



Standard of Care: Tibial Tubercle Osteotomy

Physical Therapy Management of the Patient Following Tibial Tubercle Osteotomy (TTO)

ICD 9 Codes

The following are examples of primary medical and secondary signs and symptoms ICD 9 Codes which can apply to the medical and rehabilitation diagnosis of a patient of this case type.

Consult the current year ICD 9 book at your worksite for other codes that may best support and describe your individual patient.

Osteoarthritis of the knee	715.16
Internal derangement of knee	717.9
Chondromalacia Patella	717.7
Articular cartilage disorder	718.0
Pathological dislocation	718.2
Recurrent dislocation of joint	718.3
Contracture of joint	718.4
Ankylosis of joint	718.5
Knee pain	719.46
Difficulty in Walking	719.7
Osteochondropathies	732.4

Case Type/Diagnosis

Physical Therapy Practice Patterns

Pattern D: Impaired joint mobility, muscle performance, and range of motion associated with connective tissue dysfunction.

Pattern G: Impaired joint mobility, muscle performance, and range of motion associated with fracture.

Pattern H: Impaired joint mobility, motor function, muscle performance, and range of motion associated with joint arthroplasty.

Pattern I: Impaired joint mobility, motor function, muscle performance, and range of motion associated with bony or soft tissue surgery.

Background

Tibial tubercle osteotomy (TTO) is a procedure for treating patients with patello-femoral pain and dysfunction. The premise of tubercle surgery is that select patients with patello-femoral problems have an abnormal or suboptimal position of the tubercle. This suboptimal position for distributing force is corrected by surgically moving the tubercle to a new position thereby performing a TTO¹. Patellar mal-tracking, frequently associated with malposition of the tibial tubercle, often leads to the diagnosis of chondromalacia patella (softening of the articular cartilage) which may lead to arthritic damage to the patello-femoral joint of the knee².

In 1888, Cesar Roux was the first surgeon to describe a subperiosteal transfer of the patellar tendon for a young patient with recurrent patellar dislocation, thus paving the way for this surgical procedure³. The multifaceted problems of the patello-femoral joint still present a complex challenge to the surgeon today. Although there are many surgical options for treatment, no one method is universally successful¹. Present techniques, that attempt to optimize joint stability and contact area while decreasing articular cartilage stress, continue to evolve¹.

The purpose of a TTO is to correct the anatomy and improve the biomechanics of the knee joint by moving the tubercle to a new position so that the patella will track, align and glide correctly across the articular surface of the distal femur known as the trochlea. The general concepts of physical therapy management following TTO include:

- Regaining normal range of motion
- Regaining of muscle strength, performance and balance
- Reducing and alleviating pain
- Enabling full function and hence improving quality of life

The time for recovery and rehabilitation and the intensity of physical therapy treatment interventions may vary based on the severity of the underlying pathology and other surgical and patient related factors.

Although other models for the rehabilitation following this surgery do exist⁴, this standard of care applies to the rehabilitation of patients following a tibial tubercle osteotomy (TTO) at Brigham and Women's Hospital (BWH). It serves as a resource guide for physical therapy management of this patient population according to specific practices at Brigham and Women's Hospital (BWH) in the acute care and outpatient settings.

Indications for Treatment

The patella is a sesamoid bone, in the front of the knee that is embedded in the quadriceps tendon and acts to increase the biomechanical leverage of the quadriceps. As the knee flexes and extends the convex patella glides superiorly and inferiorly in the trochlear groove. Because the patella 'floats' within the quadriceps, proper tracking of this bone in the trochlear groove is dependent on proper muscle balance. Patellar tracking is governed by a complex interaction between soft tissues and bony structures⁵. Individuals, who are candidates for a TTO, frequently have damage

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to the cartilage of the patello-femoral joint caused by patellar mal-tracking. The mal-tracking of the patellar may lead to softening of the cartilage, which leads to arthritic damage to the patello-femoral joint of the knee. This contributes to patello-femoral pain and dysfunction. Patellar mal-tracking is the result of one or a combination of conditions such as an abnormal position of the tibial tubercle, lateral patellar tracking, or an excessively long tendon causing the tendon to slide too high on the knee joint (patellar alta).

