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Lateral Opening Wedge Osteotomy of the Distal Femur for Genu Valgum

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Abstract:
Genu valgum is a risk factor for patellofemoral maltracking and recurrent instability and may cause mechanical overload of the lateral compartment leading to early arthritic changes in some patients. In skeletally mature adolescents, a varus-producing distal femoral osteotomy will correct the valgus malalignment when the femur contributes to the overall lower extremity deformity. The goal of a distal femoral osteotomy is to correct the lateral distal femur joint angle and restore a neutral mechanical axis through the center of the knee joint. We aim to discuss the indications and contraindications, pros and cons, preoperative planning, osteotomy options, surgical techniques, and postoperative protocol for a distal femur corrective osteotomy.

Key Concepts:

- Valgus malalignment can be associated with patellofemoral symptoms of pain, instability, or lateral compartment overload.
- A distal femur varus producing osteotomy improves patellar maltracking and reduces symptomatic patellar instability in some patients.
- The goal of a distal femur varus producing osteotomy is to restore a neutral mechanical alignment of the lower extremity and even the weight distribution across the joint.
- Mild limb length shortening can be addressed with a lateral opening wedge osteotomy as this procedure will lengthen the limb.

Introduction

Valgus malalignment is a risk factor for painful patellar maltracking and recurrent instability. Genu valgum may cause symptomatic mechanical overload of the lateral compartment, decreased function, and potentially early arthritic changes.[1] In adolescents and young adults with a closed physis, a distal femur varus producing osteotomy improves patellar maltracking and reduces symptomatic instability in some patients.[2] The goal is to neutralize the mechanical axis of the limb which can be accomplished with different osteotomy techniques.[3-7] Careful preoperative assessment of the deformity and planning allows selection of the proper technique to most accurately correct the deformity.

Indications and Contraindications

Genu valgum may be idiopathic, associated with metabolic bone disease or skeletal dysplasias, secondary to congenital lateral femoral condyle hypoplasia, or secondary to trauma, infection, tumor conditions or partial growth arrest. Indications for correction of valgus malalignment with a distal femur osteotomy include mechanical overload lateral joint pain, patellofemoral symptoms, or recurrent lateral patellar instability when the lateral distal femoral angle measures < 85 degrees. A varus-producing distal femur osteotomy may also be indicated in combination with other intraarticular surgery in the setting of valgus malalignment. Deformity analysis is needed to ensure the valgus deformity is not located in the femoral shaft, proximal tibia, or a result of ligamentous laxity without bony deformity. Relative contraindications include absence of symptoms with mild valgus malalignment, knee flexion contracture, and an open physis in which guided growth is a lower risk option for deformity correction.[2-4]

Advantages and Disadvantages

When the apex of the deformity is in the distal femur, metaphysis a medial closing wedge osteotomy can be performed at the level of the deformity. The medial closing wedge affords greater bone contact after osteotomy and obviates the need for bone grafting. This approach shortens the valgus limb, which may be advantageous if the extremity is longer than the contralateral limb and decreases risk of tensioning the peroneal nerve.[5,8] The disadvantages include an increased risk of femoral artery injury with the medial approach and limited access to the lateral compartment to address associated procedures.[5] Additionally, a medial closing wedge osteotomy is technically more challenging, requiring advanced planning to accurately determine the exact amount of correction needed, as intraoperative adjustments to the deformity correction are more difficult.

The approach for a lateral opening wedge osteotomy is more familiar to most surgeons. The technique involves a single bony cut which allows for better control of the intraoperative correction and adjustments to the mechanical axis. An opening wedge osteotomy adds length to the valgus limb, which is advantageous if the extremity is shorter than the contralateral limb. The disadvantages of this procedure include the need for bone grafting to support the osteotomy, potentially increased incidence of delayed union or nonunion, risk of creating an iatrogenic fracture of the opposite cortex creating a more unstable osteotomy, increased risk of peroneal nerve injury from tension, and implant irritation from the plate deep to the iliotibial band.[8-10]

When the apex of the deformity is at the physis or joint line, a true opening or closing wedge osteotomy in the supracondylar region of the distal femur fails to accurately correct the mechanical axis of the femur as it introduces a translational deformity. An external fixator assisted distal femur osteotomy with locked plating (or intramedullary nailing) is a technique to accurately correct a deformity when the osteotomy is distant from the apex of the deformity and translation of the distal segment is needed to restore the mechanical axis deviation.[7] Advantages of the fixator assisted technique include more accurate deformity correction using a limited incision with a low energy osteotomy technique to optimize bone healing without application of graft material. The external fixator allows control and stabilization of the fragments intraoperatively with ability to adjust until the lateral mechanical axis is corrected. Disadvantages include the added step of temporary monolateral external fixator application and risk of neurovascular injury with half pin placement.

