Osteotomy of the Tibial Tubercle for Anteromedialization

Márcio B. Ferrari, M.D., George Sanchez, B.S., Nicholas I. Kennedy, M.D., Anthony Sanchez, B.S., Katrina Schantz, P.A.-C., and CAPT Matthew T. Provencher, M.D., M.C., U.S.N.R.

Abstract: Patellofemoral instability is a common cause of anterior knee pain, especially in younger and more active patients. Treatment of instability varies considerably depending on the patient's symptoms as well as the cause of the instability. Lateral instability has a particularly broad spectrum of treatment algorithms including patellar taping, arthroscopy, lateral release, medial patellofemoral ligament (MPFL) reconstruction, MPFL repair, and osteotomy of the tibial tubercle for realignment. Acute traumatic lateral dislocation is commonly associated with a tear of the MPFL and, therefore, needs to be addressed. However, patients who show lateralization of the tibial tubercle with an increased tibial tubercle–to–trochlear groove distance, tibial tubercle–to–posterior cruciate ligament distance, and Q-angle measurements often display chronic instability even after an MPFL reconstruction. In these cases, an osteotomy of the tibial tubercle is required to establish proper alignment and minimize the risk of recurrence of instability. The objective of this Technical Note is to describe our preferred method to complete a Fulkerson tibial tubercle osteotomy for anteromedialization and treatment of chronic patellar instability.

Patellofemoral pathology resulting from improper biomechanics of the patellofemoral joint is rather difficult to successfully treat and ultimately results in considerable anterior knee pain and instability of the joint.[1] Given the many potential sources of patellar instability, including insufficiency of the medial patellofemoral ligament (MPFL) and malalignment of the joint, proper treatment of lateral patellar instability differs on a patient-to-patient basis. Various treatment methods, ranging from nonoperative to minimally invasive to aggressive in nature, have been described and include patellar taping, lateral release, arthroscopic management, MPFL repair, MPFL reconstruction, and osteotomy of the tibial tubercle.[2,3]

Patients who have had a lateral dislocation of the patella have been shown to almost certainly have an MPFL injury.[4] Because the MPFL has been reported to provide up to 60% of medial restraint to forces that may result in lateral translation of the patella, successful treatment of patellar lateral instability should take into account the integrity of the MPFL.[5] Moreover, in acute

From Steadman Philippon Research Institute (M.B.F., G.S., N.I.K., M.T.P.), Vail, Colorado; Jackson Memorial Hospital (A.S.), Miami, Florida; Massachusetts General Hospital (K.S.), Boston, Massachusetts; and The Steadman Clinic (M.T.P.), Vail, Colorado, U.S.A.

The authors report the following potential conflict of interest or source of funding: M.T.P. receives support from Arthrex, JRF Ortho. Consultant. Patent numbers (issued): 9226743, 20150164498, 20150150594, 20110040339. Arthrex, SLACK. Publishing royalties. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received March 5, 2017; accepted May 20, 2017.

Address correspondence to Matthew T. Provencher, M.D., M.C., U.S.N.R., Steadman Philippon Research Institute, The Steadman Clinic, 181 W Meadow Dr, Ste 400, Vail, CO 81657, U.S.A. E-mail: mprovencher@thesteadmanclinic.com

2212-6287/17286/$36.00

http://dx.doi.org/10.1016/j.eats.2017.05.012

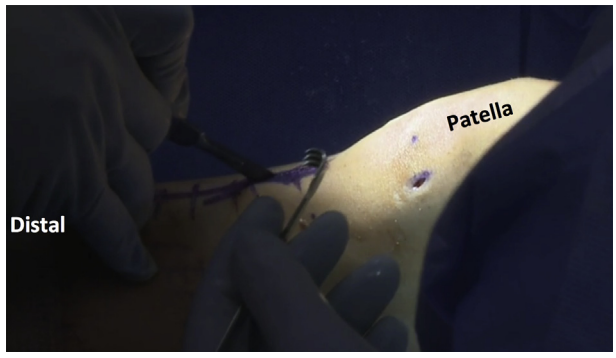

Fig 1. The distal pole of the patella and the tibial tubercle of the left knee are palpated and used as references. Using a surgical pen, the site of the initial incision is marked. Then, a longitudinal incision approximately 8 to 10 cm in length is carefully performed to adequately expose the patellar tendon.

