Technical Note

Medial Biplanar Closing-Wedge Distal Femoral Osteotomy Using an Articulated Tensioning Device for Controlled Osteotomy Closure

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Abstract: Isolated lateral compartment arthritis or focal chondral defects in the setting of genu valgum in young, active individuals can be treated with a varus-producing distal femoral osteotomy with or without cartilage treatment. Both medial closing-wedge and lateral opening-wedge techniques have been described, with neither demonstrating clear superiority. The objective of this Technical Note is to describe a technique of biplanar medial opening-wedge with controlled reduction using an articulated tensioning device to achieve a safe, reproducible result.

Varus-producing distal femoral osteotomy has been described as a treatment option for symptomatic lateral compartment osteoarthritis in active individuals with genu valgum.[1] Even with evolving fixation strategies and implants, the reported survival rates remain greater than 65% at 10 years.[2] These osteotomies can be performed either as a lateral opening-wedge (LOW) or a medial closing-wedge (MCW). Although the LOW technique offers surgeons a more familiar approach, a single osteotomy cut, and the ability to fine-tune the osteotomy gap to the desired correction, it has the disadvantages of decreased stability, given lack of bony apposition with potentially a longer time to bony union in addition to hardware irritation, given the plate's location beneath the iliotibial band.[3,4] Given these disadvantages, the MCW technique provides an alternative that allows for improved stability as well as increased healing potential, at the cost of increased technical complexity.

Whether performing the LOW or MCW variety, the osteotomy is incomplete, leaving a lateral hinge of bone, usually approximately 1 cm in width, to help maintain the rotation of the proximal and distal fragments as well as to increase stability. Furthermore, an intact hinge allows for the use of less-robust fixation than would otherwise be necessary for a completed osteotomy. When a LOW technique is used and medial hinge generated, controlled opening of the osteotomy is performed using a commercially available osteotome distractor (Arthrex, Naples, FL) or a lamina spreader to aid in opening to the desired correction. This portion of the procedure is typically performed in a slow, controlled manner to prevent a fracture of the cortical hinge. Unfortunately, when closing-wedge techniques are used, a similar hinge of bone is still used, but the same facile method of closing the osteotomy in a slow and controlled fashion has not been described. The purpose of this Technical Note is to demonstrate a biplanar MCW osteotomy using an articulated tensioning device to facilitate controlled closure of the osteotomy.

Surgical Technique (With Video Illustration)

A narrated video with demonstration of the surgical technique described in the following Technical Note may be reviewed in Video 1.

Preoperative Planning

When evaluating a patient with an isolated compartmental complaint, full-length longstanding radiographs are obtained to evaluate lower-extremity alignment. In addition, a knee series consisting of

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weight-bearing anteroposterior, Rosenberg, and lateral radiographs as well as a patella sunrise view are obtained. The weight-bearing views are examined for any evidence of joint space narrowing, subchondral sclerosis, or osteophytes on the medial compartment, which would likely preclude the patient from consideration of a distal femoral osteotomy. Furthermore, the lateral radiograph and patellar sunrise views are helpful for determining the extent of patellofemoral disease, another potential contraindication. The senior author is willing to accept mild-to-moderate changes in the patellofemoral joint if the source of the patient's pain is predominantly from the lateral compartment and not anterior in nature.

Once it is determined that the patient is a candidate for a distal femoral osteotomy, the longstanding radiographs are used for formal preoperative planning. First, a plumb line is dropped from the center of the femoral head to the center of the talus (Fig 1A). This line at the level of the knee joint line represents where the weight-bearing axis falls. In a neutral limb alignment, this should fall through the center of the tibial spines. Next, the degree of deformity to be corrected is calculated. This is performed by drawing a line from the center of the femoral head to the point on the proximal tibia of the desired correction (Fig 1B). For distal femoral osteotomies in the setting of lateral compartment osteoarthritis, it is the senior author's preference to correct to the medial downslope of the medial tibial eminence. A second line is drawn from the center of the talus to the same point and the angle between the 2 is measured and determined as the degree of correction (Fig 1B). Next, this angle is projected onto the distal femur metaphyseal bone to simulate the location of the future osteotomy (Fig 1C). The coronal orientation of the osteotomy should aim at the lateral epicondyle. Finally, if calibrated radiographs are available, the distance on the medial cortex between the closing-wedge angle projection can be measured for intraoperative replication (Fig 1C).

