphyseal plates have yet to close, so high impact activities such as depth jumps should be progressed with caution. Also, weight bearing, and plyometric activities should be varied to avoid repetitive stress to growth plates.
- **Psychological State:** For many pediatric patients, this may be their first serious injury or surgery. High levels of anxiety both pre and post operatively from patient and parent can affect pain, and thus limit weight bearing/ROM progressions, home exercise performance, and motivation. Different than adults, successful rehab will depend on collaboration with caregivers to assure proper carryover of home exercises. Positive factors found in recovery include being provided with detailed knowledge of the recovery process, developing trusting relationships with providers, having individualized goals, and including sport specific activities as much as possible.
- **Activities of Daily Living:** Pediatric ADL's differ from that of adults. Often "play" is an integral part of their day, different than an adult patient. Pediatric patients may have gym classes and recess, or active play with friends may be an important part of their preinjury daily activity. Involvement of parents, coaches, and teachers may be necessary to assure that the patient understands activity restrictions in all settings with clear expectations, as children may have difficulty self-regulating their activity level and adhering to precautions.
- **Self-reported Outcome Measures:** It is strongly suggested to use pediatric-specific outcome measures. There is strong evidence supporting the use of pediatric International Knee Documentation Committee (Pedi-IKDC) as it shown to have good properties over the Knee Injury and Osteoarthritis Outcome Score (KOOS).

PHASE I: IMMEDIATE POST-OP (0-2 WEEKS AFTER SURGERY)

Rehabilitation Goals	• Protect graft • Reduce swelling, minimize pain • Restore patellar mobility • Restore full extension, gradually improve flexion • Minimize arthrogenic muscle inhibition, re-establish quad control, regain full active extension • Patient education ○ Keep your knee straight and elevated when sitting or laying down. Do not rest with a towel placed under the knee ○ Do not actively kick your knee out straight; support your surgical side when performing transfers (i.e. sitting to laying down) ○ Do not pivot on your surgical side
Weight Bearing	*Walking* • Initially brace locked, crutches (per MD recommendation) • May start walking without crutches as long as there is no increased pain, effusion, and proper gait. ○ Allograft and hamstring autograft continue partial weight bearing with crutches for 6 weeks unless otherwise instructed by MD • May unlock brace once able to perform straight leg raise without lag. • May discontinue use of brace after 6 wks per MD and once adequate quad control is achieved. • When climbing stairs, lead with the non-surgical side when going up the stairs, and lead with the crutches and surgical side when going down the stairs.
Interventions	*Swelling Management* • Ice, compression, elevation (check with MD re: cold therapy) • Retrograde massage • Ankle pumps *Range of motion/Mobility* • Patellar mobilizations: superior/inferior and medial/lateral ○ ***Patellar mobilizations are heavily emphasized in the early post-operative phase following patella tendon autograft*** • Seated assisted knee flexion extension and heel slides with towel • Low intensity, long duration extension stretches: prone hang, heel prop • Standing gastroc stretch and soleus stretch • Supine active hamstring stretch and supine passive hamstring stretch *Strengthening* • Calf raises • Quad sets • NMES high intensity (2500 Hz, 75 bursts) supine knee extended 10 sec/50 sec, 10 contractions, 2x/wk during sessions—use of clinical stimulator during session, consider home units distributed immediate post op. • Straight leg raise ○ **Do not perform straight leg raise if you have a knee extension lag • Hip abduction • Multi-angle isometrics 90 and 60 deg knee extension
Criteria to Progress	• Knee extension ROM 0 deg • Quad contraction with superior patella glide and full active extension • Able to perform straight leg raise without lag

PHASE II: INTERMEDIATE POST-OP (3-5 WEEKS AFTER SURGERY)

Rehabilitation Goals	• Continue to protect graft. • Maintain full extension, restore full flexion (contra lateral side) • Normalize gait
Additional Interventions	*Range of motion/Mobility* • Stationary bicycle

