Technical Note

Lateral Opening-Wedge Distal Femoral Osteotomy Made Easy: Tips and Tricks

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Abstract: A lateral opening-wedge distal femoral osteotomy is useful to offload the lateral tibiofemoral compartment for focal chondral defects or isolated lateral compartment arthritis. Although beneficial for these lateral compartment disorders, a distal femoral osteotomy requires careful forethought to optimize correction accuracy and safety. We recommend the following for effective execution of a distal femoral osteotomy: (1) Plan the desired correction preoperatively while accounting for an individual patient's anatomy and femoral width. (2) Perform an iliotibial band Z-lengthening for large deformity corrections to not overconstrain the lateral structures. (3) Use the plate to help guide the level of the osteotomy, which will facilitate bony contact after the osteotomy and decrease plate prominence. (4) Perform the osteotomy with a saw anteriorly and an osteotome posteriorly for safety and stop the osteotomy approximately 1 cm short of the far cortex. (5) Fashion tricortical wedge grafts at the height of the planned correction to maintain reduction and facilitate plate placement. (6) Control the plate position to lie optimally at the level of the osteotomy, ensuring it is not proud and is parallel with the femoral shaft. With these presurgical and intraoperative steps, a lateral opening-wedge distal femoral osteotomy can be performed effectively.

Lateral opening-wedge distal femoral osteotomy offers numerous benefits to patients with lateral tibiofemoral disease. A lateral opening-wedge distal femoral osteotomy may offload joint loads in conjunction with lateral compartment cartilage procedures and lateral meniscus procedures, in addition to offering relief of symptoms for patients with lateral compartment–dominant arthritis.

Although a useful procedure with reliable return-to-work and return-to-sport outcomes,[1,2] lateral opening-wedge distal femoral osteotomy may be tricky to perform and present several risks, including those of iatrogenic fracture and loss of or inaccurate deformity correction. Careful planning preoperatively and intraoperatively can help limit complications and make the procedure more reliable. The authors present several tips and tricks in this Technical Note to make a lateral opening-wedge distal femoral osteotomy more reliable, easier, and safer to perform.

Surgical Technique (With Video Illustration)

Patient Positioning and Setup

The patient is positioned supine on the operating table. The authors prefer to drop the foot of the table and place the patient's operative leg in a leg holder. A nonsterile tourniquet is applied to the proximal thigh. A limb positioner (SPIDER2; Smith & Nephew, Walford, England, UK) is used to control knee flexion and extension as well as lower-extremity rotation. A mini fluoroscopic c-arm is used, entering from the

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The authors report the following potential conflicts of interest or sources of funding: B.J.C. reports other from Aesculap/B. Braun; personal fees, nonfinancial support, and other from Arthrex; personal fees from BandGrip and Elsevier Publishing; other from JRF Ortho, National Institute of Arthritis and Musculoskeletal and Skin Diseases, and Eunice Kennedy Shriver *National Institute of Child Health and Human Development; personal fees and other from* Operative Techniques in Sports Medicine*; personal fees from OSSIO; and other from Smith & Nephew, outside the submitted work. A.B.Y. reports grants from Arthrex and Organogenesis, outside the submitted work; consulting fees from Joint Restoration Foundation, Inc., Stryker, and AlloSource; payments for education events from Stryker; stock or stock options from Patient IQ and Icarus; and advisory board for Sparta and Stryker. All other authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. Full ICMJE author disclosure forms are available for this article online, as supplementary material.*

Received July 2, 2023; accepted August 26, 2023.

