Technical Note

Anteriorizing Tibial Tubercle Osteotomy for Patellofemoral Cartilage Lesions

Ronak M. Patel, M.D., Joshua Wright-Chisem, M.D., and Riley J. Williams, M.D.

Abstract: Patellofemoral chondral lesions are common and can lead to significant pain. A tibial tubercle osteotomy (TTO) functions to mechanically unload the patellofemoral joint and improve the clinical success of cartilage restoration procedures. The type of TTO performed is based on several factors. There is a subset of patients with patellofemoral cartilage disease who would benefit from a pure anteriorization of the tibial tubercle. We describe our technique for a pure anteriorization TTO, which functions to safely unload the patellofemoral joint in the appropriately indicated patient.

Anterior knee pain and patellofemoral chondral lesions are commonly diagnosed.[1] The causal factors may include malalignment, mechanical overload, unique surface anatomy, and instability.[1] The patellofemoral joint (PFJ) can see forces up to 6.5 times that of body weight with increased knee flexion.[2] Patients with symptomatic patellofemoral chondral lesions have significant pain and decreased quality of life that is comparable with patients undergoing total knee arthroplasty.[3] These patients are often young or lead active lifestyles, making them poor candidates for arthroplasty and complicating surgical decision-making.

The indications for tibial tubercle osteotomy (TTO) are relatively established for patellofemoral instability but are less clear for patellofemoral cartilage defects.[4] Most experts agree that an unloading TTO should be considered for patients with bipolar patellofemoral lesions when a cartilage procedure is performed.[5] The type of TTO is often debated and unclear.

An anteromedialization (AMZ) TTO is commonly performed for patellofemoral disorders and indicated for distal and lateral patellar lesions. However, many patients have normal tibial tubercle—trochlear groove (TT-TG) distances and/or a medial lesion where a pure anteriorization TTO (aTTO) may decrease global joint contact forces.[6] The aTTO is akin to the Maquet osteotomy, which fell out of favor due to complications such as wound healing, nonunion, and fracture.[1] Many of these issues were related to a 2- to 3-cm elevation of the tibial tubercle characteristic to this technique. We describe our technique for aTTO to function as an unloader of the PFJ and can be used with or without concomitant cartilage procedures.

Surgical Technique (With Video Illustration)

Preoperative Planning

The history and physical exam guide surgical planning for an aTTO (Table 1). A previous history of failed cartilage procedure in the PFJ may suggest overload of the compartment and consideration of an aTTO with revision cartilage surgery. Examination of patellar mobility, apprehension, J-sign, and crepitus help to determine the need for other concomitant procedures such as lysis of adhesions, medialization of the tubercle, or medial patellofemoral ligament repair/reconstruction. This all is evaluated in conjunction with radiographs and magnetic resonance imaging (MRI) to determine the degree osteoarthritis, focal cartilage defects, meniscal/ligament status, previous hardware, TT-TG distance, and patellar height. We also selectively use T1 rho imaging and T2 mapping as a means to identify painful patellofemoral lesions suggestive of

From the Sports Medicine and Shoulder Surgery Service, Hospital for Special Surgery, New York, New York, U.S.A.

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Address correspondence to Ronak M. Patel, M.D., Hospital for Special Surgery, 535 E. 70th St., New York, NY 10021. E-mail: patelr@hss.edu

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Table 1. Surgical Indications and Contraindications for the Pure Anteriorization Tibial Tubercle Osteotomy (aTTO)

Indications
• Symptomatic, full-thickness patellofemoral chondral or osteochondral lesions
• Previous failed patellofemoral cartilage restoration procedure
• Salvage procedure for young patients not candidates for arthroplasty
• BMI <35
Contraindications
• Kellgren–Lawrence grade 3 or 4 osteoarthritis of the medial or lateral knee compartment
• Uncorrected patellofemoral instability (increased TT-TG distance, patella alta, severe trochlear dysplasia)
• Uncorrected lower extremity coronal/sagittal plane malalignment
• Ligamentous instability of the tibiofemoral joint
• Inflammatory arthritis
• Patient factors (smoking, drug, alcohol use, etc.)

