

The Physical Root

ACL Reconstruction Rehabilitation Protocol

Criteria-based guidance with open- and closed-kinetic-chain exercise progression

Purpose

A clinician-facing framework after ACL reconstruction (ACLR). Progression must reflect graft type, fixation, concomitant meniscal or cartilage procedures, range of motion, effusion, quadriceps strength, movement quality, biological healing, patient goals, and the operating surgeon's instructions.

Protocol at a glance

Phase	Typical timing	Primary priorities
0. Readiness	Before surgery	Quiet knee, full extension, strength baseline, education
1. Protection / activation	Day 0 to week 2	Effusion control, extension, gait, quadriceps activation
2. Foundational strength	Weeks 2-6	Normalize gait, progressive CKC and appropriately dosed OKC
3. Strength / running readiness	Weeks 6-16	Restore quadriceps capacity, progressive gym lifting, running criteria
4. Power / return	Months 4-12+	Plyometrics, agility, sport exposure and reinjury reduction

Design principles

- Use both biological healing and objective criteria. Time alone is not clearance.
- Open kinetic chain (OKC) knee extension is not categorically harmful after ACLR; dosage, range, graft type, symptoms, and progression matter.
- Pair isolated quadriceps loading with closed kinetic chain (CKC) tasks to restore strength and function.
- Do not progress when effusion, pain, loss of extension, instability, or movement compensation is worsening.
- Return to competition is a graded process after restoration of physical and psychological readiness.

1. Scope, red flags, and clinical decision rules

Applies to: adults and adolescents after primary ACLR when graft type, fixation, and concomitant procedures are known. This protocol does not supersede the operative report, surgeon communication, or facility policy.

Adapt or obtain explicit clearance for: revision ACLR; multi-ligament reconstruction; meniscal root/radial repair; cartilage restoration; osteotomy; fracture; staged surgery; significant neurological, vascular, cardiopulmonary, or cognitive concerns; or other factors altering weight bearing, ROM, or loading.

Urgent and emergent escalation

Finding	Recommended action
Chest pain, severe dyspnea, syncope, new confusion, or stroke signs	Activate emergency response / call emergency services.
Concerning calf pain/swelling, warmth, color change, or unexplained shortness of breath	Stop treatment and follow the surgeon/facility pathway for urgent DVT/PE assessment.
Drainage, dehiscence, spreading redness, purulence, fever, chills, or abrupt pain increase	Contact the surgeon promptly; same-day assessment when concerning.
Traumatic pop, recurrent giving way, rapid hemarthrosis, new locking, or abrupt functional loss	Protect the knee, stop loading, and contact the surgeon promptly.
Loss of distal pulse, new foot drop, progressive sensory loss, or severe unremitting pain	Urgent surgical or emergency evaluation.

Medication and wound boundaries

Reinforce, but do not independently alter, instructions for analgesics, anticoagulation, antibiotics, brace use, dressings, bathing, or driving. Avoid soaking or direct scar work until the incision is closed and cleared.

Key monitoring variables

- Effusion grade, pain, warmth, ROM, incision status, and 24-hour response.
- Active and passive extension, flexion trajectory, patellar mobility, and straight-leg-raise lag.
- Quadriceps activation and objective strength testing when safe.
- Gait, assistive-device use, balance, squat/step mechanics, and confidence.
- Graft type, fixation, donor-site symptoms, and concomitant-procedure restrictions.

2. Operative report and graft-specific considerations

Information to obtain from the operative report

Operative detail	Why it matters
Graft source	BPTB and quadriceps tendon grafts affect the extensor mechanism; hamstring grafts affect knee-flexor capacity; allografts generally require a more conservative return-to-sport timeline.
Fixation / tunnel information	Fixation method, bone quality, tunnel concerns, or surgeon-noted limitations may alter loading.
Meniscal procedure	Repair type and location can change weight bearing, flexion limits, loaded knee-flexion depth, running, and pivoting timelines.
Cartilage procedure	Microfracture, osteochondral grafting, or chondral repair may substantially change weight bearing and impact progression.
Other ligament / structure	MCL, LCL, PCL, posterolateral corner, or extensor-mechanism procedures require procedure-specific restrictions.
Intraoperative findings	Chondral disease, graft tension, fixation concerns, ROM, and complications guide prognosis and progression.

