

PHYSICAL THERAPY PROTOCOL

Cartilage Resurfacing — Patellofemoral (Trochlea / Patella)

Microfracture, MACI, DeNovo NT, and Cartiform — Flexion-Restricted (Patellofemoral) Pathway

FOR THE PHYSICAL THERAPIST

Overview and Goals

This protocol governs rehabilitation after cartilage resurfacing of a **patellofemoral surface** — the trochlea or patella — by microfracture (marrow stimulation) or a cell-based/scaffold technique (MACI, DeNovo NT, or Cartiform). Condylar/tibial lesions and osteochondral allograft are covered by separate protocols. On the patellofemoral joint the biomechanics invert the usual pattern: contact stress rises as the knee flexes, so **range of motion (flexion) is the primary constraint**, while weight-bearing — which loads the tibiofemoral rather than the patellofemoral surface — can be advanced early.

Two technique categories set the intensity of early protection. **Category A — marrow stimulation (microfracture)** forms a fibrocartilage clot; **Category B — cell-based / scaffold (MACI, DeNovo NT, Cartiform)** is at risk of graft delamination. On the patellofemoral surface both categories are governed chiefly by the flexion restriction rather than by weight-bearing, so the two tracks differ less here than on the condyle. Dr. Roth designates the lesion location and technique category at the time of surgery.

Continuous passive motion is used for all cartilage cases beginning on the day of surgery or the first postoperative day, kept within the flexion limit. Weight-bearing as tolerated is permitted early, but always in a brace locked at 0° (advancing to 0–30° for gait once quad control returns) so that the patellofemoral surface is unloaded during stance. Quadriceps weakness is the most significant long-term functional deficit after cartilage repair — roughly a quarter to a third of patients retain a >20% deficit at one to two years — so aggressive, prolonged quadriceps rehabilitation is essential, balanced against the patellofemoral precaution below.

Progression is criterion-based. Impact activity is deferred until graft maturation (typically 4–6 months), and pivoting, cutting, and contact sport are withheld for a minimum of six months. If a concomitant procedure was performed (tibial tubercle osteotomy, MPFL reconstruction), follow the more restrictive protocol.

READ BEFORE STARTING — SCOPE & PATELLOFEMORAL PROTECTION

This protocol applies to microfracture, MACI, DeNovo NT, or Cartiform on the trochlea or patella.

- Flexion is the primary constraint: limit flexion to **0–30° for weeks 0–4**, then advance 10–15° per week. The graft is loaded by flexion, not by stance-phase weight-bearing.
- Weight-bearing as tolerated is allowed early, but only in a brace locked at 0° (unlocked to 0–30° for gait once quad control returns) so the patellofemoral surface stays unloaded during gait.
- Avoid resisted open-chain knee extension from 45° to full extension for 12 weeks — this arc drives peak patellofemoral contact stress across the graft.
- CPM begins POD 0–1, kept within the flexion limit. If a TTO or MPFL procedure was also performed, follow the most restrictive protocol.

