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Operative Techniques in
Sports Medicine

Derotational Osteotomies of the Femur and Tibia for Recurrent Patellar Instability

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Lower extremity rotational alignment must be quantified in cases of recurrent patellofemoral instability. Femoral and tibial rotation can be measured with both physical examination and radiographic studies. Derotational osteotomies of both the femur and the tibia can be used to correct patients with excessive femoral anteversion and tibial external rotation (miserable malalignment syndrome). In this article, we attempt to provide guidelines for assessing lower extremity rotation and an understanding of normal femoral and tibial rotational values. We then provide examples of one type of corrective femoral osteotomy and one type of tibial rotational osteotomy.
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Recurrent patellofemoral instability is a multifactorial problem. While attenuation and rupture of the medial patellofemoral ligament is almost always present, this may be a secondary problem related to a primary bony abnormality including distal femur valgus malalignment, internal femoral torsion, external tibial torsion, and trochlear dysplasia. Treatment of the Medial PatelloFemoral Ligament (MPFL) rupture without addressing the primary bony abnormality may contribute to recurrent patellofemoral instability. We will attempt to provide a framework for incorporating bony procedures into the patellofemoral treatment algorithm—as well as techniques for both femoral and tibial derotational osteotomies.

Femoral Anteversion Overview

Normal femoral anteversion is defined as the angular difference between the axis of the femoral neck and the transcondylar axis of the knee.[1] Anteversion in most adults is typically between 5° and 15°.[2] Increased femoral anteversion allows for significantly more internal rotation of the hip, and less external rotation on physical exam. Patients are described to have “insquinting patellae” where when standing with the feet aimed forward, their patellae aim medially at each other. Increased femoral anteversion, even more than sagittal or coronal plane deformities, significantly affects the risk of recurrent patellofemoral dislocations.[3] It can also lead to stress on the MPFL and increased lateral PatelloFemoral contact forces.[4] Rotational malalignment does not lead to an increase in hip or knee osteoarthritis.[5] The morphology of the trochlea is, however, related to femoral anteversion; increased femoral torsion is associated with flatter, more dysplastic trochleas.[6]

Physical examination of hip rotation should be performed prone rather than supine. This corresponds better to hip rotation during gait. The range of prone internal and external rotation is useful to quantitate the normal midpoint of rotation range which often corresponds to normal anteversion. Aside from physical examination of hip rotation, proper imaging can help quantitate femoral anteversion. Basic radiographic measurements can be used to identify anteversion with a Dunn/Rippstein view, however, computed tomography (CT) measurements with the technique of Yoshioka[7] are thought to be most reliable and reproducable.[8] It is the author’s preference to use an EOS system (biplanar low-dose radiographic device with 3D lower limb modeling) instead of a CT scan because of the decreased radiation exposure to the patient. Additionally, the quicker scan time and automated measurements of both femoral and tibial rotational alignment (torsion) provide a reliable and reproducible guide

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comparable to CT scan.[9] These measurements should be carefully checked against a prone hip examination to ensure that physiological range of motion matches radiographic measurements. It has been the author's experience that some ligamentously lax patients with radiographic femoral anteversion are still capable of normal hip external rotation—and therefore likely do not require femoral derotational osteotomies. This is why assigning a strict osteotomy algorithm based on radiographic measurements of femoral anteversion is challenging. In our practice, we look to correct physical exam measured internal and external rotation of the hip to normal equal values intraoperatively. Based on strictly radiographic measurements, the literature seems to support femoral osteotomy in patients with recurrent patellar instability with anteversion greater than 20°-25°.[10-14]