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2212-6287/23937

https://doi.org/10.1016/j.eats.2023.08.021

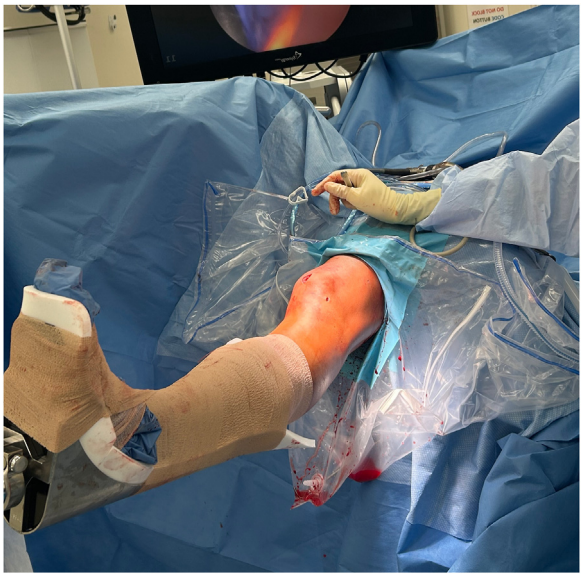


Fig 1. Patient positioning for a left lateral opening-wedge distal femoral osteotomy. The operative lower extremity is placed into a leg thigh holder, the foot of the bed is dropped, and the leg position is controlled with a limb positioner (SPIDER2; Smith & Nephew). The limb positioner allows for stability and control of the leg and limits necessity of assistants for leg positioning. The minifluoroscopic c-arm enters from the contralateral side (from the right leg in this example) and is easily maneuvered around the operative (left) leg with the foot of the bed dropped.

contralateral side (Fig 1). The following tips and tricks are discussed in Video 1.

Tip 1: Plan Correction Preoperatively

Standing long-limb weight-bearing radiographs are obtained preoperatively. A plumb line is drawn from the femoral head center to the center of the tibial plafond (ie, the mechanical axis); if this line falls toward the lateral compartment, there is valgus coronal plane alignment (Fig 2). The authors typically do not perform a distal femoral osteotomy unless the degree of correction is at minimum 5°.

To determine the goal correction, several steps are undertaken. We aim to correct the deformity to a location anywhere from neutral to the medial tibial spine for lateral compartment focal cartilage defects. For lateral compartment arthritis, we aim to correct the deformity anywhere from neutral to just medial to the medial tibial spine. Care should be taken to obtain an adequate, but not excessive, correction.

An angle is measured between the following 2 lines: (1) the center of the femoral head to the identified correction point on the proximal tibia and (2) the correction point on the proximal tibia to the center of the tibial plafond. The number of degrees away from 180° dictates the goal degrees of correction (Fig 2).

Once the target degrees of correction are calculated, the next step is to plan the opening-wedge bone graft to obtain that correction. Many have assumed that 1° of correction is accomplished with approximately 1 mm of lateral opening, but this assumption is not always accurate due to the variation and impact of femoral width.

On a calibrated radiograph, the degrees of correction are drawn at the level of the osteotomy on the distal femur. The height of the triangle approximates the width of bone graft necessary to achieve those degrees of correction (Fig 3).

Tip 2: Perform Iliotibial (IT) Band Z-Lengthening for Large Deformity Corrections

For corrections using bone graft wedges calculated to be 10 mm or more, we perform an IT band Z-lengthening. The Z-lengthening helps with exposure, allows for appropriate soft-tissue tension at the end of the case, and limits overconstraint on the lateral-sided soft-tissue structures.

The Z-lengthening is performed with the longitudinal limb at the mid-portion of the IT band at the level of the planned osteotomy. The Z cut is taken anteriorly proximally and posteriorly distally (Fig 4A). If a Z-lengthening is performed, this is loosely closed at the end of the case (Fig 4B).

Tip 3: Use a Plate to Guide Osteotomy Level

Adequate exposure is obtained distally, as a common error is to have the plate sit too proximal. The authors use the distal femoral osteotomy plate (ContourLock; Arthrex; Naples, FL) to guide the osteotomy level.

The distal aspect of the plate is placed atop the bone so that it is flush. By doing this, the proximal portion of the plate may initially sit off bone. The plate position is estimated, taking care that it is not proud distally or anteriorly.

The distal line on the plate serves as a marker for the osteotomy level. We take care to ensure that if the osteotomy were performed at this level, it would not intersect the femoral trochlea medially (Fig 5).

Tip 4: Safely Perform the Osteotomy

Guidepins are placed in the planned trajectory, which is confirmed fluoroscopically. The guidepins are bent away from the field. A radiolucent retractor is placed along the posterior cortex of the femur to protect the posterior neurovascular structures.

An oscillating saw is used to perform the cut anteriorly, with bulb irrigation to limit thermal necrosis. Posteriorly, we use an osteotome for safety (Fig 6A). The cuts with the saw and osteotome are carried medially to stop approximately 1 cm short of the medial cortex (Fig 6B).