Rehabilitation Phases

PHASE	WEIGHT BEARING	BRACE / CPM	ROM GOALS	EXERCISES	CRITERIA TO ADVANCE
PHASE 1 Weeks 0–2 <i>Protection & early motion</i>	Weight-bearing as tolerated in brace locked at 0° (full extension).	- Hinged brace locked at 0° (full extension) for gait; unlocked for CPM/ROM within the 0–30° flexion limit. CPM: - Begin POD 0–1, 0–30°	- Flexion restricted 0–30° (weeks 0–4). Priority: - Full passive extension (0°) Patella: - Gentle glides	Quadriceps activation: - Quad sets — begin POD 1 - Straight-leg raises in brace locked at 0° - NMES / Russian stim to quadriceps Adjunct: - Ankle pumps - Gluteal sets - Cryotherapy and elevation Avoid: - Active / resisted knee extension	- Quadriceps activation with SLR (no extensor lag) - Full passive extension - Flexion controlled within 0–30° - Pain and effusion controlled - Minimum 2 weeks elapsed
PHASE 2 Weeks 2–6 <i>Controlled ROM advancement</i>	Weight-bearing as tolerated; brace locked at 0° for gait (0–30° once quad control).	- Brace locked at 0° for gait; once quad control returns (SLR without lag), unlock to allow 0–30° during gait. The flexion limit (ROM column) is unchanged. CPM: - Advance flexion per restriction	0–30° through week 4, then advance 10–15°/week.⁴ Bike: - Stationary bike, low resistance, once flexion ~100° Aquatics: - Pool ROM once incisions sealed	Strengthening: - Progress SLR all planes - Mini-squats / wall slides within 0–30° - Quad sets and co-contractions - Patellar mobilizations Hip / core: - Side-lying abduction, clamshells, core Avoid: - Resisted open-chain extension 45° → full	- Flexion advancing per schedule beyond 30° - SLR without extensor lag - No effusion increase with progression - Gait normalized in locked brace - Minimum 6 weeks elapsed
PHASE 3 Weeks 6–12 <i>Progressive strengthening</i>	Full weight-bearing as gait normalizes.	- Discontinue brace once quad control and gait normalized (~6–8 wks). CPM: - Discontinue once full ROM achieved	- Advance to full ROM. Stretching: - Hamstrings, quads, ITB, gastroc/sol eus	Closed-chain: - Squats and leg press in pain-free arc (avoid loaded deep flexion), step-ups, lunges Open-chain: - Knee extension limited to 90–45° arc until week 12, then progress Neuromuscular / hip: - Single-leg balance, hip strengthening all planes Conditioning: - Bike, elliptical, swimming	- Full, pain-free ROM - No effusion - Quadriceps MMT ≥ 4/5 - Gait normalized off brace - Minimum 12 weeks elapsed
PHASE 4 Weeks 12–20+ <i>Advanced strengthening & functional</i>	Full.	None.	Full ROM maintained.	Strengthening: - Full-arc open-chain extension after week 12, progressive - Single-leg squats, press, deadlifts Plyometrics: - Bilateral → unilateral, once graft maturing Agility: - Ladder and cone drills (linear → multidirectional) Conditioning: - Straight-line jogging once graft maturing (~4–6 mo), quad ≥ 70–80%, no effusion → running	- Quadriceps strength ≥ 80% of contralateral limb - No pain or effusion with advanced activity - Single-leg hop ≥ 80% limb symmetry - Graft maturation supported clinically

PHASE	WEIGHT BEARING	BRACE / CPM	ROM GOALS	EXERCISES	CRITERIA TO ADVANCE
PHASE 5 Months 6–9 <i>Return to sport</i>	• Full.	• None.	• Full ROM.	Sport-specific progression: • Sport-specific drills at full speed • Non-contact → contact → competition Maintenance: • Continue quadriceps and hip strengthening 2–3×/week indefinitely	<i>See Return-to-Activity Criteria below.</i> • No pivoting, cutting, or contact before 6 months; RTS typically 6–9 months with all criteria met and clearance.

Procedure-Specific Considerations

Range of Motion Is the Primary Constraint

On the patellofemoral joint the graft is loaded by flexion, not by stance-phase weight-bearing: patellofemoral contact force and contact area both climb as the knee bends past roughly 20–30°. Rehabilitation therefore inverts the condylar approach — flexion is capped (0–30° for the first four weeks, then advanced 10–15° per week), while weight-bearing as tolerated is permitted early in a brace locked at 0° (unlocked to 0–30° for gait once quad control returns) so the joint stays unloaded during gait.^{2,4} Full passive extension is maintained from the outset.

Protect the Graft from Extension-Arc Loading

Resisted open-chain knee extension through the terminal 45°-to-full arc concentrates load on the patellofemoral surface and is avoided for twelve weeks; open-chain work, when reintroduced, begins in a protected 90–45° range.³ Closed-chain strengthening within a pain-free arc that avoids loaded deep flexion is the mainstay in the interim. For cell-based grafts, shear across the graft surface is also avoided for the first six weeks. DeNovo NT and chondral-only Cartiform are treated as Category B; a deeper Cartiform reconstruction with bone involvement follows the osteochondral allograft protocol — confirm the category with Dr. Roth.

Technique Modifier

Microfracture (Category A) forms fibrocartilage from marrow elements, whose durability may decline after about five years; cell-based grafts (Category B — MACI, DeNovo NT, Cartiform) mature over 12–18 months and carry a delamination rather than a clot-disruption risk.⁵ On the patellofemoral surface the two categories are governed chiefly by the shared flexion restriction, so their early courses are closely aligned; the difference is mainly in the surface-shear precaution and long-term durability counseling.

Prolonged Quadriceps Rehabilitation

Persistent quadriceps deficits greater than 20% are documented in roughly a third of patients at one year and a quarter at two years, with deficits reported up to seven years.⁷ The challenge on the patellofemoral surface is to rebuild the quadriceps aggressively while respecting the extension-arc precaution — hence the reliance on isometrics, straight-leg raises, and closed-chain work before full-arc open-chain extension is introduced at twelve weeks.

