

Anterior Cruciate Ligament Reconstruction with Patellar Tendon Rehab Protocol

General time frames are given for reference, with individual patients progressing at different rates. Progression should be dictated by time and achievement of each phase. If at any time the patient is experiencing advanced or unusual pain with the recommended exercises, the protocol may be slowed down or backed up. Please instruct the patient to call the orthopedic office for further pain management issues. Avoid aggravation of anterior knee pain in particular, as it is very difficult to subside once set in.

ACL autografts can take up to 6 weeks for the graft to effectively fixate to the tibial/ femoral bone (the first 6 weeks are the most tenuous times for graft fixation healing) and a total of 12 weeks for primary revascularization and remodeling (tensile strength of graft at 3 months is at 50% of the strength at implantation). As a result, please be mindful to avoid open-chain knee extension (40–90 deg) for the first 6 weeks. Open-chain, unloaded, terminal knee extension will start after 8 weeks. Also, please defer to the operative report and the surgeon's orders if there is noted meniscal repair and/or cartilage repair/ transplant, which could delay ROM parameters, weightbearing, and weaning from assistive devices.

Weight bearing	Crutches D/C	Brace use in Day	Brace D/C	Closed chain ROM Week 1	Closed chain ROM Week 2	Closed chain ROM Week 4	Closed chain ROM Week 8	Biking	Jogging
Week 1									
WBAT	Criteria based; ~ 2- 3 weeks	Criteria based; Locked until quad active	Criteria based; ~ 4- 6 wks	0 to 100 deg	0 to 120 deg	0 to 125 deg	Full AROM	Week 2	Criteria based; >12 wks

General timeline is provided below as a quick reference guide. Please see full details throughout the protocol.

Returning to activities and sports is based on meeting the criteria in this protocol. It is critical to meet each time-frame's goals to avoid risk of reinjury. Risk of knee reinjury is reduced by 58% for each

month return to sport was delayed until 9 months after surgery.¹ Those who returned to level I sports (involving jumping, pivoting, hard cutting, i.e. basketball/ football/ soccer) had a 4.68 times higher risk of knee reinjury than those who did not.¹

	Plyometrics Partial WB	Plyometrics Full WB	Jogging	Low-Level agility	Cutting	Return to level I sport
Autograft	2-3 months	3-4 months	3-4 months	4-5 months	5-6 months	9+ months
Allograft	3-4 months	4-5 months	4-5 months	5-6 months	6-7 months	10+months

Phase I- Immediate Postoperative Phase “restrictive motion” (1st week post-operative)

Goals:

- Absolute control of external forces and protect graft
- Nourish articular cartilage
- Decrease swelling
- Prevent quad atrophy
- Isometric quad set/extension near symmetrical to non-operative knee

POD 1

Precautions Post-Operative Day 1

- **Knee ROM Brace:** locked at zero degrees for ambulation/ rest/ sleeping
- **Weight bearing:** two crutches with weight bearing as tolerated
- **ROM:** full passive extension (0-100 degrees) in brace

Exercises

- Ankle pumps
- Passive heel prop of the knee for extension near zero
- Straight leg raises (flexion first)
- Hip abduction/adduction
- Initiate heelslides
- Quad sets
- Hamstring stretch

Modalities/ Swelling Control

- **Muscle stimulation:** Russian stimulation to quads during quad set exercise
- **CPM (if utilized):** 0 to 90 degrees
- **Ice and elevation:** ice 20 minutes per hour and elevate with knee in extension

POD 2-7

Precautions Post-Operative Days 2-7

- **Knee ROM Brace:** locked at zero degrees for ambulation until the anesthetic block wears off.
- **Knee ROM Brace use at night:**
 - Brace locked at 0 deg at night for the first 14 days.
 - Dismiss brace from night wear at 14 days post-operative.
- **Unlock Knee ROM brace from 0 deg with WBAT ambulation criteria:**
 - Active isometric quad contraction with superior patellar glide
 - No knee extension lag with 20 straight leg raises
 - Pain-free ambulation without obvious gait deviation
 - Initiate unlocking knee ROM brace first, prior to dismissing crutches
- **Crutches/ weight bearing:** two crutches with weight bearing as tolerated
- **ROM:** patient out of brace 4-5 times daily to perform self ROM 0-90/100 degrees