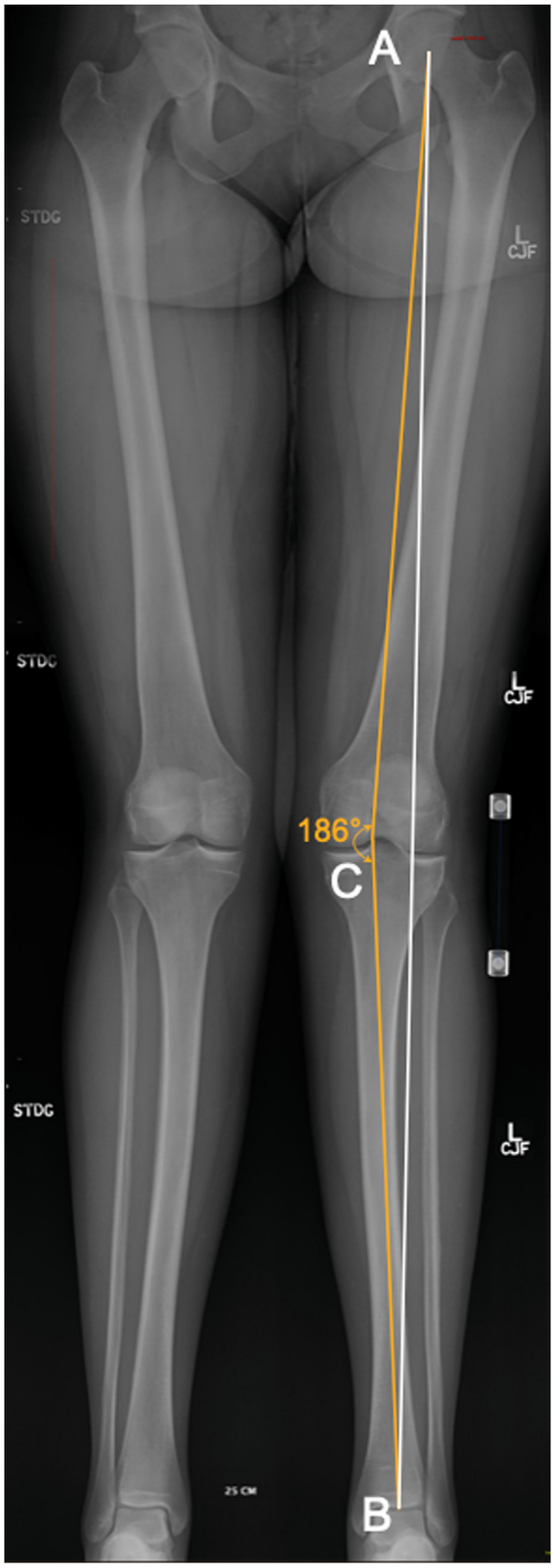


Fig 2. Determining the degree of correction. A standing limb length weightbearing radiograph is obtained. A line between point A (femoral head center) and point B (center of tibial plafond) is drawn (white line), representing the mechanical axis, which falls into the lateral compartment of the knee, confirming valgus coronal plane deformity. In this example on the left lower extremity, the medial tibial spine (point C) is used for goal correction. An angle (orange lines) is drawn between line AC and line BC. This angle measures 186°, which corresponds to 6° of correction in this case.