According to Koeter, a Dutch Orthopedic surgeon, specific indication for surgery is not just failed conservative treatment, but specific anatomical abnormality. He attests that although patella function results from the complex interaction of many factors, patellar instability remains a mechanical problem. One of the mechanical factors that can result in lateral instability is an increased distance between the trochlear groove (TG) and the tibial tuberosity (TT). Koeter states a distance of 15mm or greater is considered pathological and an indication for surgery in symptomatic patients. According to Gommoll, Minas, Farr and Cole a TT-TG distance of <15 mm is considered normal; values >20mm are abnormal and should be considered for a tibial tubercle osteotomy. Other factors include insufficiency of the medial patellar femoral ligament, trochlear dysplasia and patella alta⁵. Quadriceps weakness and wasting, especially of the vastus medialis is also commonly associated with patello-femoral symptoms⁶.

According to Hocking et al, the only absolute contraindication to performing a TTO is when there is severe tibial osteolysis involving the tibial tubercle. In these cases the concern is that the osteotomized fragment may either fracture intraoperatively or postoperatively or the fragment may progress to a nonunion, leading ultimately to failure of the extensor mechanism. Poor soft tissue coverage over the site of the tibial tubercle osteotomy as in the case in very thin patients is a relative consideration not to perform the surgery⁸.

Patient Population

According to Buuck and Fulkerson the most common patient profile is an individual between the ages of 15 to 40 years with a long history of patello-femoral symptoms. These individuals will demonstrate radiographic evidence of patellar subluxation or tilt (rotation); and, upon arthroscopy will show lesions of the patellar articular surface presumably related to abnormal shear stress and deficient contact caused by the malalignment³. On examination patients typically present with recurrent dislocations, partial dislocations or pain in front of the knee. Pain occurs especially with situations that increase patello-femoral forces such as prolonged sitting, kneeling, ascending/descending stairs or ambulating on uneven surfaces.

Pre-Operative Evaluation

Tibial tubercle osteotomy requires a comprehensive evaluation of the entire lower extremity, since all of the imbalances associated with the patello-femoral joint cannot be assigned solely to the position of the tubercle. Because a precise preoperative diagnosis is required, computer tomography (CT) scanning is used to determine an accurate measure of the tibial tuberosity/trochlear groove distance⁵. Other common measurements of tubercle relative position

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are the Q angle and the tubercle sulcus angle¹. The Q angle is measured from the iliac crest to the center of the reduced patella to the center of the tubercle either in extension or low levels of flexion¹.

In addition to a complete medical evaluation, a thorough physical therapy evaluation and treatment program should precede tubercle surgery. The intent of conservative management is to assess muscle imbalances in order to restore the normal biomechanics of the knee by attempting to optimize joint stability and contact area while decreasing articular cartilage stress.

A comprehensive rehabilitative program at the pre-operative phase should include: a stretching regime to restore flexibility of the hamstrings, quadriceps and iliotibial band, patellar mobilizations, a strengthening program emphasizing the core proximal musculature, specifically the hip abductors and external rotators and gait training focusing on avoidance of in-toeing gait⁶. During this period, the surgeon and the rehabilitation provider will learn the patient's postoperative rehabilitation potential in order to assist the patient in establishing optimal outcome expectations.

Although infrequent, TTO may also be indicated in patients undergoing either primary or revision total knee arthroplasty to assist the surgeon in achieving adequate exposure of the knee. In a study of 1400 revision total knee replacements, only 3% involved a TTO⁸.

In the event that the areas of damage are localized, cartilage cell transplantation can be added to the procedure to improve the final result (please refer to the Brigham and Women's Hospital Department of Rehabilitation Services Standard of Care for Autologous Chondrocyte Implantation)². The TTO may also be performed in combination with other osteotomies such as a high tibial osteotomy (HTO).

