The Physical Root

MPFL Reconstruction Exercise Library

Phase-matched exercise options after medial patellofemoral ligament reconstruction

Purpose

A comprehensive companion to The Physical Root MPFL Reconstruction Rehabilitation Protocol. Exercises are organized by the earliest postoperative window in which they are commonly appropriate after uncomplicated isolated MPFL reconstruction. Eligibility changes substantially when tibial tubercle osteotomy, trochleoplasty, cartilage restoration, osteochondral work, or other procedures are performed.

Library at a glance

Section	Typical timing	Primary content
Readiness	Preoperative	Quiet knee, baseline strength, movement education
Protection / activation	Day 0-week 2	Extension, swelling, quadriceps, safe gait
Motion / foundation	Weeks 2-6	ROM, CKC/OKC strength, balance, alignment
Progressive strength	Weeks 6-12	Gym lifting, unilateral loading, whole-chain control
Running readiness	Weeks 12-16+	Impact preparation and graded running
Power / agility	Months 4-9	Plyometrics, deceleration, cutting, reactive control
Return / maintenance	Months 6-9+	Sport exposure, prevention and long-term strength

How exercises enter the library

- The earliest window is a floor, not a deadline. Remain with earlier options until criteria are met.
- Every exercise must respect the operative report, brace, weight-bearing, ROM, loaded-flexion, patellar, and impact restrictions.
- Open-chain knee extension is included as one component of quadriceps recovery, not the central organizing theme.
- Dynamic alignment is addressed through foot, ankle, knee, hip, pelvis, trunk, task, speed, and fatigue.
- Exercise response is judged during the session and over the following 24 hours.

1. Selection rules, safeguards, and dosage

Before selecting an exercise

- Confirm isolated MPFL reconstruction versus combined TTO, trochleoplasty, cartilage, osteochondral, meniscal, or ligament procedure.
- Review weight-bearing status, brace settings, ROM limits, patellar-mobility boundaries, and loaded knee-flexion restrictions.
- Check incision, effusion, warmth, ROM, patellar apprehension, quadriceps activation, gait, and current response.
- Use the companion MPFL protocol progression criteria before advancing phases.

Traffic-light response rule

Response	Interpretation	Action
Green	No apprehension; no new warmth/swelling; ROM, gait, and confidence unchanged next day	Maintain or progress one variable.
Yellow	Mild transient anterior/medial discomfort; technique declines late; settles by next morning	Repeat dose, reduce range/load, or increase recovery.
Red	Increasing effusion; extension loss; instability/apprehension; next-day joint pain; wound/calf concern	Stop progression, regress, reassess, communicate when indicated.

General dosage bands

Target	Typical starting dose	Progression
Activation / motor control	5-10 repetitions or 5-10 second holds; several brief daily sessions	Improve recruitment and control before fatigue.
Strength endurance	2-4 sets of 8-15; RPE about 5-7/10	Add load with 2-3 repetitions in reserve and green response.
Maximum strength	3-5 sets of 3-8 in later phases	Use after healing, technique, and objective readiness.
Balance	2-4 bouts of 20-45 seconds or 5-10 reaches	Reduce support, add reach/perturbation/dual task.
Plyometric / agility	Low contacts first; full recovery between quality sets	Progress amplitude, speed, direction, reactivity separately.

Non-negotiable

No aggressive lateral patellar stress. Do not advance load with increasing effusion, extension loss, apprehension, or instability. Combined bony/cartilage procedures supersede this library.

2. Preoperative readiness library

Typical window: before surgery. Goal: enter surgery with a quiet knee, full extension, useful flexion, strong quadriceps activation, and improved confidence.