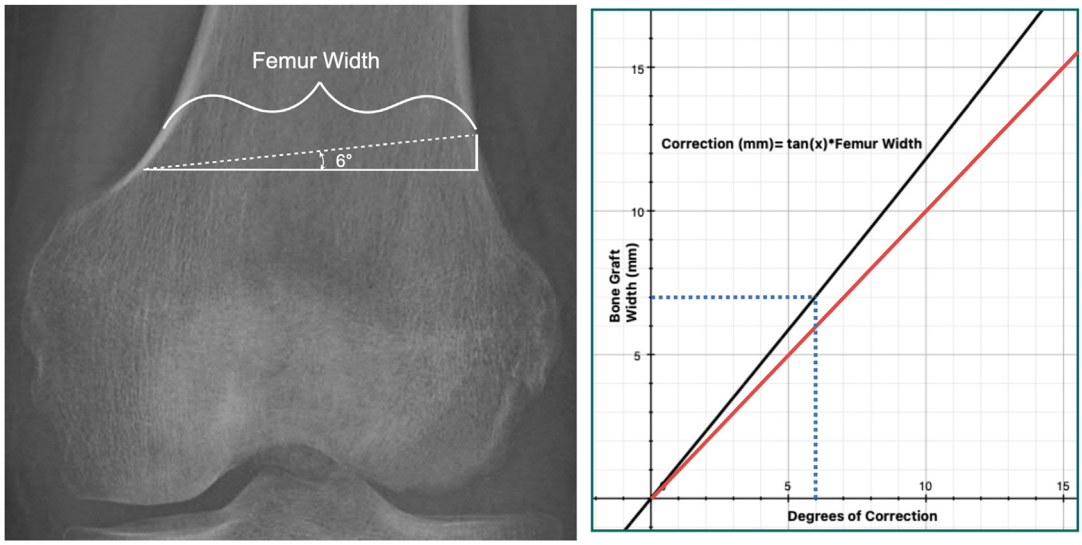


Fig 3. Determining the height of the bone wedge for deformity correction. The desired degree of correction is drawn on the distal femur at the level of the osteotomy on a calibrated radiograph (left image). The height of the triangle on the lateral femoral cortex corresponds to the size of the bone block or correction height necessary to achieve the desired correction. This will vary by femoral width (red line on right image), so one should not assume that each degree of correction always corresponds to 1 mm of bone graft width (black line on right image).

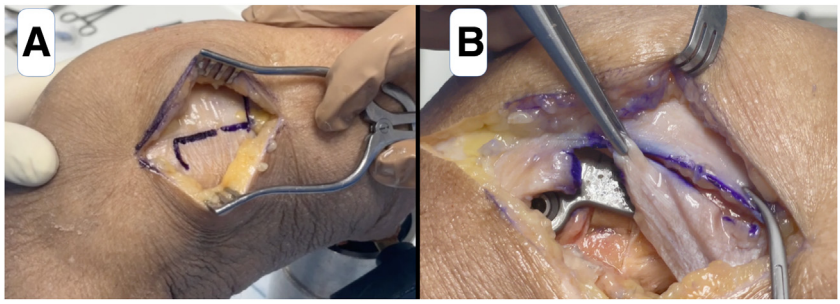
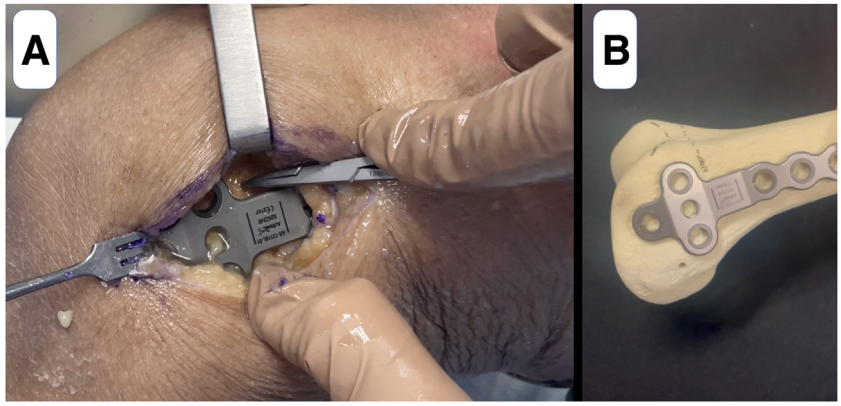


Fig 4. Demonstration of Z-lengthening. The authors perform a Z-lengthening for bone graft wedges of 10 mm or more to improve exposure and limit overconstraint on lateral-sided soft tissue structures. (A) Demonstration of the Z-lengthening with an anterior limb proximally and posterior limb distally on a left lower extremity. (B) Demonstration of how the Z-lengthening is closed at the end of the case.

