# Tibial Tubercle Anteromedialization Using the Multi-Directional Tibial Tubercle Transfer System

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**Background:** Tibial tubercle osteotomy (TTO) can realign the patellofemoral joint and reduce patellofemoral contact stress. Anteriorization can reduce compressive patellofemoral loads and medialization shifts the pulling direction on the patella, thereby lowering the load on the lateral compartments.

**Indications:** Patellofemoral instability, patellofemoral malalignment, and distal and lateral chondral defects.

**Technique Description:** The Multi-Directional Tibial Tubercle Transfer System (MD3T) uses a generic 3-dimensional cutting template to create 2 compound wedges that are individually transposed and adjusted to achieve multiplanar correction. For isolated tibial tubercle *anteriorization*, the primary wedge is solely used and the proximal bone defect is filled with autograft taken from the distal part of the wedge and synthetic bone graft substitution. For tibial tubercle *medialization*, the primary and secondary wedges are transposed, filling each other's respective spaces. Through the transposition of the primary and secondary wedges, partial filling of the defect with the patient's own bone is achieved, reducing the bone defect. For combined *anteromedialization*, both of these techniques are merged.

**Results:** During walking fatigue test and chair rising test in a cadaveric simulated 42-day healing period, no loosening or cracking occurred. Clinical study results on this technique are pending.

**Conclusion:** The MD3T system achieves with its wedge technique a precise and reproducible multiplanar correction in TTO.

**Patient Consent Disclosure Statement:** The author(s) attests that consent has been obtained from any patient(s) appearing in this publication. If the individual may be identifiable, the author(s) has included a statement of release or other written form of approval from the patient(s) with this submission for publication.

**Keywords:** tibial tubercle osteotomy; TTO; anteromedialization; MD3T; patella

## VIDEO TRANSCRIPT

This video presents the surgical technique of tibial tubercle anteromedialization using the Multi-Directional Tibial Tubercle Transfer System known as MD3T. The procedure is performed by lead surgeon Dr Seth Lawrence Sherman and his team at Stanford University.

Tibial tubercle osteotomy (TTO) is a commonly performed surgery to realign the patellofemoral joint and reduce patellofemoral contact stress.[7] This procedure allows for multiplanar corrections to address various patellofemoral pathologies. Anteriorization can reduce compressive patellofemoral loads[9]; medialization shifts the pulling direction on the patella, thereby lowering the load on the lateral patellofemoral compartment[3]; and distalization of the tibial tubercle can help address patella alta.[10] Individual plane corrections can be performed in isolation or combination as part of surgical therapy regimes for patellofemoral pathologies, such as patellofemoral instability,[5] patellofemoral maltracking,[2] focal lateral or distal chondral defects,[6] and patellofemoral arthritis.[8]

In this demonstration, we will focus on the combination of anteromedialization of the tibial tubercle. This technique is used to realign the patellofemoral joint and improve patellar tracking while simultaneously reducing the patellofemoral joint contact forces.[7]

Meticulous surgical planning and execution are crucial when dealing with combined plane corrections, as they present challenges regarding reciprocal biomechanical influences and intraoperative correction control. The commonly performed Fulkerson procedure is considered the gold standard for anteromedialization.[4] However, mastering this procedure can be challenging due to its mostly freehand cut and the large experience needed to determine intraoperatively the exact extent of the multiplanar

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corrections. Furthermore, there is a risk of extensive tissue damage or inadvertently breaching the lateral compartment, particularly for less experienced surgeons.

Several facilitating techniques have been developed to enhance TTO's control and precision. One such technique is the MD3T, which uses a proprietary 3-dimensional cutting template for all 3 plane corrections to create 2 modular compound wedges that are individually transposed and adjusted to achieve multiplanar correction. The MD3T technique offers several advantages, including safe and predictable cutting, minimal stripping of the anterior compartment, preservation of both cortices, and comprehensible and precise corrections even when correcting multiplanar in all 3 dimensions. With this, some of the disadvantages of the Fulkerson technique can be addressed.

