KEVIN M. ROTH, MD
ORTHOPAEDIC SPORTS MEDICINE

PHYSICAL THERAPY PROTOCOL

Tibial Tubercle Osteotomy

Anteromedialization, Medialization, or Distalization — With or Without Concomitant MPFL Reconstruction

FOR THE PHYSICAL THERAPIST

Overview and Goals

This protocol governs rehabilitation following tibial tubercle osteotomy (TTO) — anteromedialization, medialization, or distalization — performed with or without concomitant medial patellofemoral ligament (MPFL) reconstruction. The osteotomy is the rate-limiting factor for rehabilitation: because the tubercle is fixed with screws and must heal as bone, weight-bearing and knee flexion are protected until radiographic healing, typically 6–8 weeks.[1,2] When MPFL reconstruction is performed concurrently, the osteotomy timeline already governs, and only a small set of soft-tissue precautions is added — noted in the callouts below.

The tibial tubercle is the insertion of the patellar tendon, so active and resisted knee extension pull directly on the healing osteotomy. Extensor-mechanism protection is therefore central: quadriceps isometrics and straight-leg raises are permitted early with the brace locked in extension, but resisted open-chain extension through the 45°-to-full arc is deferred for 12 weeks, and impact and pivoting are withheld until radiographic union.

Weight-bearing after TTO is technique-dependent. A complete tubercle detachment carries a higher fracture and fixation-failure risk than an osteotomy that preserves a distal cortical hinge; historically, premature full weight-bearing after Fulkerson-type osteotomy produced a proximal tibial fracture rate of approximately 2.6%.[4,5] All patients remain at touch-down weight-bearing for the first 2 weeks; thereafter the progression depends on the osteotomy technique and fixation, confirmed with Dr. Roth.

Progression is criterion-based, and radiographic confirmation of osteotomy union gates advancement to full weight-bearing and to impact activity. Return to sport averages approximately 7–9 months and is modestly later when MPFL reconstruction is combined with TTO.[9,10]

READ BEFORE STARTING — SCOPE & OSTEOTOMY PROTECTION

This protocol applies to TTO (anteromedialization, medialization, or distalization), with or without concomitant MPFL reconstruction.

- Confirm the **osteotomy technique (distal cortical hinge vs. complete detachment)** and fixation with Dr. Roth — it determines the weight-bearing progression after the first 2 weeks.
- If a **cartilage/chondral procedure or trochleoplasty** was also performed, additional weight-bearing or ROM restrictions may apply — confirm with Dr. Roth.

Precautions that apply throughout:

- No resisted open-chain knee extension from 45° to full extension for the first 12 weeks (patellofemoral stress and osteotomy protection).
- No pivoting, cutting, or impact until osteotomy union is confirmed radiographically.
- If concomitant MPFL reconstruction: superior and medial patellar glides only (no lateral glide), and no lateral patellar stress for at least 12 weeks.