Exercise / class	Earliest typical window	Purpose and cues	Advance / modify when
Heel prop / ROM	Preoperative	Restore passive extension; heel supported, knee free.	Increase low-load duration.
Heel slide / ROM	Preoperative	Flexion recovery without patellar apprehension.	Increase comfortable range.
Quad set / OKC	Preoperative	Quadriceps recruitment; cue patellar lift and full extension.	Add NMES/biofeedback.
SLR / OKC	Preoperative	Quadriceps/hip flexor control without lag.	Add light load.
Sit-to-stand / CKC	Preoperative	Functional quadriceps/hip strength; equal pressure.	Lower seat/add load.
Box squat / CKC	Preoperative	Squat pattern; tripod foot and knee over midfoot.	Increase depth/load.
Step-up / CKC	Preoperative	Stair capacity and frontal-plane control.	Increase height/load.
Bridge / posterior chain	Preoperative	Hip extensor capacity and trunk control.	Single-leg/load.
Lateral band walk / hip	Preoperative	Hip abductor endurance and pelvis control.	Heavier band.
Calf raise / distal chain	Preoperative	Gait/propulsion capacity.	Single-leg/load.
Single-leg stance / proprioception	Preoperative	Balance and confidence; level pelvis.	Add reach/perturbation.
Pallof press / trunk	Preoperative	Anti-rotation whole-chain control.	Increase resistance/lever.

Readiness target

Aim for a trace-to-zero effusion, full active/passive extension, least-irritable useful flexion, no SLR lag, normalized gait, and informed expectations before surgery.

3. Phase 1 library - protection and activation

Typical window: day 0 to week 2. These options assume isolated uncomplicated MPFL reconstruction unless otherwise cleared.

ROM, swelling, and quadriceps activation

Exercise / class	Earliest typical window	Purpose and cues	Advance / modify when
Heel prop / ROM	Day 0	Restore extension; heel elevated, knee unsupported.	Longer gentle holds.
Prone hang / ROM	Days 2-7	Extension mobility if incision/comfort permit.	Use gravity only.
Assisted heel slide / ROM	Day 0	Progress flexion within surgeon limits; avoid force.	Increase range without flare.
Ankle pump / circulation	Day 0	Calf pump and distal movement.	Frequent sets.
Quad set / OKC	Day 0	Quadriceps recruitment; visible patellar lift.	Add NMES.
NMES quad set / OKC	Day 0	Improve recruitment with strong visible contraction.	Increase tolerable intensity.
Straight-leg raise / OKC	When lag-free	Quadriceps/hip control; knee fully straight, brace as directed.	Add repetitions before load.
Short-arc knee extension / OKC	Days 3-14 if cleared	Early quadriceps through comfortable arc.	Progress range/load gradually.
Hip abduction / OKC	Day 0-3	Hip abductor activation; pelvis stacked.	Add light resistance.
Hip extension / OKC	Day 0-3	Gluteal activation without lumbar substitution.	Add load/holds.
Adductor isometric / hip	Day 0-3	Pelvic/adductor control; gentle squeeze.	Longer hold.
Dead bug arms-only / trunk	Days 3-14	Trunk control without knee demand.	Add heel slide later.

Phase 1 - protected weight bearing and function

Exercise / class	Earliest typical window	Purpose and cues	Advance / modify when
Gait training / function	Day 0	Device/brace use, heel strike, stance stability.	Wean device only with safe gait.
Double-leg weight shift / CKC	Day 0-3	Graded loading and confidence.	Increase operative-side acceptance.
Supported mini-squat / CKC	Days 3-14 if cleared	Co-contraction and early squat pattern; shallow depth.	Increase depth with control.
Elevated sit-to-stand / CKC	Days 3-14	Functional strength; hands as needed.	Lower surface/reduce support.
Double-leg calf raise / CKC	Days 3-14	Calf pump and gait capacity.	Bias operative limb.
Bridge / posterior chain	Days 3-14	Hip extension and trunk control.	Band/longer hold.
Staggered stance balance / proprioception	Days 3-14	Early sensory reweighting with support.	Reduce support.
Foot tripod drill / motor control	Days 3-14	Foot pressure and arch control without gripping.	Integrate into squat.
Breathing / trunk stack	Day 0	Rib-pelvis control and relaxation during ROM.	Add limb movement.
Upper-body ergometer / conditioning	Days 3-14 if safe	Aerobic maintenance without lower-limb demand.	Increase duration.

Avoid

- Aggressive medial or lateral patellar mobilization unless specifically instructed.
- Forceful flexion, loaded depth, or brace/device changes beyond restrictions.
- Patellar apprehension, recurrent shift, increasing effusion, or loss of extension.

Phase 1 exit emphasis

Stable incision; full/near-full passive extension; flexion progressing; trace-to-1+ effusion trending down; lag-free SLR; safe gait with prescribed brace/device.

4. Phase 2 library - motion and foundational strength

Typical window: weeks 2 to 6. Begin only when Phase 1 criteria and procedure-specific restrictions permit.

