KNEE TIBIAL TUBERCLE TRANSFER POST-OPERATIVE GUIDELINE

The following Tibial Tubercle Transfer (TTT)/ Tibial Tubercle Osteotomy (TTO) guideline was developed by HSS Rehabilitation. Progression is both criteria-based and patient specific. Phases and time frames are designed to give the clinician a general sense of progression. Healing of the osteotomy site and concomitant procedures such as cartilage procedure, lateral release, medial patellofemoral ligament repair/reconstruction, as well as chronicity of the condition will alter the guidelines. Patients with distalization of the tibial tubercle will maintain a non-weight bearing (NWB) status for 6 weeks.

FOLLOW SURGEON MODIFICATIONS AS PRESCRIBED

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HSS

KNEE TIBIAL TUBERCLE TRANSFER POST-OPERATIVE GUIDELINE

Acute Care Phase (Ambulatory Surgery): Day of Surgery

PRECAUTIONS

- Avoid prolonged sitting, standing, and walking
- Ambulation with brace locked in extension and appropriate assistive device (AD)
- Weight bearing restrictions can range from NWB to toe touch weight-bearing (TTWB): follow surgeon orders
- Avoid pain with exercises and painful activities
- Avoid applying heat to knee
- No open chain knee extension (KE)
- Do not put a pillow under the operated knee for elevation, elevate the entire leg

ASSESSMENT

- Mental status: alert and oriented x 3
- Numeric pain rating scale (NPRS)
- Wound status
- Edema
- Post-anesthesia neurovascular screening
- Passive range of motion (PROM)/ active assisted range of motion (AAROM) of knee flexion (KF) in sitting (follow surgeon guidelines for ROM)
- Functional status including ability to manage brace, AD, gait and transfers
- Understanding/independence in home exercise program (HEP) and precautions

TREATMENT RECOMMENDATIONS

- Patient education
  - Cold therapy using unit recommended by surgeon
  - Edema management: demonstrate proper elevation techniques
  - Activity modification
  - Brace management
  - Initiate and emphasize importance of HEP
- Transfer training: bed mobility and sit to stand with AD
- Gait training: NWB/TTWB (as per surgeon) with AD and brace locked in extension on level surfaces and stairs
- HEP to include:
  - Quadriceps sets with towel roll under knee, gluteal sets, ankle pumps
  - Seated knee AAROM KF (0°-90° degrees by 4 weeks post-operative)
  - Passive KE with towel roll under heel

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CRITERIA FOR DISCHARGE FROM HOSPITAL

- Independent ambulation with appropriate assistive device and brace locked in extension on level surfaces and stairs
- Independent brace management
- Independent with transfers
- Independent with HEP

EMPHASIZE

- Reduce edema (use cooling machine/cold pack)
- Quadriceps contraction
- Independent transfers
- Gait training with appropriate assistive device and brace locked in extension
- PROM/AAROM KF
- Education on appropriate balance of activity and rest

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KNEE TIBIAL TUBERCLE TRANSFER POST-OPERATIVE GUIDELINE

Post-Operative Phase 1: (Weeks 0-6)

PRECAUTIONS

- Follow surgeon prescription for weight-bearing (WB) progression
- Avoid AROM KE
- Avoid applying heat to the knee
- Monitor response to weight bearing and adjust accordingly
- Avoid provocation: pain, quadriceps inhibition, joint effusion, active inflammation
- KF ROM as per surgeon guidelines
- Be mindful of concomitant procedures: Medial patellofemoral ligament reconstruction (MPFLR), articular cartilage procedure, osteotomy
    - STOP: Follow more conservative guideline
- Gait**:** Ambulation with brace locked in extension: progress WB at 4 weeks for TTO and at 6 weeks for distalization per surgeon recommendation

ASSESSMENT

- Lower Extremity Functional Scale (LEFS)
- International Knee Documentation Committee (IKDC)
- Numeric Pain Rating Scale (NPRS)
- Neurovascular assessment
- Wound and skin status
- Edema
- Thigh girth
- Quadriceps activation
- Knee AAROM flexion with goal of 90° by week 4 with progressive ROM
- Patella mobility (per surgeon)
- Proximal strength
- Gait and tolerance to WB