BMI, body mass index; TT-TG, tibial tubercle–trochlear groove.

overload that may not be apparent on usual MRI sequences.[7]

Patient Positioning

The patient is positioned supine on the operating room table with a tourniquet. Spinal anesthesia is administered in addition to regional nerve blocks for postoperative pain control in the outpatient setting.

Diagnostic Arthroscopy and Concomitant Procedures

A standard diagnostic arthroscopy is undertaken with anterolateral and anteromedial portals. Any MRI evidence of cartilage defects are confirmed and examined. We prefer to perform cartilage restoration at the time of aTTO.

Surgical Approach

The surgical technique is shown in Video 1. The tourniquet is used with an Esmarch. A 5- to 6-cm longitudinal incision is made lateral and adjacent to the tibial tubercle if no cartilage procedure is concurrently done (Fig 1). The incision is extended proximally if patellofemoral cartilage work is planned for a full parapatellar arthrotomy. A medial-based incision is made if the lesion is better accessed from a medial parapatellar arthrotomy or prior incisions are used. Once dissection is made through the subcutaneous fat, flaps are created to allow skin mobility.

A mark is placed 6 cm distal to the most proximal portion of the tibial tubercle for the planned osteotomy length. The medial and lateral patellar retinacula are released adjacent to the patellar tendon, and an anterior compartment fasciotomy is extended to the 6 cm mark distally. An elevator is used to bluntly dissect the anterior compartment off the lateral tibia until the posterior cortex is exposed (Fig 2). The fat pad in the pre-tibial recess is excised.

Osteotomy

An oscillating saw is used to make the medial-based osteotomy in the anteroposterior plane to the 6 cm mark (Fig 3). This is a vertical, unicortical cut and does not penetrate the posterior tibial cortex. With a retractor protecting the patellar tendon, this cut is extended into the proximal tubercle.

A retractor is placed laterally just behind the posterior tibial cortex. The saw is used to make a cut in the lateral cortex of the osteotomy segment (Fig 4). The cut is made from lateral to medial and is also 6 cm in length. The cut is made approximately 5 to 7 mm anterior to the posterior tibial cortex; it is critical to preserve the integrity of the posterior tibial cortex. This cut intersects with the medial-based osteotomy at a right angle. With a retractor protecting the patellar tendon, this cut is converged with the medial cut along the proximal tubercle (Fig 5). At the distal aspect of the lateral tubercle, the cut is turned 90° to make an anteroposterior osteotomy (Fig 6). Here it is preferable to avoid cutting the anterior and posterior cortex. Osteotomes are used to complete the osteotomy.

Anteriorization is performed with an osteotome on the lateral side with controlled levering of the tubercle. In some cases, we pre-drill the distal/anterior tibial cortex for increased malleability and/or controlled breakage. We aim for approximately 10 to 15 mm of anteriorization.

Fixation

A large k-wire is placed from lateral to medial to hold the fragment in place (Fig 7). Two 4.5-mm fully threaded screws are placed in a lag by technique manner to secure the osteotomy (Fig 8). These are

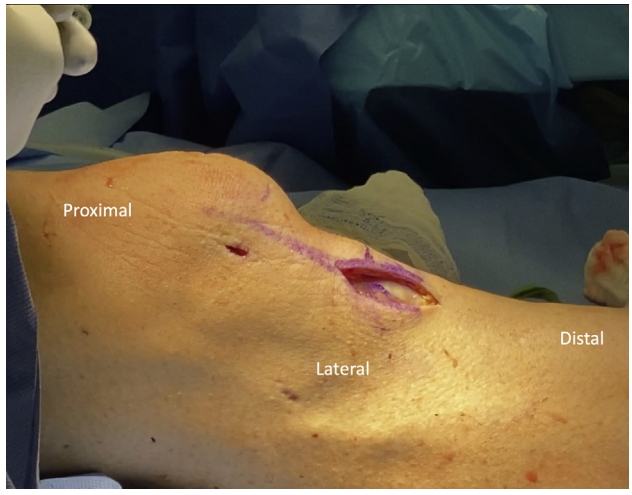

Fig 1. Photograph taken from the lateral side of the right knee with partial incision made. The patient is positioned supine. A 5- to 6-cm incision is made just lateral to the tibial tubercle. This particular patient underwent diagnostic arthroscopy before osteotomy.