Patient Positioning and Arthroscopy

The patient is placed supine on a radiolucent table. Standard fluoroscopy is positioned to enter over the contralateral limb. A nonsterile tourniquet as well as a bump are used underneath the ipsilateral greater trochanter to internally rotate the limb so that the patella is facing the ceiling. Finally, a side post is used at

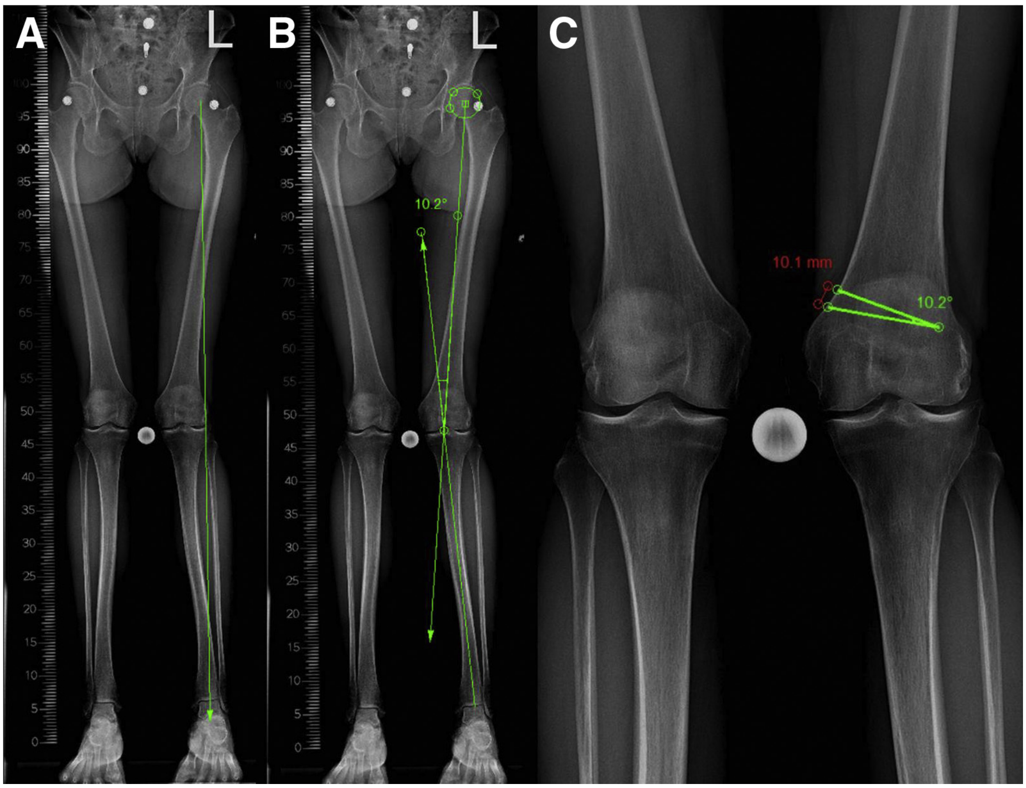

Fig 1. Preoperative templating for osteotomy. Anteroposterior standing alignment radiograph (A) with plumb line drawn from the center of the femoral head to the center of the talus demonstrating valgus alignment, (B) with intersecting lines drawn between the center of the femoral head to the medial tibial eminence and from the center of the talus to the medial tibial eminence, and measuring the angle between the intersecting lines of (B), which represents the degree of correction of the osteotomy. (C) Calibrated anteroposterior standing radiograph of bilateral knees with the angle of correction projected onto the location of the planned osteotomy with a measurement of the cortex to be removed as part of the closing wedge.

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
Standing alignment radiographs are necessary for preoperative planning and should be the primary determinant for intraoperative decision-making.	Intraoperative assessments of alignment are less reliable and do not replace preoperative planning.
A blunt, radiolucent retractor is helpful to protect the posterior neurovascular structures.	Sharp dissection should be avoided when dissecting and exposing the posterior femur.
Small k-wires should be placed above and below the site of the planned osteotomy before the cut to ensure maintenance of rotation.	Although less likely with a biplanar osteotomy, malrotation can occur in the setting of a medial hinge fracture and should be avoided.
A short one-third tubular plate is placed onto the distal fragment to aid in use of the articulated tensioning device.	The one-third tubular plate should not be placed into the proximal segment with diaphyseal bone to avoid significant stress risers from the screw holes created.
The osteotomy should be slowly closed using the articulated tensioning device in order to prevent medial hinge fracture.	If a medial hinge fracture occurs, supplemental fixation is recommended medially or anteriorly.

the level of the tourniquet to facilitate access to the medial compartment during arthroscopy. Depending on the disease process, arthroscopy could include inspection to ensure the status of the medial compartment, debridement, or to perform any concomitant cartilage restoration procedures in the lateral compartment.