While surgical correction of femoral anteversion can take place at the intertrochanteric region, most corrections for recurrent patellar instability are either diaphyseal over an IntraMedullary (IM) nail, or distal metaphyseal with a locking plate. The surgeon can plan on either osteotomy based on a host of factors. If extensive work will be done around the knee with lateral lengthening, cartilage restoration, or distal femoral realignment, then a distal osteotomy may be preferred. The benefits of a diaphyseal osteotomy include smaller exposure and earlier weight bearing. It is also important to understand that femoral derotational osteotomies can lead to significant frontal plane alignment changes.[15] Proximal femoral derotational osteotomies can result in increased varus and distal femoral derotational osteotomies can lead to increased valgus of the lower limb.[16] Recent work has been done to design distal femoral osteotomy cut guides, via mathematical models, in an attempt to mitigate the increase in valgus frontal plane alignment—as many patients suffering from recurrent patellofemoral instability are already in significant physiologic valgus.[17] Additionally, one benefit from a distal femoral approach is that a planned bidirectional osteotomy can be utilized distally to try and correct both frontal plane and rotational deformity concurrently. In patients with increased femoral external rotation (as opposed to femoral anteversion), however, the osteotomy should be performed proximally as this can lead to significant changes in the quadriceps angle and subsequent patellofemoral instability consequences.

Diaphyseal Femoral Derotational Osteotomy Technique

We begin with careful clinical measurements of femoral internal and external rotation at the hip (Fig. 1). Ideally, we would like to correct a patient to equal 45° of internal rotation and 45° of external rotation. For instance, if we measured hip internal rotation at 70° and external rotation at 20°, then we would plan a femoral change in rotation (derotation) of 25° so that both internal rotation and external rotation postoperatively would be equal and matched at 45°. With this clinical preoperative picture, we would expect that

Figure 1 Excess femoral internal rotation.

Figure 2 Ex-Fix pin placement with a 25° differential.

Figure 3 Percutaneous drilling of the metaphysis one-third of the way down the femur.

our EOS measurement of femoral rotation would show an anteversion of 25° radiographically.

Surgical Technique

Place one external-fixator pin just proximal to the knee joint (Fig. 2). This pin is placed with the patella forward to represent the frontal plane of the distal fragment. An inclinometer (Innomed, Inc Savannah, GA) is placed on this pin as it is rotated internally to the degree of desired correction. The femur is held in that position as a second pin is inserted at the level of the lesser trochanter. Make sure to place both pins in the posterior part of the femur so that the IM nail can later travel through the canal unimpeded. To improve the accuracy of pin placement, a wire can be inserted first to confirm pin placement. This is followed by a cannulated drill bit and insertion of the half pin (Fig. 3). The inclinometer is used to measure the angle between these 2 pins. If the angle is the desired correction amount then the goal is to make the pins have a zero angle at the end of the correction. If the angle is more or less than the desired amount then the correction should be adjusted to leave the pins over or undercorrected relative to the zero position. The entry point in either the greater trochanter or piriformis fossa is drilled. A beaded guidewire is then placed down the femoral canal. Drill holes for the osteotomy should be made one-third of the way down the femoral canal from the proximal femur. Drill the diaphysis of the femur with a 4.8 mm drill bit. Make one entrance hole laterally and 3 exit holes medially (Fig. 4). Make additional entrance holes anterolateral and posterolateral. Ream the medullary canal over the beaded guide rod (Fig. 5). The reamings will extrude through the drill holes reducing the risk for fat embolism and at the same time

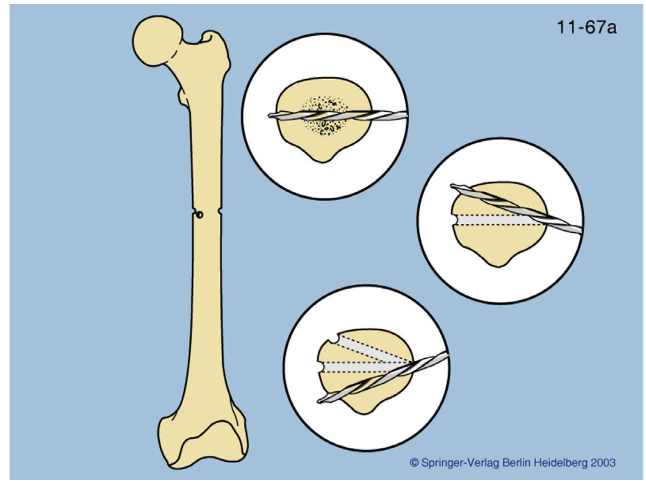

Figure 4 Drilling 3 femoral holes via 1 entry.

