

YOUR MACI + TIBIAL OSTEOTOMY RECOVERY A GUIDE TO PHYSICAL THERAPY

THE ROLE OF PHYSICAL THERAPY IN YOUR RECOVERY

You had two procedures at the same time: MACI cartilage restoration on your thigh bone and a high tibial osteotomy (HTO) to realign your leg at the shin bone. Both must heal together. The osteotomy drives the weight-bearing rules in the first six weeks — your toes barely touch the ground. After your six-week X-ray confirms the bone is healing, weight-bearing progresses and the focus shifts to building strength. The cartilage graft continues maturing for 12–18 months before high-impact sport is allowed.

Important: Toe-touch weight-bearing is mandatory for six weeks. No advancement before the Week 6 X-ray. Your brace stays locked straight for all weight-bearing and during sleep for the first four weeks.

YOUR RECOVERY TIMELINE

PHASE	TIMEFRAME	PT VISITS	WHAT YOU'RE WORKING ON
1	Weeks 1–6	2–3× per week	• Toe-touch only — crutches carry your weight for bone protection • Brace locked straight for all walking and during sleep × 4 weeks • Quad activation with electrical stimulation from Day 1 • Free range of motion when seated or lying down
2	Weeks 6–14 (after X-ray OK)	2× per week	• Weight-bearing advances after HTO X-ray confirms healing • Stationary bike and aquatic therapy — low load, good muscle activation • Unloading brace may be prescribed to protect the cartilage compartment • No deep squatting or impact activities yet
3	Months 4–9	1–2× per week + home program	• Leg press, functional squats, progressive strengthening • Jogging when quad strength and graft maturation allow • Limb symmetry testing at Month 6 • No cutting or high-impact sport before 12 months
4	Months 9–18	As needed	• Sport-specific training and progressive return to activity • Final strength and hop testing before clearance • High-impact sport: 12–18 months based on cartilage maturation • Clearance by Dr. Merritt at each stage of return

Questions about your PT progress? Call our office or bring them to your next appointment. We are always glad to coordinate with your therapist.

MACI FEMORAL CONDYLE WITH HIGH TIBIAL OSTEOTOMY (HTO) PHYSICAL THERAPY PROTOCOL

Patient Name: _____
Date of Surgery: _____

Surgeon: Andrew L. Merritt, MD
PT Start Date: _____

Overview & General Principles

MACI combined with High Tibial Osteotomy (HTO) addresses both articular cartilage damage on the femoral condyle and lower limb malalignment simultaneously. Two separate tissues must heal: the MACI scaffold (cartilage integration over 12–18 months) and the tibial osteotomy (bone union by 6–12 weeks). Rehabilitation must protect both. Weight-bearing progression is gated by the 6-week X-ray confirming osseous HTO union. ROM progression is accelerated compared with isolated MACI to prevent arthrofibrosis common after combined procedures.

1. **TIBIOFEMORAL LOADING:** The graft sits on the weight-bearing surface of the femoral condyle. Axial compressive load must be introduced gradually — NWB × 1 week allows early scaffold fixation, followed by stepwise TTWB and partial WB. WB advancement after Week 6 is gated by radiographic evidence of HTO bone union at the 6-week follow-up X-ray.
2. **OKC SEQUENCE:** Active knee extension begins from 90°←40° (terminal arc, no resistance) throughout Phase 1. ROM progression is accelerated (see table below) to prevent arthrofibrosis. Resistance is introduced in Phase 2 once the graft is stabilized; full-arc 0°–90° OKC begins in Phase 3.
3. **BRACE DISCIPLINE:** The brace is locked at 0° (full extension) for all weight-bearing activity AND during sleep for the first 4 weeks. Remove only for seated or supine ROM exercises and hygiene.
4. **DUAL HEALING:** Both the cartilage graft and the HTO osteotomy site are healing simultaneously. Weight bearing is governed by the slower-healing structure (osteotomy). An unloading brace is introduced at Weeks 6–8 to offload the graft compartment as full weight bearing is achieved. Orthotics, insoles, or heel wedges may be prescribed for ongoing alignment correction.

CONCOMITANT PROCEDURE MODIFICATIONS

Concomitant Meniscal Repair

5. When meniscal repair is performed simultaneously, weight-bearing restrictions from the meniscal repair take precedence if more conservative than the HTO/cartilage protocol. Follow surgeon instructions for WB advancement.