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TREATMENT RECOMMENDATIONS

- Patient education: emphasize patient compliance with HEP and WB precautions/progression
  - NWB x 4 weeks with brace locked in extension with crutches on level surfaces and stairs (per surgeon)
  - Distalization: NWB x 6 weeks with brace locked in extension with crutches on level surfaces and stairs (per surgeon)
  - Progressive WB at 4 weeks (6 weeks if distalization) with brace locked in extension with crutches on level surfaces and stairs (see Appendix 1)
    - Progress 20 lb. every 2 days
    - If pain with progression, go back to previous weight
    - If pain at osteotomy site, contact surgeon immediately
  - Cryotherapy: home cold therapy unit
  - Bone stimulator: 20 minutes, 2-3x/ day
  - Home electrical stimulation for quadriceps re-education: towel roll under knee, as needed
- Seated knee ROM exercises
  - AAROM KF at edge of bed
  - PROM KE in supine
- Quadriceps set with towel roll under knee, with electrical stimulation
- Patella mobilization as per surgeon guidelines
- Hip progressive resisted exercises (PREs): e.g. pain-free straight leg raise (SLR)
- Distal strengthening: e.g. ankle plantarflexion with resistance band
- Flexibility exercises: e.g. hamstrings, gastrocnemius
- Consider blood flow restriction (BFR) program with FDA approved device and qualified therapist if patient cleared by surgeon
- Short crank bicycle if achieved ROM 80°-90° KF and WB initiated at 4 weeks

CRITERIA FOR ADVANCEMENT

- Radiographic evidence of adequate healing and clearance from surgeon
- Fair quadriceps contraction
- Good patellar mobility
- ROM: 0° KE to ≥90° KF
- 0/10 NPRS pain at rest
- Able to SLR pain-free without quadriceps lag

EMPHASIZE

- NWB x 4-6 weeks if distalization was performed
- Improving quadriceps contraction
- Controlling pain/effusion
- PROM KE
- KF > 90° at 4 weeks
- Compliance with home instructions: cold therapy unit, bone stimulator, quadriceps re-education with electric stimulation unit

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KNEE TIBIAL TUBERCLE TRANSFER POST-OPERATIVE GUIDELINE

Post-operative Phase 2: (Weeks 7-12)

PRECAUTIONS

- Avoid provocation of pain, inflammation, quadriceps inhibition, joint effusion
- Concomitant procedures: MPFLR, articular cartilage procedure, osteotomy
    - Follow more conservative guideline
- Pathological gait pattern (quadriceps avoidance; bent knee)
- Do not perform AROM open chain KE (per surgeon)
- Avoid painful arcs of motion
- Avoid discharge of AD too soon
- Avoid pivoting or turning with foot planted

ASSESSMENT

- LEFS
- IKDC
- NPRS
- Neurovascular integrity
- Wound, skin, scar status
- Edema (girth and descriptive)
- Thigh girth
- Quadriceps activation
- Tolerance to WB
- Knee ROM flexion/extension
- Patellar mobility (per surgeon)
- Proximal strength
- Gait mechanics with appropriate AD and brace use
- Single leg stance (SLS): alignment and control
- Current level of activity: monitor step count

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TREATMENT RECOMMENDATIONS

- Patient education: activity modification, progression of gait training, cryotherapy
- Patellar mobilization, as per surgeon guidelines
- ROM exercises
  - AAROM KF, progress from seated to stair ROM
  - Maintain full PROM KE
- Gait training (See Appendix 1)
  - Normalize gait pattern with brace open or functional brace and AD to ensure quadriceps control during loading response; hydro–treadmill (given adequate wound healing) or anti-gravity treadmill; retro-walking to encourage neuromuscular control with KF during loading response
  - Emphasize heel toe gait pattern with AD and brace open to 90° or functional brace
  - Determining factors to unlocking post-op brace or applying functional brace include:
    - Adequate quadriceps control as demonstrated by SLR without a quadriceps lag or pain
    - Ability to achieve KE and KF adequate for gait
    - Surgeon preference
  - Determining factors to discharge AD
    - No quadriceps avoidance during loading response
    - Tolerance to load: pain, edema
- Quadriceps strengthening progression:
  - Continue with NMES and/or biofeedback, quadriceps sets/SLR, as needed
  - Leg press: monitor arc of motion and for compensation (bilateral progressing to single leg to eccentric)
  - Leg press for static loading with knee unlocked (soft knee)
  - Initiate forward step up (FSU) progression: 4-6 inch step with adequate strength (without compensation)
- Stationary bicycle
  - Progress from short crank to standard bike as appropriate
- Flexibility exercises: evaluation-based
- Proximal and core strengthening progression
- Hydrotherapy for single leg (SL) alignment and stability, proximal strengthening, functional strengthening
- Initiate balance and proprioceptive training:
  - double limb support on progressively challenging surfaces
  - progress to SL support on level surface only with demonstration of good alignment, stability and neuromuscular control
- Advance HEP as tolerated
- Continue phase 1 exercises, as appropriate