Fig 5. The distal aspect of the plate is placed flush against the distal femur cortical bone (left lower extremity demonstrated). (A) The distal line on the plate serves as the location of the osteotomy. (B) Demonstrated on a sawbone model is the location of the distal line of the plate relative to the femoral trochlea. Care should be taken to ensure that if this line were carried across medially, it does not intersect with the femoral trochlea.



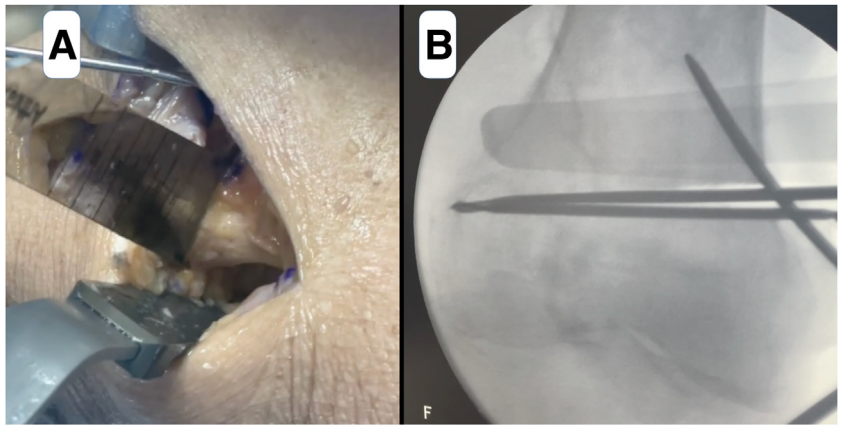


Fig 6. Performing the osteotomy. A saw is used along the breakaway pin trajectory anteriorly, stopping 1 cm short of the medial cortex. A left lower extremity is demonstrated. (A) A radiolucent retractor is placed along the posterior femoral cortex to protect the posterior neurovascular structures. The osteotome is used to complete the cut posteriorly, again stopping 1 cm short of the medial cortex. (B) Fluoroscopic view demonstrating pin placement and the osteotome stopping short of the far cortex.

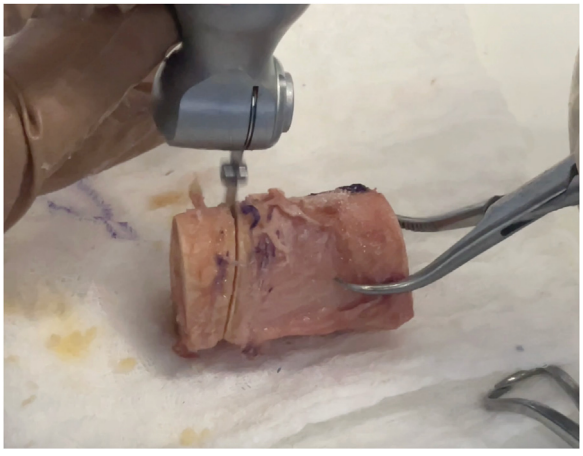


Fig 7. Preparing the tricortical allograft wedge. A distal tibial allograft is used and fashioned in a doorstop configuration with the maximal height set to the predetermined width from preoperative planning.

Tip 5: Insert Tricortical Wedge Graft to Maintain Correction

A tricortical allograft from a distal tibia is used. The graft is fashioned in a doorstop configuration (Fig 7); the height of the graft cut is according to the predetermined width from preoperative planning. Gentle varus stress is applied to the osteotomy to facilitate insertion of the graft into the posterior aspect of the osteotomy. The posterior wedge is inserted to appropriate depth with the graft not proud past the lateral cortex. Varus stress is then relaxed and the osteotomy correction should be held by the posterior wedge. We then measure the new anterior osteotomy gap with a ruler (Fig 8). A new wedge is then fashioned to fill the anterior gap at this measured width; often this is similar or less than that of the posterior planned wedge (Fig 8). Fluoroscopic images are taken to confirm the correction (Fig 9).