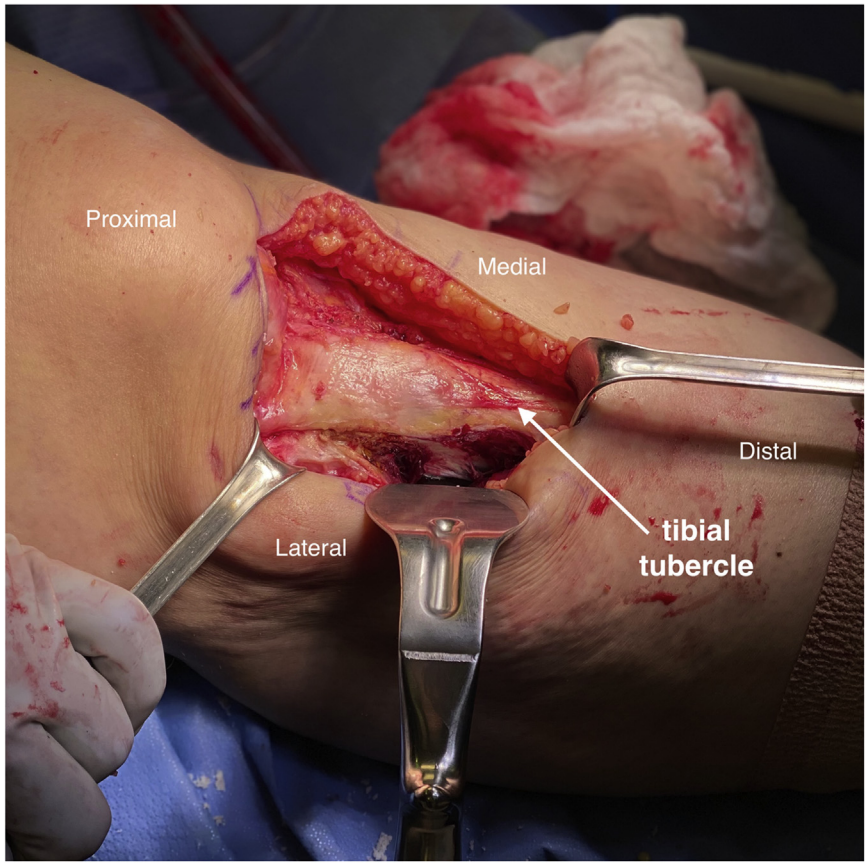

Fig 2. Intraoperative photograph of the knee showing exposure of the lateral aspect of the tibial tubercle. The anterior compartment is dissected off the tibia until the posterolateral tibial cortex is visible. A retractor is placed around the posterior tibia to protect neurovascular structures.

placed obliquely from lateral/anterior to medial/posterior. This trajectory is ideal to avoid displacement. Intraoperative fluoroscopy is used to confirm appropriate screw length and preservation of posterior cortex integrity (Fig 9). Demineralized bone graft (Grafton, Medtronic, Minneapolis, MN) is placed into