**Continue with Phase I interventions*	• Gentle stretching all muscle groups: prone quad stretch, standing quad stretch, kneeling hip flexor stretch *Strengthening* • Standing hamstring curls • Step ups and step ups with march • Partial squat exercise • Ball squats, wall slides, mini squats from 0-60 deg • Lumbopelvic strengthening: bridge & unilateral bridge, sidelying hip external rotation-clamshell, bridges on physioball, bridge on physioball with roll-in, bridge on physioball alternating, hip hike *Balance/proprioception* • Single leg standing balance (knee slightly flexed) static progressed to dynamic and level progressed to unsteady surface • Lateral step-overs • Joint position re-training
Criteria to Progress	• No swelling (Modified Stroke Test) • Flexion ROM within 10 deg contra lateral side • Extension ROM equal to contra lateral side

PHASE III: LATE POST-OP (6-8 WEEKS AFTER SURGERY)

Rehabilitation Goals	• Continue to protect graft site • Maintain full ROM • Safely progress strengthening • Promote proper movement patterns • Avoid post exercise pain/swelling • Avoid activities that produce pain at graft donor site
Additional Interventions **Continue with Phase I-II Interventions*	*Range of motion/Mobility* • Rotational tibial mobilizations if limited ROM *Cardio* • 8 weeks: Elliptical, stair climber, flutter kick swimming, pool jogging *Strengthening* • Gym equipment: leg press machine, seated hamstring curl machine and hamstring curl machine, hip abductor and adductor machine, hip extension machine, roman chair, seated calf machine ○ Hamstring autograft can begin resisted hamstring strengthening at 12 weeks **If resistance machines are to be used, the patient must be sized appropriately to the machine. Adolescent patients may be too small for machines or not be able to independently decide on appropriate weight/progression. In this case, body weight exercises or smaller loads applied in the clinic under close supervision are encouraged. Parents may be included in the process to assure carryover for home program.* • Progress intensity (strength) and duration (endurance) of exercises **The following exercises to focus on proper control with emphasis on good proximal stability • Squat to chair • Lateral lunges • Romanian deadlift • Single leg progression: partial weight bearing single leg press, slide board lunges: retro and lateral, step ups and step ups with march, lateral step-ups, step downs, single leg squats, single leg wall slides • Knee Exercises for additional exercises and descriptions • Seated Leg Extension (avoid anterior knee pain): 90-45 degrees with resistance

	Balance/proprioception • Progress single limb balance including perturbation training
Criteria to Progress	• No effusion/swelling/pain after exercise • Normal gait • ROM equal to contra lateral side • Symmetrical Joint position sense (<5-degree margin of error)

PHASE IV: TRANSITIONAL (9-12 WEEKS AFTER SURGERY)

Rehabilitation Goals	• Maintain full ROM • Safely progress strengthening • Promote proper movement patterns • Avoid post exercise pain/swelling • Avoid activities that produce pain at graft donor site
Additional Interventions **Continue with Phase II-III interventions*	• Begin sub-max sport specific training in the sagittal plane • Bilateral PWB plyometrics progressed to FWB plyometrics *Balance & motor control: Progress to Plyometric and Agility Program (Appendix 2)* *Please review special consideration for epiphysial plate in the intro for this protocol*
Criteria to Progress	• No episodes of instability • Maintain quad strength • 10 repetitions single leg squat proper form through at least 60 deg knee flexion • Drop vertical jump with good control • KOOS-sports questionnaire >70% • Functional Assessment ○ Quadriceps index >80%; HHD or isokinetic testing 60d/s ○ Hamstrings ≥80%; HHD or isokinetic testing 60 d/s ○ Glut med, glut max index ≥80% HHD

PHASE V: EARLY RETURN TO SPORT (3-5 MONTHS AFTER SURGERY)

Rehabilitation Goals	• Safely progress strengthening • Safely initiate sport specific training program • Promote proper movement patterns • Avoid post exercise pain/swelling • Avoid activities that produce pain at graft donor site
Additional Interventions **Continue with Phase II-IV interventions*	• Interval running program ○ Return to Running Program • Progress to plyometric and agility program (with functional brace if prescribed) ○ Agility and Plyometric Program *Balance & motor control: Progress to Plyometric and Agility Program (Appendix 2)* *Please review special consideration for epiphysial plate in the intro for this protocol*
Criteria to Progress	• Clearance from MD and ALL milestone criteria below have been met • Completion jog/run program without pain/effusion / swelling • Functional Assessment ○ Quad/HS/glut index ≥90%; HHD mean or isokinetic testing @ 60d/s ○ Hamstring/Quad ratio ≥66% ○ Hop Testing ≥90% compared to contra lateral side, demonstrating good landing mechanics