Open-chain and machine options

Exercise / class	Earliest typical window	Purpose and cues	Advance / modify when
Long-arc knee extension / OKC	Weeks 2-6 if cleared	Isolated quadriceps through comfortable arc.	Progress range, then resistance.
Knee extension machine / OKC	Weeks 3-6 if cleared	Quantifiable low-load quadriceps work.	Increase 5-10% with green response.
Isometric knee extension / OKC	Weeks 2-6	Angle-specific recruitment without repeated motion.	Add angles/time.
Loaded SLR / OKC	Weeks 2-6	Quadriceps endurance; no lag.	Increase ankle load.
Seated hamstring curl / OKC	Weeks 2-6 if cleared	Knee-flexor strength.	Increase range/load.
Standing hip abduction / OKC	Weeks 2-6	Frontal-plane hip capacity.	Add cable/band.
Standing hip extension / OKC	Weeks 2-6	Gluteal strength with controlled trunk.	Add resistance.
Hip adduction machine / OKC	Weeks 2-6	Adductor capacity.	Increase load.
Seated soleus raise / OKC	Weeks 2-6	Soleus capacity for stance/deceleration.	Add load.
Tibialis raise / OKC	Weeks 2-6	Dorsiflexor strength and foot clearance.	Increase lever/load.

Open-chain perspective

Open-chain knee extension is appropriate when surgeon restrictions, symptoms, and procedure type permit. Begin low load in a comfortable arc and progress gradually. It complements, but does not replace, gait, CKC strength, proprioception, and whole-chain retraining.

Phase 2 - closed chain, balance, and alignment

Exercise / class	Earliest typical window	Purpose and cues	Advance / modify when
Leg press / CKC	Weeks 2-6 if cleared	Quadriceps/hip strength in permitted ROM.	Range then load.
Goblet box squat / CKC	Weeks 2-6	Squat mechanics; foot tripod, knee centered.	Lower box/add load.
Wall squat / CKC	Weeks 2-6	Quadriceps endurance with controlled depth.	Longer hold/lower depth.
Low step-up / CKC	Weeks 2-6	Concentric unilateral strength and stairs.	Height/load.
Supported split squat / CKC	Weeks 3-6	Unilateral loading and pelvis control.	Reduce support/deepen.
Bridge with band / posterior chain	Weeks 2-6	Hip extension plus abductor engagement.	Load/single leg.
Hip hinge with dowel / kinetic chain	Weeks 2-6	Posterior-chain pattern; neutral trunk.	Add kettlebell RDL.
Lateral band walk / alignment	Weeks 2-6	Hip abductor endurance and pelvis control.	Heavier band/longer steps.
Band-feedback squat / alignment	Weeks 2-6	External cue for knee-over-foot strategy.	Fade cue over time.
Single-leg stance / proprioception	Weeks 2-6	Static balance; soft knee, level pelvis.	Reach/head turn/foam.
Tandem perturbation / proprioception	Weeks 2-6	Reactive trunk/hip/ankle control.	Single-leg progression.
Pallof press / trunk	Weeks 2-6	Anti-rotation control linked to alignment.	Resistance/lever.

Patellofemoral loading rule

Depth and load should be symptom-guided and procedure-specific. After TTO or cartilage procedures, use the surgeon-defined loaded-flexion and weight-bearing limits.

5. Phase 3 library - progressive gym strength

Typical window: weeks 6 to 12. Add load only with full extension, stable minimal effusion, improving gait, and controlled foundational tasks.

Exercise / class	Earliest typical window	Purpose and cues	Advance / modify when
Full-range knee extension / OKC	Weeks 6-12 if cleared	Primary isolated quadriceps strength/hypertrophy.	Load/sets/eccentric control.
Eccentric knee extension / OKC	Weeks 6-12	Quadriceps eccentric capacity.	Increase load/slower lowering.
Single-leg leg press / CKC	Weeks 6-12	Unilateral quadriceps/hip strength.	Range then load.
Front-foot elevated split squat / CKC	Weeks 6-12	Knee-dominant unilateral loading.	Depth/load.
Reverse lunge / CKC	Weeks 6-12	Unilateral control with manageable braking.	Load/deficit.
Step-down / CKC	Weeks 6-12	Eccentric quadriceps and alignment.	Height/load.
RDL / posterior chain	Weeks 6-12	Hip extensors/hamstrings; hinge control.	Load/single leg.
Hip thrust / posterior chain	Weeks 6-12	Hip extensor strength.	Add barbell/load.
Hamstring curl / OKC	Weeks 6-12	Knee-flexor strength.	Load/tempo.
Assisted Nordic / OKC	Weeks 8-12 if cleared	Eccentric hamstring preparation.	Reduce assistance.
Single-leg calf raise / CKC	Weeks 6-12	Gastrocnemius and propulsion.	Add load.
Loaded soleus raise / OKC	Weeks 6-12	Soleus for running/deceleration.	Progress heavy.