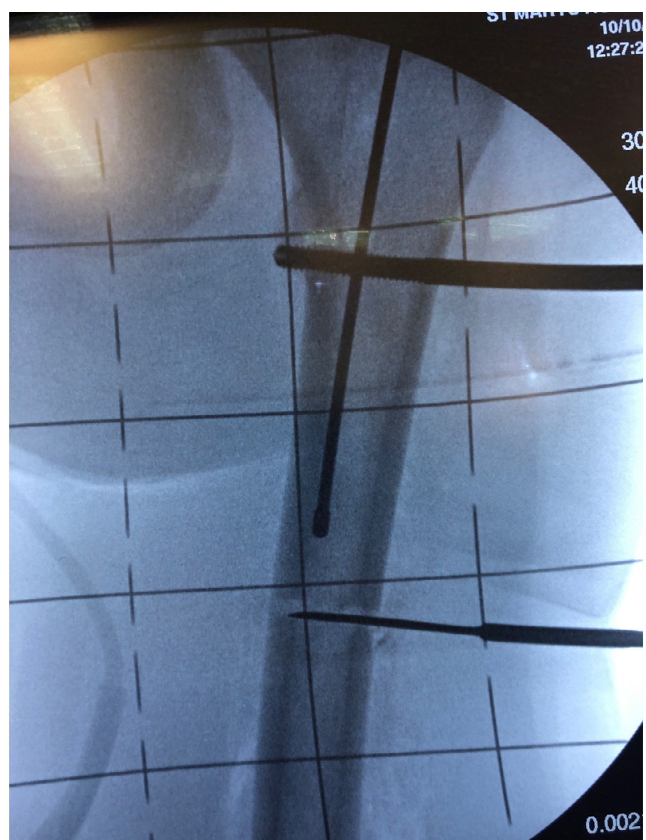

Figure 5 Osteotomy after femoral reaming.

Figure 6 Osteotomy completion above and below linea aspera.

autografting the osteotomy site. After the reaming is completed depending on the size of IM rod to be used, the diaphyseal osteotomy is completed percutaneously with a small sharp osteotome (Fig. 6). Care is taken to prevent a butterfly fragment by cutting across the lateral, anterior, and posterior cortices before exiting out the medial side. Since the guide rod is still in place it is easy to allow the femur to rotate such that the external fixation pins are more in line with each other. The intramedullary nail is inserted and using the drill guide locked proximally (Fig. 7). The distal femur is then rotated to make the pins line up with each other. It is best to bend the knee and rotate by using the tibia as a handle than to manipulate the pins which could bend or cut out thus losing their reference position (Fig. 8). The inclinometer is placed on the pins again to adjust the desired angle between them. The distal end of the nail is then locked. Final hip rotation is performed to verify that we have matching internal and external rotation of 45°. Postoperatively, the patient is allowed to weight bear as tolerated with crutches.

Tibial Torsion Overview

Many patients with patellofemoral maltracking have significant external tibial torsion. Tibial torsion is defined as the angle between the knee flexion extension axis and the ankle joint axis.[18] Physical examination of these patients reveals increased thigh foot angles and increased quadriceps angles.