Surgical Procedure

The surgery is accomplished in two stages. In stage one the surgeon uses an arthroscope to accurately diagnose the location of the cartilage loss on the patella or the trochlea and determine whether or not TTO surgery would be indicated and helpful in the patient's pain and symptoms. If it is determined that the arthritic changes are localized then stage two of the surgery is performed. This involves an open surgical procedure as described below².

In rare instances the trochlear groove is either developmentally dysplastic or so degenerated and damaged from excessive wear due to mal-tracking that a trochleoplasty may be required. Trochleoplasty involves reshaping the groove by chiseling away cartilage and bone and advancing the articular linings to protect the surfaces from rubbing bone on bone².

A TTO is a surgical fracture of the tibial tubercle at the site of the patella tendon attachment. During this surgery, the tibial tubercle is relocated so that the patella will track centrally in the trochlear groove in order to reestablish and maintain effective tracking and contact area of the

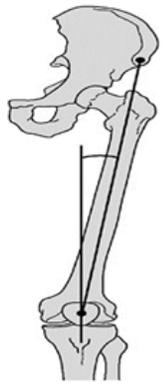


Figure 1: The direction of pull of the quadriceps on the patella is described in terms of the Q angle, the angle formed by the intersection of a line drawn from the center of the patella to the tibial tuberosity and a line drawn from the center of the patella to the anterior superior iliac spine.⁷

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patello-femoral joint. The goals are to normalize the distance between tibial tuberosity (TT) and the trochlear groove (TG) distance and transfer stress from areas of chondrosis to areas of intact cartilage and increase patello-femoral contact by improving congruity and decreasing contact stress⁶. This will delay degeneration of the articular surfaces. The ability to vary the angle of the osteotomy gives the surgeon a wide variety of options in treating patients with different types of patello-femoral malalignment³.

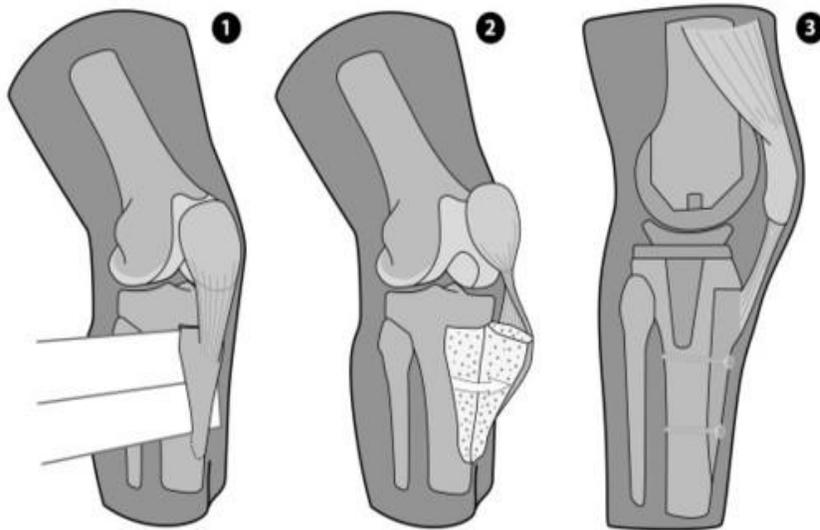


Figure 2: 1) Cut at the proximal end of the osteotomy is made with a thin osteotome. 2) Distal part of the quadriceps tendon, the patella, the patellar ligament and the tibial tuberosity is retracted. 3) Cortical screws used for fixation⁹.