Gym entry rule

Use a written exercise menu and defined ROM. No unplanned maximal testing. Progress one variable at a time and require a green 24-hour response.

Phase 3 - proprioception and dynamic alignment

Exercise / class	Earliest typical window	Purpose and cues	Advance / modify when
Star reach / proprioception	Weeks 6-12	Multi-directional balance and knee control.	Reach distance/load.
Y-Balance pattern / proprioception	Weeks 6-12	Standardized reach with pelvis level.	Symmetry/consistency.
Single-leg ball toss / proprioception	Weeks 6-12	Reactive balance with visual/manual challenge.	Surface/direction/speed.
Single-leg perturbation / proprioception	Weeks 6-12	Reactive stabilization through whole chain.	Unpredictability.
Lateral step-down / alignment	Weeks 6-12	Pelvic drop, foot collapse, knee drift control.	Height/load.
Single-leg RDL / kinetic chain	Weeks 6-12	Hip-dominant unilateral control.	Contralateral load/reach.
Rear-foot elevated split squat / CKC	Weeks 8-12	Unilateral strength and pelvic control.	Load/range.
Hip airplane - supported / alignment	Weeks 8-12	Rotational hip/pelvis control.	Reduce support.
Copenhagen plank - short lever / chain	Weeks 8-12	Adductor and trunk capacity.	Long lever/dynamic.
Side plank + hip abduction / chain	Weeks 8-12	Lateral trunk/hip abductor capacity.	Band/long lever.
Farmer/suitcase carry / chain	Weeks 6-12	Whole-body stiffness and gait control.	Load/asymmetry.
Backward sled drag / CKC	Weeks 8-12 if cleared	Quadriceps work with controllable range.	Load/distance.

Alignment coaching

Use mirror/video feedback and external targets. Correct the foot, pelvis, trunk, speed, and task demand rather than cueing the knee alone.

6. Phase 4 library - running readiness

Typical window: weeks 12 to 16+ after isolated uncomplicated MPFLR. TTO, trochleoplasty, and cartilage procedures commonly delay impact.

Exercise / class	Earliest typical window	Purpose and cues	Advance / modify when
Bilateral pogo / plyometric	Weeks 12-16+	Low-amplitude ankle stiffness; quiet contacts.	Contacts/amplitude.
Jump rope / plyometric	Weeks 12-16+	Rhythm, stiffness, conditioning.	Duration/alternating feet.
Snap-down / landing	Weeks 12-16+	Rapid athletic landing position.	Arm action/small drop.
Squat jump and stick / plyometric	Weeks 12-16+	Power plus controlled bilateral landing.	Repeated jumps.
Low box jump / plyometric	Weeks 12-16+	Power with reduced landing demand; step down.	Box height.
March / running skill	Weeks 12-16+	Posture, hip flexion, foot strike.	A-march/A-skip.
A-skip / running skill	Weeks 12-16+	Elastic coordination.	Speed/distance.
Wall acceleration drill / skill	Weeks 12-16+	Body angle and hip drive.	Rapid exchanges.
Walk-jog intervals / conditioning	When criteria met	Graded running exposure on level surface.	Run time before speed.
Heavy knee extension / OKC	Weeks 12-16+	Quadriceps maximum strength.	RPE/RIR guided load.
Heavy split squat / CKC	Weeks 12-16+	Unilateral strength and alignment.	Load/depth.
Heavy soleus/calf / chain	Weeks 12-16+	Running stiffness and propulsion.	Load/full excursion.

Suggested impact entry

Full ROM, trace-to-zero effusion, no patellar apprehension/instability, stable lifting response, controlled repeated single-leg squat/step-down, and quadriceps strength approximately 80% or greater.