Prior to surgery, the medical history, clinical examination, and radiograph images should be obtained. The patient we are presenting is a 34-year-old healthy, active male recreational runner, who has a history of recurrent patellar dislocations after failed isolated medial patellofemoral ligament (MPFL) reconstruction 2 years ago. He exhibits moderate effusion, lateral patellar movement spanning over 2 quadrants during extension without a defined endpoint, a slight J-sign, a tight lateral retinaculum, and excellent knee range of motion. Apart from the identified MPFL insufficiency in quadrant testing, the other ligamentous examinations are normal. Radiographs indicate proper leg alignment and normal patella height. The magnetic resonance imaging (MRI) reveals diffuse lateral patella and trochlea cartilage damage (graded I-II) with Dejour A/B trochlea dysplasia. In addition, there is an increased tibial tubercle-trochlear groove (TT-TG) distance measuring 32 mm, and rotational computed tomography (CT) scans show no significant abnormalities. The primary contributors to patellofemoral instability are the elevated TT-TG distance, MPFL insufficiency, and tight lateral retinaculum. Consequently, we have planned a procedure involving TTO anteromedialization, MPFL reconstruction, and lateral lengthening to address these factors. TTO has limitations in addressing severe cases of trochlear dysplasia, emphasizing the need to assess additional risk factors. Evaluating other associated factors is crucial as complementary procedures alongside osteotomy might prove beneficial in achieving patellofemoral stability and knee function.

There are different methods to assess and quantify how much medialization is necessary for correction, including measurements for TT-TG distance or tibial tubercle-posterior cruciate ligament (TT-PCL) distance. Aimed values are subject of ongoing investigation, as well as depend on addressed and concomitant pathologies. Larger degrees of medialization may be associated with worse International Knee Documentation Committee scores, independent of the TT-TG distance.[1] Our goal is therefore to correct to the upper normal values.

TTO with MD3T uses a standard joint surgery set along with the MD3T set, which includes the use of specified implants. Fixation is achieved using 2 bicortical screws of choice. The patient is positioned supine on the operating table with an adjustable footrest. Before performing the TTO, an arthroscopic examination is conducted to assess and possibly address concurrent pathologies; in our case, it confirmed the presence of low-grade and diffuse lateral cartilage damage. The inferior aspect of the patella is marked along with the patella tendon and the tibial tubercle. Palpate the tibial crest and make an incision just lateral to that site. This helps prevent scar irritation. If necessary, the incision can be extended to address concomitant pathologies and perform additional procedures such as MPFL reconstruction, lateral lengthening, or cartilage restoration procedures. Following the skin incision, subcutaneous tissue dissection is performed, revealing the anterior compartment, tibial tubercle, and patellar tendon. With the patellar tendon fully exposed, careful delineation

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of its boundaries is carried out, including the fat pad lying beneath. The soft tissue work here is crucial, because it allows the patella to freely translate and follow the changed direction of the tibial tubercle without being restrained from attaching soft tissues. Be cautious and aware of the blood supply of the patella and patellar tendon. It is imperative that you do not over extensively dissect.

In contrast to the Fulkerson procedure, a limited subperiosteal release of the anterior compartment is necessary, exposing only up to 5 mm of the lateral cortex while preserving the anterior compartment musculature structures.

The primary guide is positioned centrally on the tibial tubercle. The ideal location is craniocaudal directly beneath the attachment of the patellar tendon as high on the tibial tubercle as possible; mediolateral that the cuts do not violate the medial or lateral cortices or the patellar tendon; and rotational that the guide aligns with the tibial spine. To assist in locating this ideal position, press the cortical finder of the primary guide against the lateral cortex while using the index finger in the infrapatellar space as buttress. Once the correct location is determined, insert in the primary guide two 4.5-mm unicortical set screws. We recommend beginning with the proximal screw to stabilize the craniocaudal and mediolateral position and then verifying the proper rotation of the guide before placing the second distal screw. The now fixated primary guide determines the location of the primary wedge.

The next step is to remove the lateral cortex finder and place and fixate the cutting sleeve onto the primary guide. Monitoring that the cuts will not violate the cortices or the tendon is vital. In the event that the cuts are predicted to breach either the medial or lateral cortex, it becomes essential to make adjustments to the mediolateral position of the primary guide. If the mediolateral position is accurate but the tendon is too thick and at risk of being affected by the cuts, incorporating one or both of the outriggers can assist in widening the primary bone wedge. Once the mediolateral position is confirmed, we can proceed to cut along the guide slots to form the primary wedge, which serves as the basis for all subsequent multiplanar corrections.