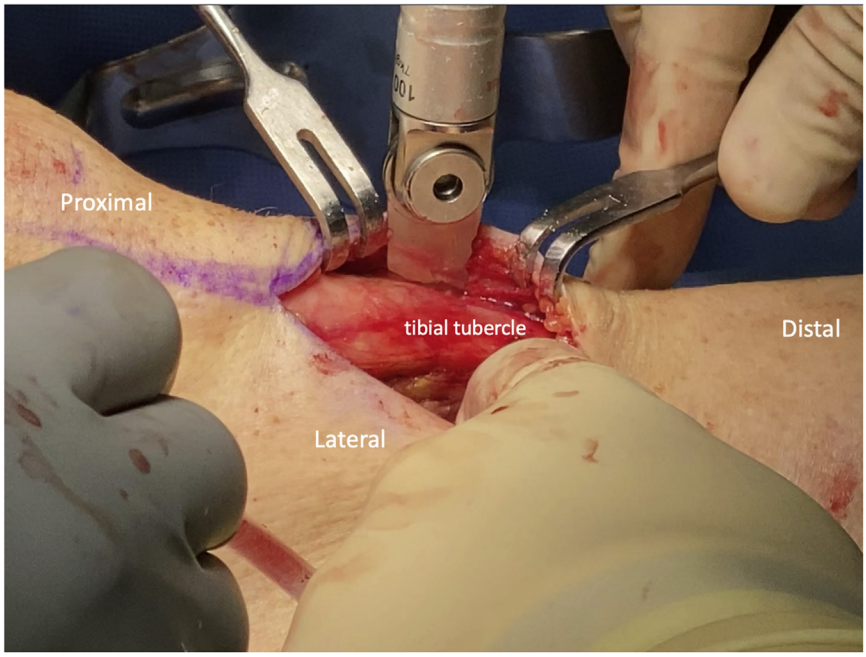

Fig 3. Photograph showing the medial-based anteroposterior plane osteotomy. A saw is used to make this just medial to the tibial tubercle in a vertical trajectory. Care must be taken to avoid penetration of the posterior tibial cortex.

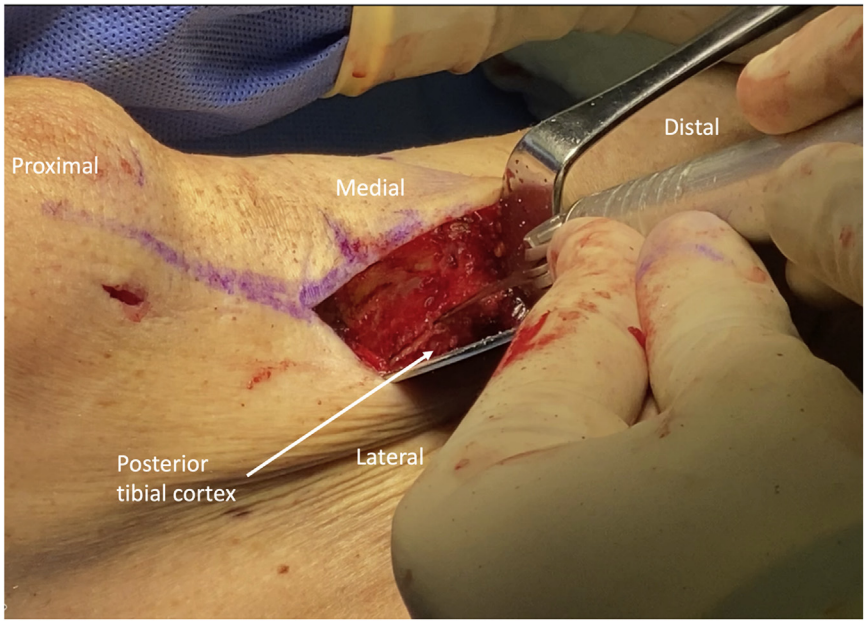

Fig 4. Photograph from the lateral aspect showing the lateral-based, medial-lateral plane osteotomy. A saw cut is made just anterior to the posterior tibial cortex from lateral to medial. A retractor is placed posteriorly. This osteotomy should meet the previous medial-based osteotomy while keeping the medial and posterior tibial cortices intact.

the osteotomy site. The tourniquet is released and hemostasis achieved. The wound is closed in a layered fashion.

Postoperative Rehabilitation

The patient is allowed toe-touch weight-bearing with a hinged knee brace locked in extension and crutches. Continuous passive motion is used if indicated for a concomitant cartilage procedure. The patient is transitioned to weight-bearing as tolerated locked in extension at 3 weeks. At 4 weeks, closed chain exercises and an exercise bike are started along with isometric quadriceps sets. The brace is unlocked and used until appropriate quadriceps control. Progressive rehab continues with a focus on quadriceps strengthening. A return-to-sports program is tailored on an individual basis typically starting with a jogging program at 6 months. Sport-specific training and unrestricted activities are progressed thereafter.