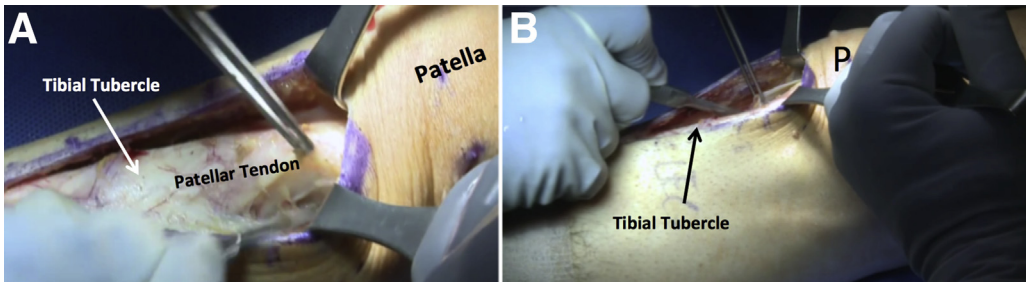

Fig 2. To decrease the risk of an iatrogenic lesion to the patellar tendon of the left knee, the medial and lateral borders of the tendon must be identified. (A) After the initial incision, blunt dissection is performed in the subcutaneous tissue to expose the borders of the patellar tendon. (B) A scalpel is used to properly release the lateral and medial borders of the tendon. (P, patella.)

traumatic lateral dislocations, MPFL reconstruction in isolation has shown exceptional treatment outcomes.[6] However, in cases of chronic instability with a lateralized tibial tubercle, MPFL reconstruction will not suffice and correction of patellofemoral alignment is necessary.[6]

Increased lateralization of the tibial tubercle is associated with an increased tibial tubercle—to—trochlear groove (TT-TG) distance, tibial tubercle—to—posterior cruciate ligament distance, and Q-angle measurements on imaging, as well as increases in lateral patellar tracking and patellofemoral joint contact forces on physical examination.[7] Therefore, surgical intervention should center on medialization of the tibial tubercle to correct patellofemoral malalignment. A tibial tubercle osteotomy with anteromedial repositioning, more popularly known as a Fulkerson osteotomy, is a popular technique undertaken to correct patellofemoral malalignment. This procedure was initially described in 1983 by Fulkerson[1] as a technique that allowed for restoration of the extensor mechanism without use of a bone graft through anteromedialization of the tibial tubercle. The Fulkerson osteotomy allows for restoration of proper medial and lateral alignment while reducing patellofemoral joint contact forces.[8-10]

The objective of this Technical Note is to describe our preferred method to complete a Fulkerson tibial tubercle osteotomy for anteromedialization and treatment of chronic patellar instability while noting pearls and pitfalls associated with the technique to arrive at a successful treatment outcome.

Surgical Technique

Preoperative Positioning and Anesthesia

After induction of general anesthesia, the patient is placed in the supine position on the operating table (Video 1). Before the initial incision, a thorough examination under anesthesia is performed to evaluate and confirm patellofemoral instability, crepitation, and errors in patellar tracking. Afterward, the same examination is completed on the contralateral, nonsymptomatic limb to confirm the malalignment to be corrected in the affected leg. A well-padded high-thigh tourniquet is then placed around the proximal thigh of the operative leg, whereas no leg holder is used on the contralateral limb.

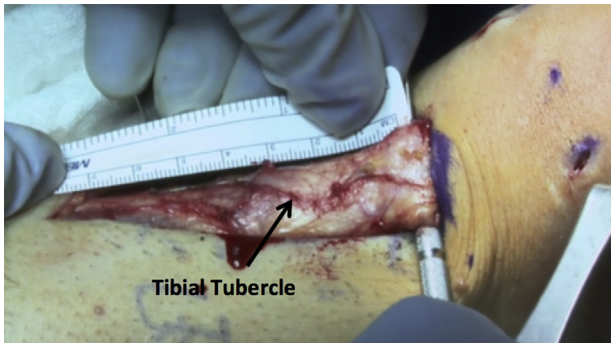

Fig 3. Once the medial and lateral borders of the patellar tendon in the left knee are identified, a surgical ruler is used to ensure the correct length of the osteotomy.