7. Phase 5 library - power and multidirectional control

Typical window: months 4 to 6 after successful running progression and adequate bilateral landing control.

Exercise / class	Earliest typical window	Purpose and cues	Advance / modify when
Countermovement jump / plyometric	Months 4-6	Vertical power and force sharing.	Increase intent.
Broad jump and stick / plyometric	Months 4-6	Horizontal force and landing control.	Repeated broad jump.
Lateral bound and stick / plyometric	Months 4-6	Frontal-plane force acceptance.	Distance/continuous.
Low drop landing / landing	Months 4-6	Deceleration mechanics.	Modest height increase.
Single-leg hop and stick / plyometric	Months 4-6	Unilateral landing control and confidence.	Distance/direction.
Split squat jump / plyometric	Months 4-6	Unilateral power and scissoring control.	Repeated contacts.
Medicine-ball squat throw / chain	Months 4-6	Whole-body power with alignment.	Ball speed/load.
Forward deceleration / agility	Months 4-6	Braking strategy and trunk control.	Shorter stop distance.
Lateral shuffle to stick / agility	Months 4-6	Frontal-plane braking.	Entry speed.
Figure-8 run / agility	Months 4-6	Curved running and direction loading.	Tighter radius/speed.
Sled push / CKC	Months 4-6	Horizontal force and conditioning.	Load/speed.
Heavy single-leg press / CKC	Months 4-6	Unilateral strength reserve.	3-6RM when appropriate.

8. Phase 6 library - agility and return preparation

Typical window: months 6 to 9. Requires strong running tolerance, adequate strength, quality hopping, and no reactive effusion or apprehension.

Exercise / class	Earliest typical window	Purpose and cues	Advance / modify when
Repeated single-leg hops / plyometric	Months 6-9	Elastic unilateral capacity.	Distance/speed/contacts.
Triple hop progression / plyometric	Months 6-9	Horizontal power/endurance.	Timed/crossover.
Crossover hop progression / plyometric	Months 6-9	Frontal/transverse control.	Distance with quality.
Depth jump / plyometric	Months 6-9	Rapid stretch-shortening cycle.	Intent before height.
45-degree cut - planned / agility	Months 6-9	Controlled redirection with lower center of mass.	Approach speed.
90-degree cut - planned / agility	Months 6-9	Higher braking/redirection demand.	Reactive cue later.
Reactive shuffle / agility	Months 6-9	Perception-action coupling.	Cue complexity.
Mirror drill / agility	Months 6-9	Reactive whole-body movement.	Duration/area.
Accel-decel intervals / conditioning	Months 6-9	Sport-relevant speed changes.	Peak speed/recovery.
Lateral hurdle series / plyometric	Months 6-9	Repeated frontal-plane contacts.	Single-leg/reactive.
Landing with perturbation / alignment	Months 6-9	Maintain alignment under challenge.	Timing/force.
Fatigue-state landing / motor control	Months 6-9	Retain strategy under workload.	Only after pristine fresh control.

Apprehension rule

A patient who demonstrates patellar apprehension, avoidance, or recurrent instability during advanced tasks is not ready for greater speed or unpredictability. Reassess stability, capacity, confidence, and task design.

9. Phase 7 library - return to sport and maintenance

Typical window: months 6 to 9+ after objective clearance. Complex procedures and high-risk sports commonly require longer.

Exercise / class	Earliest typical window	Purpose and cues	Advance / modify when
Noncontact practice / exposure	Months 6-9+	Restore sport volume without contact.	Duration/intensity.
Small-sided practice / exposure	Months 6-9+	Decision density with controlled area/player count.	Space/speed/contact.
Full practice - restricted / exposure	Months 6-9+	Integrate team demands while controlling workload.	Weekly volume.
Competition - restricted / exposure	Months 6-9+	Initial competition with planned minutes/reps.	Advance only with green response.
Competition - unrestricted / exposure	Months 6-9+	Full role after graded exposure.	Maintain strength/prevention.
Heavy knee extension / OKC	Months 6-9+	Maintain quadriceps strength.	Periodic testing.
Heavy squat / CKC	Months 6-9+	Bilateral maximum strength.	Strength/power cycles.
Heavy unilateral strength / CKC	Months 6-9+	Maintain side-to-side capacity.	Split squat/step-up/press.
Nordic hamstring / OKC	Months 6-9+	Eccentric hamstring capacity.	Volume/range.
Copenhagen plank / chain	Months 6-9+	Adductor/trunk capacity.	Long lever/dynamic.
Neuromuscular warm-up / prevention	Months 6-9+	Landing, cutting, balance, strength habits.	At least twice weekly.
Periodic reassessment / testing	Months 6-9+	Detect capacity loss and guide maintenance.	Preseason/workload transitions.