After arthroscopy but before the open approach, alignment is confirmed intraoperatively by using a metal alignment rod. After confirming correct placement overlying both the center of the hip and the ankle, the location at the level of the knee is determined. A true anteroposterior image of the knee, with 50% overlap of the fibular head by the tibia, is essential for alignment determinations.

Surgical Approach

A 6-cm medially based incision is made at the mid-axis of the distal thigh. This incision is midway between the medial intermuscular septum and quadriceps. Skin flaps are created and the posterior intermuscular septum is identified. Using bovie cautery and blunt dissection, the vastus medialis is carefully elevated from the septum and an anterior femoral retractor is placed beneath the quadriceps muscle to expose the anteromedial femur. Using bovie cautery, the posterior intermuscular septum is carefully elevated off the femur. Blunt dissection is then used to elevate the soft tissue off the posterior femur, with care taken to avoid neurovascular injury (Table 1). Finger palpation ensures that the soft tissue is released in its entirety to the lateral cortex and a radiolucent retractor can be placed to protect the posterior neurovascular structures.

A precontoured titanium medial distal femoral locking plate (TomoFix; DePuy Synthes, Warsaw, IN) is placed at the medial femoral cortex and a fluoroscopic image is taken to estimate the location of the planned osteotomy cut. The area between the holes in the plate, corresponding to the location of the planned osteotomy is then marked with a bovie. A radiolucent retractor is placed around the posterior femur (Table 1). Two k-wires are placed in the posterior two-thirds of the femoral shaft, one anterior and one posterior, under fluoroscopic guidance aimed at the lateral epicondyle. Care is taken not to perforate the lateral cortex. Two more convergent pins are placed proximal to the first

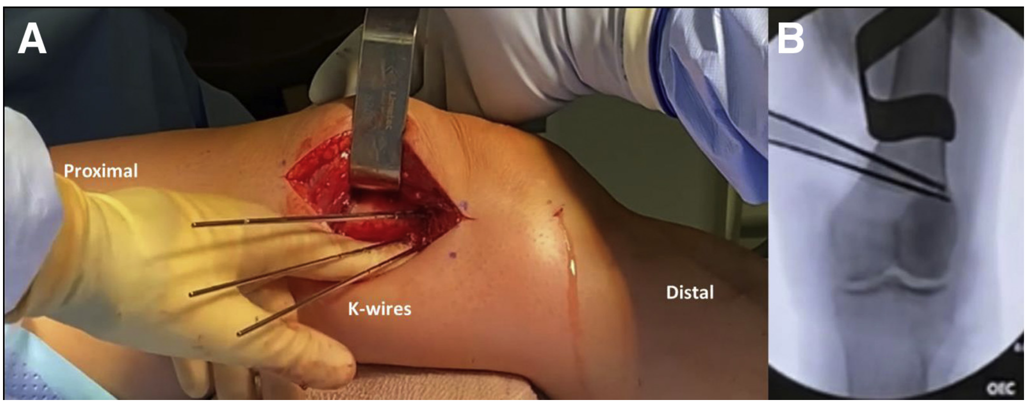

Fig 2. (A) Intraoperative photograph demonstrating 4 k-wires placed in the location and trajectory of the templated closing-wedge osteotomy site. In the photograph, the supine patient's torso is positioned to the left side of the image. The inner distance between the proximal and distal sets of k-wires corresponds to the distance measured in Figure 1D. (B) Anteroposterior fluoroscopic image is shown, representing (A).

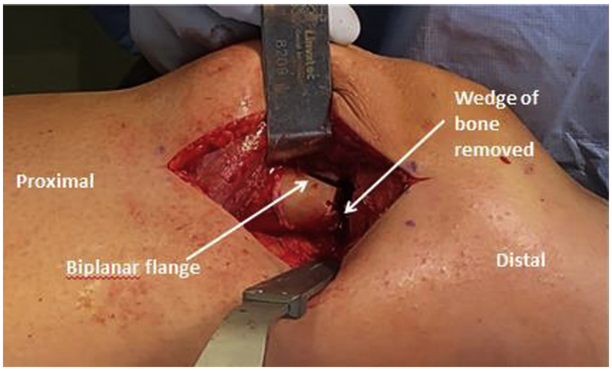

Fig 3. Intraoperative photograph demonstrating the medial closing-wedge osteotomy after removal of the wedge of bone and after the biplanar, anterior portion of the osteotomy has been completed. In the photograph, the supine patient's torso is positioned to the left side of the image.