PHASE VI: UNRESTRICTED RETURN TO SPORT (6+ MONTHS AFTER SURGERY)

Rehabilitation Goals	• Continue strengthening and proprioceptive exercises • Symmetrical performance with sport specific drills • Safely progress to full sport
Additional Interventions	• Multi-plane sport specific plyometrics program • Multi-plane sport specific agility program

**Continue with Phase II-V interventions*	• Include hard cutting and pivoting depending on the individuals' goals (~7 mo) • Non-contact practice→ Full practice→ Full play (~9 mo)
Criteria to Progress	• <u>Functional Assessment</u> ○ Quad/HS/glut index ≥95%; HHD mean or isokinetic testing @ 60d/s ○ Hamstring/Quad ratio ≥66% ○ Hop Testing ≥95% compared to contra lateral side, demonstrating good landing mechanics • Improvement on Pedi International Knee Documentation Committee (Pedi-IKCD) questionnaire

Revised 04/2024

Contact	Please email MGHSportsPhysicalTherapy@partners.org with questions specific to this protocol

References:

1. Adams D, Logerstedt D, et al. Current Concepts for Anterior Cruciate Ligament Reconstruction: A Criterion-Based Rehabilitation Progression. *JOSPT* 2012 42(7): 601-614.
2. Baechle TR, Earle RW, editors. Essentials of strength training and conditioning. Human kinetics; 2008.
3. Di Stasi S, Myer GD, Hewett TE. Neuromuscular Training to Target Deficits Associated with Second Anterior Cruciate Ligament Injury. *JOSPT* 2013 43 (11): 777-792.
4. Glazer DD. Development and Preliminary Validation of the Injury-Psychological Readiness to Return to Sport (I-PRRS) Scale. *Journal of Athletic Training.* 2009;44(2):185-189.
5. Haitz K, Shultz R, et al. Test-restest and interrater reliability of the functional lower extremity evaluation. *JOSPT.* 2014. 44(12): 947-954.
6. Irrgang JJ, Anderson AF, Boland AL, et al. Development and validation of the International Knee Documentation Committee Subjective Knee Form. *Am J Sports Med*. 2001;29:600-613.
7. Logerstedt DS, Scalzitti D, et al. Knee stability and movement coordination impairments: knee ligament sprain revision 2017. *JOSPT.* 2017. 47(11): A2-A47.
8. Mandelbaum BR, Silvers HJ, Watanabe DS, et al. Effectiveness of a Neuromuscular and Proprioceptive Training Program in Preventing Anterior Cruciate Ligament Injuries in Female Athletes: 2-year follow-up. *Am J Sports Med.* 2005;33:1003-1010.
9. Matsuzaki Y, Chipman DE, Perea SH, Green DW. Unique considerations for the pediatric athlete during rehabilitation and return to sport after anterior cruciate ligament reconstruction. *Arthroscopy, Sports Medicine, and Rehabilitation*. 2022 Jan 1;4(1):e221-30.
10. Noehren B, Snyder-Mackler L. Who's afraid of the big bad wolf? Open-chain exercises after anterior cruciate ligament reconstruction. *JOSPT.* 2020. 50(9): 473-475.
11. Van Der Velden, C.A., Van Der Steen, M.C., Leenders, J., Van Douveren, F.Q., Janssen, R.P. and Reijman, M., 2019. Pedi-IKDC or KOOS-child: which questionnaire should be used in children with knee disorders?. BMC musculoskeletal disorders, 20, pp.1-8.
12. Wright RW, Haas AK, et al. Anterior Cruciate Ligament Reconstruction Rehabilitation: MOON Guidelines. *Sports Health* 2015 7(3): 239-243.
13. Wilk KE, Macrina LC, et al. Recent Advances in the Rehabilitation of Anterior Cruciate Ligament Injuries. *JOSPT* 2012 42(3): 153-171.