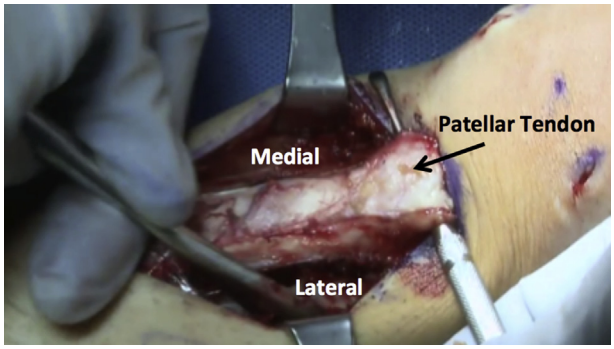

Fig 4. A Cobb elevator is used to expose the lateral and medial aspect of the proximal tibia of the left knee in preparation for the osteotomy to be performed. The length of the osteotomy to be completed was previously defined through use of a surgical ruler.

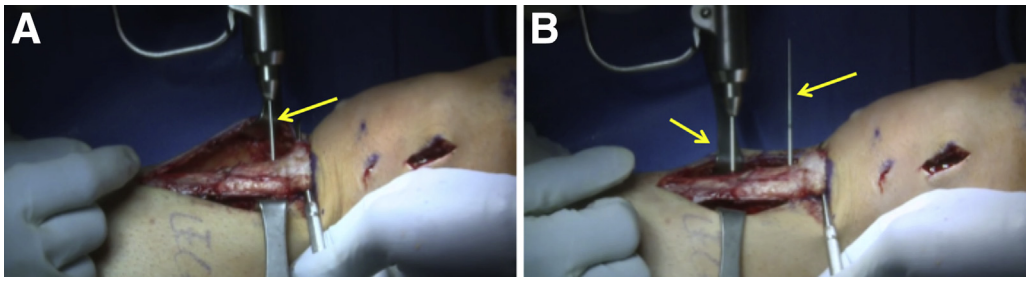

Fig 5. After exposure of the patellar tendon and proximal tibia of the left knee, 2 K-wires are used to guide the osteotomy. (A) The first K-wire (arrow) is placed at a 45° angle to the tibial shaft. (B) The second K-wire (arrow) is placed as the first wire (arrow) is used as a reference. The 2 wires must be parallel to each other.

Diagnostic Arthroscopy

Once the examination is complete and the tourniquet has been placed, the limb is prepared in a standard fashion. Before full exposure of the tibial tubercle, anteromedial and anterolateral portals are created, and an arthroscopic evaluation of all knee compartments is then performed. At this point, any concomitant pathology is addressed. In this case a chondral defect is detected. With the use of a probe and as the knee is maintained in 20° of flexion, all loose cartilage fragments are removed.

Exposure of Tibial Tubercle and Placement of Provisional K-wires

Once the arthroscopic portion of the procedure is complete, exposure of the tibial tubercle is performed. The inferior pole of the patella and the tibial tuberosity are used as references for the initial incision. A longitudinal incision approximately 8 to 10 cm in length is then carefully performed to adequately expose the patellar tendon (Fig 1). To avoid potential damage to the patellar tendon, the patellar tendon is carefully visualized and demarcated (Fig 2). With the use of a ruler, the site of the osteotomy is evaluated (Fig 3). The tibial tubercle is then further exposed through use of a Cobb elevator at the lateral and medial aspect of the proximal tibia (Fig 4). Afterward, two 4.5-mm Kirschner wires are placed in the proximal aspect of the tibia in an oblique position (45° angle) with care taken to carefully place the K-wires parallel to one another. The degree of obliquity can be modified, depending on the amount of anteriorization and medialization required (Fig 5).

Osteotomy of Tibial Tubercle

A small oscillatory saw is used to perform the osteotomy based on the direction of the K-wires. A half-inch osteotome is then carefully used to complete the osteotomy while a potential fracture of the proximal tibia or portion of the tibial tubercle to be translated is avoided (Fig 6). The amount of medialization is confirmed with the use of a ruler, which in this case is 0.9 mm (Fig 7). The amount of medialization needed is determined based on imaging, TT-TG measurements, and intraoperative stabilization. After this, a surgical pen or coagulator is used to mark the site of the screws that will be used to fix the portion of the tibial tubercle to be translated in place. In instances of patella alta, this should be addressed concurrently, by correcting the Caton-Deschamps index simultaneously with the TT-TG measurement. This will address both patella alta and lateral displacement of the patella.