Preoperative Evaluation

A detailed history and physical examination is performed including assessment for contractures, range of motion, knee stability, patella tracking, and rotational profile of the lower extremity. An AP, lateral, patella, and notch view of the knee is obtained to evaluate the patellofemoral and tibiofemoral joints and additional pathology such as an osteochondritis dissecans lesion. Magnetic resonance imaging may be obtained to evaluate meniscal, ligament, and cartilage pathology. Coronal plane deformity is evaluated with an AP weight-bearing

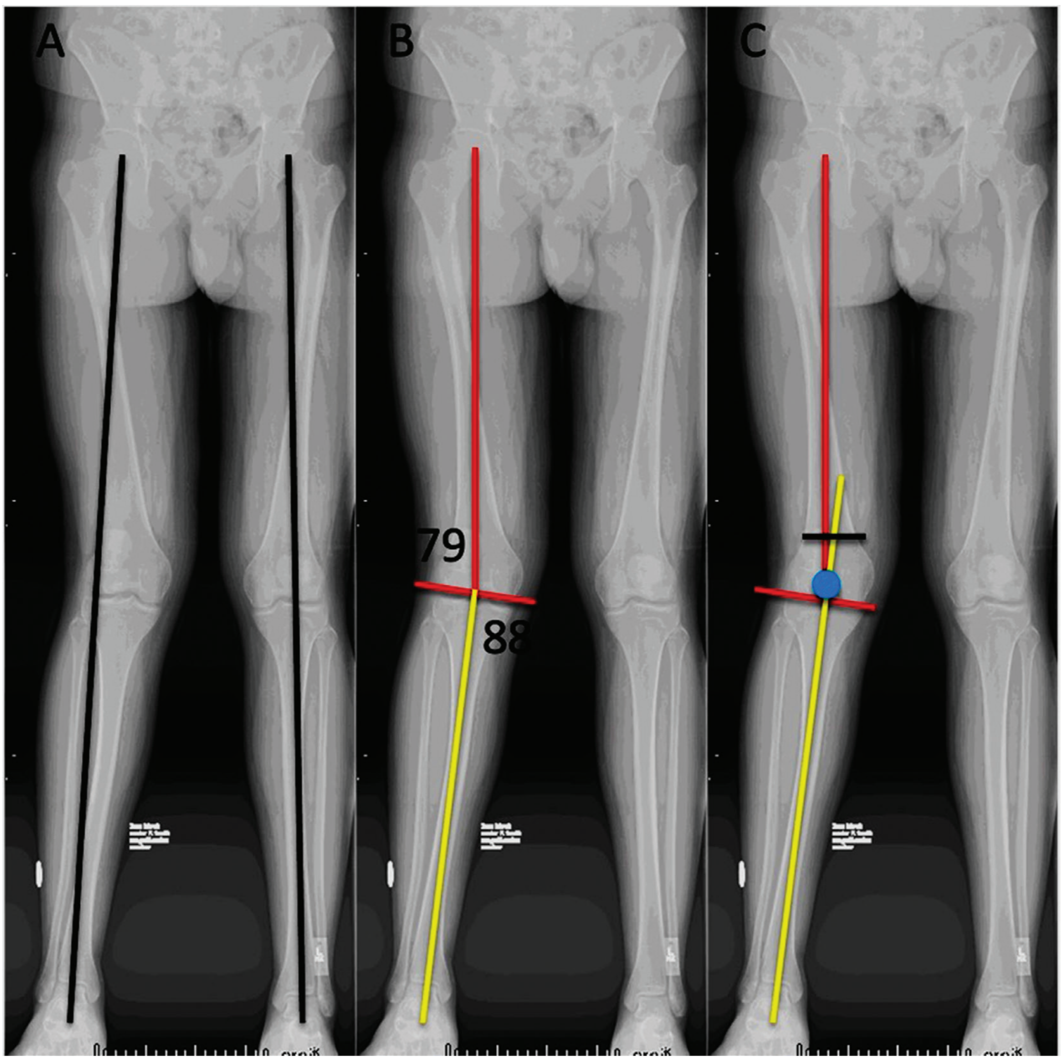

Figure 1A-C. *Assessment of the limb alignment and identification of the deformity apex. Constructing the mechanical axis of the limb is noted on the first x-ray, and the deviation of this axis confirms from the midline that a valgus deformity is somewhere in the limb. One then needs to determine where the deformity is by measuring the distal femoral and proximal tibia axis. Because the LDFA is < 87 degrees, there is valgus in the femur; because the MPTA is not greater than 87 degrees, there is no valgus in the tibia. In the third panel, the location of the deformity in the femur is determined by finding the intersection of the normal proximal and distal mechanical axis. The deformity in this case is at the level of the physeal scar.*

hip to ankle film of both lower extremities and sagittal plane deformity is assessed with a lateral weight-bearing hip to ankle film of both lower extremities for comparison with the knee in maximum extension.

Deformity Assessment[11,12]

- Draw the mechanical axis of the lower extremity from the center of the femoral head to the center of the ankle (Figure 1A).
- Confirm valgus malalignment if the mechanical axis deviates lateral to the center of the knee.
