Technical Note

Anterior Slope Correction—Flexion Osteotomy in Traumatic Genu Recurvatum

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Abstract: A decreased posterior tibial slope has been associated with an increased risk of posterior cruciate ligament failure, anterior knee pain, and premature knee osteoarthritis. Trauma is a common cause of osseous genu recurvatum. Surgical management is recommended to correct the tibial slope and prevent knee pain and osteoarthritis progression. This article discusses our preferred treatment using a proximal tibial opening-wedge osteotomy for surgical management of genu recurvatum secondary to significant anterior tibial slope.

A recurvatum knee is an incapacitating condition because there is an imbalance of tibial translation in the sagittal plane. During gait, the anteroposterior translation is governed by the anterior cruciate ligament (ACL), the posterior cruciate ligament, the posterolateral and posteromedial structures, the menisci, as well as the posterior tibial slope (PTS).[1] This means that even light activities such as walking on uneven ground will be cumbersome due to difficult active locking of the joint, which will obliterate the patellofemoral lever arm and compromise the extensor mechanism, even exacerbating the recurvatum deformity. Commonly, the quadriceps muscle tends to atrophy, and anterior knee pain develops. The stability of the knee joint is contingent on soft-tissue integrity and bony balance in the frontal and sagittal planes during gait.

High PTS is a well-known intrinsic factor for ACL injury, as patients with this deformity are predisposed to ACL lesions.[2] The extent of sagittal imbalance can be quantified by the anterior tibial translation, also termed tibial shift, during early flexion, or posterior tibial translation, also known as tibial sag, in later flexion.

Sagittal imbalance of the knee has numerous causes, and the literature describes mainly 3 patterns.[1] This case concerns a genu recurvatum with alterations of the bony elements: The deformity is purely osseous and located in the tibial metaphysis with an inversion of the normal PTS.

Symptomatic hyperextension of the knee beyond 5° has been defined as symptomatic genu recurvatum.[3] In contrast, hyperextension is considered physiological when it is less than 15° and bilateral. It is also known as constitutional genu recurvatum. As such, proximal tibial opening wedge osteotomies are indicated for cases of symptomatic genu recurvatum. A systematic review supported surgical management of symptomatic genu recurvatum using an anterior opening-wedge proximal tibial osteotomy. Correcting the anterior slope to a more anatomic, posterior orientation would allow the ligaments to return to their normal tension and restore the native biomechanics of the knee.[3]

Patient Evaluation

A thorough knee physical examination is done, directed toward identifying ligamentous causes of knee hyperextension and range of motion, such as Lachman's, pivot, posterior drawer, varus, and valgus stress, dial, and posterolateral drawer tests. The clinical examination must always be carried out regarding the contralateral limb. An assessment of previous surgical scars allows for planning of any subsequent surgery.

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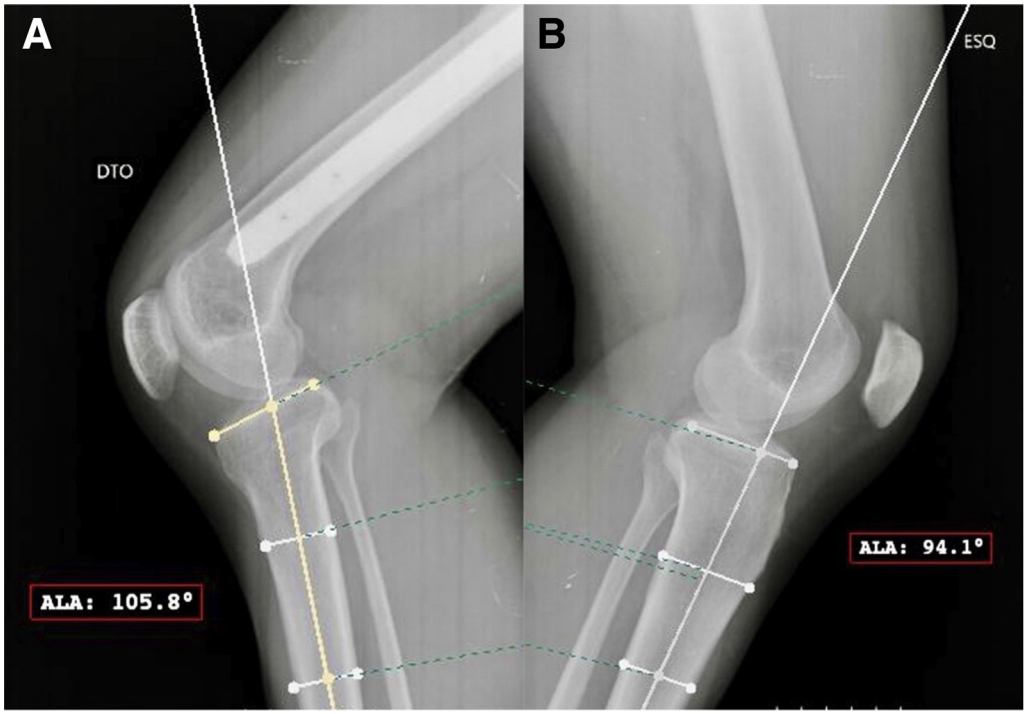