Discussion

The addition of an aTTO for patellofemoral cartilage lesions may improve outcomes when combined with cartilage restoration especially in patients who are not ideal candidates for an AMZ TTO. Recent attention to

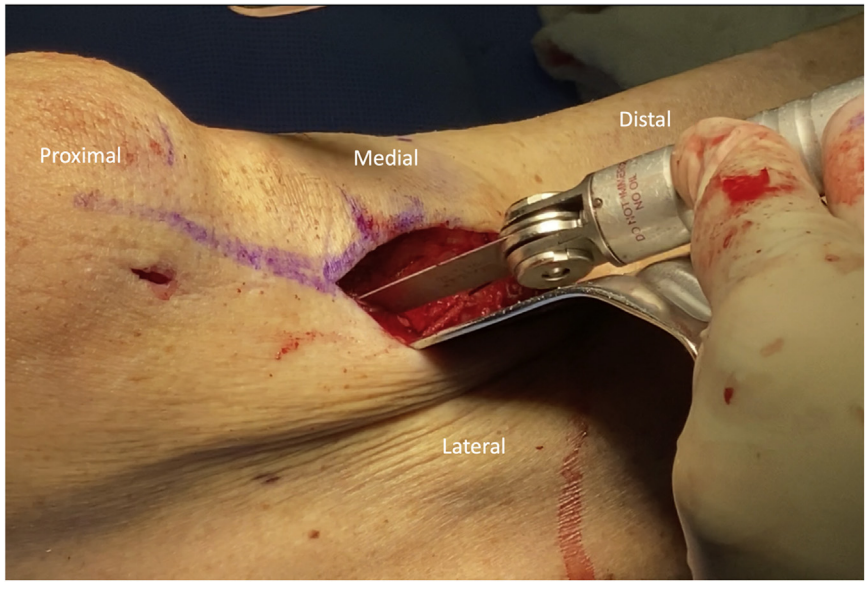

Fig 5. Photograph showing the proximal aspect of the lateral-based osteotomy which is angling anteriorly toward the patellar tendon. This should meet the medial-based cut for adequate mobilization.

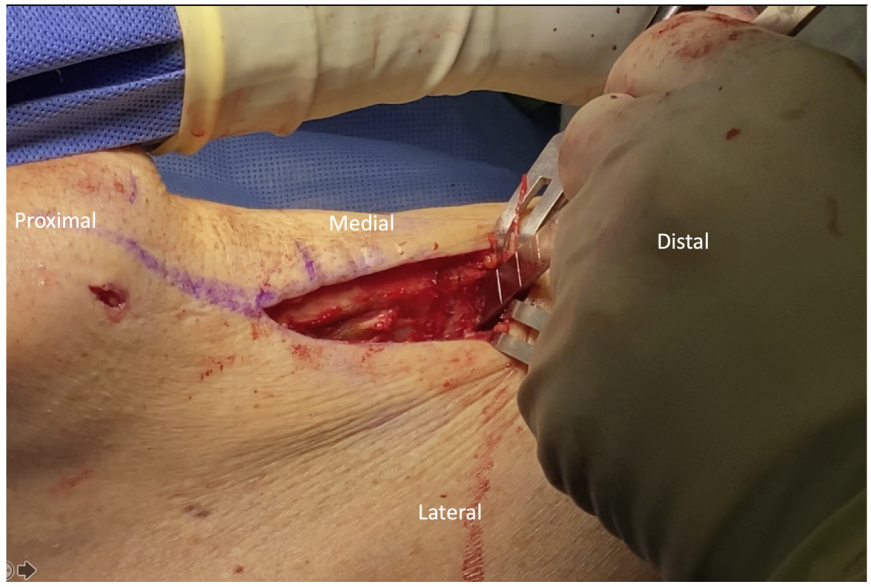

Fig 6. Photograph showing the distal aspect of the lateral-based osteotomy which is made anterior to posterior. The posterior cortex is kept intact and is preferable to preserve the anterior cortex.

the sagittal TT-TG distance has associated a posteriorly positioned tibial tubercle in patients with symptomatic patellar chondral lesions.[6] Further clinical studies are needed to investigate the outcomes of an aTTO in these patients.