Required communication

Review the operative report before advancing weight bearing, loaded knee flexion, running, or pivoting. Clarify graft type, fixation, meniscal/cartilage restrictions, brace parameters, and whether the surgeon has specific OKC knee-extension limits.

Graft-informed loading notes

Graft	Clinical emphasis	Common modification
BPTB	Quadriceps recovery and patellar-tendon donor-site tolerance	Dose knee extension to donor-site symptoms; avoid underloading the quadriceps.
Quadriceps tendon	Quadriceps and rectus-femoris donor-site loading	Use progressive isolated quadriceps loading and objective testing.
Hamstring	Knee-flexor harvest-site recovery	Delay aggressive hamstring loading per surgeon; early OKC knee extension may begin in a protected range when indicated.
Allograft	Slower biological incorporation	Delay running/high-level progression after criteria and commonly target return to sport at 12+ months.

3. Phase 0 - preoperative readiness

- Restore full active and passive extension, flexion as tolerated, trace-to-zero effusion, and a normal or near-normal gait.
- Obtain baseline quadriceps strength, patient-reported function, activity goals, and psychological readiness when feasible.
- Teach postoperative ROM, swelling management, assistive-device use, initial exercises, and realistic return-to-sport expectations.
- Address modifiable risks including smoking/nicotine exposure, poor sleep, low conditioning, and inadequate home support.

Suggested baseline measures

KOS-ADLS, IKDC, KOOS, or PROMIS Physical Function; ACL-RSI when appropriate; knee ROM; effusion grade; quadriceps dynamometry; gait; sit-to-stand; and functional strength testing as safe.

4. Phase 1 - protection, extension, and activation

Typical timing: day 0 through week 2. Concomitant procedures may require slower weight-bearing or ROM progression.

Goals

- Achieve full passive extension and progressive active extension.
- Reduce effusion and pain; protect the incision and graft.
- Restore quadriceps activation and straight-leg raise without lag.
- Establish safe gait and transfers with the prescribed brace/device.

Interventions

Domain	Examples
ROM / swelling	Heel prop or prone hang, heel slides, patellar mobilization, compression/elevation, cryotherapy when appropriate.
Quadriceps / OKC	Quad sets, NMES, straight-leg raise when lag-free, short-arc or long-arc knee extension with low load according to surgeon/clinic pathway.
CKC / function	Weight shifts, supported mini-squat, calf raise, gait training, sit-to-stand from an appropriate height.
Hip / trunk	Hip abduction/extension, trunk control, and nonoperative-limb training without violating weight-bearing restrictions.
Dose	Frequent short sessions; use extension, effusion, pain, and next-day response to guide progression.

Avoid

- Resting with a pillow directly behind the knee.
- Progressing load when effusion or extension loss is worsening.
- Unsafe gait without the prescribed device or brace.
- Ignoring meniscal, cartilage, or other procedure-specific restrictions.

Phase 1 progression criteria

Progress when most are present	Hold, regress, or communicate when
Incision stable; full or near-full passive extension; flexion progressing; trace-to-1+ effusion trending down; straight-leg raise without lag; safe gait with prescribed device; program understood.	Worsening wound/systemic symptoms; extension regression; increasing effusion; repeated buckling; calf symptoms; uncontrolled pain; new locking or instability.

Effusion rule

Do not advance strengthening intensity when effusion is greater than 1+, increasing, or accompanied by loss of extension. A sudden two-grade effusion increase or persistent 2+ effusion warrants load reduction and clinical communication.

5. Phase 2 - foundational strength and gait

Typical timing: weeks 2 to 6. Entry depends on ROM, effusion, gait, and concomitant restrictions.

Goals

- Normalize gait and achieve full extension with progressive flexion.
- Develop quadriceps, hip, calf, and trunk capacity.
- Advance CKC tasks and isolated OKC quadriceps loading without a reactive effusion.
- Establish a structured return-to-gym plan.

Open- versus closed-kinetic-chain progression

Method	Initiation and progression
OKC quadriceps	May begin immediately with activation and low-load knee extension. A conservative option is 90-45 degrees initially, especially when graft or surgeon factors warrant, then progress toward 90-0 degrees as symptoms and control permit. Delaware guidance supports light full-ROM knee extension early.
CKC quadriceps	Mini-squat, sit-to-stand, leg press, step-up, split-squat pattern, and supported single-leg tasks. Control depth according to ROM, effusion, and concomitant restrictions.
Hamstrings	Isometrics and light curls as permitted. After hamstring autograft, delay aggressive loading per surgeon and donor-site response.
Hip / calf / trunk	Bridge, hip hinge, hip abduction/adduction, heel raise, trunk anti-rotation, and balance progression.