Concomitant ACL Reconstruction

6. If combined with ACL reconstruction, bracing and WB restrictions from the ACL protocol apply during Phase 1. The MACI maturation timeline and OKC extension arc restrictions (90°←40° Phase 1, no full extension load) remain unchanged.

PHASE 1 — PROTECTION (Weeks 0–6)

INFORMATION FOR THE PATIENT — What to Expect This Phase

This is the most protected phase of your recovery. The cartilage graft needs time to attach to the bone and begin integrating into your joint surface. For the first week, you must keep your foot completely off the floor (non-weight bearing) to allow early fixation of the scaffold. After that, you will gradually add a little weight each week.

Your brace must be locked straight — at 0° — whenever you are standing, walking, or sleeping for the first 4 weeks. Remove the brace only for your lying-down bending exercises and hygiene.

Bending your knee is important and moves faster after this combined procedure to prevent stiffness. Your targets are: 90° by Week 1, 105° by Week 2, 115° by Week 3, 125° by Week 4, and 125°+ by Week 6. The table below shows your weekly targets.

Goals:

7. Protect graft from tibiofemoral compressive and shear forces
8. Control swelling and pain
9. Restore full passive knee extension (0°)
10. Progress knee flexion ROM on milestone schedule (see table below)
11. Restore quadriceps activation — SLR without extensor lag by Week 3–4
12. Begin patellar and scar tissue mobilization from Day 1

Weight-Bearing Status: Non-weight bearing (NWB) × 1 week — foot must not contact floor. Progress: toe-touch weight bearing (TTWB, foot contacts floor for balance only, approx. 20–30 lbs) Weeks 1–3, then partial weight bearing (approx. 25% body weight on crutches) Weeks 4–5. Extended standing must be avoided through Phase 1.

Bracing: Hinged knee brace locked at 0° (full extension) for all weight-bearing activity AND during sleep for Weeks 0–4. Remove brace only for seated or supine ROM exercises and hygiene. At Weeks 4–6 brace may be unlocked during ROM exercises as quad control improves — continue wearing brace locked for all WB until surgeon discontinues at 6-week visit.

Range of Motion: Active and active-assisted ROM exercises are used throughout — no continuous passive motion (CPM). ROM progression is ACCELERATED compared with isolated MACI to prevent arthrofibrosis after combined HTO/MACI. Passive flexion must meet aggressive milestone targets below. Do NOT force ROM past the scheduled target but do NOT fall behind. Maintain full passive extension (0°) throughout Phase 1. Patellar mobilization from Day 1.

Milestone	Target Passive Flexion
Week 1	90°
Week 2	105°
Week 3	115°
Week 4	125°
Week 6	125°+

Exercises:

13. NMES to VMO/quad — 20–30 min, 2× daily; begin Day 1–2 post-op
14. Quad sets — 3×15, every waking hour; VMO activation priority
15. Straight-leg raises (hip flexion initially, then all planes) — 3×10 each
16. Heel slides (active-assisted knee flexion within ROM milestone schedule) — 3×15
17. Ankle pumps — hourly

18. Patellar mobilization: superior, inferior, medial and lateral glides (gentle) — 2×10 each, 2× daily. Avoid direct compression of the graft surface.
19. Active OKC knee extension 90°←40°, no resistance — 3×15. Avoids the 0°–40° zone of peak tibiofemoral contact. Begin Week 1.
20. Weight shifts bilateral (brace locked) — introduce Weeks 2–3; shift body weight side to side for early loading tolerance
21. Toe/calf raises (bilateral, standing, brace locked) — begin Week 2, 3×15
22. Hip strengthening: clamshells, supine hip abduction, prone hip extension — 3×15
23. Isometric leg press (minimal load, 0°–10° only) — introduce Week 4, 3×15
24. Pool deep-water walking (when incision healed, Weeks 4–5): forward, backward, sideways — full joint offloading via buoyancy
25. Upper extremity and core conditioning as tolerated
26. Ice and elevation after each session — 20 minutes

Progression Milestones — Must Meet All Before Advancing:

27. NWB compliance maintained × 1 week without foot loading
28. ROM: 90° passive flexion by Week 1 (accelerated HTO target)
29. ROM: 105° passive flexion by Week 2
30. ROM: 115° passive flexion by Week 3
31. ROM: 125° passive flexion by Week 4
32. Full passive extension (0°) maintained
33. SLR without extensor lag by Week 3–4
34. Quad activation established with NMES and quad sets
35. Pain and swelling diminishing