In case of an isolated anteriorization, only this primary bone wedge is needed and the cutting sleeve can be removed. In tibial tubercle medialization and anteromedialization, a secondary wedge of the planned correction size is cut, which includes the thickness of the saw-blade. The triangular secondary wedge is made adjacent and medial to the primary wedge with the help of an outrigger. The wedge osteotomies are completed cranially beneath the patellar tendon without a cutting guide, while ensuring the patella tendons integrity. Before unhinging the osteotomies, the surgeon must verify that all cuts made with the saw and osteotome are connected in a continuous manner, ensuring that the wedges are completely detached, especially at the corners.

For isolated tibial tubercle *anteriorization*, the primary wedge is solely used and the proximal bone defect is filled with autograft taken from the distal part of the wedge and synthetic bone graft substitution. Anteriorization extent can be controlled with a guide or ruler and should be repeated after fixation, as autologous or allogenic bone support alone has been shown to be not very accurate. In our example, we have here anteriorized 8 mm to provide considerable stress relief on the anterior compartment.

For tibial tubercle *medialization*, the primary and secondary wedges are transposed, filling each other's respective spaces. Through the transposition of the primary and secondary wedges, we achieve partial filling of the defect with the patient's own bone, reducing the bone defect.

For combined *anteromedialization*, both of these techniques are merged. It is important to note that anteriorization and medialization do not have a direct one-to-one correlation due to the triangular shape of the wedge, which affects both planes simultaneously and causes a medial translation as it moves anteriorly. For instance, if a 10 mm anteriorization and 8 mm medialization are planned, the secondary bone wedge should only be 4 mm wide instead of a full 8 mm medial translation, as it also moves anteriorly. A chart that is provided with the MD3T set accounts for the complex interaction between the 2 corrective movements. Otherwise, no additional alterations for this multiplanar correction are needed.

Once the desired anteromedialization is achieved, the primary wedge is temporarily fixed with a Steinmann pin and the unicortical screws are removed. Next, the guide is taken out, and 2 screws of your preference are inserted. We personally use two 5-mm bicortical fully threaded headless lag screws to achieve compression and withstand axial and translational forces.

Subsequently, we evaluate screw position and intraoperative patellar tracking with fluoroscopy, passive patellar tracking, Q-angle, and tubercle-sulcus angle. Any additional concurrent procedures are completed, and the wound is closed in a standard manner.

As TTO is rarely an isolated procedure, any concomitant procedures should be taken into consideration during postoperative rehabilitation. For an isolated tibial tubercle anteromedialization, patients are restricted from full weightbearing and are only allowed to weightbear up to a maximum of 10% of their body weight for 4 to 6 weeks with the assistance of crutches. A hinged knee brace is typically worn for 4 weeks locked in extension, followed by a gradual brace weaning. Patients are granted immediate full passive range of motion as tolerated and active assisted movements are started at 4 weeks postoperatively in progressive physiotherapy. Straight leg raises are allowed starting at 6 weeks postoperatively. We expect that most patients will be able to resume their sports activities depending on their sport intensity and impact between 6 and 12 months after the surgery.

Two years after the operation, the patient showed excellent clinical outcomes, with no dislocations and no complications. The osteotomy had fully healed, enabling the patient to fully participate in sports activities again. In a biomechanical study of Merchant on cadavers, neither the walking fatigue test nor the chair rising test caused any loosening or cracking in the MD3T construct during the simulated 42-day healing period. A force of 2500 N was necessary for construct failure, indicating excellent

primary stability. The clinical study results for this technique are still pending. Potential complications align with those seen in other TTO methods, but can be reduced through meticulous patient selection and accurate guide placement. The extensive surgical approach might carry a higher risk of infection, and the bilateral parapatellar arthrotomy could pose a threat to the patellar blood supply, although this issue has not been observed in our patients thus far. The prior mentioned tips and tricks to avoid complications are summarized briefly here.

In summary, the MD3T system achieves with its wedge technique a precise and reproducible multiplanar correction in TTO. This system simplifies the complexity of this challenging surgery to reconstruct favorable biomechanics for the patient. Using the MD3T system, surgeons can lay the foundation for optimal clinical outcomes, ensuring the best possible clinical results for their patients.

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