Progression criteria

- Full extension maintained; flexion adequate for selected tasks.
- Trace-to-zero or stable minimal effusion.
- Normalizing gait and controlled bilateral squat/step-up.
- No next-day increase in joint pain, warmth, swelling, or stiffness.

6. Open-chain exercise and gym lifting framework

Evidence interpretation

The 2018 systematic review found limited-to-moderate evidence of no clinically important differences in anterior laxity, strength, or patient-reported function between early/late OKC and CKC programs. Study protocols varied, and evidence specific to early hamstring-autograft loading was less consistent. Brinlee and colleagues support immediate isolated quadriceps strengthening through full ROM with soreness and effusion monitoring.

Recommended OKC progression

Stage	Suggested application	Progression signal
Immediate to week 2	Quad sets, NMES, SLR when lag-free, low-load assisted or active knee extension. Use protected ROM if surgeon/graft factors warrant.	No extension loss, stable effusion, good contraction.
Weeks 2-6	Long-arc knee extension with cuff weight or machine. Conservative range 90-45 degrees may progress toward full ROM.	No joint flare; donor site tolerates load; movement controlled.
Weeks 6-12	Progress full-ROM concentric/eccentric knee extension, tempo, sets and resistance.	Objective strength improving; no reactive effusion.
12+ weeks	Use machine knee extension for hypertrophy/strength and periodic 5RM/1RM-informed testing when safe.	Technique stable; RPE/RIR-guided load tolerated.

Return to lower-extremity gym lifting

Typical window	Gym activities	Required safeguards
0-2 weeks	Home/clinic activation; upper body or nonoperative-limb work in protected positions.	No violation of weight bearing, brace, or incision precautions.
2-6 weeks	Bike when ROM permits; leg press in permitted range; sit-to-stand; calf raise; bridge; hip machine work; light knee extension.	Stable gait, controlled mechanics, trace-to-1+ effusion trending down.
6-12 weeks	Progress leg press, squat pattern, split squat, step-up/down, RDL/hinge, hamstring curl, knee extension and unilateral work.	Full extension, stable minimal effusion, no next-day joint flare.
12-16+ weeks	Heavier bilateral/unilateral lifting; greater ROM; more demanding machine and free-weight work.	Objective load tolerance and consistent movement quality.
4-6+ months	Heavy strength, rate-of-force development and power preparation.	Appropriate strength criteria, landing readiness, surgeon/clinician clearance.

Gym rule

Returning to the gym is not the same as unrestricted training. Begin with a written exercise menu, defined ROM and load, no unplanned testing, and a 24-hour response rule. Progress one variable at a time.

7. Phase 3 - progressive strength and running readiness

Typical timing: weeks 6 to 16. Running commonly begins around weeks 12 to 16 when criteria are met.

Goals

- Restore quadriceps and hamstring capacity with objective testing.
- Build unilateral squat, step and hinge control.
- Develop aerobic fitness and prepare for impact.
- Progress gym loading without recurrent effusion.

Strength and conditioning menu

Capacity	Exercise examples	Progression signal
Quadriceps	Machine knee extension, leg press, squat, split squat, step-up/down, Spanish squat	Improving dynamometry/1RM estimate with stable effusion.
Posterior chain	RDL, bridge/hip thrust, hamstring curl, Nordic progression when appropriate	Donor-site tolerance and controlled eccentric work.
Hip / calf / trunk	Hip abductor/adductor, calf raise, soleus work, trunk control	Improved single-leg stability and propulsion.
Impact preparation	Pogos, landing preparation, jump-rope or low amplitude drills when criteria permit	No pain/effusion and acceptable landing mechanics.
Aerobic	Bike, elliptical, pool, walking progression, then criterion-based running	Sustainable exertion without next-day joint response.

Suggested running-entry criteria

- Full ROM and trace-to-zero effusion.
- No pain with daily activity or progressive lifting.
- Quadriceps strength index approximately 80% or greater, interpreted with absolute strength and graft type.
- Controlled repeated single-leg squat/step-down and hopping preparation.
- Surgeon restrictions satisfied; delay at least one additional month after criteria for allograft pathways when appropriate.

