

PHYSICAL THERAPY PROTOCOL

Cartilage Resurfacing — Femoral Condyle & Tibial Plateau

Microfracture, MACI, DeNovo NT, and Cartiform — Weight-Bearing–Restricted (Tibiofemoral) Pathway

FOR THE PHYSICAL THERAPIST

Overview and Goals

This protocol governs rehabilitation after cartilage resurfacing of a **weight-bearing (tibiofemoral) surface** — the femoral condyle or tibial plateau — by microfracture (marrow stimulation) or a cell-based/scaffold technique (MACI, DeNovo NT, or Cartiform). Patellofemoral lesions and osteochondral allograft are covered by separate protocols. Rehabilitation is driven more by lesion location and technique than by any single brand: on the condyle and plateau, the graft is loaded during the stance phase of gait, so **weight-bearing is the primary constraint**, while range of motion is comparatively free.

Two technique categories set the intensity of early protection. **Category A — marrow stimulation (microfracture)** forms a fibrocartilage clot that must be protected from shear; per Dr. Roth's practice, all microfracture cases remain protected for about six weeks. **Category B — cell-based / scaffold (MACI, DeNovo NT, Cartiform)** is at risk of graft delamination and follows an evidence-based accelerated schedule to full weight-bearing by eight weeks.^{3,4} 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, and range of motion is advanced early — arthrofibrosis is a recognized complication, and early motion promotes cartilage repair while loading is protected. Quadriceps weakness is the most significant long-term functional deficit after every cartilage procedure; roughly a quarter to a third of patients retain a >20% strength deficit at one to two years, so aggressive, prolonged quadriceps rehabilitation is essential.⁷

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 (osteotomy, ligament reconstruction, meniscal transplant), follow the more restrictive protocol.

READ BEFORE STARTING — SCOPE & GRAFT PROTECTION

This protocol applies to microfracture, MACI, DeNovo NT, or Cartiform on the femoral condyle or tibial plateau.

- Confirm the **technique category** with Dr. Roth: Category A (microfracture) is protected ~6 weeks; Category B (cell-based) follows the accelerated 8-week weight-bearing schedule.
- Weight-bearing is the primary constraint on this surface — respect the technique-specific schedule strictly; premature loading risks clot disruption or graft delamination.
- CPM begins POD 0–1 for all cases. Advance range of motion early, but avoid loaded deep flexion (>90°) for the first 4–6 weeks to limit posterior condylar loading.
- If a partial patellectomy, osteotomy, ligament, or meniscal procedure was also performed, follow the most restrictive protocol and confirm with Dr. Roth.

Rehabilitation Phases

PHASE	WEIGHT BEARING	BRACE / CPM	ROM GOALS	EXERCISES	CRITERIA TO ADVANCE
PHASE 1 Weeks 0–2 <i>Protection & early motion</i>	Category A (MFx): - Toe-touch weight-bearing, brace locked in extension Category B (cell-based): - Toe-touch weight-bearing, brace locked in extension	- Hinged brace locked in extension for weight-bearing/transfers; unlocked for CPM and ROM. CPM: - Begin POD 0–1, 0–90°, per tolerance	- Relatively free — advance as tolerated. - PROM / AAROM 0–90° Avoid: - Loaded deep flexion (>90°) Priority: - Full passive extension; patellar 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	- Quadriceps activation with SLR (no extensor lag) - Full passive extension - ROM advancing toward 90°+ - Pain and effusion controlled - Minimum 2 weeks elapsed
PHASE 2 Weeks 2–6 <i>Protected weight-bearing & ROM</i>	Category A (MFx): - Toe-touch weight-bearing through week 6 Category B: - From week 2, increase ~25% body weight per week to full by week 8^{3,4}	- Continue brace locked in extension for gait; may unlock once quad control (SLR without lag). CPM: - Continue; advance flexion toward full	- Advance toward full ROM as tolerated. Bike: - Stationary bike, low resistance, once flexion permits (~100°) Aquatics: - Pool ROM/gait once incisions sealed	Strengthening: - Progress SLR all planes - Quad sets, co-contractions - Standing calf raises within WB status - Patellar mobilizations Hip / core: - Side-lying abduction, clamshells - Core stabilization Avoid: - Loaded deep flexion; open-chain resisted extension	- Weight-bearing advanced per technique schedule - Full or near-full ROM - SLR without extensor lag - No effusion increase with progression - Minimum 6 weeks elapsed
PHASE 3 Weeks 6–12 <i>Weight-bearing advancement & strengthening</i>	Category A: - Advance from toe-touch to full weight-bearing by ~week 8 Category B: - Full weight-bearing by week 8^{3,4}	- Wean brace and crutches as gait normalizes and quad control returns. CPM: - Discontinue once full ROM achieved	- Full ROM. Stretching: - Hamstrings, quads, ITB, gastroc/sol eus	Closed-chain: - Squats and leg press (0–60°, progressing), step-ups, lunges Open-chain: - Knee extension, progressive as tolerated Neuromuscular / hip: - Single-leg balance, hip strengthening all planes Conditioning: - Bike, elliptical, swimming	- Full weight-bearing, gait normalized off crutches/brace - Full, pain-free ROM - No effusion - Quadriceps MMT ≥ 4/5 - Minimum 12 weeks elapsed
PHASE 4 Weeks 12–20+ <i>Advanced strengthening & functional</i>	Full.	None.	Full ROM maintained.	Strengthening: - Progressive single-leg squats, press, deadlifts - Full-arc open-chain extension, progressive Plyometrics: - Bilateral → unilateral, once graft maturing Agility: - Ladder and cone drills (linear → multidirectional) Conditioning:	- 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
				Straight-line jogging once graft maturing (~4–6 mo), quad ≥ 70–80%, no effusion → running	
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