Over the years there have been many variations and advancements of tibial tubercle osteotomies. Presently the procedure most commonly employed in the United States is that of an oblique osteotomy, which allows anterior elevation and medialization of the tibial tubercle to decompress the patello-femoral joint in its usual wear pattern. This is referred to as the Fulkerson type osteotomy.²

Tibial tubercle osteotomy begins with a longitudinal incision along the anterior surface of the knee. This is often combined with a release of the tight tissues laterally along with the advancement of the loose medial tissues specifically the vastus medialis oblique (VMO) quadriceps muscle referred to as VMO advancement and a possible repair or reconstruction of the medial patello-femoral ligament¹. The bone is then cut obliquely at the insertion of the patella tendon at the tibial tubercle after the muscle compartments have been stripped off of the bone to protect them from injury². In order to avoid fracture of the tibial tubercle, the osteotomy needs to be a straight cut and of adequate length and width. Koeter et al recommend a length of at least 5cm and a thickness of .75cm¹⁰.

Once the bone has been mobilized or relocated, and the soft tissues above the patella have been balanced, then the tibial tubercle is reattached with two or three screws until the bone unites. These screws are usually left in place unless they become painful for the patient².

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Outcomes

The Cartilage Repair Center™ reports that it takes about six to nine months before patients no longer think about their surgery and experience 90% pain relief as compared to their pre-operative condition. On average, 80% pain relief occurs for the first five years following surgery and 60% at eight years. Many patients are able to participate in outdoor activities for 10-15 years before requiring any additional intervention. Approximately one-third of patients will require a total knee replacement 10 years after a TTO if the initial diagnosis was for chondral loss². If the TTO was performed for instability in the absence of a cartilage defect, the longevity of this procedure is enhanced².

In a four to twelve year follow up study of 36 patients, good to excellent results were reported by 86% of patients who underwent anteromedialization of the tibial tubercle. Seven of the patients were able to return to heavy labor, nine to moderate work and 18 to light duty³.

In this same study 67% of the patients were satisfied with their level of recreational activity at follow up. Thirty-six percent returned to running or court sports and four out of five of the high school athletes in the study returned to their sport³.

Evaluation

Medical Record Review

Review the pertinent past medical and surgical history. Attention to pre-operative range of motion (ROM) and strength values for the knee are among the most important data for the physical therapist during the medical history review. It is also imperative to review relevant diagnostic imaging and other tests that lead to the current diagnosis and decision to pursue surgical management. Inquire about presenting signs and symptoms including: duration/severity, impact on function, and any prior management of symptoms, medication, or other conservative means. This information will help with treatment planning and setting realistic short term and long term goals.

History of Present Illness: Per the procedures followed by Brigham and Women's Hospital Rehabilitative Services, post-operative laboratory workup, especially hematocrit and INR level, need to be monitored when evaluating patients after a TTO procedure in the acute care setting. INR levels should not exceed 3.0 as this places patients at risk for post-operative hemarthrosis. If the patient's INR is 3.0 or higher, the therapist must consult with the surgical team. In addition review of the operative note is indicated to fully understand the extent of surgery and whether or not additional procedures have been performed. Ideally, the surgical note should delineate exactly where the cartilage lesions (if present) were located. The date of surgery and any post operative complications should be identified. All of this information can be found in the electronic medical record and the patient's chart.

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Social History/Prior level of function: Inquire regarding current vocation, occupational history, home environment, family/caregiver support, and previous use of assistive devices. Information about prior level of function including participation in daily activities, social roles and physical fitness activities are also important components of the social history.

Medications: Review current pharmacological management for individual patients. Common medications used in the acute management of patients following tibial tubercle osteotomy are: bupivacaine, hydromorphone, oxycodone, oxycontin and toradol. Anticoagulants are indicated following surgery and typically include Coumadin. Take note of the route of administration for medications (i.e. via epidural, intravenous (IV), by mouth (PO), etc), as this will ensure safe handling of patients during examination and treatment. On post-op day (POD) #1 mobilizing out of bed may be deferred pending a thorough PT assessment of motor and sensory performance. The effects of the epidural may result in a residual motor and sensory block up to six hours after disconnection.