Return to Running Program

This program is designed as a guide for clinicians and patients through a progressive return-to-run program. Patients should demonstrate > 80% on the Functional Assessment prior to initiating this program (after a knee ligament or meniscus repair). Specific recommendations should be based on the needs of the individual and should consider clinical decision making. If you have questions, contact the referring physician.

PHASE I: WARM UP WALK 15 MINUTES, COOL DOWN WALK 10 MINUTES

Day	1	2	3	4	5	6	7
Week 1	W5/J1x5		W5/J1x5		W4/J2x5		W4/J2x5
Week 2		W3/J3x5		W3/J3x5		W2/J4x5	
Week 3	W2/J4x5		W1/J5x5		W1/J5x5		**Return to Run**

Key: W=walk, J=jog

***Only progress if there is no pain or swelling during or after the run*

PHASE II: WARM UP WALK 15 MINUTES, COOL DOWN WALK 10 MINUTES

Week	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	20 min		20 min		20 min		25 min
2		25 min		25 min		30 min	
3	30 min		30 min		35 min		35 min
4		35 min		40 min		40 min	
5	40 min		45 min		45 min		45 min
6		50 min		50 min		50 min	
7	55 min		55 min		55 min		60 min
8		60 min		60 min			

Recommendations

- Runs should occur on softer surfaces during Phase I
- Non-impact activity on off days
- Goal is to increase mileage and then increase pace; avoid increasing two variables at once
- 10% rule: no more than 10% increase in mileage per week

Agility and Plyometric Program

This program is designed as a guide for clinicians and patients through a progressive series of agility and plyometric exercises to promote successful return to sport and reduce injury risk. Patients should demonstrate > 80% on the Functional Assessment prior to initiating this program. Specific intervention should be based on the needs of the individual and should consider clinical decision making. If you have questions, contact the referring physician.

PHASE I: ANTERIOR PROGRESSION

Rehabilitation Goals	• Safely recondition the knee • Provide a logical sequence of progressive drills for pre-sports conditioning
Agility	• Forward run • Backward run • Forward lean in to a run • Forward run with 3-step deceleration • Figure 8 run • Circle run • Ladder
Plyometrics	• Shuttle press: Double leg→alternating leg→single leg jumps • Double leg: ○ Jumps on to a box→ jump off of a box→ jumps on/off box ○ Forward jumps, forward jump to broad jump ○ Tuck jumps ○ Backward/forward hops over line/cone • Single leg (these exercises are challenging and should be considered for more advanced athletes): ○ Progressive single leg jump tasks ○ Bounding run ○ Scissor jumps ○ Backward/forward hops over line/cone
Criteria to Progress	• No increase in pain or swelling • Pain-free during loading activities • Demonstrates proper movement patterns

PHASE II: LATERAL PROGRESSION

Rehabilitation Goals	• Safely recondition the knee • Provide a logical sequence of progressive drills for the Level 1 sport athlete
Agility **Continue with Phase I interventions*	• Side shuffle • Carioca • Crossover steps • Shuttle run • Zig-zag run • Ladder
Plyometrics **Continue with Phase I interventions*	• Double leg: ○ Lateral jumps over line/cone ○ Lateral tuck jumps over cone • Single leg (these exercises are challenging and should be considered for more advanced athletes): ○ Lateral jumps over line/cone ○ Lateral jumps with sport cord
Criteria to Progress	• No increase in pain or swelling • Pain-free during loading activities • Demonstrates proper movement patterns

PHASE III: MULTI-PLANAR PROGRESSION

Rehabilitation Goals	• Challenge the Level 1 sport athlete in preparation for final clearance for return to sport
Agility **Continue with Phase I-II interventions*	• Box drill • Star drill • Side shuffle with hurdles
Plyometrics **Continue with Phase I-II interventions*	• Box jumps with quick change of direction • 90 and 180 degree jumps
Criteria to Progress	• Clearance from MD • Functional Assessment ○ Quad/HS/glut index ≥90% contra lateral side (isokinetic testing if available) ○ Hamstring/Quad ratio ≥70% ○ Hop Testing ≥90% contralateral side • KOOS-sports questionnaire >90% • International Knee Committee Subjective Knee Evaluation >93 • Psych Readiness to Return to Sport (PRRS)