Fixation of Tibial Tubercle Portion

Two provisional 4.5-mm K-wires are placed 1 cm from the marked position of the screws. The screws (Arthrex, Naples, FL) are then fixed into the tibial tubercle in standard fashion while potential damage to the patellar tendon is avoided. The screws are fixed into place in bicortical fashion through a lag technique. Once the screws are fixed into place, the K-wires are

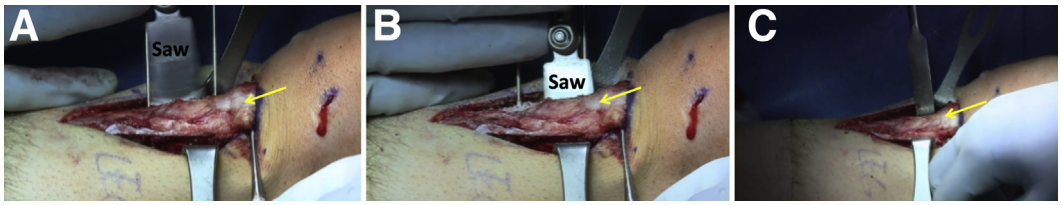

Fig 6. Once the 2 K-wires are in the correct position, an oscillating saw is used to perform the osteotomy in the left knee. (A, B) The oscillating saw is placed above the K-wires, which are used to guide the osteotomy. (C) An osteotome is used to complete the osteotomy and complete the anteromedialization of the portion of the tibial tubercle. Care must be taken to avoid damage to the insertion of the patellar tendon on the tibial tubercle (arrows).

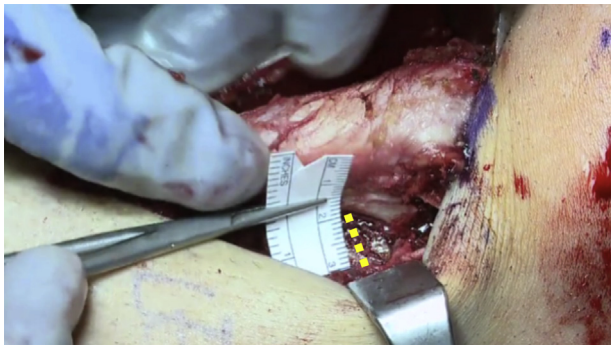

Fig 7. After the use of the oscillating saw and osteotome to complete the osteotomy in the left knee, free movement of the fragment should be possible. For verification, a surgical ruler is used to measure the degree of anteromedialization. In this case the amount of anteromedialization (dotted line) is 9 mm.

removed. Then, the screws are tensioned again to ensure proper and stable fixation of the fragment (Fig 8). Once the tibial tubercle portion is fixed and stable, thorough saline solution irrigation is performed to remove any remaining debris from the osteotomy.

Injection of Autologous Conditioned Plasma and Platelet-Rich Plasma and Closure

A combination of autologous conditioned plasma and platelet-rich plasma is injected at the site of the osteotomy to maximize healing potential through use of a Double Syringe System (Greyledge Technologies, Vail, CO) (Fig 9). Before this, 60 mL of peripheral blood is collected from the patient and submitted to centrifugation for approximately 10 minutes to heterogeneously divide the blood. Once the combination of autologous conditioned plasma and platelet-rich plasma has been injected, bone wax is applied to the lateral aspect of the tibia where the tibial tubercle has been removed to minimize postoperative bleeding. The lateral fascia is then repaired with No. 0 Vicryl (Ethicon, Somerville, NJ) in a figure-of-8 fashion. After this, the subcutaneous and skin layers are closed in standard fashion. The advantages and disadvantages associated with this technique are listed in Table 1, and pearls and pitfalls are shown in Table 2.

Rehabilitation

The patient is immobilized in a knee brace for the initial 6 weeks after the surgical procedure. Weight bearing is limited to toe-touch weight bearing for the first 4 weeks. After this initial period, weight bearing as tolerated is encouraged. Passive range of motion is limited to 30° of flexion during the first week, with 15° of flexion added each week until full flexion is reached. From the first postoperative day, exercises focused on patellar tendon mobilization, extension mobilization, and quadriceps and hamstring muscle reactivation are encouraged as tolerated until week 8. At week 6, toe and heel raises as well as exercises to regain balance are initiated. During the first 8 weeks, use of a stationary bicycle with the contralateral, unaffected limb is encouraged. After these first 8 weeks, use of a stationary bicycle with no resistance is encouraged for both limbs. Use of a stationary bicycle with progressive resistance should commence at week 9, with other exercises such as treadmill walking with a 7% inclination, aqua jogging, and swimming with fins also encouraged. Balance squat, single-leg dead