Load monitoring

Use external load, repetitions, sets, tempo, range, and task complexity deliberately. When maximal testing is not appropriate, use repetitions in reserve or RPE. A next-day joint flare requires load reduction; expected muscular soreness without joint swelling does not automatically require regression.

Strength-testing rule

Do not infer quadriceps recovery from leg press or hop tests alone. Prefer isokinetic testing, fixed handheld dynamometry, or standardized knee-extension testing. Leg press can overestimate isolated quadriceps recovery because of compensation.

8. Phase 4 - power, return to sport, and documentation

Typical timing: month 4 through month 12 and beyond.

Goals

- Develop jumping, landing, acceleration, deceleration, cutting, and sport-specific capacity.
- Restore preinjury conditioning and workload tolerance.
- Address psychological readiness and confidence.
- Continue strength and secondary prevention at least twice weekly after return.

Return-to-sport framework

Domain	Minimum considerations
Time / biology	Generally no level-I pivoting sport before 9 months; allograft pathways commonly 12+ months.
Strength	Quadriceps isometric/isokinetic symmetry at least 90%, with acceptable absolute strength and graft-site tolerance.
Performance	Hop battery at least 90%, quality landing/cutting, and restoration of sport-specific conditioning.
Symptoms	Full ROM, trace-to-zero effusion, no pain, instability, or reactive swelling.
Patient report	KOS-ADLS or comparable function at least 90%; ACL-RSI or other psychological readiness measure interpreted clinically.
Exposure	Noncontact practice, small-sided or controlled contact, full practice, restricted competition, then unrestricted competition.

Clinician documentation checklist

- Graft type, fixation, concomitant procedures, restrictions, and surgeon follow-up.
- ROM, effusion grade, pain, gait, objective quadriceps/hamstring strength, and patient-reported outcomes.
- Exact OKC/CKC exercise range, load, sets, repetitions, tempo, RPE/RIR, and 24-hour response.
- Criteria and rationale for gym progression, running, plyometrics, cutting, practice, and competition.
- Communication with the surgeon and resulting changes.

Communication triggers

Trigger	Examples
Immediate / emergency	Cardiopulmonary emergency, loss of distal perfusion, severe neurological change.
Same day	Concerning DVT/PE signs, significant wound issue, systemic infection, acute traumatic loss of function.
Prompt non-emergent	Extension regression, persistent 2+ effusion, recurrent giving way, locking, sudden strength loss, failure to progress.
Routine	Clarify meniscal/cartilage restrictions, OKC range, donor-site loading, brace, running, work, or sport progression.

Quality marker

A high-quality ACL protocol does not choose OKC or CKC. It uses both, measures quadriceps recovery directly, monitors the knee response, and progresses exposure according to biology and objective readiness.

9. Evidence and protocol synthesis

This original clinical synthesis reflects major academic pathways and contemporary ACL literature: restoration of a quiet knee, early extension and activation, combined OKC/CKC quadriceps loading, objective strength testing, criterion-based gym and running progression, delayed return to pivoting sport, and ongoing secondary prevention.

Primary protocol models consulted

Source family	Contributions reflected
University of Delaware / Delaware Physical Therapy Clinic ACLR principles and Brinlee et al.	Immediate isolated quadriceps loading, objective milestones, effusion/soreness rules, strength testing, delayed return to sport.
Perriman et al. 2018 systematic review and meta-analysis	Limited-to-moderate evidence comparing early/late OKC and CKC exercise, with graft- and range-specific caution.
Massachusetts General Hospital ACL reconstruction protocol	Phase structure, graft/concomitant procedure precautions, ROM, strengthening, running and return criteria.
The Ohio State University Wexner Medical Center ACL reconstruction guideline	Clinical decision rules, red flags, criterion-based loading, running, agility, testing, and return to sport.
JOSPT/APTA knee ligament and injury-prevention guidance	Objective outcomes, progressive loading, movement quality, psychological readiness, and secondary prevention.

Important interpretation note

Protocols differ in OKC initiation, knee-extension range, weight bearing, bracing, running, and return-to-sport timing. Graft type and concomitant meniscal, cartilage, or ligament procedures can materially change progression. The operative report and direct surgeon instructions take precedence.

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