Return is a continuum

Clearance initiates graded exposure; it does not end rehabilitation. Continue heavy strength and neuromuscular prevention at least twice weekly.

10. Dedicated quadriceps and open-chain library

Quadriceps recovery is central after MPFL reconstruction, but exercise selection must coexist with patellar stability, symptom response, and procedure-specific restrictions.

Exercise	Earliest typical window	Primary target	Key modification
Quad set	Day 0	Activation	NMES/biofeedback.
SLR	Lag-free, usually week 0-2	Quadriceps/hip flexor	No load with lag.
Short-arc knee extension	Week 0-2 if cleared	Quadriceps	Comfortable arc.
Long-arc knee extension	Weeks 2-6 if cleared	Quadriceps	Low load; progress range.
Knee extension machine	Weeks 3-6 if cleared	Quantifiable strength	Range then load.
Isometric knee extension	Weeks 2-6	Angle-specific force	Multiple angles.
Eccentric knee extension	Weeks 6-12	Eccentric force	Assist concentric.
Heavy knee extension	Weeks 12-16+	Maximum strength	RPE/RIR guided.
Seated hamstring curl	Weeks 2-6 if cleared	Knee flexors	Progress load.
Nordic assisted	Weeks 8-12 if cleared	Eccentric hamstrings	Reduce assistance.
Hip ab/adduction machine	Weeks 2-6	Frontal-plane hip	Avoid pelvic compensation.
Seated soleus raise	Weeks 2-6	Soleus	Progress heavy.

Open-chain principle

The clinical questions are not simply “open or closed chain?” Ask: isolated or combined procedure, which range, what load, how much volume, what symptoms, and what was the 24-hour response?

11. Dedicated closed-chain and gym library

Exercise	Earliest typical window	Primary target	Progression
Weight shift	Day 0	Weight acceptance	Reduce support.
Supported mini-squat	Days 3-14 if cleared	Co-contraction	Depth.
Sit-to-stand	Days 3-14	Functional strength	Lower seat/load.
Leg press	Weeks 2-6 if cleared	Quadriceps/hip	Range then load.
Goblet box squat	Weeks 2-6	Squat mechanics	Lower box/load.
Step-up	Weeks 2-6	Concentric unilateral	Height/load.
Supported split squat	Weeks 3-6	Unilateral control	Support/depth.
Step-down	Weeks 6-12	Eccentric quadriceps	Height/load.
Reverse lunge	Weeks 6-12	Unilateral control	Deficit/load.
Rear-foot elevated split squat	Weeks 8-12	Unilateral maximum strength	Load/range.
Single-leg leg press	Weeks 6-12	Unilateral strength	Load/depth.
Backward sled drag	Weeks 8-12 if cleared	Quadriceps capacity	Load/distance.
Sled push	Months 4-6	Horizontal force	Load/speed.
Heavy squat	Months 4-6	Maximum strength	Periodized loading.

Procedure modifiers

- After TTO, bony healing and surgeon clearance govern weight bearing, loaded flexion, and heavy strength.
- After cartilage/osteochondral procedures, lesion-specific restrictions supersede typical ranges.
- Use box height, stance, heel elevation, external load position, and tempo to control demand.

12. Dedicated proprioception and dynamic alignment library

Proprioception progression

Exercise	Earliest window	Progression sequence
Staggered stance	Days 3-14	Hand support -> no support -> head turn.
Single-leg stance	Weeks 2-6	Firm -> foam -> eyes closed.
Star/Y reach	Weeks 6-12	Reach distance -> load -> speed.
Single-leg ball toss	Weeks 6-12	Predictable -> unpredictable direction.
Perturbation balance	Weeks 6-12	Trunk/limb perturbation -> reactive step.
Landing perturbation	Months 6-9	Predictable -> unpredictable challenge.