Physical Examination/Systems Review

Pain: Intensity of pain at rest and with treatment is documented at every patient encounter using the visual analogue scale (VAS) or verbal report scale (VRS). Plan of action such as pre-medication or cryotherapy should also be included in documentation. Other qualitative details of pain that are important to obtain include the location, frequency, alleviating/aggravating factors, and descriptors of pain.

Lines, Tubes, and Devices: The typical patient following TTO on POD #1 will commonly have the following lines, tubes, and positioning devices:

- Epidural catheter, femoral nerve catheter, and/or PCA pump for pain medication administration.
- Foley catheter.
- Nasal canula for oxygen therapy.
- Cryocuff over the knee joint for cryotherapy.
- Venodyne (compression) boots for DVT prophylaxis.
- Telemetry/cardiac and/or continuous oxygen saturation monitors if an epidural catheter is in place.
- Continuous passive motion (CPM) machine. The CPM machine is started on POD #1 to help restore range of motion and is typically set at 30 degrees of flexion and advanced 10 degrees per day as tolerated. If combined with additional surgical procedures it is necessary to follow the most conservative protocol.
- An adjustable hinged knee brace is used to support the operative extremity, assist in stabilizing the knee joint and to maintain the operative knee locked in extension for all mobility, transfers, and ambulation. The brace may be unlocked when the patient is in the CPM, in bed or when sitting to encourage knee flexion.
- Towel roll under the ankle of the operative leg while in bed to maintain knee extension.
- Hemovac or Jackson Pratt (JP) drain to extract excess fluid from the operated knee joint typically removed by POD #2.

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Musculoskeletal

- Anthropometrics: Body Mass Index (BMI) and/or height and weight of the patient should be included in the systems review to assist with guiding your examination.
- ROM: Goniometric measurement of the hip and knee joints and gross assessment of ROM of the upper extremity (UE) joints are to be documented in the systems review. Since the tibial tubercle is the anatomical site for the attachment of the quadriceps muscle, **active extension of the knee is contraindicated and the patient is allowed only passive knee extension.** Active and passive ROM of the operative knee is measured, to include extension (while positioned in supine over ankle towel roll), and flexion while seated. Limitations in ROM are also documented to further describe the end-feel of the joint (i.e. firm, bony, empty/painful).
- Joint mobility: Assessment of patello-femoral joint play of the operative knee is often indicated in the post-operative phase. However, depending on surgeon preference, patello-femoral joint mobilization may begin as soon as POD#1.
- Strength: Manual muscle testing (MMT) of the upper extremity muscles and non-operated lower extremity muscles should be documented. For the operated extremity, special attention is given to assess quadriceps activation by observing the quality of an isometric quadriceps contraction (i.e. trace, poor, fair, good) via palpation and observation. It is well established that quadriceps weakness, along with pain, is one of the first symptoms reported by patients with knee osteoarthritis¹¹. Even though joint surgery is successful at eliminating many joint related factors, reduced muscle mass and strength reduction are not addressed by surgical interventions. It has been found that the quadriceps cross-sectional area at 10 days post-operatively is decreased by 10% as compared to preoperatively.¹² Therefore, attention to these impairments is important in developing an appropriate treatment plan and achieving good outcomes.
- Posture/alignment: Assessment and documentation of leg length discrepancy and/or posture in supine, sitting, or standing are important information to capture from a systems review. For example: whether the patient's knees (both operative and non-operative) are in valgus or varus alignment, as well as noting the resting position of the LE (neutral or rotated).
- Gait: Qualitative gait assessment is detailed with statements on the type, pattern, and biomechanics of gait, as well as the type of assistive device used. Changes in stride and step length, as well as cadence should be documented in patients after TTO. Prior to the gait assessment patients are instructed in techniques to maintain their weight bearing precautions and the use of assistive devices. Patients are typically ordered by the surgeon to be either touch down (TDWB) or partial weight bearing (PWB).