Fig 1. (A) Preoperative lateral view radiograph of the right knee showing an anterior tibial slope of 15.8°. (B) Lateral view radiograph of the left knee, showing anterior tibial slope of 4.1°. The tibial slope was measured using the anatomic tibial axis using points at approximately 5 and 15 cm distal to the joint line on both the anterior and posterior tibial cortices. The midpoint between the respective anterior and posterior points was then established. These midpoints were connected with a vertical line to establish the longitudinal axis of the posterior tibial slope calculation.

Patients should have lateral and long leg weight-bearing views and Schuss views taken of their knee. To measure the tibial slope, the anatomic tibial axis was used using a full-length lateral tibia radiograph. The anatomic axis[4] is calculated using points at approximately 5 and 15 cm distal to the joint line on both the anterior and posterior tibial cortices. The midpoint between the respective anterior and posterior points was

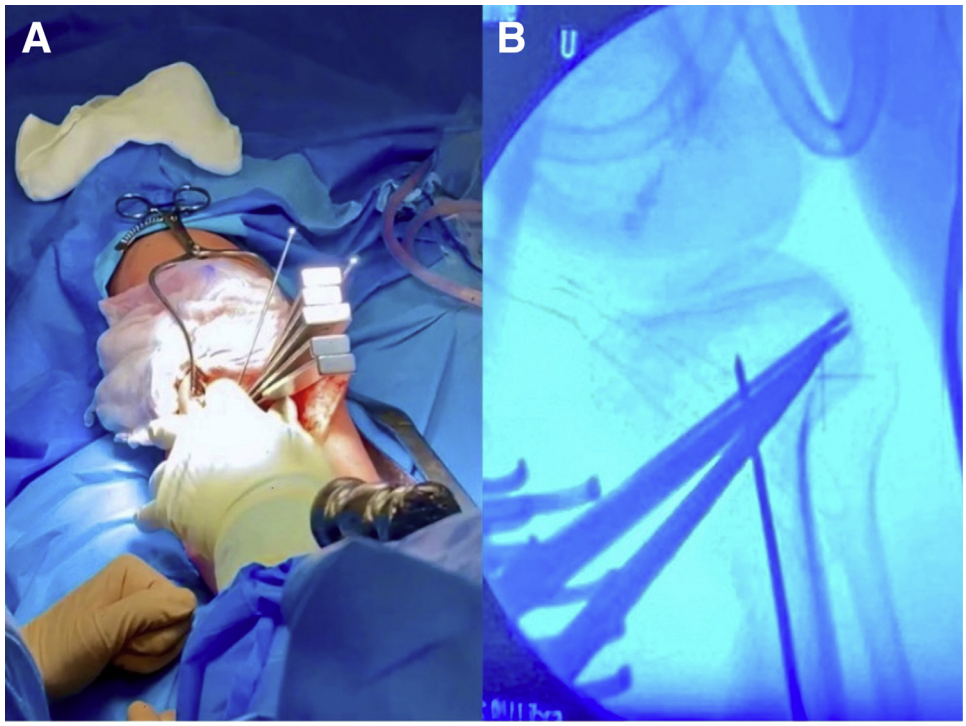

Fig 2. Right knee. (A) Intraoperative photo of stacked osteotomes being used to create the opening wedge in the right tibia. (B) Intraoperative fluoroscopic lateral imaging of the proximal tibial is performed to confirm the correct depth of the osteotomy, to make sure the posterior tibial cortex is intact, and to evaluate the degree of slope correction.

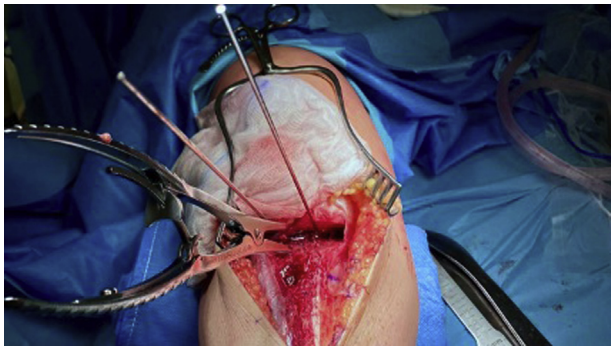

Fig 3. Right knee. Anterior intraoperative photo of a spreader device maintaining distraction to achieve stress relaxation of the posterior cortex to minimize the risk of an undesired fracture, after gradual and continuous opening with osteotomes until the desired tibial slope is achieved on fluoroscopic imaging.

then established. These midpoints were connected with a vertical line to establish the longitudinal axis of the PTS calculation (Fig 1).

Indications

Proximal tibial anterior opening-wedge osteotomy should be considered in patients with symptomatic genu recurvatum >15° or recurrent instability or after a failed posterior cruciate ligament reconstruction. Contraindications consist of grade IV osteoarthritis according to Kellgren and Lawrence or severe leg malalignment (e.g., valgus or varus >10°). Here, we describe a proximal tibial anterior opening-wedge osteotomy technique with iliac crest autograft bone graft as a treatment for symptomatic genu recurvatum with 15.8° anterior tibial slope.

Operative Technique (With Video Illustration)

The patient is brought into the operating room and placed in the supine position and induced under general anesthesia without any complications. Cefazolin (2 g) is given before incision. A well-padded high thigh tourniquet is placed. Range of motion is assessed under general anesthesia.

The surgical technique is demonstrated in Video 1. Intra-articular pathology is addressed before the osteotomy. An anteromedial skin incision is made in line with the medial border of the patellar tendon, raising full-thickness subcutaneous flaps. Medial dissection is performed, and the periosteum under the medial collateral ligament is elevated to the posteromedial corner of the tibia. Lateral dissection is accomplished carefully with the detachment of the tibialis anterior. Then, the patellar tendon is isolated, and the tibial tuberosity is exposed. An osteotomy of the tibial tubercle is performed (with a bone block 6-8 cm long that should reach into the metaphyseal bone). Careful protection and upward retraction of the tibial tuberosity and patellar tendon are performed. Two guide pins are introduced anteriorly approximately 4 to 5 cm below the joint line directed posteriorly and aimed at the level of the insertion of the posterior cruciate ligament. The pins are inserted until they hit the posterior cortex of the tibia, and their position is confirmed by fluoroscopy. These pins are used as guides for performing the osteotomy. A saw blade power tool

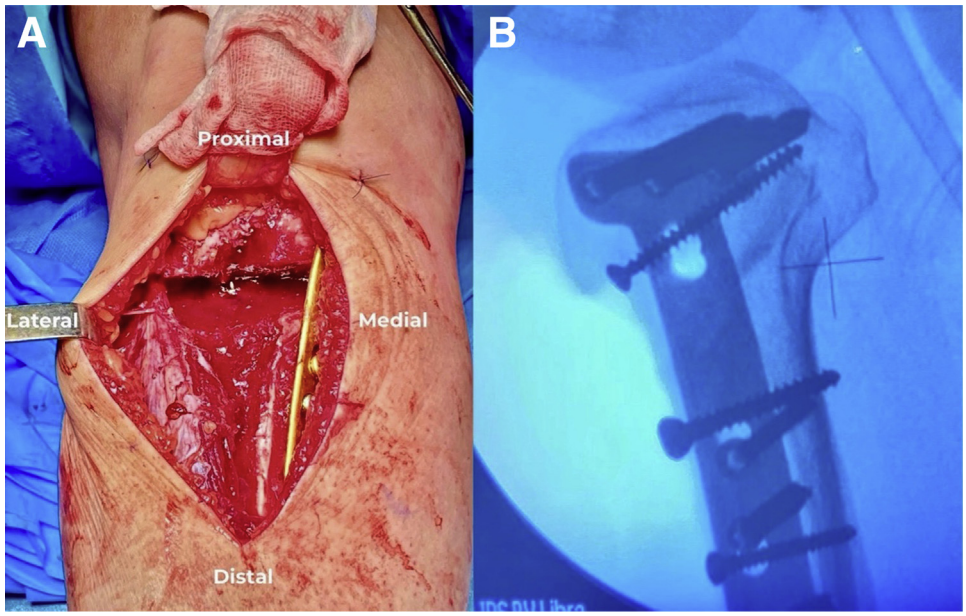

Fig 4. Right knee. (A) A TomoFix plate is placed just medial to the tibial tuberosity osteotomy and fixed in full extension. To achieve correct adaptation of the plate to bone, the use of a 4.5-mm cortical screw in the first of the 3 distal holes is recommended. Once adapted to the tibia, the rest of the distal fixation can also be carried out with angular stability screws. (B) Lateral intraoperative fluoroscopy confirmed proper placement of the plate and screws and correction of the anterior tibial slope.

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
Place the guide pins anteriorly approximately 4-5 cm below the joint line directed posteriorly and aimed at the level of the insertion of the posterior cruciate ligament fibers.	The osteotomy of the tibial tuberosity should have a 6- to 8-cm long bone block and should reach into the metaphyseal bone.
Osteotomes should be inserted from the medial side during the opening to minimize increasing varus, which frequently is associated with anterior tibial osteotomies.	It is crucial to control the progress of the pins with fluoroscopy to prevent inadvertent damage to the neurovascular structures.
Make sure the anterior opening-wedge osteotomy cut is complete around the medial and lateral cortex to avoid fracture of the osteotomy and an appropriate posterior hinge.	The tibial tuberosity bone block is proximally advanced concerning the distal tibial fragment, by the same amount as the opening wedge osteotomy, to avoid a patella infera.
An osteotomy opening of 1 mm is equivalent to 2° of tibial slope correction.	The final correction should be controlled clinically and with fluoroscopy to avoid a hypercorrection and resulting flexion.
Slow progression in the opening of the osteotomy using a specific spreader device and leaving it in place for at least 5 minutes to allow for stress relaxation of the posterior cortex can minimize the risk of an undesired fracture.	Delayed union or non-union may happen with opening wedge osteotomies. Filling the gap with bone graft minimizes the risk of these complications.
To achieve a correct adaptation of the plate to bone, it is recommended to use a 4.5-mm cortical screw in the first of the 3 distal holes.	Stiffness can occur if the patient is not able to follow the established rehabilitation protocol.

(Stryker, Kalamazoo, MI) is used to make anterior, anteromedial, and anterolateral cortical cuts. After correct placement is confirmed by fluoroscopy, an osteotome is used until it is within 1 cm of the posterior cortex both medially and laterally. Great care is taken not to violate the posterior cortex while using the osteotome. Opening of the osteotomy is achieved by the sequential introduction of several osteotomes (Fig 2).

The spreader device is placed. The opening spreader is opened gradually and continuously until the posterior tibial slope is in the desired neutral position on fluoroscopy and the recurvatum is eliminated (Fig 3). The spreader device is left in place for a few minutes to allow for stress relaxation of the posterior cortex.

The appropriate medial locking plate (TomoFix; DePuy Synthes, Raynham, MA) is placed just medial to the tibial tuberosity osteotomy. The plate is fixed proximally with three 5.0-mm, titanium locking head screws, self-tapping, and distally with one 4.5-mm cortical screws plus three 5.0-mm, titanium locking head screws, self-tapping (Fig 4). The osteotomy is then packed with iliac crest autograft bone graft. The tibial tuberosity is fixed proximally with one 4.5-mm cancellous bone screw and distally with two 4.5-mm