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CRITERIA FOR ADVANCEMENT

- ROM 0° KE→ 130° KF
- Normalized gait pattern without AD
- Good quadriceps contraction (no gluteal compensation)
- Good patellar mobility
- Postural stability, alignment and neuromuscular control in SL stance
- 0/10 pain with ADLs and therapeutic exercise
- Independent with HEP

EMPHASIZE

- Symptom control with ADLs and therapeutic exercise
- Minimizing knee effusion
- Normalized gait pattern
- Postural stability, alignment, neuromuscular control in SL stance

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KNEE TIBIAL TUBERCLE TRANSFER POST-OPERATIVE GUIDELINE

Post-operative Phase 3: (Weeks 13-24)

PRECAUTIONS

- Avoid provocation of pain and active inflammation/effusion, quadriceps inhibition
- Avoid overloading the joint
- Do not perform AROM open chain KE (per surgeon)
- Avoid “too much, too soon” progression
- Avoid poor movement quality and strategies
- Monitor for secondary complaints resulting from compensations

ASSESSMENT

- LEFS
- IKDC
- NPRS
- Edema (girth)
- Thigh girth
- Scar mobility
- Knee ROM flexion/extension
- Patellar mobility (per surgeon)
- Apprehension
- Gait pattern and tolerance to weight bearing
- Quadriceps activation
- Proximal and distal ROM, flexibility
- Proximal strength
- SLS: alignment and control
- Function:
    - Squat: pain-free, movement strategy, depth, alignment, symmetry
    - FSU: pain, alignment, compensations
- Performance of HEP
- HSS Return to Sport Testing (3 month)

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TREATMENT RECOMMENDATIONS

- Patient education: activity modification (monitor step count), individualized, and cryotherapy
- Strength progressions: double leg (DL) to SL
    - Quadriceps strengthening: progress as tolerated
        - Squat progression
        - FSU progression
        - Eccentric quadriceps strength:
            - Eccentric leg press
            - SL squat to chair with support of opposite foot
            - Forward step down (FSD) progression
    - Proximal strength
        - Bridging progression
        - Standing clam shell, clock
        - RDL, windmill, lawn mower
        - Core training (planks, side planks, Sahrmann progression)
- Consider BFR program with FDA approved device and qualified therapist if patient cleared by surgeon
- ROM exercises as needed
- Flexibility as needed
- Gait training to emphasize heel-toe gait pattern and loading response
- Balance progression with postural alignment and neuromuscular control:
    - static to dynamic, introduce different planes of motion, challenging surfaces
- Functional movement: assess for quality of movement
- Cross training: elliptical trainer, bicycle (80 RPM), swimming (avoid breaststroke and butterfly due to frog kick)

CRITERIA FOR ADVANCEMENT

- ROM within normal limits (WNL)
- No pain or edema
- Ability to demonstrate SL functional strength
- Ability to demonstrate alignment, control, stability in SL stance during dynamic activities
- Core stability: SL bridge = 30 seconds, planks = 15-30 seconds
- Able to ascend 6-8 inch step with good control
- Able to descend 6-8 inch step with good control and alignment demonstrated throughout the full arc of motion
- Movement strategy, alignment, symmetry (DL tasks), control (SL tasks) during selected movement patterns
- 70-80% limb symmetry index (LSI) or torque/BW ratio of >1.7 Nm/kg.
    - Consider:
        - hand-held or isokinetic dynamometry
        - 1 repetition maximum or 3 repetition maximum on leg press

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- Quantitative assessments ≥ 90% of contralateral LE
    - Note that contralateral side may be subpar
- Independent with HEP