Maquet[1] described an aTTO that was placed 7 to 8 mm posterior to the tibial crest and extended 15 cm distally. This was elevated 2 to 3 cm and held in place by iliac grafts just beneath the tibial tuberosity. Wound dehiscence and infection were frequent. The patients

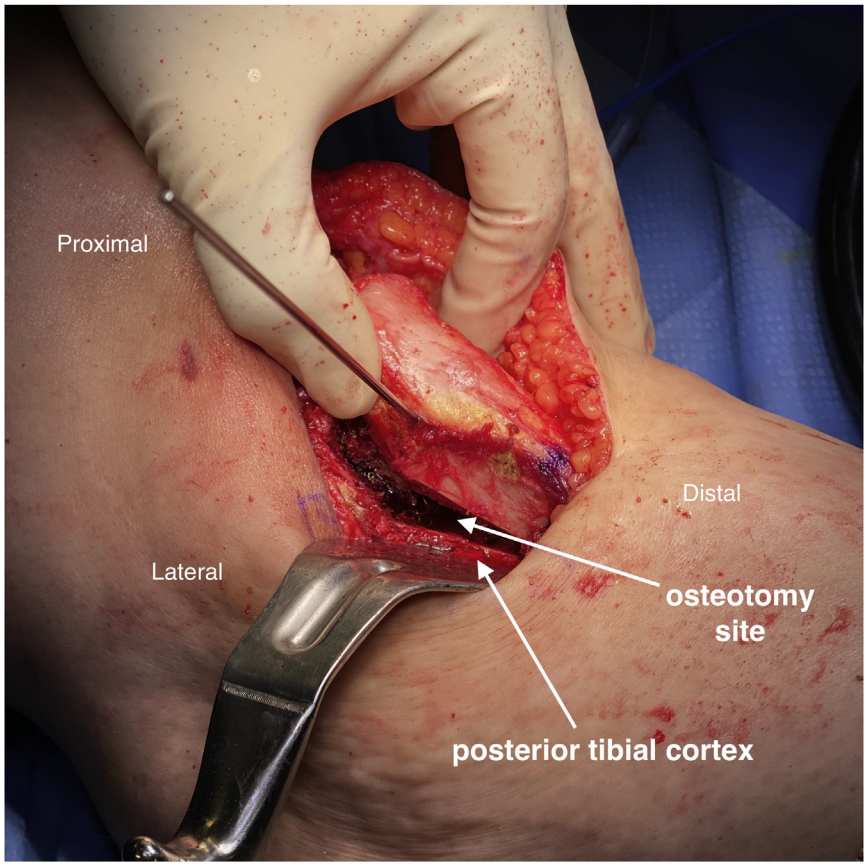

Fig 7. Intraoperative photograph after osteotomy completion and elevation of the tibial tubercle. The posterior tibial cortex is left intact by making the posterior osteotomy just anterior to this boundary. A k-wire is placed to hold the osteotomy in the desired anterior position.