RED FLAGS — CONTACT DR. ROTH

- Sudden increase in effusion or hemarthrosis.
- Mechanical symptoms — locking, catching, or giving way (concern for graft delamination or a loose body).
- Loss of previously achieved ROM, especially loss of extension.

- Persistent anterior knee pain at the graft site with loading or stairs.
- Signs of wound infection, or failure to progress ROM or strength as expected.

Return-to-Activity Criteria

Progression is criterion-based and gated on graft maturation. The tiers below are guides; individual patients advance faster or slower depending on technique, lesion size, and recovery of quadriceps strength.

Activity Tier	Criteria & Timing
Full weight-bearing off brace	Once quad control returns and gait is normalized, typically weeks 6–8; weight-bearing itself is permitted early, the brace protects flexion.
Stationary bike / swimming / elliptical	Flexion $\geq$ ~100°, incisions sealed, no effusion; bike once flexion permits, pool once sealed.
Jogging / running	Graft maturation supported (typically 4–6 months), quadriceps strength $\geq$ 70–80% of contralateral limb, no pain or effusion.
Agility, plyometrics, sport-specific drills	Quadriceps strength $\geq$ 80% of contralateral limb, single-leg hop $\geq$ 80% limb symmetry, no effusion with advanced activity, full-arc extension restored.
Full return to sport (cutting, pivoting, contact)	Quadriceps strength index $\geq$ 90% LSI; hop battery $\geq$ 90% LSI; no effusion or apprehension; confirmed graft maturation; physician clearance. No pivot/cut/contact before 6 months; typically 6–9 months.

REALISTIC EXPECTATIONS

Cartilage recovery is a tissue-maturation timeline: impact and sport are gated on graft maturation, not on how the knee feels. On the patellofemoral surface, anterior knee pain with stairs and inclines is common early and settles as the quadriceps rebuilds and the graft matures. Microfracture produces fibrocartilage, whose durability may decline after about five years; cell-based grafts mature over 12–18 months. Quadriceps weakness is the deficit most likely to persist, so ongoing strengthening is essential. A sudden effusion, new mechanical symptoms, or loss of extension should prompt re-evaluation by Dr. Roth.⁷

References

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Glossary

AAROM — Active-assisted range of motion; the patient initiates motion with assistance.

Cartiform — A cryopreserved osteochondral allograft disc used to resurface chondral (or shallow osteochondral) defects.

Category A / Category B — Dr. Roth's technique groupings: A = marrow stimulation (microfracture); B = cell-based / scaffold (MACI, DeNovo NT, Cartiform).

CKC — Closed kinetic chain; exercises with the foot fixed (squats, leg press).

CPM — Continuous passive motion; a machine that moves the knee through a set arc to nourish cartilage and limit stiffness.

Delamination — Separation of a cell-based graft from its bed — the principal early risk for Category B techniques.

DeNovo NT — Particulated juvenile articular cartilage, fixed with fibrin glue.

Fibrocartilage — The repair tissue formed after microfracture; less durable than native hyaline cartilage.

ITB — Iliotibial band.

LSI — Limb Symmetry Index; operative limb as a percentage of the contralateral limb.

MACI — Matrix-associated autologous chondrocyte implantation; cultured chondrocytes on a collagen membrane.

Microfracture (MFx) — Marrow stimulation; controlled perforation of subchondral bone to form a fibrocartilage clot.

MMT — Manual muscle test; a graded (0–5) clinical assessment of strength.

NMES — Neuromuscular electrical stimulation (“Russian stim”) to augment quadriceps activation.

OKC — Open kinetic chain; exercises with the foot free (seated knee extension).

Patellofemoral — The joint between the patella and the trochlear groove of the femur; contact stress rises with flexion.

PROM — Passive range of motion; the joint is moved while the patient stays relaxed.

SLR — Straight-leg raise.



Kevin M. Roth, MD

Board-Certified Orthopaedic Surgeon · Subspecialty Certification in Sports Medicine

Dr. Roth completed his orthopaedic surgery residency at Harvard Medical School and his sports medicine fellowship at the Kerlan-Jobe Orthopaedic Clinic in Los Angeles. In practice since 2013, he specializes in advanced arthroscopic techniques and sports medicine procedures, and sees patients at Palo Alto Medical Foundation's Palo Alto and Dublin offices. He welcomes calls from physical therapists about his patients or this protocol.

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