Neuromuscular

- Sensation: Light touch sensation is assessed in bilateral LE especially on POD #1-2 to ensure that there is complete resolution of the epidural anesthesia and no nerve damage. Residual effects of the epidural anesthesia may last up to six hours following discontinuation of the medication.
- Proprioception: Knee joint proprioceptive testing may be indicated depending on the stage of post-operative course.
- Balance: It is important to assess and document both static and dynamic balance in the sitting and standing positions, including the use of UE support. Particularly in the acute post-

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operative phase, standing balance will be impaired secondary to the patients touch down weight bearing precautions, thereby impacting the overall plan of care. In the sub-acute period, patients after TTO should be examined in their ability to perform static and dynamic balance tests with or without assistive devices as appropriate while maintaining and following weight bearing precautions.

Cardiovascular/Pulmonary

- **Vital Signs:** Blood pressure, heart rate, respiratory rate, and peripheral oxygen saturation should be assessed and documented as appropriate during patient encounters based on the patient's symptoms, particularly in the early post-operative days. Anemia and concomitant orthostatic hypotension are common complications immediately after TTO. They can cause clinical symptoms such as shortness of breath, lightheadedness or dizziness, blurred vision, and nausea. The clinical signs include drop in blood pressure with positional changes, tachycardia, diaphoresis, and vomiting. Attention to these signs and symptoms including appropriate documentation is important during the patient examination following TTO, in addition to communication with the clinical team.
- **Endurance:** Examination of activity tolerance by utilizing the rate of perceived exertion (RPE) scale or a gross subjective and objective assessment of fatigue level for transfer and gait activities should be documented for patients s/p TTO.

Integumentary

- **Skin:** Observe the surgical incision and monitor for presence/absence of dressing, discoloration/erythema, drainage, or ecchymosis. The patient's wound is often closed with stitches, staples or steri-strips. The entire lower extremity must also be assessed for areas of skin irritation from use of the hinged knee brace.
- **Edema:** Soft tissue swelling commonly occurs immediately after TTO, as well as in the sub-acute phase. Therefore, the amount of LE edema is documented by gross qualitative assessment, or via circumferential measurements of the knee as appropriate. Following lower extremity surgeries, patients may be at risk for compartment syndrome. Signs of compartment syndrome are edema with excessive pain, and increased skin temperature and firmness. If suspected alert MD and nursing immediately.

Communication, Affect, Mental Status/Cognition, Language, and Learning Style: The patient's level of arousal/alertness, orientation, ability to follow commands, communicate/make needs known, and learning preferences is taken into account and documented in the examination.

Functional Tests and Outcome Measures

The following functional tests and measures may be used in the acute care setting and during the home phase of rehabilitation and at least one of these should be selected in the outpatient setting to assess loco-motor and functional capacity of TTO patients:

- Timed Get Up and Go (TUG)
- Six Minute Walk Test (6MWT)
- Stair Climbing Test (SCT)

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- Lower Extremity Functional Scale (LEFS)
- Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)
- Short-Form-36 (SF-36)

Assessment

Impairment List

Patients following this surgery may demonstrate the following impairments:

- Range of motion
- Muscle performance (including strength, power, and endurance)
- Motor control
- Proprioception
- Balance
- Gait
- Tissue integrity
- Pain tolerance
- Edema control

As a result of these impairments patients may demonstrate the following functional limitations particularly in the first few days of post operative treatment:

- Decreased independence with:
 - Bed mobility
 - Transfers
 - Ambulation
 - Functional activities
 - Basic/Instrumental activities of daily living (B/IADL)
 - Quality of life

Short Term Goals (STGs): Stage One (0-6 weeks)

Short-term goals for this patient population during their acute hospital course (2 to 3 days) are as follows:

- Patients will perform all bed mobility and transfers independently with the use of the most appropriate assistive device.
- Patients will ambulate household distances (50-100 ft) independently with the use of the most appropriate assistive device.
- Patients will negotiate stairs (step-to pattern) with minimal assistance and the use of the most appropriate assistive device.
- Patients will demonstrate a fair to good isometric quad contraction and ability to perform a straight leg raise (SLR).
- Patients will demonstrate LE MMT grades of $\geq 3/5$ to increase independence with bed mobility, transfers, and ambulation.