Weight-Bearing Is the Primary Constraint

On the femoral condyle and tibial plateau the repair sits directly in the load path during the stance phase of gait, so the weight-bearing schedule — not range of motion — is the variable that protects the graft. Range of motion, by contrast, is advanced early and freely (with continuous passive motion) because it nourishes the repair and prevents stiffness, provided loaded deep flexion beyond 90° is avoided for the first four to six weeks to limit posterior condylar contact. Tibial plateau lesions follow the same weight-bearing logic as the femoral condyle.^{1,6}

Technique Sets the Weight-Bearing Timeline

Microfracture (Category A) forms a fibrocartilage clot from marrow elements; premature loading disrupts the clot and yields softer, less durable repair tissue, so Dr. Roth keeps all microfracture cases on toe-touch weight-bearing for approximately six weeks before advancing to full weight-bearing by about week eight. The evidence on isolated small tibiofemoral lesions suggests weight-bearing restriction may not always be required,² but Dr. Roth's standard is the conservative toe-touch course above. Cell-based and scaffold techniques (Category B — MACI, DeNovo NT, Cartiform) are at risk of graft delamination rather than clot disruption; two level-1 randomized trials showed that an accelerated eight-week approach to full weight-bearing was safe, with no graft complications and better quality-of-life scores maintained at ten years,^{3,4} and the MACI label itself recommends early mobilization to promote maturation and reduce delamination.⁵

Protect the Graft Surface from Shear

For cell-based grafts, shear across the graft surface is the principal early threat; avoid resisted open-chain extension and loaded pivoting for the first six weeks while the graft integrates. DeNovo NT (particulated juvenile cartilage, fibrin-glue fixation) and chondral-only Cartiform are treated as Category B. If Cartiform is used to fill a deeper osteochondral defect with meaningful bone involvement, Dr. Roth may designate the osteochondral allograft protocol instead — confirm the category.

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 after marrow stimulation and cell-based repair, with deficits reported up to seven years.⁷ Quadriceps and hip strengthening should therefore be aggressive and continue well beyond the point of pain-free walking, ideally two to three times per week on an ongoing basis.

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 pain at the graft site with loading.
- 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 crutches	Category A (MFX) by ~week 8 after the protected period; Category B by ~week 8 on the accelerated schedule; gait normalized, no effusion.
Stationary bike / swimming / elliptical	Flexion adequate (bike ~100°), incisions sealed, no effusion; typically weeks 4–6 for the bike, 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 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, not a symptom timeline: impact and sport are gated on graft maturation rather than on how the knee feels, which can be weeks ahead of the biology. Microfracture produces fibrocartilage, whose durability may decline after about five years; cell-based grafts mature over 12–18 months. Across all techniques, quadriceps weakness is the deficit most likely to persist, so ongoing strengthening is essential rather than optional. 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.

NWB / TTWB / WBAT — Non-weight-bearing / toe-touch weight-bearing / weight-bearing as tolerated.

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

SLR — Straight-leg raise.



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