Rehabilitation Phases

PHASE	WEIGHT BEARING	BRACE	ROM GOALS	EXERCISES	CRITERIA TO ADVANCE
PHASE 1 Weeks 0–2 *Protection & early mobilization*	• Touch-down weight-bearing with crutches, brace locked in extension — for the first 2 weeks regardless of osteotomy technique.[2,4]	• Hinged brace locked in full extension for ambulation and sleep. • Unlock only for supervised ROM exercises.	• 0–60° (PROM / AAROM), progress toward 90° by end of week 2. **Priority:** • Maintain full extension (0°) **Patella:** • Superior glides (add medial if concomitant MPFL) — no lateral glide	**Quadriceps activation:** • Quad sets (isometric) • Straight-leg raises in all planes — flexion, abduction, adduction, extension (brace locked) • NMES to quadriceps as needed **ROM / mobility:** • Gentle passive extension to maintain full extension • Ankle pumps **Proximal / adjunct:** • Gluteal sets • Cryotherapy for pain and edema	• Quadriceps activation with SLR (minimal or no extensor lag) • Full passive extension maintained • ROM approaching 90° • Pain and effusion controlled • Minimum 2 weeks elapsed
PHASE 2 Weeks 2–6 *Protected weight-bearing & progressive ROM*	• After week 2, advance by osteotomy technique (confirm with Dr. Roth): **Distal hinge / robust fixation:** • Progress partial → weight-bearing as tolerated over wks 2–6; full without crutches by ~wk 6 **Complete detachment:** • Continue touch-down through 6 weeks, then advance with radiographic confirmation	• Continue locked in extension for ambulation. • May unlock for gait when quadriceps control is adequate (typically wks 4–6).	• 0–90° by week 4; 0–120° by week 6. **Patella:** • Continue superior mobs (add medial if MPFL) **Bike:** • Stationary bike when ROM ~110°, elevated seat	**Strengthening:** • Progress SLR all planes (add ankle weights as tolerated) • Heel slides for ROM • Mini-squats / wall slides (0–30° → 0–45°) • Standing calf raises (when weight-bearing permits) **Hip / core:** • Side-lying hip abduction, clamshells • Prone hip extension • Core stabilization **Neuromuscular:** • Balance / proprioception — bilateral stance, stable → unstable surface	• Weight-bearing advanced per technique without osteotomy-site pain • Brace unlocked for gait without extensor lag • ROM ≥ 120° • Gait normalized for weight-bearing status • Minimum 6 weeks elapsed
PHASE 3 Weeks 6–12 *Progressive strengthening — union-gated*	• Full weight-bearing once achieved per technique and confirmed healing.	• Discontinue when SLR is performed without extensor lag and Dr. Roth approves (typically wks 6–8).	• Full ROM (0–135°+) by weeks 8–12. **Stretching:** • Hamstrings, quads, ITB, gastroc/soleus	• Milestone: radiographs at 6–8 weeks to confirm osteotomy healing before impact.[2] **Closed-chain:** • Squats, leg press (0–60°), step-ups (forward and lateral), lunges **Open-chain (limited arc):** • Begin knee extension 90–045° only — no resisted extension 45°→full **Neuromuscular / hip:** • Single-leg balance and proprioception • Lateral band walks / monster walks • Hip strengthening all planes, progressive **Conditioning:** • Elliptical, swimming (flutter kick)	• Full, pain-free ROM • No effusion • SLR without extensor lag • Radiographic evidence of osteotomy healing • Quadriceps MMT ≥ 4/5 • Minimum 12 weeks elapsed
PHASE 4	• Full.	• None.	• Full ROM	**Strengthening:**	• Quadriceps

PHASE	WEIGHT BEARING	BRACE	ROM GOALS	EXERCISES	CRITERIA TO ADVANCE
Weeks 12–20 *Advanced strengthening & functional training*	*Prerequisite: confirmed radiographic osteotomy union.*		maintained.	• Full-arc open-chain knee extension — progress resistance gradually (permitted after week 12) • Single-leg squats, single-leg press, single-leg deadlifts • Continue hip and core strengthening **Plyometrics:** • Bilateral → unilateral (box jumps, drop jumps, lateral hops) **Agility:** • Ladder and cone drills (linear → lateral → multidirectional) • Sport-specific movement patterns **Conditioning:** • Straight-line jogging (typically wk 14–16, when quad ≥ 70% of contralateral, no pain/effusion, and union confirmed) → interval running	strength ≥ 80% of contralateral limb • No pain or effusion with advanced activities • Single-leg hop ≥ 80% limb symmetry • Minimum 20 weeks for RTS phase
PHASE 5 Weeks 24–36+ *Return to sport*	• Full.	• None.	• Full ROM.	**Sport-specific progression:** • Sport-specific drills at full speed • Non-contact → contact practice → full competition, over ~4–6 weeks **Maintenance:** • Continue quadriceps and hip strengthening 2–3×/week • Ongoing neuromuscular and proprioceptive training • Monitor for recurrent instability or anterior knee pain	*See Return-to-Activity Criteria section below.* • Return to sport typically ~7–9 months (contact to ~9); all criteria below met with confirmed union and physician clearance.[9,10]

Procedure-Specific Considerations

The Osteotomy Is the Rate-Limiting Factor

Rehabilitation timing is governed by bony healing of the osteotomy, not by soft-tissue recovery. Weight-bearing progression and the return to impact activity are gated on radiographic evidence of union, typically confirmed at 6–8 weeks.[1,2] This is the central difference from an isolated MPFL reconstruction, where weight-bearing is limited only by comfort. When a TTO and MPFL reconstruction are performed together, the osteotomy timeline is the more restrictive of the two and therefore governs; the MPFL soft-tissue precautions are layered in without extending the overall timeline.