PHASE 1 PRECAUTIONS — GRAFT PROTECTION

36. Strict NWB × 1 week — no foot contact with floor, no partial weight bearing
37. Brace locked at 0° for all WB and sleep × 4 weeks — non-negotiable
38. No loaded knee flexion past 45° during weight-bearing activities in Phase 1
39. Avoid extended standing — repetitive low-level axial load can disrupt early scaffold adhesion
40. No jogging, running, jumping, or impact activities
41. No OKC extension in the 0°–40° arc under load — highest tibiofemoral contact zone
42. Stop exercise if sharp joint pain or excessive swelling occurs and contact surgeon

Rationale: The MACI scaffold is in its most fragile phase (Weeks 0–6). Early axial compressive load and shear forces at the implantation site risk delamination, graft displacement, or failure of cellular integration. NWB the first week allows the fibrin glue fixation to stabilize before any mechanical loading begins.

PHASE 2 — TRANSITION (Weeks 6–12)

INFORMATION FOR THE PATIENT — What to Expect This Phase

At Week 6 you will have an X-ray to check whether the tibial bone cut has healed. If the bone shows good healing, you can begin putting real weight through your leg and progressing off crutches. If the bone needs more time, your surgeon will tell you to stay on crutches longer. An unloading brace and orthotics or heel wedges may be given to help align the

knee as you start walking. Your knee bending is now unrestricted, but loaded bending past 90° should still be avoided until Month 5.

Goals:

43. Full weight bearing without crutch by Weeks 8–9 (after 6-week X-ray confirms HTO union)
44. Progress ROM to full by Week 12 (ROM should already be 125°+ from Phase 1 accelerated progression)
45. Quad strength 50–60% contralateral
46. Establish closed-chain strengthening in safe ROM arc (0°–60° initially)
47. OKC extension with progressive resistance beginning Week 8
48. Stationary cycling and aquatic therapy established by Weeks 6–8

Weight-Bearing Status: WB advancement after Week 6 is GATED by the 6-week X-ray confirming osseous HTO union. If union is confirmed: begin WBAT at Week 6 and progress bilateral crutches → single crutch by Week 7–8 → no crutch by Weeks 8–9. If union is not confirmed: continue TTWB until surgeon directs advancement at follow-up imaging. Do not advance WB without radiographic clearance.

Bracing: Post-operative brace discontinued at Week 6. An unloading knee brace is introduced at Weeks 6–8 to offload the medial tibiofemoral compartment at the graft site. Orthotics, arch supports, or heel wedges may be prescribed per surgeon guidance as part of the HTO alignment correction strategy.

Range of Motion: ROM restriction lifted at Week 6. Progress flexion gradually to 125°–135° by Week 8 and full ROM by Week 12. Maintain full passive extension throughout. Avoid loaded flexion past 60° initially (Weeks 6–10); advance to 0°–90° by Weeks 12. No deep squats, step-downs past 90°, or loaded deep flexion until Month 5.

Exercises — Weeks 6–10:

49. Stationary recumbent bike — begin Week 6–8; low resistance, 15–20 min. Recumbent preferred initially to reduce joint load.
50. Pool therapy (shallow water): walking, heel raises, gentle squats — begin Weeks 6–8
51. OKC knee extension 90°←40° with progressive resistance — begin resistance Week 8, add 1 lb/week as tolerated, 3×15
52. Mini-squats (0°–45° only) — 3×15, begin Week 8
53. Leg press (0°–60° arc) — 3×12; avoid deep flexion loading
54. Step-ups (2–4 inch step) — 3×10, begin Week 8–10
55. Terminal knee extension (TKE) with resistance band — 3×15
56. Standing hip abduction/adduction with resistance band — 3×12
57. Single-leg balance on firm surface — 3×30 sec
58. Toe/calf raises (bilateral, progress to single-leg) — 3×15

Exercises — Weeks 10–12 (add to above):

59. Mini-squats progress to 0°–90° as tolerated — monitor for reactive effusion
60. Upright stationary cycling — introduce Week 10–12 when ROM adequate
61. Stair machine (StairMaster) — introduce by Week 12; low resistance, short duration
62. Leg press progress to 0°–90° by Week 12 — no deeper flexion until Phase 3
63. Step-ups progress to 4–6 inch — 3×10
64. Treadmill walking program — begin Weeks 10–12 on level surface
65. Single-leg balance: progress to unsteady surface and dynamic challenges
66. Elliptical trainer — low resistance when ambulating pain-free