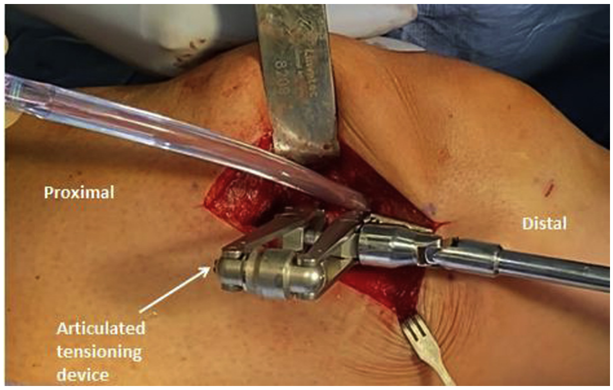

Fig 5. Intraoperative photograph demonstrating the application of the articulated tensioning device to close down the osteotomy gap. In the photograph, the supine patient's torso is positioned to the left side of the image.

pins at the distance of the preplanned correction (Fig 2). The anterior, sagittally oriented flange cut is marked with a bovie. This begins one third of the length of the femoral shaft diameter posterior from the anterior cortex at the level of the osteotomy and is angled toward the anterior cortex proximally (Fig 3). Smaller k-wires can be placed proximal to the osteotomy and distal to it to ensure rotation is not altered during the osteotomy (Table 1). Under fluoroscopy, a sagittal saw is then used to complete the osteotomy of the posterior two-thirds of the femur between the 2 sets of pins. The posterior femur is cut last with careful attention to protect the posterior neurovascular structures. This portion of the cut can be completed with an osteotome. After the posterior two-thirds cut is made, the biplanar flange cut is completed with the sagittal saw (Fig 3). A curette can be used to help remove the bone wedge.

Distal to the osteotomy and anterior of the planned location for the final plate, a 2- or 3-hole one-third tubular plate is placed in the distal fragment (Fig 4). The articulated tensioning device is then hooked to the one-third tubular plate on the distal fragment, and a unicortical Steinman pin is placed in the other end of the tensioning device just proximal to the osteotomy site. The osteotomy is carefully and slowly closed using the tensioning device, with care taken not to break the medial cortical hinge (Fig 5). A pituitary rongeur can be used to remove more bone that might be impeding the closure of the osteotomy and the cortical hinge can also be perforated with a drill to increase its malleability. Appropriate bony contact of the osteotomy is confirmed upon wedge closure. Before plate fixation, fluoroscopic images are taken to ensure the appropriate correction with the long alignment rod.

The precontoured medial distal femoral plate is placed and fixed with a combination of cortical and locking screws proximally with locking screws distally (Fig 6). Distal locking screws are placed carefully to ensure they do not penetrate the notch. Final fluoroscopic images are taken to ensure the appropriate correction with the long alignment rod (Fig 7). The wound is closed in layers.

Postoperative Rehabilitation

The patient is made to perform toe-touch weight-bearing (20%) for 3 weeks followed by progression to

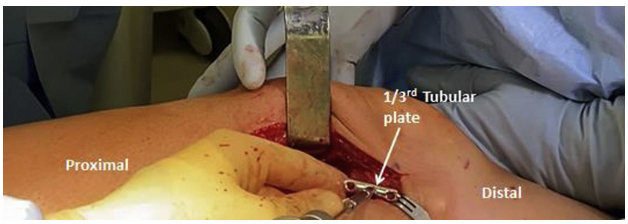

Fig 4. Intraoperative photograph demonstrating application of a short one-third tubular plate onto the distal fragment to facilitate use of the articulated tensioning device to close down the osteotomy gap. In the photograph, the supine patient's torso is positioned to the left side of the image.

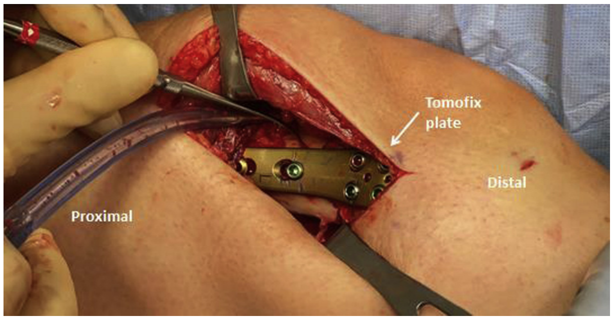

Fig 6. Intraoperative photograph demonstrating the final construct with application of the titanium, precontoured locking plate and complete bony apposition at the site of the osteotomy which is demonstrated by the freer at the site of the osteotomy. In the photograph the supine patient's torso is positioned to the left side of the image.