- Determine which bone is contributing to the overall deformity by measuring the mechanical lateral distal femur angle (Normal LDFA = 87° [85°-90°]) and medial proximal tibia angle (Normal MPTA = 87° [85°-90°]) (Figure 1B).

Preoperative Templating[11]

- This method can be applied to a single level distal femur deformity with a normal MPTA and no ligamentous laxity.
- Identify the apex (exact location) of the deformity by extending the tibia mechanical axis line proximally until intersecting with the femur mechanical axis line (Figure 1C).
- The femur represents the proximal axis line (above the deformity), and the tibia represents the distal axis line (below the deformity).
- The magnitude of the deformity is the angle created between the proximal and distal axis lines.
- Choose the level of the bone cut based on anatomy and availability of adequate bone for fixation, the distal femur metaphysis (Figure 2).
- Draw a line that bisects the obtuse angle formed by the proximal and distal reference lines (Figure 2).
- Choose a hinge point (rotational point of correction) along the bisector line for the desired type of correction (Figure 3).

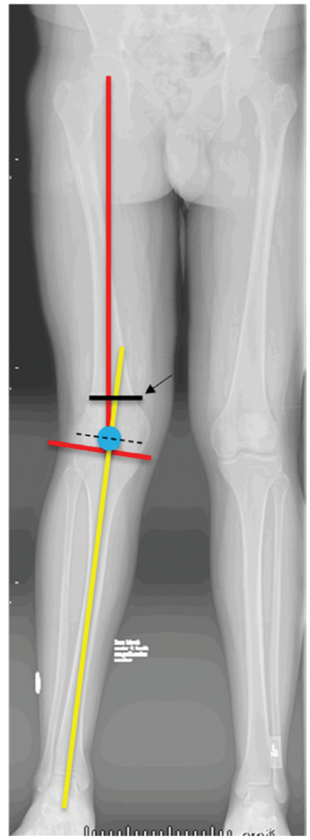

Figure 2. *Templating the site of osteotomy (arrow) and the hinge line for the deformity correction (dotted line). Because the osteotomy is not at the site of the deformity, simple angulation at the osteotomy will introduce some translation.*

- Convex hinge point → Opening wedge correction (adds length)
- Concave hinge point → Closing wedge correction (shortens length)
- Central hinge point → Neutral wedge osteotomy
- Plan the acute correction, using software of choice, by rotating the distal segment around the hinge point until the proximal and distal axes are aligned.