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- Patients will be independent and able to verbalize/demonstrate donning and doffing the hinged brace.
- Patients will be independent and able to verbalize/demonstrate home exercise programs and activity precautions.

These STGs may vary slightly depending on the patient’s prior functional level, additional procedures performed, and patient’s own personal goals.

Long-Term Goals: Stage Two (6-12 weeks)

The primary goals for this phase are to increase functional mobility while continuing to protect and avoid overloading the graft. The emphasis for PT management is to increase tibial–femoral and patella-femoral mobility and to restore quadriceps control.

Some of the long term goals for this phase are:

- Patients will achieve full weight bearing status with a cane as needed.
- Patients will ambulate community level distances with a cane as needed.
- Patients will negotiate stairs with a reciprocal pattern with a cane as needed.
- Bracing will be discontinued and patients will achieve full range of motion.
- Patients will be participating in outpatient physical therapy and typically participate in the activities and interventions as outlined and described in Stage Two of the Protocol.

Treatment Planning / Interventions

Due to the short length of stay following TTO, the focus of physical therapy (PT) management is on patient evaluation, education, mobility and functional training, as well as interventions to increase ROM and motor control of the articular and peri-articular structures of the knee joint. It is important to keep in mind that ROM, along with proper soft tissue balance is required to ensure proper biomechanics in the knee joint. Therefore, PT must address all impairments in order to ensure good outcomes.

Established Pathway	<input type="checkbox"/> Yes, see attached.	<input checked="" type="checkbox"/> No
Established Protocol	<input checked="" type="checkbox"/> Yes, see below.	<input type="checkbox"/> No

Physical therapy management for patients following TTO at Brigham and Women’s Hospital are guided by the established Tibial Tubercle Osteotomy PT Protocol described below as indicated from Cartilage Repair Center™.

Stage One (0-6 weeks)

The following post-operative activity recommendations from the MD are included in the PT consult for patients following TTO in the acute care setting and continue for stage one of the PT protocol which is 0-6 weeks in duration:

- Primary goals:
 - Increase tibial-femoral and patella femoral mobility
 - Restore quadriceps control.
- Weight bearing status: Usually touch down weight bearing (TDWB) to partial weight bearing (PWB) (<40 lbs pressure)
- Range of Motion: (ROM)
 - **No active knee extension.** Passive ROM for knee extension only.
 - Full PROM and gentle A/AROM for knee flexion.
- CPM and ROM Goals:
 - Usually 0-30 degrees immediately post-operatively then increased 10 degrees per day as tolerated (if additional procedures are performed, follow the most conservative rehabilitation protocol).
 - Minimum 90 degrees flexion by 3 weeks
 - 110 degrees by 6 weeks
 - Full ROM by 12 weeks post-op
- Bracing: Hinged knee brace locked in 0 degrees extension for all mobility and gait. Brace may be unlocked when sitting or in bed.
- Therapeutic Exercise:
 - Quad sets
 - Ankle pumps
 - Glut sets
 - Heel slides with PROM for knee extension
 - Knee flexion in sitting with PROM for knee extension
 - No straight leg raises
 - Stationary bicycle with no resistance once 90 degrees of flexion obtained (~4 weeks)
 - Gentle multidirectional patella mobilizations may commence immediately after surgery or once edema has resolved
- Other Therapeutic Interventions:
 - Cryotherapy with cryocuff or ice packs
 - Electrical stimulation for VMO/quadriceps re-education and biofeedback at home or in an outpatient setting
 - Gentle soft tissue massage to hamstring insertions and supra patellar quadriceps generally 2-3 weeks following surgery

It is important to recognize signs and symptoms of early post-operative complications and consult with other appropriate health care providers. The most common acute complications following TTO are:

- Blood loss requiring transfusion

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- Deep vein thrombosis (DVT)
- Pulmonary embolism (PE)
- Compartment syndrome

If a patient presents during the first few days post-operatively with signs and symptoms related to the above listed complications, physical therapy interventions must be stopped, and the medical team consulted.