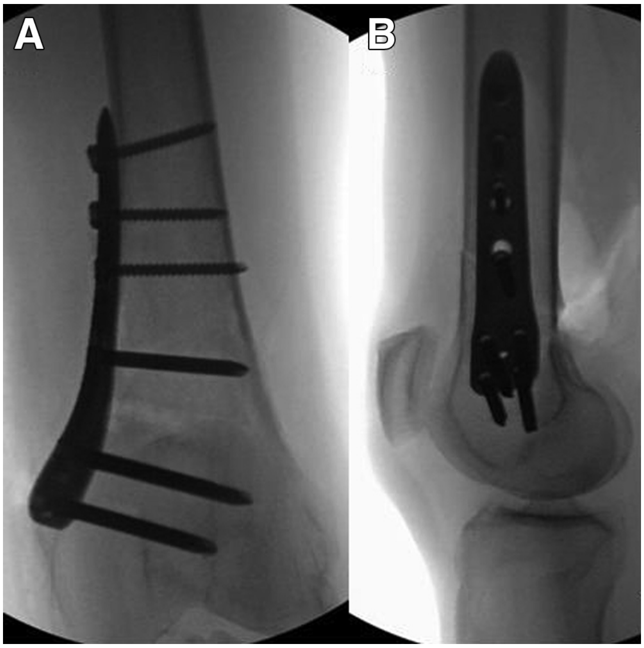

Fig 7. (A) Anteroposterior and (B) lateral fluoroscopic images of the left distal femur demonstrating the final construct.

50% partial weight-bearing for the next 3 weeks with a progression to full weight-bearing. A hinged knee brace is applied to the knee at the time of surgery and is locked in extension during ambulation for the first 2 weeks. Lower-extremity strengthening commences after radiographic healing.

Discussion

Varus-producing distal femoral osteotomies are an excellent surgical option for patients with genu valgum and symptomatic cartilage damage of the lateral compartment, especially in young, active patients who wish to participate in high-impact activities discouraged with arthroplasty procedures. As a joint-preservation procedure, these have a historical survivorship of greater than 65% at 10 years.[2,3,5]

Two options exist for type of osteotomy, LOW and MCW, both with their own profiles of disadvantages and benefits. LOW techniques have the advantage of a more familiar approach as well as an opening osteotomy that allows for easier intraoperative changes and manipulation. Unfortunately, these come with a greater rate of hardware irritation,[3] less stability and, in theory, a greater risk of nonunion. In contrast, MCW techniques, although inherently more stable with less hardware-related prominence and irritation, come with the disadvantages of a less commonly used approach, a more technically challenging osteotomy cut, as well as a small but definitive decrease in femoral length.

Two recent systematic reviews[2,3] have investigated the published literature on both techniques. Unfortunately, there are currently no randomized controlled trials or high-quality comparative studies available to differentiate the 2 techniques. Both techniques have demonstrated similar survivorship at 10 years with steady deterioration thereafter,[2] significant improvements in patient-reported outcome measures,[6] complications rates between 10% and 15%. Hardware prominence and removal rates have been shown to be approximately 2.5 times greater in the LOW group. Given similarities in survivorship and patient-reported outcome measures, surgeon preference is often the deciding factor between techniques. Although this Technical Note presents the planning and execution for MCW techniques, surgeons should be familiar with both approaches and tailor the procedure to the patient.

In addition to the option of a medial versus lateral approach, a second decision point involves a uni-versus biplanar osteotomy. The biplanar technique offers an additional technical step but, if executed properly, allows for several additional benefits. Biomechanical studies have demonstrated that distal femoral biplanar osteotomies reduce external rotation at the osteotomy site and increase torsional stiffness.[7] Furthermore, a biplanar osteotomy provides an additional healing surface at the osteotomy site as well as a secondary indicator for both osteotomy flexion and rotation in the case of a cortical hinge fracture. In the setting of a closing wedge osteotomy, the additional bony surface area available for healing in combination with additional torsional control imparted by the geometry of the osteotomy can potentially allow for both earlier weight-bearing, range of motion at the knee, strengthening, and ultimately a quicker recovery.

Given the factors discussed, the senior author's preferred technique in most circumstances is the biplanar medial closing-wedge technique. With careful preoperative planning, controlled closing of the osteotomy with the articulated tensioning device, and robust locking plate fixation, the technique described in this Technical Note can be performed both safely and may allow for earlier mobilization with a faster recovery.

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