Progression Milestones — Must Meet All Before Advancing:

- 67. Full WB without crutch with near-normal gait
- 68. Full ROM (0°–130°+)
- 69. Mini-squat (0°–45°) ×15 without pain
- 70. Stationary bike 20–30 minutes without pain
- 71. Hamstring strength within 20% of contralateral limb
- 72. Quad strength within 30% of contralateral limb
- 73. Balance within 30% of contralateral limb

PHASE 2 PRECAUTIONS — HTO + MACI DUAL HEALING

- 74. WB advancement requires 6-week X-ray confirmation of HTO osseous union — do not advance WB without radiographic clearance
- 75. WB progression guided by pain, swelling, and quad control — do not rush crutch weaning if joint is reactive
- 76. Use unloading brace as directed — do not discontinue early; helps protect graft from compartment overload
- 77. No loaded knee flexion past 60° in Weeks 6–10 — advance to 90° only after Week 10 if no reactive effusion
- 78. No running, jumping, or high-impact activities
- 79. No deep squats, lunges past 90°, or step-downs until Phase 3
- 80. Monitor for joint effusion after each session — increased swelling is a signal to reduce load

PHASE 3 — STRENGTHENING (Months 3–6)

INFORMATION FOR THE PATIENT — What to Expect This Phase

This phase builds the muscle strength needed for full function. You will progress from partial to full depth squats and lunges, begin resisted OKC extension through the full 0°–90° arc, and establish a maintenance program to carry independently from Weeks 16–20. No running yet — that begins Month 9–12.

Goals:

81. Quad strength $\geq$ 75–80% contralateral
82. Full ROM unrestricted including loaded deep flexion after Month 5
83. Low-impact conditioning well established (cycling, swimming, elliptical)
84. Neuromuscular control during single-leg functional tasks
85. Maintenance program established by Weeks 16–20

Weight-Bearing Status: Full, unrestricted.

Range of Motion: Full, unrestricted. Loaded deep flexion ($>90^\circ$) permitted after Month 5.

Exercises — Months 3–5:

86. Leg press (0°–60°; progress to 0°–90°) — progress ROM and resistance
87. Bilateral squats — 0°–60° initially; progress to 90° by Month 4, full depth after Month 5
88. Step-ups (6–8 inch) — 3×10
89. Step-downs (eccentric control) — introduce Month 4–5
90. Forward and reverse lunges — progress depth and load
91. OKC knee extension 0°–90° — begin with low resistance; increase 1 lb/week from approximately Week 20. Monitor for anterior knee pain or reactive effusion.
92. Stationary bike at increasing resistance — 30–40 minutes
93. Elliptical trainer, ski machine — low resistance, progress duration
94. Swimming (freestyle, backstroke) — excellent low-impact option
95. Walking program on treadmill — increase distance, cadence, incline
96. Single-leg squat — 3×10, progress depth
97. Hip strengthening: hip thrust, lateral band walks, single-leg bridge

Exercises — Month 5+ (add when cleared for deep loaded flexion):

98. Full-depth squats and full leg press ROM — now permitted
99. Lunges past 90° — forward, reverse, and lateral
100. OKC extension with progressive loading through full arc

Maintenance Program (Weeks 16–20): Establish a home-based maintenance program to continue independently: squats, step-ups, hip strengthening, cycling, and stretching 3–4×/week.

Progression Milestones — Must Meet All Before Advancing:

101. Quad strength $\geq$ 80% contralateral
102. Squat to 90° under load without pain

- 103. Step-down (8 inch) with symmetric mechanics and no pain
- 104. 30+ minutes of low-impact cardio without pain or reactive swelling
- 105. Balance and stability within 75–80% of contralateral extremity

PHASE 3 PRECAUTIONS

- 106. No running until Month 9–12 and quad strength criteria met — regardless of lesion size
- 107. No plyometrics (jumping, hopping) before Month 12
- 108. No aggressive pivoting or cutting before Month 12–18
- 109. Monitor for reactive effusion after loading sessions — persistent swelling indicates too much progression

PHASE 4 — RETURN TO ACTIVITY (Months 6–18)

INFORMATION FOR THE PATIENT — What to Expect This Phase

The final phase progresses you toward your activity goals. Running begins with walk-jog intervals at Month 9–12 once strength criteria are met. Plyometrics and cutting sports begin after Month 12. Return to full sport requires passing hop testing, achieving strength symmetry, and surgeon clearance.