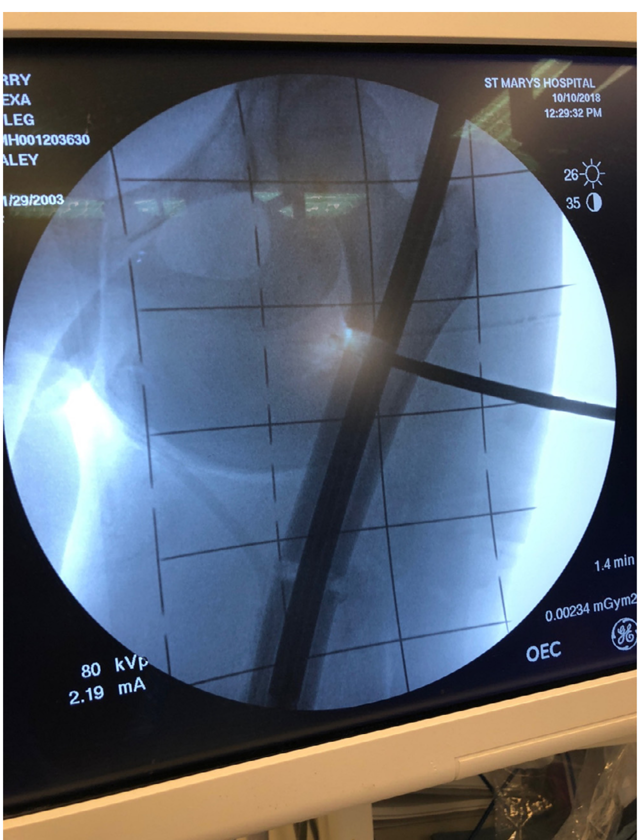

Figure 7 IM nail placement.

Figure 8 Final internal rotation 45° after locking the nail.

Figure 9 Increased tibial external rotation.

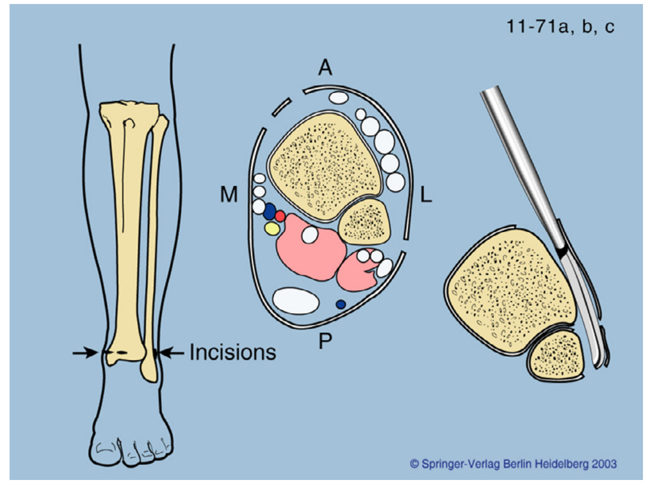

Figure 10 Subperiosteal dissection map.

When combined with excessive femoral anteversion, these patients are thought to have "miserable malalignment syndrome" (Fig. 9).

Tibial torsion is best measured clinically in a prone position; thigh foot axis. Tibial torsion can also be measured by CT examination and is defined as the angle between a line adapted to the posterior contour of the tibial head and the intramalleolar axis. Normal values are thought to be from 10° to 30° but may have considerable variability.[19] EOS scan for low-dose biplanar radiography can also quantify tibial rotation.[20] The author's preference is to use clinical measurement instead of radiographic assessment for tibial torsion because thigh foot axis measured with a goniometer may be as accurate as CT radiographic tibial rotation studies.[21]

Another recent and interesting radiographic measurement for patellofemoral instability may be in assessing tibial tubercle tubercle torsion—instead of entire tibial rotation based on magnetic resonance imaging measurements. Tibial tubercle external torsion greater than 11.5° was consistent with increased patellofemoral instability.[22]

Torsional osteotomies of the tibia to correct patellofemoral malalignment can be subdivided into 2 categories: osteotomies above the patellar tendon insertion to reduce the quadriceps angle, and distal osteotomies to reduce the thigh foot angle—with or without femoral anteversion correction.