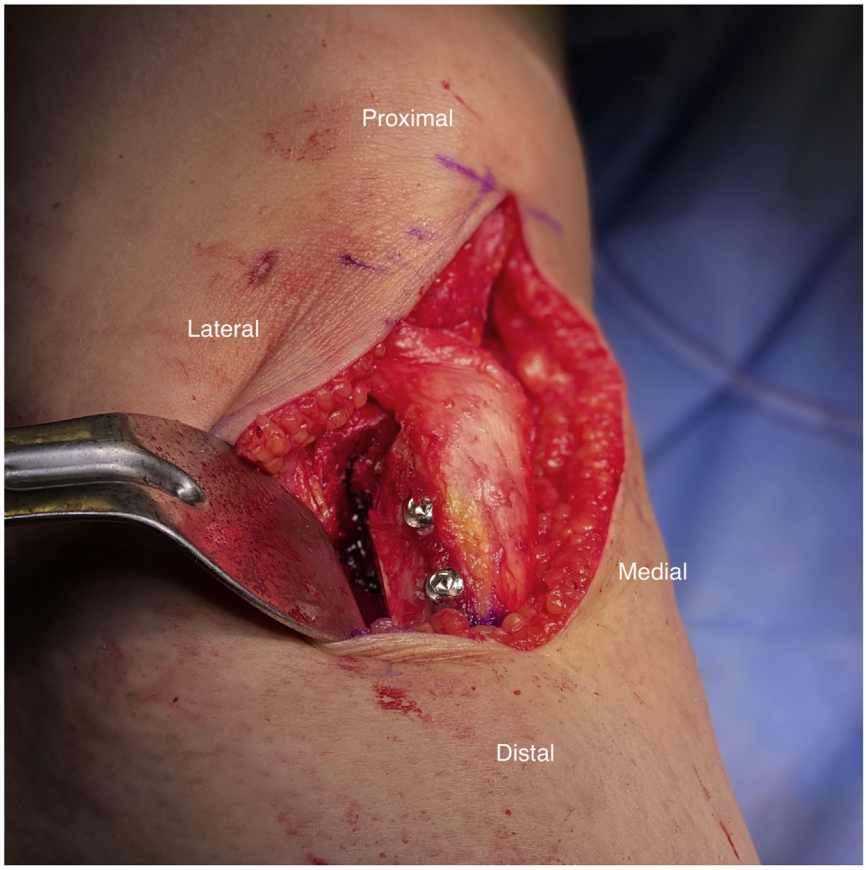

Fig 8. Intraoperative photograph of the osteotomy secured with 2 fully-threaded 4.5-mm screws placed in lag by technique. These are directed from lateral/anterior to medial/posterior. This prevents settling of the anterior displacement and are aimed away from critical neurovascular structures. The k-wire is kept in place until both screws are secured.

were allowed immediate weight-bearing and motion. Other descriptions of anteriorization have described the use of an offset bone graft inserted into an AMZ TTO site to affect the desired anterior displacement without bone graft.[8]

Our technique has several adaptations and, in our experience, has led to a low incidence of complications. First, we prefer to make the incision lateral to the tibial tubercle to ensure a robust overlying soft tissue envelope. Full-thickness flaps are made for adequate skin

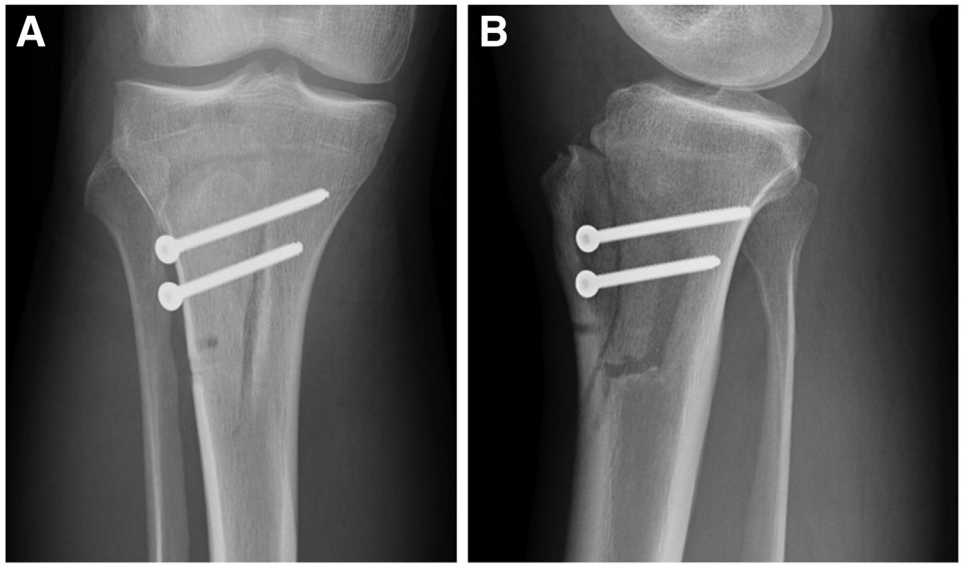

Fig 9. Postoperative radiographic images of an (A) anteroposterior and (B) lateral view of the knee showing fixation of the pure anteriorization tibial tubercle osteotomy. These images show predrilling of the distal/anterior cortex to facilitate hinging of the osteotomy fragment.