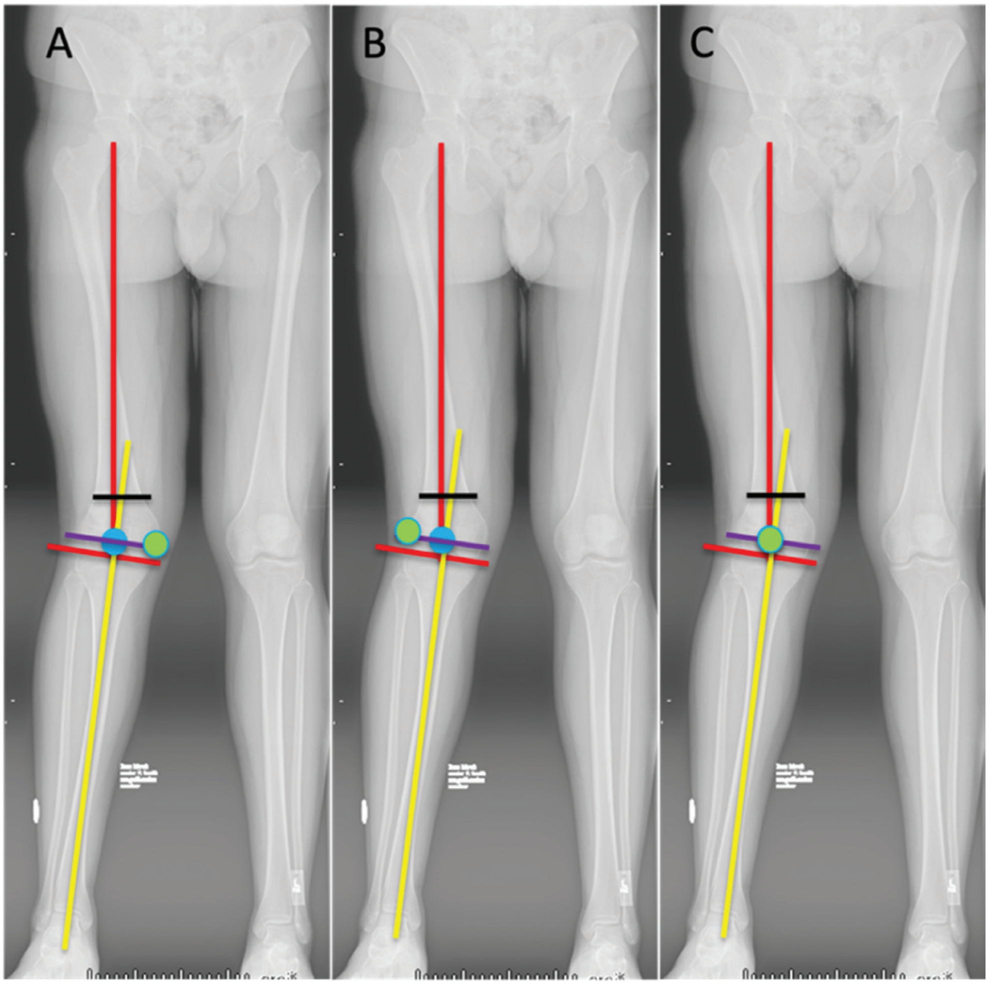

Figure 3. Choosing hinge point for deformity correction. A) Convex hinge point, B) Concave hinge point, C) Central hinge point.

- Notice that the distal segment translates laterally to restore the correct mechanical axis (Figure 4).
- The goal of surgery is to match the preoperative template.
- Practice templating with different osteotomy styles and hinge points before implementing the plan in the operating room. Notice what happens when the hinge point is placed on the medial cortex at the level of the osteotomy to create a simple opening wedge osteotomy. The proximal and distal femur axes do not align (Figure 5)
- To minimize this error, an opening wedge oblique osteotomy can be performed from proximal lateral to distal medial for correction of mild valgus deformity with the goal of placing the hinge point as close to the bisector line as possible (near the physis or joint line). Without translation, the proximal and distal femur axes are aligned within 1-2 mm creating an acceptable deformity correction template (Figure 6).