Goals:

- 110. Quad strength $\geq 90\%$ contralateral
- 111. Hop test $\geq 90\%$ limb symmetry index (single, triple, crossover, timed)
- 112. Return to full recreational or sport activity

Weight-Bearing Status: Full, unrestricted.

Range of Motion: Full, unrestricted.

Exercises:

- 113. Continue maintenance program 3–4×/week with progressive resistance
- 114. Emphasis on entire lower extremity strength and flexibility
- 115. Progressive agility and balance drills
- 116. Running program — begin walk-jog intervals at Month 9–12 (flat surface, no hills initially). This timeline applies regardless of lesion size.
- 117. Plyometric progression (Month 12+): bilateral jump/land → single-leg hops. No jumping or plyometrics before 12 months.
- 118. Agility, cutting, deceleration drills (Month 12–15)
- 119. Sport-specific skill training at progressive intensity
- 120. Hop testing: single-leg hop, triple hop, crossover hop, timed 6-meter hop

Progression Milestones — Clearance for Sport:

- 121. Quad strength $\geq 90\%$ contralateral (isokinetic or functional testing)
- 122. Hop test $\geq 90\%$ limb symmetry index
- 123. Running 20 minutes continuous without pain
- 124. Surgeon clearance (MRI recommended at 12 months)

PHASE 4 PRECAUTIONS

- 125. High-impact/cutting sports — 12 months minimum; no exceptions regardless of subjective readiness
- 126. Running program must be walk-jog intervals initially — no continuous running before building base
- 127. Plyometrics only after Month 12 AND bilateral jump-landing mechanics are sound
- 128. Persistent pain, swelling, or giving way with activity requires surgeon evaluation before advancement

RETURN TO ACTIVITY CRITERIA

All criteria below must be satisfied AND surgeon clearance obtained before return to high-impact or cutting/pivoting sports.

Return-to-Activity Criterion	Required Threshold
Quadriceps Strength (LSI)	≥90% contralateral limb
Hamstring Strength (LSI)	≥90% contralateral limb
Single-Leg Hop Testing (LSI)	≥90% contralateral (single, triple, crossover, timed)
Full Pain-Free ROM	Equal to contralateral, including loaded deep flexion
No Reactive Effusion	No joint effusion after functional activity
HTO Hardware Review	Surgeon review of osteotomy hardware; removal per surgeon preference
Minimum Time — Running	Month 9–12 (after criteria met)
Minimum Time — High-Impact/Cutting	12 months post-operative minimum
MRI Assessment	Recommended at 12 months prior to sport return
Surgeon Clearance	Required prior to return to full sport

Clinical Timeline Summary

Non-weight bearing: Week 0–1

Toe-touch weight bearing: Weeks 1–6 (until 6-week X-ray)

Partial weight bearing: Weeks 4–5 (while awaiting 6-week X-ray)

6-week X-ray (HTO union assessment): Week 6 — required before WB advancement

WBAT progressing: Week 6 (if X-ray confirms HTO union)

Full WB without crutch: Weeks 8–9 (after confirmed HTO union)

Unloading knee brace: Introduced Weeks 6–8; continue as directed

Orthotics / heel wedges: Introduced per surgeon guidance at Phase 2

Brace discontinued: Post-op brace at Week 6; unloading brace per surgeon

Low-impact conditioning (cycling, pool therapy): Week 6–8 (after X-ray clearance)

Loaded deep flexion (>90°): Month 5+

OKC extension 90°←40° no resistance: Phase 1 (Weeks 0–6)

OKC extension 90°←40° with resistance: Phase 2 (Week 8+)

OKC extension full arc 0°–90°: Phase 3 (Month 3+)

Maintenance program established: Weeks 16–20

HTO hardware review: Per surgeon preference; typically discussed at 12-month visit

Running (walk-jog program): Month 9–12 (after criteria met)

Plyometrics: Month 12+

Cutting, pivoting, impact sports: Month 12–18 — all criteria met & surgeon clearance required

MRI and surgeon review: 12-month post-op visit

Note: Rehabilitation timelines reflect MACI scaffold maturation biology. Clinical judgment and objective strength/hop testing must guide advancement at each phase. Reactive effusion after any session is a signal to reduce loading intensity.

Surgeon Notes / Special Instructions: