Technical Note

Distal Femoral Derotational Osteotomy for Excessive Femoral Anteversion

Mallory Podosin, B.S., Kathleen Hopps, B.S., Jason Goodrum, M.D., Dallas Smuin, M.D., and Brian B. Gilmer, M.D.

Abstract: Excessive femoral anteversion (FA) is an underappreciated contributor to patellar maltracking and instability. Positive screening for anteversion with a hip examination should be followed by computed tomography scan to confirm and quantify the degree of malrotation. Derotational femoral osteotomy allows the surgeon to correct abnormal FA and thereby improve patellar tracking. Correction of the deformity with plate fixation in a supracondylar location has several advantages for reducing morbidity. This article describes our technique for distal derotational femoral osteotomy using a digital inclinometer and plate fixation with standard instrumentation to correct increased FA.

Excessive femoral anteversion (FA) is often discussed academically but rarely incorporated into clinical workup and treatment of patellar maltracking. It is an independent risk factor from trochlear dysplasia and patella alta and, hence, needs to be treated independently. Improved outcomes have been reported by addressing the relevant contributors to recurrent patellar instability: patella alta, trochlear dysplasia, patellar tilt, and rotational abnormalities.[1-6] In this article, we present a distal approach for derotational femoral osteotomy (DeFO).

Surgical Technique

The complete surgical technique is presented in Video 1.

Preoperative Planning

Screening examination for increased FA is performed by flexing the hip and knee to 90° and then evaluating the relative internal and external rotation of the hip. The presence of excessive internal rotation beyond 60° with limited external rotation should trigger investigation with a computed tomography scanogram.

Computed tomography scan is performed at the proximal femur involving the entirety of the femoral head, neck, and peritrochanteric region. Subsequently, under the same "spin," the distal femur and proximal tibia are scanned. Noted in the protocol is the ability to quantify tibial torsion if indicated—even in adulthood.[6]

Generally, FA greater than 25° is considered outside normal values.[3,7] The goal of our procedure is to decrease the FA to approximately the normative average of 15°.[3] In our practice, excessive FA greater than 20° beyond normative values is a firm indication for derotation, with consideration of osteotomy above 15° depending on the clinical presentation. For example, with 17° to 20° used as a reference for normal, a combined (hip and knee) FA greater than 37° to 40° would be an indication for DeFO (Fig 1).

Further workup consists of standard radiographs and a full-length hip-knee-ankle radiograph to evaluate coronal-plane deformity. Further diagnostic examination is performed with a magnetic resonance image of the knee to evaluate the medial patellofemoral ligament (MPFL) and the status of the patellofemoral cartilage, as well as associated pathology, and to assess the trochlear morphology.

Examination Under Anesthesia

A preoperative examination under anesthesia is performed to estimate relative FA based on physical

From University of Nevada, Reno School of Medicine, Reno, Nevada, U.S.A. (M.P.); Mammoth Orthopedic Institute Mammoth Hospital, Mammoth Lakes, California, U.S.A. (K.H., B.B.G.); Barton Center for Orthopedics and Wellness, South Lake Tahoe, California, U.S.A. (J.G.); and Taos Orthopaedic Institute, Taos, New Mexico, U.S.A. (D.S.).

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Address correspondence to Brian B. Gilmer, M.D., Mammoth Orthopedic Institute, 85 Sierra Park Rd, Mammoth Lakes, CA 93546, U.S.A. E-mail: bbgilmer@gmail.com

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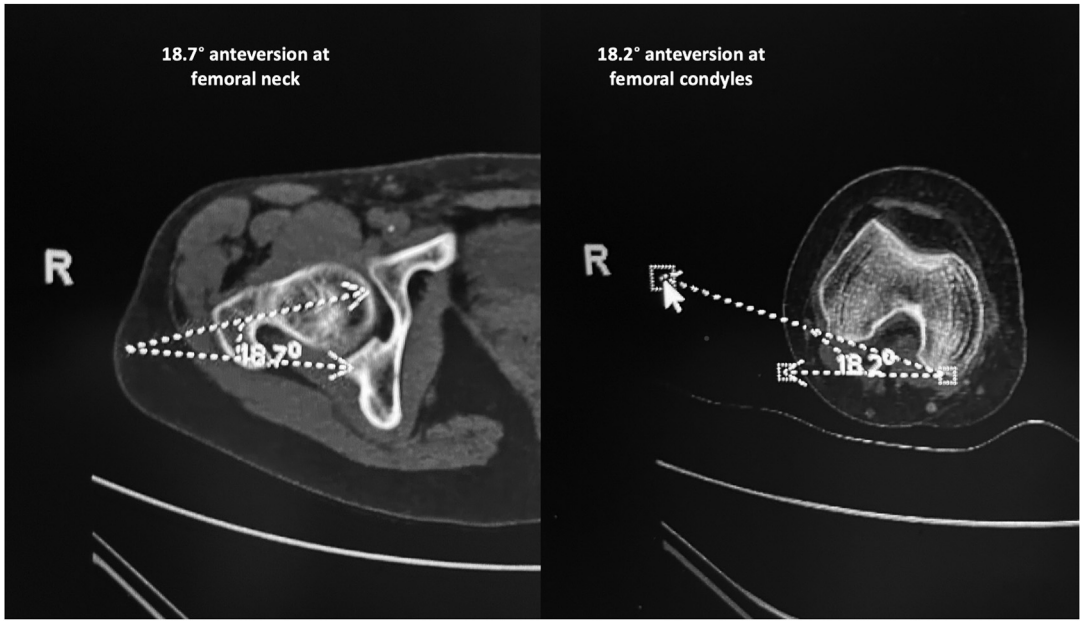

Fig 1. Preoperative computed tomography scanogram anteversion protocol used to assess femoral anteversion of femoral neck and distal femoral condyle. In this example, there is excessive combined femoral anteversion of approximately 37° (18.7° at the femoral neck and 18.2° at the femoral condyles). R indicates right side or R + right leg.

examination. This should demonstrate increased internal rotation of the hip with diminished external rotation (Fig 2).

Arthroscopic Examination

Standard knee arthroscopy is performed. With the arthroscope in the lateral portal, there will appear to be reduced lateral space in the patellofemoral articulation and relative patellar tilt (Fig 3). Excessive lateral mobility of the patella can be evaluated, and a dynamic tracking examination through a range of motion generally demonstrates lateral tracking and overcompression of the lateral facet, which gradually corrects in deeper flexion. Chondroplasty or related procedures should be performed at this time as indicated.

Exposure and Preparation

A standard lateral approach to the distal femur with the patient supine is performed. A small bump under the ipsilateral hip can prove helpful for exposure but should be removed prior to the placement of reference wires for the osteotomy to allow the limb to lie

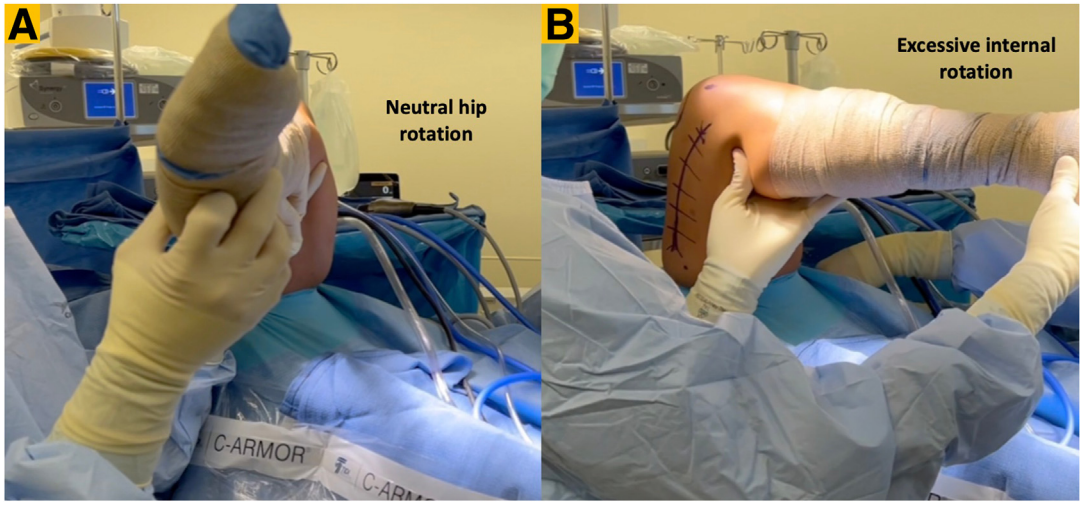

Fig 2. Clinical view of right lower extremity showing neutral hip rotation (A) and excessive internal rotation of approximately 80°, typical of excessive femoral anteversion (B).

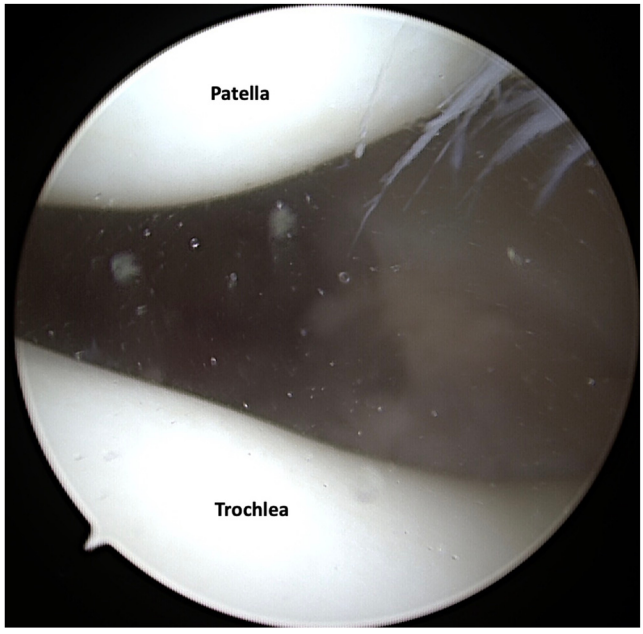

Fig 3. Arthroscopic view of right knee, with arthroscope viewing from lateral portal, showing lateral patellar tracking and patellar tilt consistent with excessive femoral anteversion.

flat with the bed level. After the iliotibial band is split, the vastus lateralis is reflected anteriorly and dissected off the intermuscular septum, with care taken to achieve hemostasis of penetrating branches. Retraction with large Bennett retractors or self-retaining retractors can be helpful.

The selected plate—which can be a standard distal femoral trauma plate or, as demonstrated, a pediatric distal femoral 5.0-mm locking plate (pediatric distal femoral osteotomy plate; Synthes, Warsaw, IN)—is placed in the proposed position on the distal-lateral femoral metaphysis, between the proximal and distal locking holes of the chosen plate. In general, the level of osteotomy should be near the meta-diaphysis where the surface area for contact is increasing in the distal flare but still well above the trochlea and condyles (Fig 4). An electrocautery device is used to mark the level of the osteotomy (Fig 5), or it may be helpful to use a saw or an osteotome to score the location of the osteotomy so that it can be easily identified after the plate is removed to complete the osteotomy.

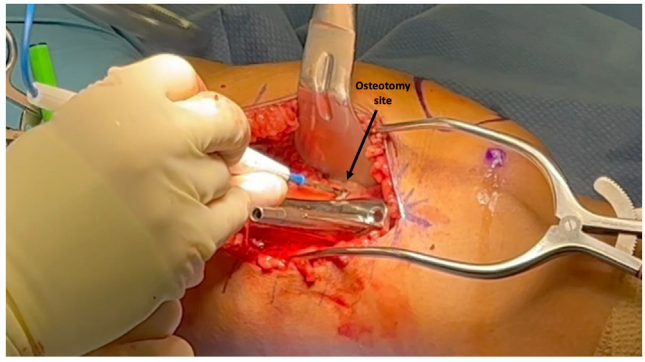

Fig 5. Open view of lateral distal femur in right knee. The osteotomy site is marked with an electrocautery device.

Reference Wire Placement

With the plate still in place, a Kirschner wire should be inserted anterior to the plate so as not to interfere with final fixation. This should be placed parallel to the floor and have solid fixation in the bone because it will

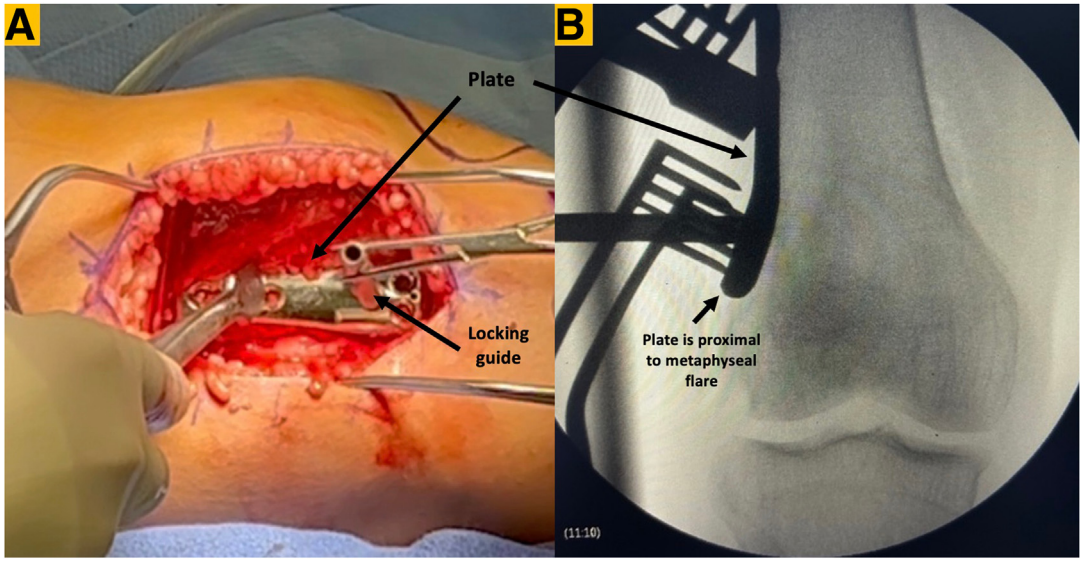

Fig 4. (A) Open view of lateral distal femur in right knee. The plate is provisionally placed, and the position is held with a Kirschner wire. (B) The plate position is confirmed with biplanar fluoroscopy to be appropriately positioned just proximal to the metaphyseal flare.

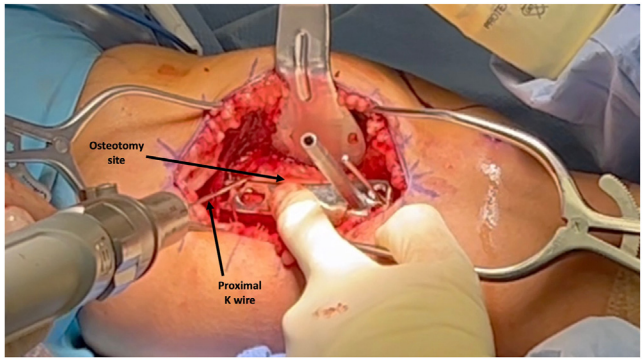

Fig 6. Open view of lateral distal femur in right knee. A proximal wire is placed anterior to the plate for reference.

be used for reference (Fig 6). A potential pitfall is losing the fixation or orientation of this wire after the osteotomy.

By use of a digital inclinometer phone application (Clinometer; Phoenix Solutions [developed by Tue Nguyen Minh, Vietnam) in a sterile covering, the relative angle of the wire is measured. Ideally, this is 0° relative to the floor of the operating room (Fig 7).

A second Kirschner wire is placed distal to the osteotomy site at the desired angulation of correction. The wire should be placed in relative internal rotation to the first wire and should be remote from the plate. After the osteotomy, this wire and the distal limb will be externally rotated to achieve the desired correction. That is, posterior placement of the Kirschner wire will result in increased internal rotation and anterior placement of the Kirschner wire will result in increased external rotation after the correction is performed. It is much easier to rotate the distal extremity relative to the proximal side, so it is easiest if the proximal wire rests at approximately 0° (Fig 8).

Prior to initiation of the osteotomy cut, the relative angulation of each wire should be confirmed to ensure that the desired amount of correction will be achieved. Typically, 15° to 20° of combined postoperative FA is targeted (Fig 9).

The plate is then removed to allow completion of the osteotomy. The location of the cut is confirmed, and circumferential retraction is achieved to prevent neurovascular injury. The placement of the blade should be confirmed under fluoroscopy as perpendicular to the long axis of the femoral shaft. This will make the saw blade appear as a thin line or wire on fluoroscopic imaging. An osteotomy that is oblique to the long axis of the femur can introduce undesired coronal-plane changes in alignment after derotation (Fig 10).

With the osteotomy completed, the distal limb is rotated until the 2 Kirschner wires are parallel (Fig 11). The plate is replaced and provisionally held with a clamp until the correct alignment is confirmed (Fig 12). Standard screw fixation is then performed proximally and distally (Fig 13). A repeated examination of the hip shows improved hip external rotation with decreased internal rotation (Fig 14).

Postoperative Rehabilitation

Concomitant procedures may dictate adjustments to postoperative rehabilitation. However, in the case of isolated distal femoral derotational osteotomy, toe-touch weight bearing is applied at 0 through 2 weeks postoperatively, followed by gradual weight bearing as tolerated. Range of motion is not restricted. Gait training is initiated at 2 weeks and

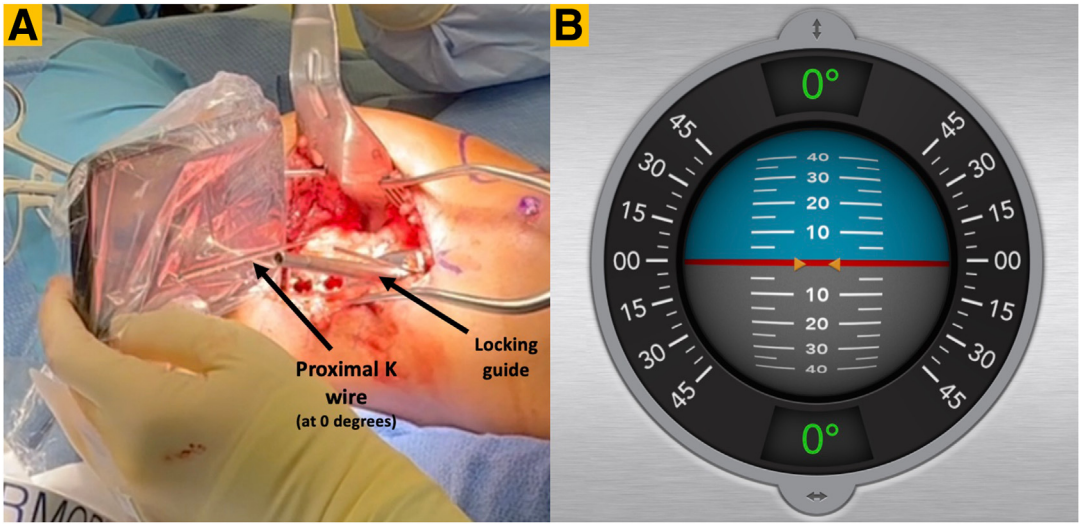

Fig 7. (A) Open view of lateral distal femur in right knee. A Kirschner wire is placed in the proximal segment anterior to the plate in a position parallel to the floor. (B) Goniometer displaying 0°.

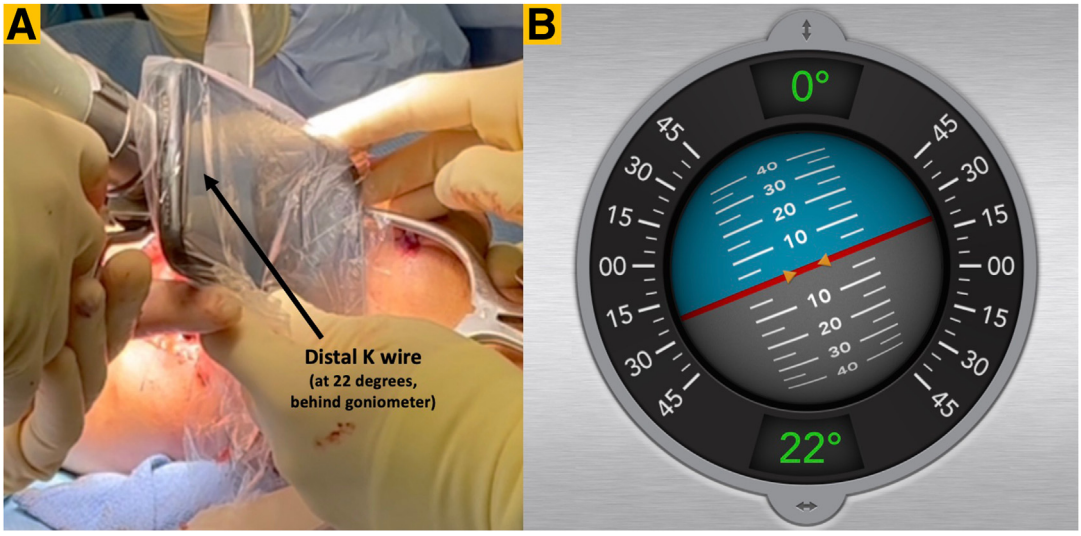

Fig 8. (A) Open view of lateral distal femur in right knee. A Kirschner wire is placed in the distal segment distal to the plate in a position 22° anteverted (internally rotated) relative to the first wire. (B) Goniometer displaying 22°.

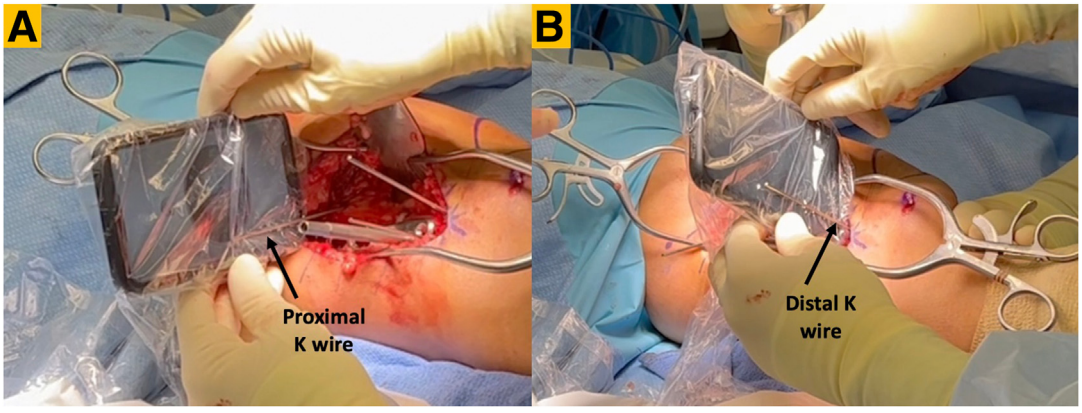

Fig 9. Open view of lateral distal femur in right knee. The position of the Kirschner wires is confirmed to be divergent by the angle of planned correction with the distal wire internally rotated (anteverted) relative to the proximal wire. (A) Proximal Kirschner wire at 0°. (B) Distal Kirschner wire at 22° (angle of correction).

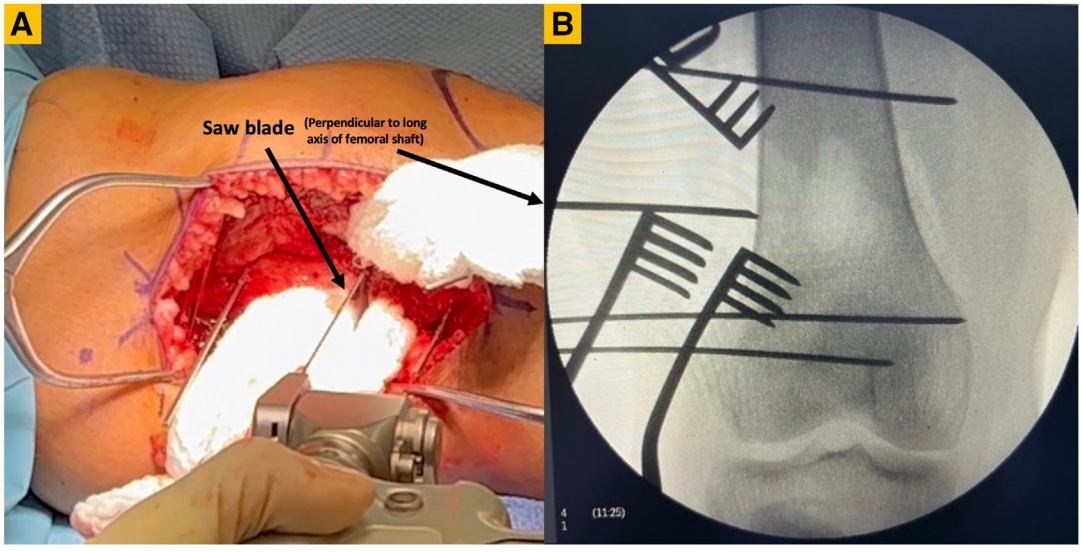

Fig 10. (A) Open view of lateral distal femur in right knee. The saw blade is introduced in a position perpendicular to the long axis of the femoral shaft to avoid introduction of varus or valgus deformity. (B) The saw blade is confirmed to be perpendicular to the long axis of the femur under fluoroscopy prior to initiation of the osteotomy.

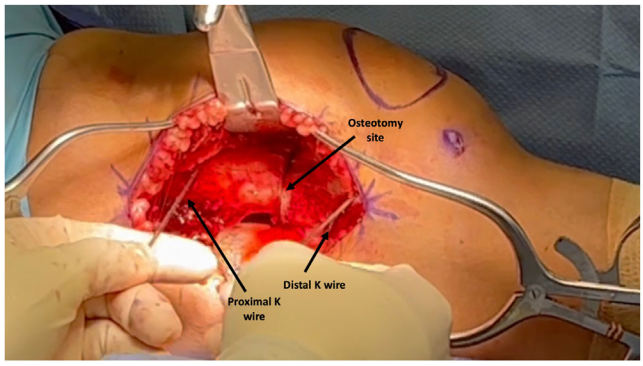

Fig 11. Open view of lateral distal femur in right knee. After completion of the osteotomy, the distal segment is externally rotated until the Kirschner wires are parallel.

continues through 6 weeks postoperatively with the use of crutches, with most normal activities of daily living resuming at around 3 months postoperatively and with a return to sports and activity at between 4.5 and 6 months. Table 1 reviews the pearls and pitfalls applicable to the procedure.

Discussion

Untreated FA can significantly impair clinical outcomes of patients undergoing surgery for patellar instability. Moreover, increased FA often goes undiagnosed and may lead to persistent symptoms and dissatisfaction despite soft-tissue stabilization.

DeFO allows for correction of FA.[1,3] Zhang et al.[4,5] concluded that patients with increased FA and recurrent patellar dislocations have improved outcomes with DeFO and MPFL reconstruction over isolated MPFL reconstruction. Nelitz et al.[7] further suggested that DeFO addresses the root problem of excess torsion behind patellar maltracking and should be considered in patients with recurrent patellar dislocations and increased FA. Finally, an additional advantage of DeFO lies in its ability to improve the tibial tuberosity–trochlear groove distance.[2,8]

Despite the numerous advantages of our technique, there are some disadvantages to consider. One potential issue is that the plate may interfere with the lateral exit point for an MPFL tunnel or may complicate correct tunnel placement, especially if the plate extends distally on the lateral femoral condyle. Additionally, there is a risk of malunion if the osteotomy cut is not made perfectly perpendicular to the axis of the femoral shaft, which could inadvertently introduce a coronal-plane deformity.

Our technique for DeFO has several advantages. It uses simple and widely available instrumentation, eliminating the need for patient-specific guides, and can be performed with any standard plating system. The osteotomy is performed near the knee, which localizes the surgical morbidity to a region close to the area in which other related procedures are performed. This approach has shown reliable healing and permits early weight bearing postoperatively. These benefits make our technique a practical and effective solution for addressing excessive FA in patients with patellar instability. In conclusion, this article describes our technique for a distal DeFO using a digital inclinometer and plate fixation with standard instrumentation to correct increased FA.

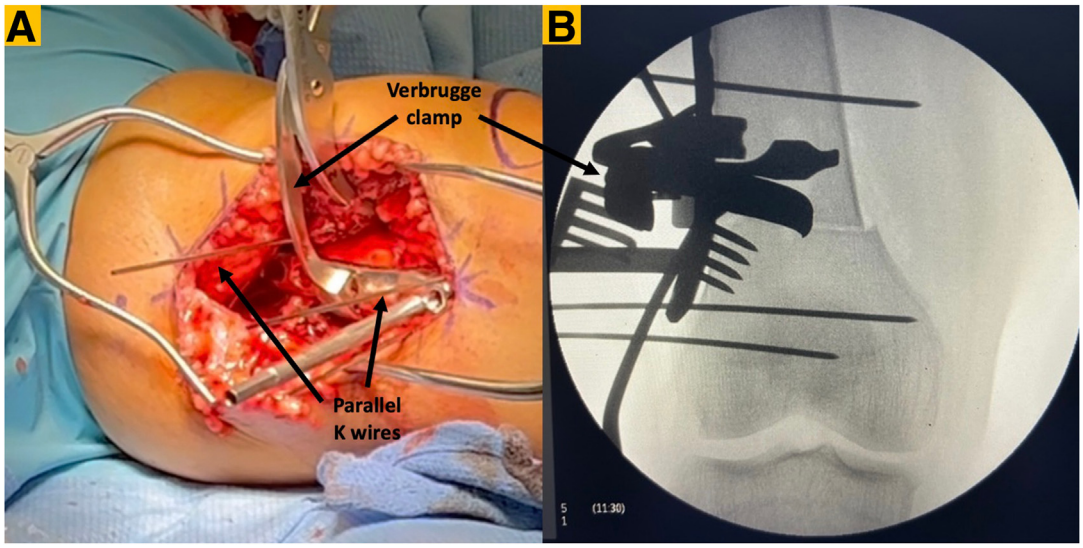

Fig 12. (A) Open view of lateral distal femur in right knee. The plate is replaced and provisionally clamped to maintain the reduction in the corrected position with external rotation of the distal fragment. (B) The plate position and reduction of the osteotomy are confirmed fluoroscopically.

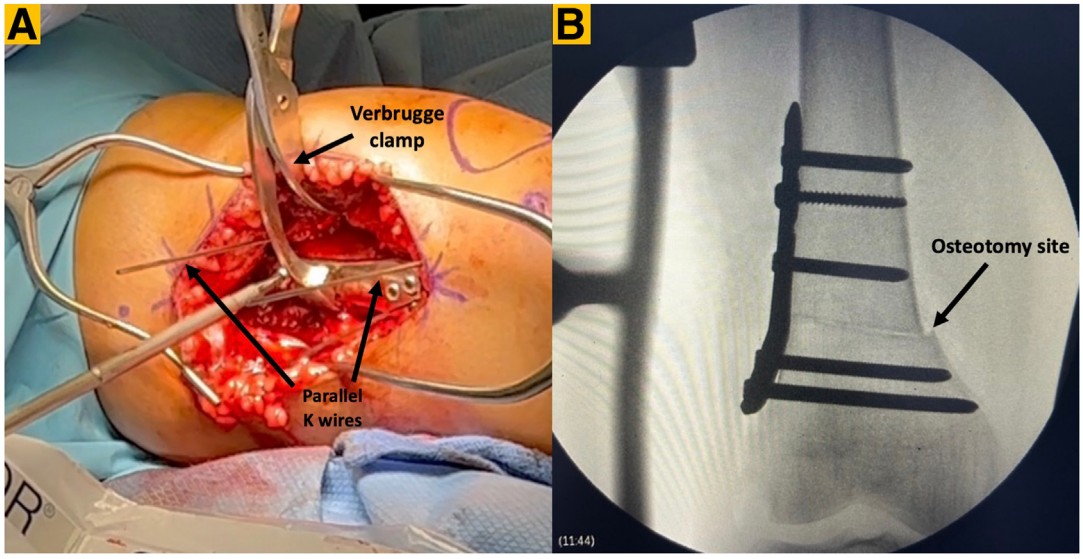

Fig 13. (A) Open view of lateral distal femur in right knee. Standard screw fixation is performed with locking fixation distally, followed by proximal fixation with a non-locking compression screw and then additional locking screw fixation. (B) The final position of the osteotomy is confirmed fluoroscopically.

Disclosures

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: K.H. reports that administrative support; article publishing charges; equipment, drugs, or supplies; and writing assistance were provided by Mammoth Hospital. B.B.G. reports a consulting or advisory relationship with Arthrex and Miach Orthopaedics; receives speaking and lecture fees from Arthrex and Miach Orthopaedics; receives travel reimbursement from Arthrex, Miach Orthopaedics, Stryker Orthopaedics, and DePuy Orthopaedics; owns equity or stocks in Doximity; receives funding grants from Breg; receives nonfinancial support from Breg; is an editorial board member for *Arthroscopy*; is Course Chairman of Mammoth Sports Course, which receives industry support; and is Fellowship Director of Mammoth Orthopedic Institute Sports Medicine Fellowship, which receives industry support. All other authors

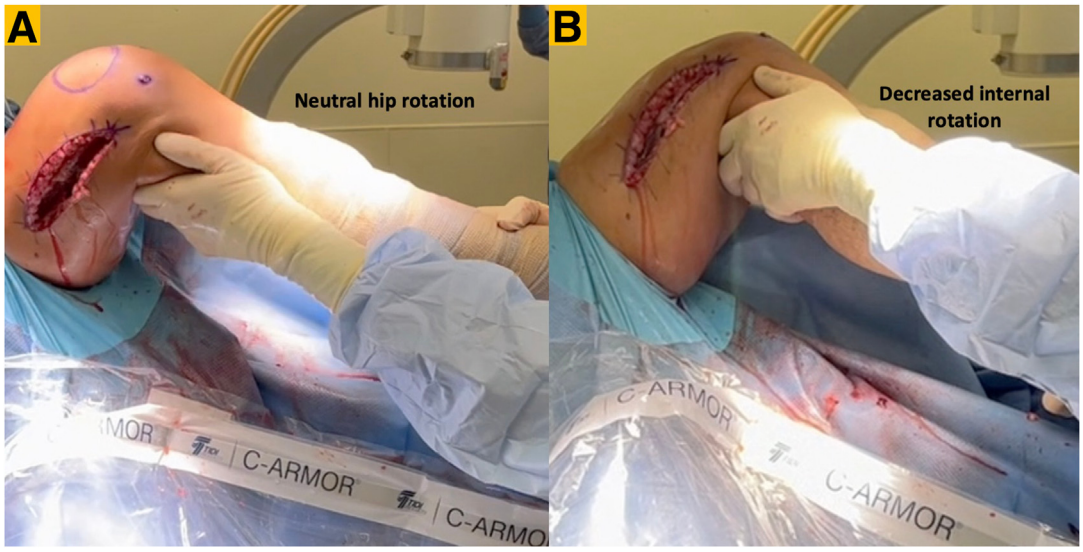

Fig 14. Clinical view of right lower extremity showing neutral hip rotation (A) and decreased internal rotation (B) relative to preoperative examination.

Table 1. Pearls and Pitfalls

Pearls
Patient positioning: The patient should be positioned flat on the bed without bumps or positioning aids.
Plate application: The plate should be applied first to ensure that the Kirschner wires are placed appropriately out of the way and the osteotomy site can be planned and marked.
Bicortical fixation: Bicortical fixation of the Kirschner wires can prevent inadvertent displacement.
Wire positioning: The surgeon should ensure that the proximal Kirschner wire is placed at 0°, parallel to the floor, and the distal wire should be placed more anterior in the distal fragment because it is much easier to externally rotate the distal limb than the proximal limb.
Radiolucent retractors: Radiolucent Bennett retractors or lap sponges can be used to create a circumferential field of retraction while allowing for fluoroscopy during the osteotomy.
Provisional fixation: A Verbrugge clamp or collinear clamp should be used for provisional fixation prior to the insertion of screws to ensure that the ideal correction has been achieved.
Saw blade orientation: The surgeon should ensure that the saw blade appears as a line on fluoroscopy, indicating no obliquity in the transverse osteotomy, to avoid unwanted coronal-plane alignment changes.
Perpendicular cut: The surgeon should ensure that the osteotomy cut is perfectly perpendicular to the axis of the femoral shaft to avoid introducing a coronal-plane deformity.
Pitfalls
Saw blade alignment: The surgeon should ensure that the saw blade is perpendicular to the long axis of the femur and appears as a single thin line on fluoroscopic imaging. Failure to do so may result in unwanted changes to coronal-plane alignment.
Osteotomy marking: Failure to mark the osteotomy site with a saw or osteotome can make it difficult to determine the proper location when the plate has been removed.
Wire placement: Placement of the wires should be performed before placing the plate provisionally. These wires are the reference point and should not be compromised or moved after the osteotomy because doing so risks losing the reference for the correction.
Loss of fixation: Loss of fixation of either Kirschner wire after completion of the osteotomy risks being unable to determine the degree of correction.
Plate positioning: The surgeon should avoid placing the plate too proximally over the shaft, which has less healing capacity compared with a more distal placement near the metaphysis.
Rotation planning: Failing to plan for external rotation of the distal wire relative to the proximal wire can lead to inadvertently increasing the anteversion. A repeated hip examination should confirm increased hip external rotation and diminished hip internal rotation relative to the preoperative state.
Tunnel interference: The surgeon should be aware that the plate may interfere with the lateral exit point for an MPFL tunnel or complicate correct tunnel placement, particularly if the plate extends distally on the lateral femoral condyle, making fluoroscopic identification of the tunnel challenging.
Concomitant procedures: The surgeon should ensure that concomitant procedures such as MPFL reconstruction will not interfere with plate placement and plan accordingly.

MPFL, medial patellofemoral ligament.

(M.P., J.G., D.S.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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