Late-onset complications following TTO may include:

- Skin breakdown secondary to the Bledsoe brace.
- Large hematoma formation. Patients are often asked to rest the knee joint, use ice to help decrease the size of the hematoma, and stop taking anticoagulants. If the hematoma does not resolve, patients may need surgical evacuation.
- Wound healing complications in the first few weeks after surgery.
- Infection.
- Non-union of tuberosity.
- Tibial fracture from early, excessive weight bearing.

Stage Two (6-12 weeks)

- Primary Goals:
 - Do not overload the surgical site
 - Increase tibial-femoral and patello-femoral mobility
 - Restore quadriceps control
- Brace: Not indicated.
- Gait: Touch down weight bearing (TDWB) with crutches as needed for 4 more weeks.
- Therapeutic exercise:
 - ROM: Progress towards full AROM equal to contra-lateral side
 - Stationary bicycling with very low resistance as tolerated
 - Treadmill (forward and retro-walking), Nordic Track, and elliptical machine permitted
 - Gait training
 - Aquatic therapy: flutter/straight leg scissor kick and running in water permitted
 - Continue gentle closed-chain LE strengthening through functional range - terminal knee extension 0-40 degrees and 120-70 degrees extension from flexed position
 - Open-chain terminal extension with resistance is **not** permitted
- Other therapeutic interventions:
 - Continue multi-directional patella mobilization as needed
 - Continue cryotherapy and soft tissue mobilization for edema control
 - Electrical-stimulation for VMO/quadriceps muscle re-education/biofeedback as needed
 - Ultrasound to hamstring and quadriceps insertions and supra-patellar regions (see BWH ultrasound procedure for parameters)
 - Soft tissue mobilization and massage to scar, hamstring insertions, quadriceps, patella gutters, and supra/infra-patellar regions

Note:

- Activity level should be modified if increased pain, catching, or edema occurs.
- Activities/exercises with excessive patello-femoral compressive forces should be avoided. For example: deep squats, open chain terminal knee extensions with or without resistance.
- **No running or plyometrics including activities involving jumping until 9-12 months post surgery.**

After stage two, protocols for patients s/p TTO are individualized per patient needs following evaluation by the surgeon in the clinic.

9-12 Months Post Surgery

Patients may resume full functional, recreational and sports related activity as tolerated including activities involving running, jumping and plyometrics.

Re-evaluation

The average inpatient length of stay following TTO is 2-3 days. Patients are re-evaluated on a daily basis with respect to their range of motion, quality of movement, muscle contraction, pain intensity, gait quality, and functional independence. If the patient's hospital course is prolonged due to complications, a formal re-evaluation will be performed every 7-10 days to re-assess progression towards the previously outlined goals and outcomes. In the outpatient setting, the patient is to be formally re-evaluated every 30 days, however, impairments such as ROM should be monitored at each visit.

Discharge Planning

It is expected that most patients following TTO will be discharged home after the acute rehabilitation phase. All patients will be discharged home with a continuous passive motion (CPM) device to be used 4-6 weeks post-operatively. Patients s/p TTO will also discharge home with home care services (PT and nursing). Several factors including age, co-morbidities, complex living spaces, and lack of assistance/support from family/caregiver may all contribute to a patient's discharge to a short-term rehabilitation setting instead of directly home.

Commonly expected outcomes for discharge home are:

- Ability to perform bed mobility and functional transfers independently.
- Safe ambulation of household distances (50-100 ft) and ability to ascend and descend stairs.
- Increased knee ROM and strength, as previously identified in the goals outlined above.

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