EMPHASIZE

- Normalized gait pattern
- Identifying and addressing muscle/soft tissue imbalances
- SL strengthening
- Neuromuscular control
- Functional progression
- Quality of movement: symmetry during DL tasks, hip movement strategy, alignment and control during selected movement patterns (squat, SL squat to chair)

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KNEE TIBIAL TUBERCLE TRANSFER POST-OPERATIVE GUIDELINE

Post-operative Phase 4: (Months 6-8)

PRECAUTIONS

- Avoid pain with therapeutic exercise and functional activities
- Follow surgeon instructions when performing AROM open chain KE
- Ensure adequate strength, functional strength, ROM, and flexibility for progression
- Avoid activity level greater than ability

ASSESSMENT

- LEFS
- IKDC
- NPRS
- Edema
- Thigh girth
- Patellar mobility and apprehension
- LE flexibility
- Eccentric quadriceps strength
- SL ability: alignment and control
- Neuromuscular control during SL tasks
- Fundamental LE strength
- Function:
    - Squat: pain-free, movement strategy, symmetry, depth, alignment
    - FSU/FSD: pain-free, alignment, control
- HSS Return to Sport Testing (6 month)

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TREATMENT RECOMMENDATIONS

- Continue to advance LE strengthening, flexibility, dynamic SL stability and agility programs
- Continue to address muscle imbalances: evaluation-based
- Advance core stability
- Cross training
- Plyometric program initiation progressing from DL to SL and from vertical to horizontal
    - Progress 1 exercise per week (see Appendix 2)
    - Vertical jumping progression
        - DL box jump → jump in place → drop jump
        - SL box jump → jump in place → drop jump
    - Horizontal jumping progression (DL to SL)
        - Forward hops
        - Side to side hops
        - Broad jump
        - Side to side jumps
- Running program initiation on non-consecutive days with interval training
    - Utilize antigravity treadmill if available

CRITERIA FOR DISCHARGE OR ADVANCEMENT TO PHASE 5 IF RETURNING TO SPORT

- Medical clearance by surgeon to initiate return to sport progression
- HSS Return to Sport Assessment
- Successful completion of plyometric training
- Strength and flexibility maximized as to meet demands of individual's sport activity
- Ability to demonstrate hip strategy, symmetry (DL tasks), control (SL tasks) and alignment during selected movement patterns: squat, FSD, jumping tasks, SL squat
- Cardiovascular fitness to meet demands of sport
- Lack of apprehension with sport specific movements

EMPHASIZE

- Quality of movement
- Functional progression
- SL strength

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KNEE TIBIAL TUBERCLE TRANSFER POST-OPERATIVE GUIDELINE

Post-operative Phase 5: (Months 8-10+) Return to Sport

PRECAUTIONS

- Avoid pain with therapeutic exercise and functional activities
- Ensure adequate strength, functional strength, ROM, flexibility, fitness when returning to sport
- Ensure adequate rest
- Note the importance of gradual return to participation with load and volume monitoring under guidance of physical therapist, exercise physiologist, physician, certified athletic trainer (ATC) and coach
- Avoid premature or too rapid full return to sport

ASSESSMENT

- LEFS
- IKDC
- NPRS
- Edema
- Thigh girth
- Patellar mobility and apprehension
- LE Flexibility
- Eccentric quadriceps strength
- SL ability: alignment and control
- Neuromuscular control during SL tasks
- Proximal strength
- Function
    - Squat for pain-free, movement strategy, symmetry, depth, alignment
    - FSU/FSD: pain-free, alignment, control
- Independence with HEP
- HSS Return to Sport Testing (9-12 month)

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TREATMENT RECOMMENDATIONS

- Gradually increase volume and load to mimic load necessary for return to sport or activity
- Progress movement patterns specific to patient's desired sport or activity
- Progression of agility, cutting, and deceleration (see Appendix 3)
- Increase cardiovascular load to match that of desired activity
- Collaborate with ATC, performance coach/strength and conditioning coach, skills coach and/or personal trainer to monitor load and volume with return to participation
- Consult with referring surgeon on return to sport timing including any recommended limitations
- Continue to advance LE strengthening, flexibility, dynamic SL stability, core stability and agility
- Plyometric program advancement with surgeon clearance
    - Horizontal jumping progression: broad jump to hop to opposite to SL hop
- Running program progression