Table 2. Pearls and Pitfalls of Surgical Technique

Pearls	Pitfalls
• Incision on lateral side of tibial tubercle to ensure adequate soft-tissue envelope and tension-free closure • Modify incision to medial side if access to medial joint is needed for concomitant cartilage restoration • Limit distal extent of osteotomy to 6 cm • In cases of rigid bone, pre-drill the distal/anterior cortex to facilitate hinging of the osteotomy • Screws placed from lateral/anterior to medial/posterior to prevent settling of anteriorization, compress osteotomy site, and cover screw heads with anterior compartment.	• Avoid compromise of the posterior tibial cortex • Make sure osteotomy cuts are completed before elevation to prevent propagation of a fracture • Limit elevation of the tibial tubercle to 10-15 mm to avoid wound complications • A screw trajectory that is directed too much in the anteroposterior direction can result in settling of the tubercle elevation • Control hemostasis after tourniquet release to decrease risk of hematoma and compartment syndrome

mobilization and minimal tension upon closure. We keep the incision relatively small (5-6 cm) if done in isolation. Second, the osteotomy is extended only 6 cm distal to the most proximal aspect of the tibial tubercle; the coronal plane cut is made 5-7 mm anterior to the posterior tibial cortex. This allows adequate elevation of the tubercle while maintaining a small incision. In addition, the orientation of the osteotomy ensures a large surface area for bony union. Third, an attempt is made to preserve the anterior and posterior tibial cortex. This allows early weight-bearing, range of motion, and no instances of fracture in our experience. Lastly, the osteotomy does not require a structural bone graft and is fixed with rigid lag screws.

While our technique has advantages compared with other aTTO techniques, there are limitations to consider (Table 2). First, this technique is not suitable for and can exacerbate patellar instability. Second, the use of screws can lead to symptomatic hardware and patients should be counseled regarding removal. An aTTO should be considered in the appropriately indicated patient, especially when concomitant cartilage restoration is performed. Future studies investigating the clinical and radiological outcomes are ongoing.

References

1. Middleton KK, Gruber S, Shubin Stein BE. Why and where to move the tibial tubercle: Indications and techniques for tibial tubercle osteotomy. *Sports Med Arthrosc Rev* 2019;27:154-160.
2. Osborne JD, Brandon Luczak S, Acker WB, Bicos J. Patellofemoral joint contact pressures: Current concepts and use in patellar instability studies. *Orthopedics* 2019;42:E172-E179.
3. Heir S, Nerhus TK, Røtterud JH, et al. Focal cartilage defects in the knee impair quality of life as much as severe osteoarthritis: A comparison of knee injury and osteoarthritis outcome score in 4 patient categories scheduled for knee surgery. *Am J Sports Med* 2010;38:231-237.
4. Song YF, Wang HJ, Yan X, et al. Tibial tubercle osteotomy may not provide additional benefit in treating patellar dislocation with increased tibial tuberosity—trochlear groove distance: A systematic review. *Arthroscopy* 2021;37(5).
5. Chahla J, Hinckel BB, Yanke AB, et al. An expert consensus statement on the management of large chondral and osteochondral defects in the patellofemoral joint [published online March 16, 2020]. *Orthop J Sports Med*. https://doi.org/10.1177/2325967120907343.
6. Lansdown DA, Christian D, Madden B, et al. The sagittal tibial tubercle—trochlear groove distance as a measurement of sagittal imbalance in patients with symptomatic patellofemoral chondral lesions [published online January 22, 2020]. *Cartilage*. https://doi.org/10.1177/1947603519900802.
7. Wang T, Belkin NS, Burge AJ, et al. Patellofemoral cartilage lesions treated with particulated juvenile allograft cartilage: A prospective study with minimum 2-year clinical and magnetic resonance imaging outcomes. *Arthroscopy* 2018;34:1498-1505.
8. Fulkerson J. *Disorders of the patellofemoral joint*. Baltimore: Williams & Wilkins, 1996.