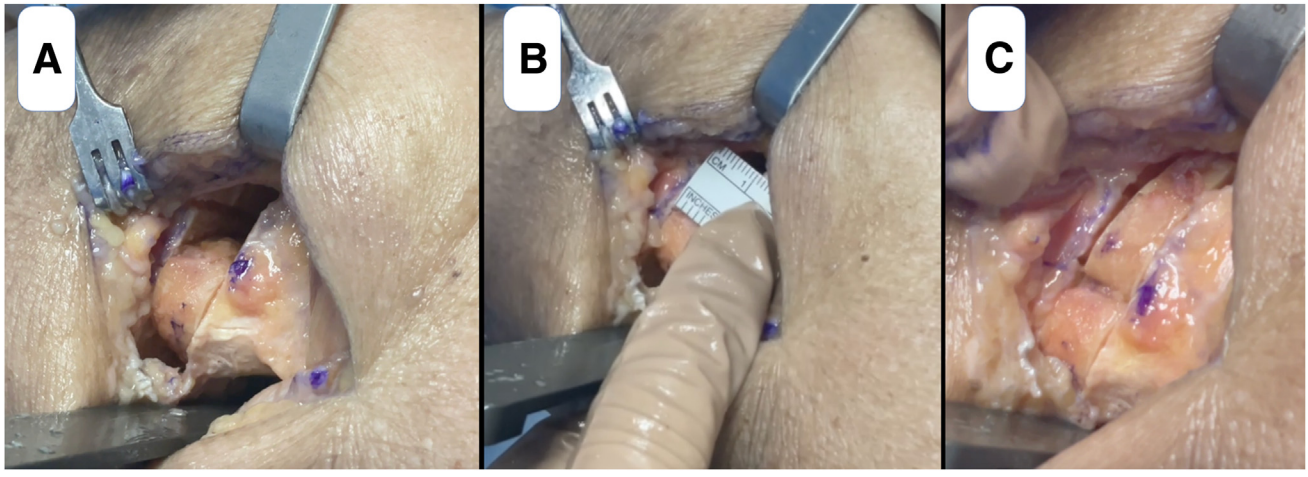


Fig 8. Obtaining and maintaining the opening-wedge correction. Gentle varus stress is applied and held with the limb positioner to facilitate insertion of the wedges. A left lower extremity is demonstrated. (A) The previously fashioned doorstop configuration tricortical distal tibial allograft to the predetermined height is placed in the osteotomy site posteriorly, as this is the area of largest correction based on the femoral geometry. (B) Once the posterior wedge is in place, varus stress may be relaxed. The remaining anterior gap is measured with a ruler to determine the height of the anterior bone wedge. (C) A new tricortical wedge is fashioned and placed into the anterior portion of the osteotomy.

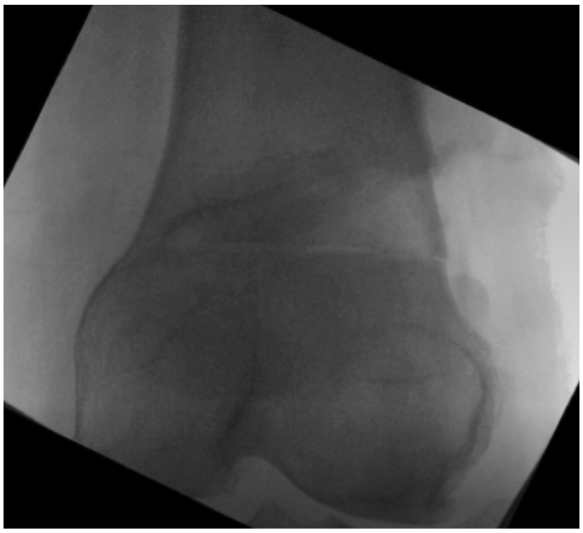


Fig 9. Fluoroscopic anteroposterior image demonstrating the deformity correction with the tricortical wedges in place for a lateral opening-wedge distal femoral osteotomy of the left femur.

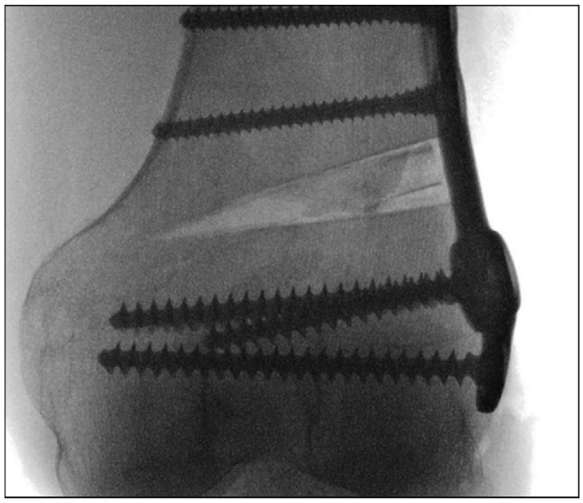


Fig 11. Fluoroscopic anteroposterior image demonstrating the final construct with the plate and screws in place on a left femur. The plate sits flush on bone radiographically.