Weight-Bearing Depends on Osteotomy Technique

All patients remain at touch-down weight-bearing for the first 2 weeks. After that, the progression depends on how the tubercle was cut and fixed. An osteotomy that preserves a distal cortical hinge (as in a Fulkerson-type anteromedialization) provides greater intrinsic stability and tolerates a faster progression to weight-bearing as tolerated over weeks 2–6. A complete tubercle detachment — more common with distalization — carries a higher fracture and fixation-failure risk and is held at touch-down through 6 weeks, then advanced only with radiographic confirmation.[4,5] Premature full weight-bearing is the historical driver of proximal tibial fracture after TTO, so confirm the technique with Dr. Roth before advancing.

Protect the Extensor Mechanism

The tibial tubercle is the patellar tendon insertion, so knee extension against resistance transmits force directly across the osteotomy. Quadriceps isometrics and straight-leg raises are safe and

encouraged early because the brace is locked in extension and the loading is controlled. Resisted open-chain extension through the 45°-to-full arc, however, is deferred for 12 weeks; open-chain extension is reintroduced in a protected 90–045° arc in Phase 3 and progressed to full arc only after week 12.[6] Closed-chain loading (squats, leg press, step-ups) is the mainstay of quadriceps strengthening in the interim.

Extension First — Arthrofibrosis Risk

Arthrofibrosis is among the most common complications after TTO, reported in roughly 4–10% of cases.[5,7] Restoring and maintaining full passive extension from the first phase is the most important safeguard, balanced against the graded flexion progression that protects the osteotomy. Any loss of previously achieved extension is a red flag and warrants prompt re-evaluation by Dr. Roth.

WHEN COMBINED WITH MPFL RECONSTRUCTION

When MPFL reconstruction is performed at the same time as the TTO, this protocol is unchanged in its timeline — the osteotomy healing requirements are already more restrictive than the graft's. Two soft-tissue precautions are added: perform superior and medial patellar glides only (never lateral, which tensions the medial graft), and avoid lateral patellar stress for at least 12 weeks while tunnel-graft integration completes. Return to sport is modestly later for the combined procedure than for isolated MPFL reconstruction, but return-to-sport rates are comparable.[3,9]

Return-to-Activity Criteria

Progression is criterion-based and gated on radiographic union. Return to sport after TTO averages approximately 7–9 months, with contact sport often deferred to around 9 months; the combined TTO + MPFL reconstruction returns modestly later than isolated MPFL reconstruction (approximately 12.8 vs. 8.4 months in comparative series), with similar return-to-sport rates.[9,10]

Activity Tier	Criteria & Timing
Activities of daily living (ADLs)	Full pain-free ROM, quadriceps control without extensor lag, gait normalized off crutches and brace. Timing depends on weight-bearing progression and confirmed healing; typically weeks 8–12.
Stationary bike / swimming / elliptical	Flexion ≥ 110° for the bike; no effusion. Bike typically weeks 4–6 (elevated seat); elliptical and flutter-kick swimming in Phase 3.
Jogging / running	Confirmed osteotomy union, quadriceps strength ≥ 70% of contralateral limb, no pain or effusion. Straight-line jogging typically weeks 14–16, progressing to interval running.
Agility, plyometrics, sport-specific drills	Confirmed union, quadriceps strength ≥ 80% of contralateral limb, single-leg hop ≥ 80% limb symmetry, no pain/effusion with advanced activity. Typically Phase 4 (weeks 12–20).
Full return to sport (incl. cutting, pivoting, contact)	Quadriceps strength index ≥ 90% LSI; hop battery ≥ 90% LSI (single, triple, crossover, timed); no pain, effusion, or apprehension; confirmed radiographic union; sport-specific drills complete; psychological readiness; physician clearance. Typically ~7–9 months (contact ~9).

REALISTIC EXPECTATIONS & COMPLICATIONS

Patients should be counseled that TTO recovery is a bone-healing timeline: full weight-bearing,

impact, and sport are gated on radiographic union rather than on how the knee feels. The most common TTO-specific complications are arthrofibrosis (4–10%), painful hardware that may later require removal (~6–8%), and — historically, with premature full weight-bearing — proximal tibial fracture.[5,6,7] Criteria-based progression and radiographic confirmation before advancing are what keep these risks low. Persistent osteotomy-site pain with weight-bearing, loss of extension, or failure to reach radiographic union by 12 weeks should prompt re-evaluation by Dr. Roth.