Exercises:

- Initiate seated stepping machine (Nu-Step) at low resistance, if available.
- Closed chain seated/supine A/AAROM exercises (supine/ seated knee F to 100 degrees)
- Patellar mobilizations (4 directions)
- Ankle pumps
- Straight leg raises (4 directions)
- Standing weight shifts and mini squats (0-30 ROM)
- Continue quad sets

Modalities/ Swelling Control:

- **Muscle stimulation:** Russian stimulation to quads during active exercises
- **CPM:** 0 to 90 degrees
- **Ice and elevation:** ice 20 minutes per hour and elevate with knee in extension

Criteria for Progression:

- Knee flexion to 100 deg
- SLR 20 rep's without quad lag
- Isometric quad set knee extension to near 0 deg
- Ambulation in brace unlocked with two crutches without knee buckling/ giving out
- No significant increase in anterior knee pain
- No significant increase in joint effusion

Phase II: Maximum Protection Phase (weeks 2-11)

Goals:

- Improve stability of the knee joint
- Continue to protect graft site
- Minimize sudden, external forces to the knee joint and protect graft
- Nourish articular cartilage
- Decrease swelling
- Improve quad activation with client demonstrating near 0 deg extension during quad sets
- Good knee control and symmetry with CKC exercises
- Avoid activities that produce pain at graft site

Weeks 2-3

Precautions Week 2-3

- **Knee ROM Brace use at night:**
 - Brace locked at 0 deg at night for the first 14 days.
 - Dismiss brace night wear at 14 days post-operative.
- **Continue to wear Knee ROM brace with ambulation until 4-6 weeks post-operative.**
- **Continue to evaluate/ achieve, "Unlock the knee ROM brace from 0 deg" criteria:**
 - Active isometric quad contraction with superior patellar glide
 - No knee extension lag with 20 straight leg raises
 - Pain-free ambulation without obvious gait deviation
 - Initiate unlocking knee ROM brace first, prior to dismissing crutches
- **Weaning from crutches criteria:**
 - Meet all "Unlock Knee ROM brace from 0 deg" criteria from POD 2-7
 - Complete half day of activities about home without crutches
 - Complete full day activities about home without crutches
 - Advance from in-home to small trips in community on dry surfaces
- **ROM:** self ROM (4-5 times daily) without brace, with emphasis on maintaining zero degrees passive extension
- **KT 2000 Test** (15 lb anterior-posterior test only)

Exercises:

- Initiate biking if able to achieve > 110 deg knee flexion AROM.
- Multi angle knee flexion/ hamstring isometrics at 90, 60, 30 degrees
- Straight leg raises (4 directions)
- Mini squats (0-40 degrees) and weight shifts
- Forward Lunges (partial)
- Leg press (0-60 degrees)
- Supine/seated AROM/AAROM knee F up to 120 degrees
- Patellar mobilization 4-directions
- Hamstring and calf stretching
- Proprioception training (Ex: step forward/ backward, postural sways)
- ~~Well~~ Contralateral leg exercises in stance, as needed
- Progressive Resistive Exercise (PRE) program start with 11lb, progress 1lb per week. Initiate with 4-way SLR's and closed-chain heelslides.
- **Hamstring autograft/ knee F may start resistance training into flexion at week 12.**

Modalities/ Swelling Control: ice, compression, elevation with Russian stimulation as needed

Criteria for Progression:

- Knee flexion to 120 deg
- SLR without quad lag
- Knee extension / quad sets to near 0 deg
- Ambulation in brace unlocked without AD and good knee extension control

Weeks 4-6

Precautions Weeks 4-6

- **Dismiss Knee ROM Brace criteria between weeks 4- 6:**

- Meet all “Weaning from crutches criteria”, from above wk 2- 3
- Symmetrical gait pattern without pain
- Single Limb Stance time on operative limb > 10 seconds without UE support
- **ROM:** self ROM (4-5 times daily) emphasis on maintaining zero degrees passive extension
- **KT 2000 Test** (week 4, 20 lb anterior and posterior test)

Exercises:

- Continue from week 2-3
- Supine/seated AROM/AAROM knee F up to 125 degrees
- Pool walking program, swimming
- Standing hamstring curls
- Leg press (0- 60 deg)
- Emphasize closed kinetic chain (CKC) exercises including:
 - Partial squats (0-45 deg)
 - Step ups and steps ups with march
 - Ball squats/ Wall Slides
 - Wall sits
- Single Leg standing balance (knee slightly flexed) progressing static to dynamic exercises; level and unsteady surface
- Gait training: lateral step overs, step forward/ backward
- Cardio: bicycle, seated stepping machine for ROM stimulus and endurance
- Optional: Nordic track/ stair climber

Modalities/ Swelling Control: ice, compression, elevation, Russian stimulation as needed

Weeks 6-7

Precautions Weeks 6-7

- **Knee ROM Brace:** Discontinue use of brace if meeting all, “Dismiss Knee ROM Brace” criteria, per wk 4-6.
- **KT 2000 Test** week 6, 20lb and 30lb anterior and posterior test

Exercises:

- Continue from week 4-6
- Hamstring curls with light resistance; **hamstring autograft can begin resisted hamstring strengthening at 12 weeks**
- Pool program
- Supine/seated AROM/AAROM knee F up to 125 degrees
- Initiate open chain, unloaded knee extension AROM at 90-45 deg at week 6
- Emphasize bilateral lower extremity CKC ~~closed chain~~ exercises:
 - Squat to chair
 - Lateral lunges
 - Romanian deadlift
- Single leg progression CKC:
 - Partial weight bearing single leg press
 - Step Ups/ Downs, initiating at shallow step heights
 - Lateral Step Ups
 - Washcloth slides on floor: retro/lateral

- Single Leg wall slides
- Progress Single Leg balance including perturbation training
- Cardio: Bicycle, stair climber, Nu-Step.

Modalities/ Swelling Control: ice, compression, elevation, Russian stimulation as needed

Weeks 8= 11

- **KT 2000 Test** week 8, 20lb and 30lb anterior and posterior test

Exercises:

- Continue PRE program
- Continue to emphasize CKC strengthening
 - Leg press (0-60 degrees)
 - Partial squats (0-45 degrees)
 - Lateral step ups
- Full, seated or supine closed- chain A/PROM allowed
- May advance to open chain, unloaded, terminal knee extension at week 8
- Begin PWB B LE plyometrics (leg shuttle, Total Gym angled, double leg bounding (constant contact) on trampoline with handhold on rails) at week 8
- Single leg squat with good form thru 60 deg knee partial squat at week 9
- Advance open chain terminal knee extension PRE starting at 1 lb per week at week 10
- Cardio: standing elliptical, stair climber, treadmill walking

III: Moderate Protection Phase (weeks 12-18)

Goals

- Maximal strengthening for quads/lower extremity
- Protect knee/ tibiofemoral joint
- Avoid post exercise pain/ swelling
- Avoid activities that produce pain at graft site
- Promote proper movement patterns
- No episodes of instability of the knee joint during exercise progression
- Drop vertical jumps with good control
- Progress plyometrics from PWB to FWB

Weeks 12- 18

Exercises:

- Reorganize HEP to optimize strengthening, jogging criteria, agilities, and plyometrics advancements
- Continue to advance OKC and CKC strengthening with weights, bands, kettle bells
- Progress jogging criteria approximate > week 12:
 - Must be able to complete 20 single leg hop and holds with proper neuromuscular control at trunk, hip, knee without valgum deformity
 - Must be able complete 20 single leg partial squats without trunk, hip, knee valgum deformity
 - No pain/ reactive effusion with initiation of short-distance jogging at each progression level of jogging
 - Jogging frequency of every other day (increase rest as necessary)
 - See "Return to Jogging Progression" recommendations (**Table 1**)

- Progress full plyometrics criteria approximate > week 12:
 - Must be able to perform 60% of body weights squat five times in 5 seconds.
 - Begin with 30-40 foot contacts and advance per session; no more than 80-120 foot contacts per session
 - Must be able to demonstrate symmetrical takeoff/landing, hip hinge/glute incorporation (no knees over toes), soft landing, avoid knee valgus
 - Initiate Double Leg plyometrics in place, forward, 90 deg and 180 deg rotations, then tuck jumps
 - Progress to Single Leg plyometrics: bounding, contralateral step and hold (L > R, R > L), contralateral hop and hold (L > R, R > L), and triple hop.
 - Progress to low height double leg box jumps (starting at 2-4") to/from box
 - Progress to Jumping TO Box: 2 legs to 2 legs, 2 legs to 1 leg, 1 leg to opposite leg, 1 leg same leg (starting at 2-4").
 - Progress to Jumping FROM Box: 2 legs to 2 legs. (start with drop at 2-4")
- Progress Agilities
 - Ladder Drills
 - Carioca, side shuffle, backpedaling
 - Skipping different heights, distance, speed
- Progress Neuromuscular control
 - BOSU ball- ball toss, SLS, split squats, step and hold
 - Unstable surface squats, scissors
 - Resisted bungee/cable steps/ lunges
- **Level 1 Return to Play Test** (4 months post-operative) completed for those returning to low level sports (non- level I sports listed on front page)
 - Functional control and without pain: 8" forward step down, 18" drop jump, and lateral shuffle 2x5 yards
 - Single leg squat to near parallel with goal of 25 rep's each side
 - Single leg calf raise with goal of 25 rep's each side
 - MMT Hip abduction/ extension bilaterally 3 rep's of 5" holds without break
 - Satisfactory ACL- RSI Outcome Measure

IV: Light Active Phase (week 18- 25)

Criteria to enter Phase IV:

- Full AROM
- 1 RM contralateral side, knee flexor/extensor rated 70-80%
- No change in KT scores (+2 or less)
- Continuance of Return to Jogging Progression without pain/ compensations
- Good neuromuscular control of knee with plyometrics without genu valgum, compensations, and good quad control with minimal glut/ hamstring substitution.
- Minimal/no effusion
- Satisfactory clinical exam with < than 5 mm anteroposterior shift for stable A/P drawer I

Goals

- Development of strength, power, endurance
- Begin gradual return to functional activities

Weeks 18- 25

Exercises

- Emphasize CKC, step ups, mini squats, deadlifts, leg press to improve equivalence of LE strength
- Progress OKC terminal knee extension/ flexion strength
- Power weightlifting if appropriate (3-4 sets of 1-5 rep's)
- Hypertrophy weightlifting if appropriate (3-4 sets of 8-15 rep's)
- Strength weightlifting if appropriate (3-4 sets of 2-8 rep's)
- Continue to progress plyometrics:
 - Complex box jumping of height, speed, 90 deg rotation
 - Progress squat jumps
 - Complex jumping (1 leg:2 leg, scissor, split, et al)
 - Jumping TO box: 2 legs to 2 legs, 2 legs to 1 leg, 1 leg to opposite leg, 1 leg same leg.
 - Jumping FROM Box: 2 legs to 2 legs. (Drop Vertical at 2-4")
 - Drop box landing progressions
- Continue to progress jogging to running program greater than 1 mile in duration, once criteria in **Table 1** Return to Jogging Progression has been met
- Advance sport specific agilities, including hopping drills, jump-drop drills, cutting.
- Work toward Limb Symmetry Index (LSI)/ Isokinetic test: 85-90% > of opposite leg (quads), 90% > of opposite leg (hamstring)**2**. See **Limb Symmetry Index (Table 2)**.
- Isokinetic test- quad torque/body weight (180degrees/sec) (60-65% males) (50-55% females)

Testing: Isokinetic test (180/300 degrees/sec, full ROM, 10/15 reps)

KT 2000 Test total displacement at 15lb, 20lb, 30lb, manual maximal test

V: Return to Activity/ Sport Activity Phase (months 6-9)

Goals:

- Achieve maximal strength and endurance, return to sport activities
- 1RM quadriceps and hamstring test > 90% LSI on knee extension and hamstring curl; hamstring/quad ratio > 66%
- Standardized Hop tests (Single-leg hop test, Drop Jump Test, or Timed Hop Test) demonstrating contralateral symmetry >90%.³ See **Return to Play Test** (7+ month)
- If/when possible, Estimated Pre-Injury Capacity (EPIC- obtained by comparing the involved limb measures to uninvolved limb measures before ACL construction) > 90%.¹
- If possible, Landing Error Scoring System (LESS) for jump-landing test demonstrates no excessive knee valgus, excessive knee flexion angle, or landing instability.²

Exercises:

- Sport Specific Activities- individual basis of coordination
- Continued single leg strengthening as needed
- Power weightlifting as appropriate (3-4 sets of 1-5 rep's)
- Hypertrophy weightlifting as appropriate (3-4 sets of 8-15 rep's)
- Strength weightlifting as appropriate (3-4 sets of 2-8 rep's)
- Continue to progress dynamic running with interval sprinting/ running program, to develop max speed (**Table 3**)
- Continue to advance plyometric box jumps to/from advanced heights as tolerates
- **Level I Return to Play Test** (7+ month interval):
 - 90 deg cut running
 - Triple Hop (90% average contralateral LE) for distance 3 rep's
 - Single Leg Hop for distance 3 rep's within 90%

- Crossover Triple hop for distance 3 rep's within 90%

Table 1 Return to Jogging Progression- Complete each level 3 repetitions without pain/ effusion prior to advancement to next level.

	Warm Up Walk	Jog	Walk	Repetitions	Cool Down Walk	Total Time
Level 1	3 minutes	1 minute	3 minutes	3	5 minutes	20 minutes
Level 2	4 minutes	1 minute	2 minutes	5	4 minutes	23 minutes
Level 3	5 minutes	2 minutes	1 minute	6	5 minutes	28 minutes
Level 4	5 minutes	3 minutes	1 minute	5	5 minutes	30 minutes
Level 5	5 minutes	5 minutes	1 minute	4	5 minutes	34 minutes
Level 6	5 minutes	7 minutes	1 minute	3	5 minutes	34 minutes
Level 7	5 minutes	Up to 1 mile	-	1	5 minutes	

Adaptations from The Ohio State University Walk: Jog Program and Sanford Health: ACL Reconstruction Rehabilitation Guideline: Return to Running Program

Table 2 Limb Symmetry Index (LSI) calculation (Affected limb value/un-affected limb value)x 100

Please utilize at least one test to validate the LSI for Return to Sport Progression:

Single Leg Hop for Distance	Single Leg Side Hop for Distance	Triple Hop for Distance	6 Meter Hop for Time
Lateral Hop Test	Single Leg Vertical Hop test	Star Excursion Balance Test (SEBT)	

Table 3 Interval Sprinting/ Running Program

Goals: 1) Increase total distance by 10% per workout

2) Complete without pain/ effusion x3 sessions before advancing from Stage I to II

Stage I: Build up work capacity and improve technique (1 minute work :5 minute rest ratio)

Stage II: Build on increased speed and build intensity (1:3 work: rest ratio)

5x20 yards OR	5x ¾ court (63 ft)
4x50 yds OR	4x 2 full courts (168 ft)
5x40 yds OR	5x 1 ½ courts (63 ft)
2x50 yds OR	2x full courts (168 ft)
1x100 yds OR	1x3 full courts (252 ft)

Adapted from ACL Reconstruction Rehabilitation Guideline, Sanford Health

**** This protocol is designed to be administered by a licensed physical therapist and/or certified athletic trainer. Please do not hesitate to contact our office should you have any questions regarding the rehabilitation protocol.****

References:

- 1) Grindem H, Snyder-Macker L, Moksnes H, Engebretsen L, Risberg M.A. Simple decision rules can reduce reinjury risk by 84% after ACL reconstruction: the Delaware–Oslo ACL cohort study. *Br J Sports Med*. 2016 Jul; 50 (13): 804–808.
- 2) Giuseppe Gianluca Costa, et al. Minimizing the risk of graft failure after anterior cruciate ligament reconstruction in athletes. A narrative review of the current evidence. *Journal of Experimental Orthopaedics*. 2022 Sept; 26.
- 3) Lewek M, Rudolph K, Axe M, Snyder-Mackler L. The effect of insufficient quadriceps strength on gait after anterior cruciate ligament reconstruction. *Clin Biomech* (Bristol Avon) 2002; 17: 56– 63.

LOCATIONS

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