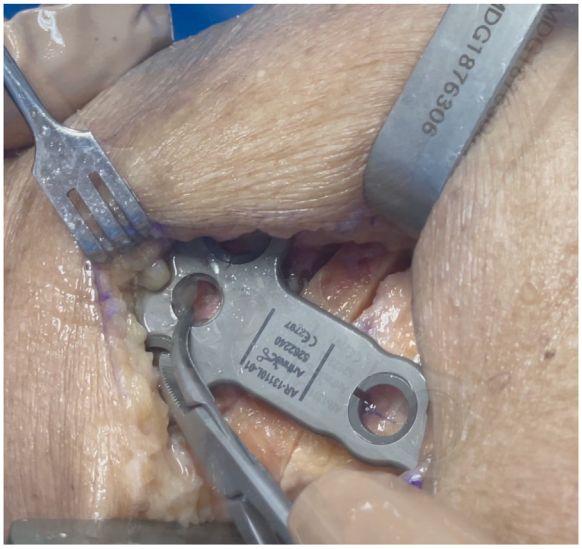


Fig 10. Demonstration of plate position after deformity correction with the tricortical bone wedges in place in a left femur. The distal aspect of the osteotomy lies at the distal line on the plate, and the opening wedges lie proximal to that location. The plate should sit flush on bone both distally and proximally.

Tip 6: Control Plate Positioning

The reduction is now held in place by the tricortical distal tibial allograft wedges and all coronal plane stress on the knee should be relaxed. The plate can then be inserted without needing to hold the reduction manually. The distal aspect of the osteotomy should lie at the distal line of the plate, and the opening wedges lie proximal to that distal line of the plate (Fig 10).

We ensure the plate does not sit proud and care is taken to avoid anterior or posterior translation of the proximal aspect of the plate. If the correction was performed properly, the entire plate should now sit flush along the bone (Fig 11). Table 1 summarizes the authors' tips and tricks.

Postoperative Rehabilitation

Rehabilitation may be altered by concomitant procedures accordingly, and changes may be made based on healing as confirmed by radiography. Patients are placed into a hinge knee brace postoperatively, which is initially locked in extension.

From weeks 0 to 6, weight-bearing status is heel-touch only. Range of motion is permitted from 0 to 90° during home exercises, but the brace is locked in extension during heel-touch weight-bearing. During weeks 7 and 8, weight-bearing is advanced as tolerated. Full range of motion is thereafter permitted. Low-impact activities such as biking, elliptical, and swimming are permitted at 12 weeks' postoperatively. Functional training begins after 16 weeks, and full-impact activity is permitted after minimum 20 weeks as guided by the surgeon.

Discussion

The presented technique specifically describes a lateral opening-wedge distal femoral osteotomy. This procedure is commonly used as an adjunct to procedures for lateral compartment chondral defects or lateral meniscal deficiency, or to mitigate symptoms from lateral-compartment predominant tibiofemoral arthritis.

Table 1. The Authors' Tips and Tricks for Performing a Lateral Opening-Wedge Distal Femoral Osteotomy