References

1. Vidra M, Sigal J, Mitchnik IY, et al. Rehabilitation Protocols Following Patellar Instability Surgery: A Structured Review of Published Recommendations and AI-Generated Guidance. Curr Rev Musculoskelet Med. 2026;19(1):45.
2. Rahnel T, Weitz FK, Mattila VM, et al. Effect of Accelerated Postoperative Rehabilitation After Tibial Tubercle Distalisation: A Randomised Controlled Trial Protocol. PLoS One. 2024;19(7):e0304075.
3. Koshino Y, Taniguchi S, Kobayashi T, Samukawa M, Inoue M. Protocols of Rehabilitation and Return to Sport, and Clinical Outcomes After Medial Patellofemoral Ligament Reconstruction With and Without Tibial Tuberosity Osteotomy: A Systematic Review. Int Orthop. 2022;46(11):2517–2528.
4. Stetson WB, Friedman MJ, Fulkerson JP, Cheng M, Buuck D. Fracture of the Proximal Tibia With Immediate Weightbearing After a Fulkerson Osteotomy. Am J Sports Med. 1997;25(4):570–574.
5. Payne J, Rimmke N, Schmitt LC, Flanigan DC, Magnussen RA. The Incidence of Complications of Tibial Tubercle Osteotomy: A Systematic Review. Arthroscopy. 2015;31(9):1819–1825.
6. Lehane K, Wolfe I, Buseck A, et al. Predictors of Increased Complication Rate Following Tibial Tubercle Osteotomy (TTO). The Knee. 2025;53:93–102.
7. Lundeen A, Macalena J, Agel J, Arendt E. High Incidence of Complication Following Tibial Tubercle Surgery. J ISAKOS. 2023;8(2):81–85.
8. Shah AK, Uppstrom TJ, Rizy ME, Gomoll AH, Strickland SM. Incidence of Complications After Tibial Tubercle Osteotomy and Tibial Tubercle Osteotomy With Distalization. Am J Sports Med. 2024;52(5):1274–1281.
9. Li ZI, Garra S, Eskenazi J, et al. Patients Who Undergo Tibial Tubercle Anteromedialization With MPFL Reconstruction Demonstrate Similar Rates of Return to Sport Compared to Isolated MPFL Reconstruction. Knee Surg Sports Traumatol Arthrosc. 2024;32(2):371–380.
10. Liu JN, Wu HH, Garcia GH, et al. Return to Sports After Tibial Tubercle Osteotomy for Patellofemoral Pain and Osteoarthritis. Arthroscopy. 2018;34(4):1022–1029.
11. Stokes DJ, Elrick BP, Carpenter ML, et al. Tibial Tubercle Osteotomy: Indications, Outcomes, and Complications. Curr Rev Musculoskelet Med. 2024;17(11):484–495.

Glossary

AAROM — Active-assisted range of motion; the patient initiates motion with assistance from gravity, a strap, or the therapist.

ADL — Activities of daily living.

Anteromedialization — A TTO that moves the tubercle anteriorly and medially (e.g., Fulkerson osteotomy), typically preserving a distal cortical hinge.

AROM — Active range of motion; the patient moves the joint independently against gravity.

Arthrofibrosis — Excessive intra-articular scar formation causing stiffness and loss of motion.

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

Distal cortical hinge — An intact strip of distal cortical bone left attached during the osteotomy; it adds stability and lowers complication risk versus complete detachment.

Distalization — A TTO that moves the tubercle distally to correct patella alta; often requires complete tubercle detachment.

HHD — Hand-held dynamometer; a portable device for objective strength measurement.

ITB — Iliotibial band.

LSI — Limb Symmetry Index; the operative limb's value as a percentage of the contralateral limb (operative ÷ contralateral × 100).

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

MPFL — Medial patellofemoral ligament; the primary passive restraint against lateral patellar translation.

NMES — Neuromuscular electrical stimulation; used to augment quadriceps activation.

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

PROM — Passive range of motion; the therapist or a strap moves the joint while the patient stays relaxed.
ROM — Range of motion.
SLR — Straight-leg raise.
TTO — Tibial tubercle osteotomy.

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.

Palo Alto Medical Foundation · Sutter Health · KevinRothMD.com