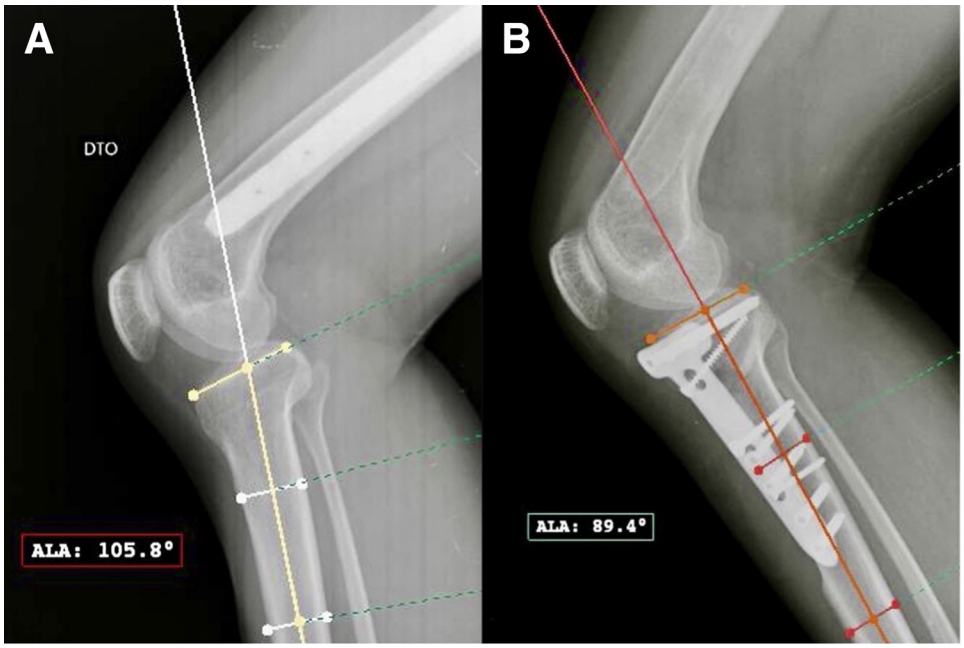

Fig 5. Right knee. (A) Preoperative lateral view radiograph showing anterior tibial slope of 15.8°. (B) Postoperative lateral view radiograph showing posterior tibial slope of 0.6° after the anterior opening-wedge osteotomy, demonstrating a correction of 16.4°.

Table 2. Advantages and Disadvantages

Advantages	Disadvantages
Allows for correction of a negative tibial slope.	Donor-site morbidity following anterior iliac crest bone-grafting.
A fixed-angle plate achieves superior stability and allows early rehabilitation.	Risk of injury to popliteal neurovascular structures.
Tibial tuberosity osteotomy avoids patella infera and acts as a biological plate.	Technically challenging procedure.

cortical screws (Arbeitsgemeinschaft für Osteosynthesefragen screws). Final fluoroscopic images are obtained to confirm osteotomy position, hardware position, and adequate bone grafting (Table 1).

The tourniquet is released, and copious irrigation is performed. The deep tissues are closed with 0 and 2-0 VICRYL, followed by staples for the skin. A sterile dressing is applied.

Partial weight-bearing is allowed immediately. Progressive mobilization of the knee, limited to 90° for 60 days (to ensure consolidation of the tibial tubercle osteotomy). Physical therapy should begin the day after surgery to ensure early articular motion and muscle strengthening.

Deep-vein thrombosis prophylaxis with enoxaparin for 5 weeks is performed. Anteroposterior and lateral radiographs are obtained on postoperative day 1, week 2, and at 8 weeks (Fig 5).

Discussion

Anterior opening-wedge proximal tibial osteotomy is usually indicated for cases of genu recurvatum secondary to increased anterior tibial slope.[5] A systematic review found that anterior slope is the predominant cause of genu recurvatum.[3]

A case series study by Kim et al.[6] showed that the mean anterior tibial slope was 17° (range, 14-25°) preoperatively and −0.4° (range, −5° to 5°) postoperatively. All 5 osteotomies achieved complete union by 3 months without complications. Another case series study, by van Raaij et al.,[7] showed complete union and no deep infections in all 24 anterior opening wedge osteotomies. The excellent overall outcome after performing corrective osteotomy was 83%. The average patellar height was 0.9 preoperatively and showed a significant decrease in patellar height to 0.7 according to Blackburne−Peel method.

Patella infera is the most frequent problem after performing open-wedge osteotomy when the location of the osteotomy is proximal to the insertion of the patellar tendon. Therefore, associated tibial tuberosity osteotomy is sometimes necessary to correct patellar height.[8]

The open-wedge osteotomy is more simplified than closed-wedge osteotomy because it is easy to adjust the correction during operation and can correct leg length. However, there are many considerations with this technique,[9] namely plate positioning[10] and type, as well as the choice to use or not void fillers.

Overall, anterior opening-wedge anterior proximal osteotomy is a consistent surgical treatment option for genu recurvatum, with patients able to expect correction of knee hyperextension, restoration of a more posterior tibial slope, and increased subjective outcome scores (Table 2).

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