Proximal osteotomies require an understanding of the anatomy around the fibular head and proximal tibia. They may require a decompression of the peroneal nerve including the intramuscular septum between the anterior and lateral compartments of the leg.[23] Fasciotomy of the anterior compartment is also recommended. Some authors recommend limiting acute derotation to 20° unless an external fixator-type device is used for more gradual correction.[24] A special L-shaped osteotomy has been described to move the tuberosity medially with external to internal rotation of the tibia.[25]

Distal tibial osteotomy does not require nerve decompression, but cannot be used to correct the quadriceps angle in isolation. It is often an excellent means, however, to correct an increased thigh foot angle. Distal osteotomy has much less risk of neurovascular injury since the tibial cuts are distal to the popliteal artery/nerve and peroneal nerve, however, risks to the anterior tibial artery and posterior tibial artery are still present.

Our distal tibial/fibular osteotomy preference is for a percutaneous cut approximately 2 cm above the joint line using a Gigli saw, with fixation via 3 headless tibial screws and one headless fibular screw. The osteotomy must be performed just above the tibial fibular joint.

Tibial Derotational Osteotomy Technique

A percutaneous incision is made anteromedial to the tibia approximately 2 cm proximal to the tibial plafond (Fig. 10). A small periosteal elevator is used to dissect subperiosteally over the anterior portion of the tibia and fibula (Fig. 11). This passes under the anterior compartment and the peroneal vessels. Where the elevator wants to exit through the skin a small longitudinal incision is made. Another incision is made posteromedial to the tibia. An elevator is used to dissect subperiosteally under the adjacent tibialis posterior tendon. The elevator follows the posterior cortex of the tibia and fibula and also exits out the longitudinal lateral incision. A long curved clamp (tonsil) is used to pass a heavy suture from the lateral incision to the anteromedial one. A Gigli saw is tied to the suture anteromedially and the Gigli saw is passed from through to the lateral side (Fig. 12). The tonsil

Figure 11 Subperiosteal dissection 2 cm above the joint line.

Figure 12 Grabbing the passing suture for the Gigli saw.

Figure 13 Using the Gigli saw to come across the Fibula and then the Tibia.

Figure 14 Restoring normal external tibial rotation.

clamp is used to pass the same suture from lateral to posteromedial. The Gigli saw is then pulled through the posteromedial incision. The Gigli saw now loops around the fibula laterally and around the entire tibia to exit medially through the 2 incisions (Fig. 13). The tibia and fibula can now be cut with the Gigli saw without damaging the surrounding soft tissues.

Following successful transection of both the tibia and the fibula, the foot is then internally rotated to a normal thigh foot angle (Fig. 14). The guide wire for headless screws (Acutrak 2- Acumed: Hillsboro, OR) is inserted retrograde from the medial malleolus obliquely across the osteotomy site. Another wire is inserted retrograde and obliquely from the lateral side. The bone is drilled over these wires and 2 headless screws are inserted to fix the tibia in the corrected position (Fig. 15). A third and final tibial headless screw is inserted antegrade from anterior on the tibia aiming for the posterior lip of the tibia. Finally, the fibula can be fixed using a retrograde headless screw by inserting a guide wire from the tip of the lateral malleolus into the fibular shaft (Fig. 16). The fibula translation may have to be reduced percutaneously in order to insert this wire. This fixation is stable enough that it allows for early controlled weightbearing with a cast or boot on the leg and foot.

This technique was developed and used by the senior author in 25 femurs and 15 tibias between 2009 and 2018. All the femurs, tibias and fibulas were radiographically healed

Figure 15 Osteotomy fixation with large headless compressive screws.

Figure 16 Completing the fibular fixation by rotating the fragments and then placing a fibular screw over a k-wire.

by 3 months after surgery. The intramedullary nails were removed in most of the patients while the headless screws were left in place. The thigh foot axis was returned to the normal range (+5° to 15°) in all cases and the prone hip rotation profile was corrected such that postoperative hip rotation of internal and external rotation was more balanced than preop. All patients achieved improved foot progression angles in the desired direction. Most patients improved their symptomatology and were satisfied with the correction. No patient was unsatisfied or found no improvement from the correction.

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