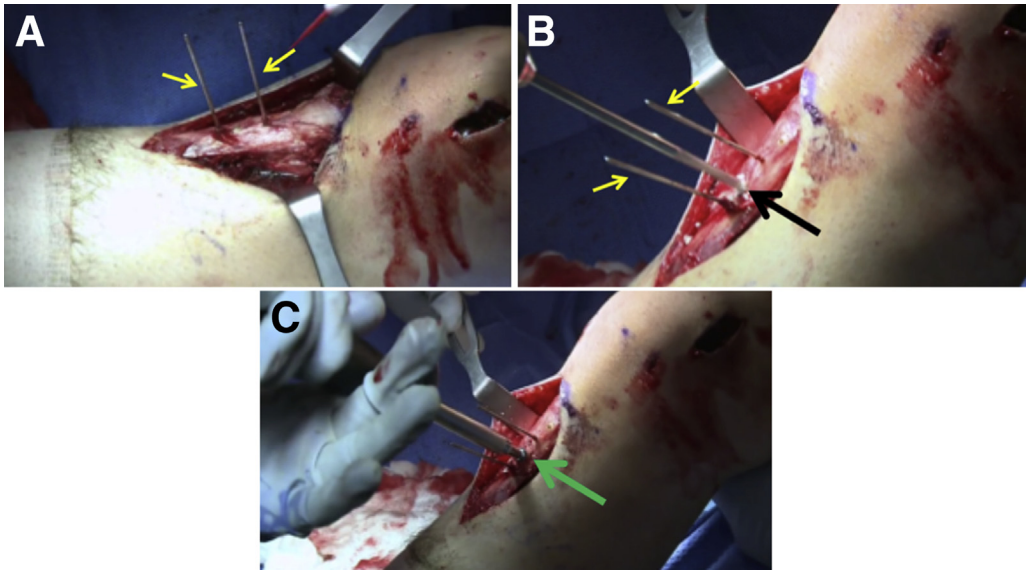

Fig 8. (A) The portion of the tibial tubercle in the left knee is moved anteromedially, and 2 K-wires (arrows) are then inserted to momentarily fix the fragment. (B) A drill (black arrow) is used between and parallel to the K-wires (yellow arrows). (C) The first cortical screw (arrow) is used to secure the portion of the tibial tubercle in the desired position.

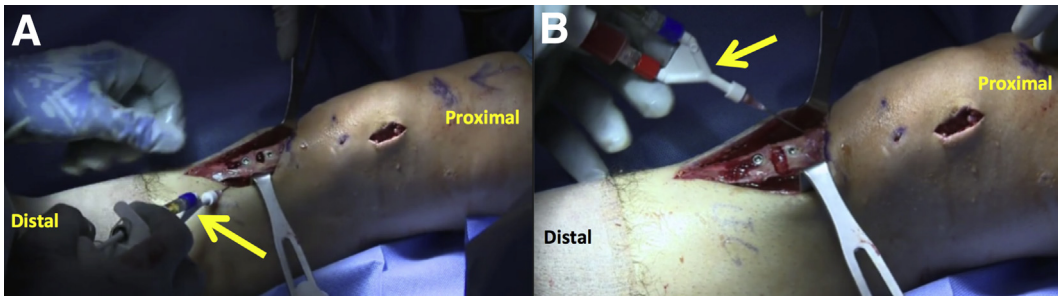

Fig 9. (A, B) Once the definitive fixation is performed with 2 cortical screws in the left knee, a combination of autologous conditioned plasma and platelet-rich plasma is injected (arrows) at the borders of the osteotomy to maximize healing potential.

lift, and leg press exercises are encouraged as tolerated beginning at week 10. At week 20, agility exercises including running in a single plane with a slow progression toward multidirectional running are encouraged. A return to full activities and sports without restrictions is dependent on each patient's individual progress but typically occurs approximately 24 weeks after surgery.

Discussion

Patients with chronic lateral instability and an increased TT-TG measurement who are treated by a Fulkerson osteotomy in conjunction with an MPFL reconstruction have shown significant improvement in patient subjective scores.[11] In cases of severe patellar instability, both aspects of surgery, including realignment of the joint and reconstruction of the medial restraint, are critical given that the osteotomy restores proper mechanics and minimizes improper joint contact forces while the MPFL acts as the primary restraint to excess lateral displacement.

Although excellent outcomes have been reported after the Fulkerson procedure, it is a demanding procedure with many potential intraoperative complications previously reported. Moreover, postoperative complications including a fracture of the proximal shaft have been described, even several weeks after surgery.[12] Therefore, optimal positioning of the portion of the tibial tubercle and proper fixation along with a safe rehabilitation protocol are absolutely essential to arrive at the best postoperative outcome possible.