Dynamic alignment progression

Exercise	Earliest window	Primary target
Band-feedback squat	Weeks 2-6	Knee-over-foot awareness and hip engagement.
Lateral band walk	Weeks 2-6	Hip abductor endurance/pelvis.
Lateral step-down	Weeks 6-12	Pelvic drop, foot collapse, knee drift.
Single-leg RDL	Weeks 6-12	Hip rotation, trunk, stance foot.
Hip airplane	Weeks 8-12	Rotational pelvis control.
Single-leg hop and stick	Months 4-6	Frontal-plane landing.
Lateral bound and stick	Months 4-6	Lateral force acceptance.
Planned cut with target	Months 6-9	Foot placement, trunk/braking.
Reactive cut	Months 6-9	Perception-action control.
Fatigue-state landing	Months 6-9	Strategy retention under load.

Coaching hierarchy

Reduce task difficulty, use external targets/video, adjust foot placement and trunk strategy, build missing capacity, then rebuild speed and fatigue.

13. Whole-kinetic-chain, conditioning, and sample programming

Region / goal	Exercise options	Earliest typical window
Trunk anti-extension	Dead bug, plank progression	Days 3-14 basic
Trunk anti-rotation	Pallof press, suitcase carry	Weeks 2-6
Lateral trunk	Side plank, side plank + abduction	Weeks 2-6
Hip extension	Bridge, hip thrust, RDL, single-leg RDL	Day 3 to week 12 progression
Hip abduction/adduction	Sidelying, bands, machines, Copenhagen	Day 0 to week 12 progression
Calf / soleus	Double/single-leg raise, seated soleus, pogos	Day 3 to week 12 progression
Foot / ankle	Tripod, tibialis raise, inversion/eversion	Week 0 to week 6 progression
Carries	Farmer, suitcase, rack carry	Weeks 6-12
Aerobic base	Walking, bike, pool after wound closure, elliptical	Day 0 to week 12 progression
Running / sprint	Walk-jog, tempo, acceleration intervals	Weeks 12-16+ to month 6

Phase-matched sample menu

Phase	Example menu
0-2 weeks	Heel prop; heel slide; quad set + NMES; lag-free SLR; weight shift; mini-squat; bridge; calf raise; gait.
2-6 weeks	Bike; low-load knee extension; leg press; box squat; step-up; supported split squat; lateral walk; balance; Pallof.
6-12 weeks	Knee extension machine; single-leg press; split squat; step-down; RDL; hamstring curl; soleus; Y reach; side plank.
12-16+ weeks	Heavy knee extension; heavy split squat; single-leg RDL; calf/soleus; pogos; snap-down; A-skip; walk-jog.
4-6 months	Heavy strength; broad jump; lateral bound; hop and stick; drop landing; planned deceleration; figure-8.
6-9+ months	Strength maintenance; repeated/crossover hops; planned then reactive cuts; mirror drill; graded practice.

Whole-chain principle

Patellar stability is local; performance is global. Address trunk control, pelvic strategy, hip force, ankle stiffness, foot control, conditioning, confidence, and sport-specific decision making.

14. Evidence and library synthesis

This original exercise library accompanies The Physical Root MPFL Reconstruction Rehabilitation Protocol. It synthesizes recurring exercise categories and progression principles from major academic patellofemoral stabilization pathways and contemporary rehabilitation literature.

Primary source families

Source family	Contributions reflected
University of Delaware / Delaware Physical Therapy Clinic principles	Criterion-based progression, quadriceps recovery, movement quality, testing, and whole-chain rehabilitation.
Massachusetts General Hospital MPFL reconstruction protocol	Phase structure, precautions, ROM, strength, running, and return-to-sport progression.
The Ohio State University Wexner Medical Center MPFL guidance	Clinical decision rules, exercise progression, testing, agility, and return criteria.
Hospital for Special Surgery and other academic pathways	Procedure-specific protection, brace/weight bearing, gym, running, and sport exposure.
Contemporary MPFL and patellar-instability literature	Protocol variability, objective criteria, dynamic alignment, psychological readiness, and recurrence prevention.

Important interpretation note

Exercise timing varies widely across institutions. The distinction between isolated MPFL reconstruction and combined TTO, trochleoplasty, cartilage, osteochondral, or other realignment procedures is essential. The operative report and direct surgeon instructions take precedence over every timeframe in this library.

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