CRITERIA FOR DISCHARGE

- Medical clearance by surgeon to initiate return to play progression
- Quadriceps LSI >90% and torque/BW ratio >2.5 Nm/kg
- Hop test $\geq$ 90% limb symmetry with good alignment, strategy and control
- Lack of pain and apprehension with sport specific movements
- Maximize strength and flexibility as to meet demands of individual's sport activity
- Ability to decelerate with good control and alignment on SL
- Cardiovascular fitness to meet demands of sport
- Flexibility to meet demands of sport
- Independent with gym program for maintenance and progression of therapeutic exercise program
- Demonstrates good quality of movement with required sports-specific activities

EMPHASIZE

- Return to participation
- Collaboration with Sports Performance experts

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KNEE TIBIAL TUBERCLE TRANSFER POST-OPERATIVE GUIDELINE

Appendix 1: Weight Bearing Progression

Tibial Tubercle Osteotomy Weight Bearing (WB) Progression

- Weeks 0-4
  - NWB with crutches and brace locked in extension
- Weeks 4-6
  - Progressive WB with crutches and brace locked in extension
    - Add 20 lbs every 2 days with crutches and brace locked in extension (use scale for accuracy)
    - If painful when increasing WB return to previous WB (e.g., if painful at 40 lbs, decrease to 20 lbs)
    - If painful at osteotomy site (tibial tubercle) contact surgeon
- Weeks 6-8
  - Full weight bearing (FWB) with brace locked, no crutches, or WBAT with brace open and crutches (as tolerated means to knee's tolerance- watch for increase in swelling, pain, stiffness, warmth); at physical therapist's (PT) discretion
- Weeks 8-10
  - WBAT with crutches to cane and brace unlocked or no brace

Tibial Tubercle Osteotomy with Distalization WB Progression

- Weeks 0-6
  - NWB with crutches and brace locked in extension
- Weeks 6-8
  - Progressive WB with crutches and brace locked in extension
    - Add 20 lbs every 2 days with crutches and brace locked in extension (use scale for accuracy)
    - If painful when increasing WB return to previous WB (e.g., if painful at 40 lbs, decrease to 20 lbs)
    - If painful at osteotomy site (tibial tubercle) contact surgeon
- Weeks 8-10
  - FWB with brace locked, no crutches, or WBAT with brace open and crutches (to knee's tolerance- watch for increase in swelling, pain, stiffness, knee warmth); at PT's discretion
- Weeks 11 and 12
  - WBAT with crutches to cane and brace unlocked or no brace

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KNEE TIBIAL TUBERCLE TRANSFER POST-OPERATIVE GUIDELINE

Appendix 2: Phase 4 – Examples of Plyometrics Progression

Example 1

- Week 1: Onto box
- Week 2: In place and jumping rope
- Week 3: Drop jumps
- Week 4: Broad jumps
- Week 5: Side to side hops
- Week 6: Hop to opposite

Example 2

1. Bilateral plyometrics on leg press
2. Bilateral jumps onto a 6” box
3. Bilateral jumps in a cross pattern, e.g., clockwise (below right) and counterclockwise (below left)

1	**2**
4	**3**

1	**4**
2	**3**

4. Bilateral jumps on/off box 6” / 8” / 12”
5. Unilateral jumps in a cross pattern, e.g., clockwise (below right) and counterclockwise (below left)

1	**2**
4	**3**

1	**4**
2	**3**

6. Unilateral jumps on/off box

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Appendix 3: Phase 5 – Agility

- Throughout agility program, monitor for knee valgus, hip strategy, compensatory movement, apprehension and good knee control before advancing to higher level activity.
- Progress drills from non-contested to contested drills; non-contact scrimmage before contact scrimmage then live play.
- Time progression (note: may need to spend more than one week at each phase to ensure quality of movement)
    - Week 1: Forward running, back pedaling, side shuffles, cariocas- 50% effort
    - Week 2: Increase to 75% effort
    - Week 3: 45° cuts, figure eight, circle cone- 50% effort
    - Week 4: Increase to 75% effort
    - Week 5: Four corners, T-drills, 90° cuts, acceleration/deceleration- 50%-75% effort
    - Week 6: Increase to 80% - 100% effort
    - Week 7: Reaction drills- 80%-100% effort
    - Week 8: Sports-specific/dual tasking drills

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Created: 8/2020
Revised: 9/2022; 9/2024

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