Table 1. Advantages and Disadvantages

Advantages	Disadvantages
• No need for an allograft	• Technically demanding
• Provides anteriorization and medialization with only 1 osteotomy	• Potential risk of fracture of proximal tibia intraoperatively and postoperatively
• Relieves contact forces placed on patellofemoral joint	

Given the complex causes possibly resulting in patellar instability, a thorough preoperative evaluation is key. Radiographic measurements including the TT-TG and tibial tubercle—to—posterior cruciate ligament distances, as well as Q-angle measurements, are particularly important for a formal diagnosis of patellofemoral joint malalignment. Aside from preoperative imaging, a thorough history and clinical examination including the patient's description of the nature of the first instance of patellar instability, as well as the number of instability events thereafter, will provide further confirmation of the necessary treatment.

In conclusion, chronic lateral patellar instability is a fairly common yet challenging condition to treat as a result of the complex causes and variety of treatment options associated with it. Nevertheless, the anteromedial translation of a portion of the tibial tubercle for realignment of the joint, as described, provides an effective way to treat this challenging condition.

Table 2. Pearls and Pitfalls

Pearls	Pitfalls
• Adequate exposure of the patellar tendon's margins minimizes the risk of tendon rupture.	• The degree of anteriorization changes with the inclination of the osteotomy and may jeopardize the procedure if performed incorrectly.
• Protection of the patellar tendon during the osteotomy minimizes iatrogenic injury.	• A fracture of the proximal tibia may occur intraoperatively or postoperatively if fixation is performed incorrectly or an excessively aggressive rehabilitation protocol is encouraged.
• Care must be taken to avoid potential damage to the deep peroneal nerve and anterior tibial artery during the osteotomy.	
• Weight bearing must be avoided during the first 4 wk after surgery to minimize the risk of a proximal tibial fracture postoperatively.	

References

1. Fulkerson JP. Anteromedialization of the tibial tuberosity for patellofemoral malalignment. *Clin Orthop Relat Res* 1983:176-181.
2. McConnell J. The physical therapist's approach to patellofemoral disorders. *Clin Sports Med* 2002;21:363-387.
3. Larson RL. Subluxation-dislocation of the patella. In: Kennedy JC, ed. *The injured adolescent knee*. Baltimore: Williams & Wilkins, 1979;161-204.
4. Nomura E. Classification of lesions of the medial patellofemoral ligament in patellar dislocation. *Int Orthop* 1999;23:260-263.
5. Desio SM, Burks RT, Bachus KN. Soft tissue restraints to lateral patellar translation in the human knee. *Am J Sports Med* 1998;26:59-65.
6. Krych AJ, O'Malley MP, Johnson NR, et al. Functional testing and return to sport following stabilization surgery for recurrent lateral patellar instability in competitive athletes [published online December 27, 2016]. *Knee Surg Sports Traumatol Arthrosc*. doi:10.1007/s00167-016-4409-2.
7. Anley CM, Morris GV, Saithna A, James SL, Snow M. Defining the role of the tibial tubercle-trochlear groove and tibial tubercle-posterior cruciate ligament distances in the work-up of patients with patellofemoral disorders. *Am J Sports Med* 2015;43:1348-1353.
8. Stephen JM, Lumpaopong P, Dodds AL, Williams A, Amis AA. The effect of tibial tuberosity medialization and lateralization on patellofemoral joint kinematics, contact mechanics, and stability. *Am J Sports Med* 2015;43:186-194.
9. Ferguson AB Jr, Brown TD, Fu FH, Rutkowski R. Relief of patellofemoral contact stress by anterior displacement of the tibial tubercle. *J Bone Joint Surg Am* 1979;61:159-166.
10. Kuroda R, Kambic H, Valdevit A, Andrish JT. Articular cartilage contact pressure after tibial tuberosity transfer. A cadaveric study. *Am J Sports Med* 2001;29:403-409.
11. Mulliez A, Lambrecht D, Verbruggen D, Van Der Straeten C, Verdonk P, Victor J. Clinical outcome in MPFL reconstruction with and without tuberositas transposition. *Knee Surg Sports Traumatol Arthrosc*. June 2, 2015. [Epub ahead of print.]
12. Eager MR, Bader DA, Kelly JD IV, Moyer RA. Delayed fracture of the tibia following anteromedialization osteotomy of the tibial tubercle: A report of 5 cases. *Am J Sports Med* 2004;32:1041-1048.