Step	Tip/Trick	Benefits	Pitfalls
Preoperative			
Determine degree of correction	Aim to correct to the medial tibial spine for lateral compartment chondral defects Aim to correct to medial to the medial tibial spine for lateral compartment arthritis	The desired degree of correction can be used to estimate the height of correction	Not using calibrated long-length alignment radiographs can alter estimations of coronal plane deformity
Determine height of correction	Translate the desired degrees of correction to the level of the osteotomy on a calibrated radiograph Measure the height on the lateral femoral cortex to determine the primary bone wedge width	Takes into account femoral width	Making the assumption that degrees of correction and height of correction correlate in a 1:1 ratio
Intraoperative			
Exposure	Perform Z-lengthening for deformity corrections greater than 10 mm	Improve exposure Limit soft-tissue constraints	Overconstraining the lateral side of the knee may impact knee mechanics
Determining osteotomy location	Use the distal line on the plate to be the starting point of the osteotomy Make sure the distal aspect of the plate is flush on the distal femur before performing the osteotomy	Improve ability for the plate to have full cortical contact at end of case	Placing the plate too distal such that the distal line intersects with the femoral trochlea medially may increase risk of intra-articular penetration and fracture
Performing the osteotomy	Stop 1 cm short of the far cortex with the osteotomy Use a saw anteriorly and an osteotome posteriorly, protected by a radiolucent retractor along the posterior femoral cortex	Improve safety of the osteotomy and limit risk of intraoperative fractures and neurovascular complications	Extending the osteotomy too far medially may increase risk for fractures, which should be managed with contralateral side hardware Not placing the retractor directly along the posterior cortex may increase risk for neurovascular injury
Placing the tricortical wedges	Fashion the tricortical allograft wedges in a doorstop configuration to insert into the osteotomy Create the posterior wedge to match the height of the planned deformity correction Measure the remaining anterior gap and fashion the anterior wedge to match that gap Use the limb positioner to control position with gentle varus to open the osteotomy to insert the wedges and then relax all coronal plane stress on the leg	Perform a predictable deformity correction Facilitate plate placement without manual stress	Not performing preoperative planning will result in variable amount of correction Applying too much stress on the leg after the osteotomy is made may increase risk of fracture
Plate placement	The distal line on the plate should lie on the distal aspect of the osteotomy The plate should sit flush on cortical bone throughout Evaluate the plate position critically to limit plate angulation and/or translation	Potentially less symptomatic hardware Better mechanical control of the osteotomy may reduce rates of nonunion, malunion, and loss of correction	Malposition of the plate may increase stress on the hardware and the osteotomy site
Postoperative			
Rehabilitation	Limit weight-bearing early in recovery Allow for early range of motion	Increase rates of union Improve final range of motion	Accelerating rehabilitation in weight-bearing or impact too early may decrease healing rates and contribute to loss of reduction Limiting range of motion may increase risk of arthrofibrosis

Optimal patient selection and timing of the procedure can enhance the benefits of the procedure. Patients can expect reliable return to activities, sport, and work with good mid- and long-term outcomes from the procedure.[2-4]

Pre- and intraoperative planning remain the keystones of success with this procedure. Appropriate planning may limit the known risk of collapse or loss of correction and can help facilitate reliable radiographic results.[4,5] Furthermore, inserting fashioned tricortical allograft wedges limit the demand on the plate to hold the osteotomy at the desired degree of correction.

Many complications of distal femoral osteotomy occur in the early postoperative period, with one study showing a $\leq$90-day complication rate of 42%.[6] Risks for complications or lower survivorship in the literature include smoking, concomitant cartilage or ligament procedures, surgical indication for arthritis, and other medical conditions.[6,7] One of the most common complications of a distal femoral osteotomy is symptomatic hardware.[5,8,9] The authors aim to limit this complication by their plate-positioning tips. By initially placing the plate flush on the bone distally, the planned osteotomy correction typically allows for the plate to sit flush on the bone proximally at the end of the procedure. Furthermore, adequate soft-tissue exposure (including Z-lengthening for large deformity corrections with wedges $>$10 mm) facilitates plate placement and assessment to make sure that it is not proud in any location. Having the plate sit on cortical bone may also limit the risks of hardware failure, malunion, and nonunion.[5]

Another complication that may occur is fracture, including intra-articular fractures and medial cortical fractures.[6] By ensuring the line on the plate does not intersect the femoral trochlea medially, the plate position is more proximal to avoid risk of intra-articular fracture. Intraoperatively, to limit medial cortical breach, the saw and osteotome are stopped short of the cortex by 1 cm. The authors limit excessive varus stress on the osteotomy site and place the wedges within the osteotomy to hold the correction while placing the plate under less mechanical stress.

By following these tips, the authors believe that a successful lateral opening-wedge distal femoral osteotomy may be performed safely, effectively, and according to plan.

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