Special Equipment/Instrumentation

- Radiolucent table
- Fluoroscopy
- Distal femur locking plates
- Hohmann retractors

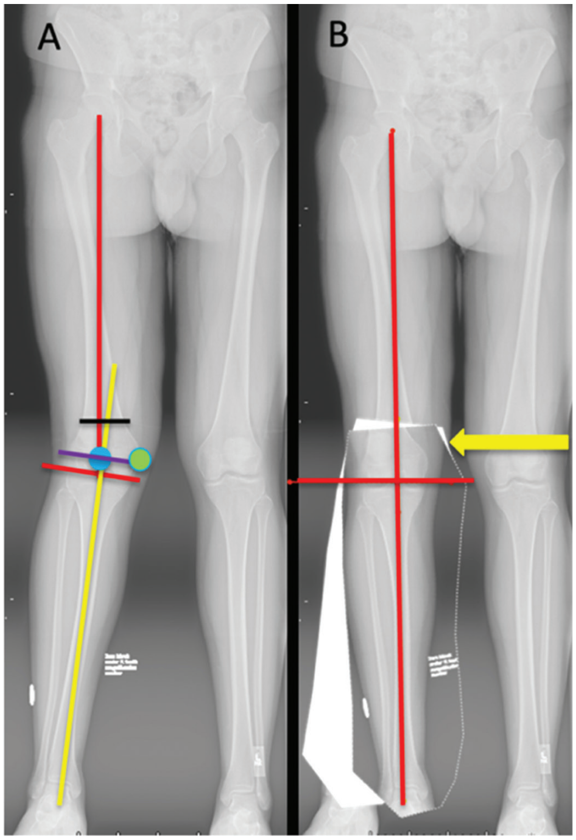

Figure 4. *A) Preoperative template of the deformity correction with a convex hinge point leading to a lateral opening wedge osteotomy. B) The distal segment translates laterally to restore the correct mechanical axis.*

- Radiolucent alignment grid (alternatively, an electrocautery cord can be used to measure the mechanical axis intraoperatively)
- Goniometer
- Rectangular bump

Lateral Opening Wedge

- 1.6-2.0 mm K-wires
- Lamina spreader
- Oscillating saw
- Osteotome set
- Mallet
- Structural allograft or autograft

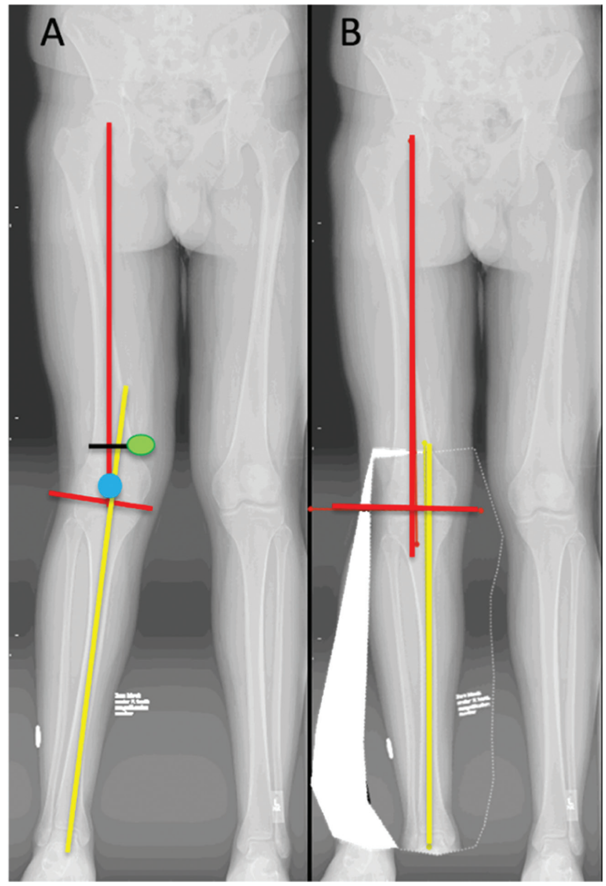

Figure 5. *A) Preoperative template of the deformity correction with a convex hinge at the level of the osteotomy. B) This leads to medial translation of the distal segment and poor overall mechanical axis alignment.*

External Fixator Assisted Osteotomy

- Monolateral external fixator (6 mm half pins x 2, pin-bar clamps x 2, bar)
- 4.5-5.0 mm Drill bit
- Osteotome set

Positioning

Under general anesthesia, the patient is positioned supine with a bump under the ipsilateral hemipelvis on a radiolucent table to allow imaging of the hip, knee, and ankle joints. If available, the radiolucent grid should be placed under the table cushion before positioning the patient. The procedure is performed without a tourniquet,

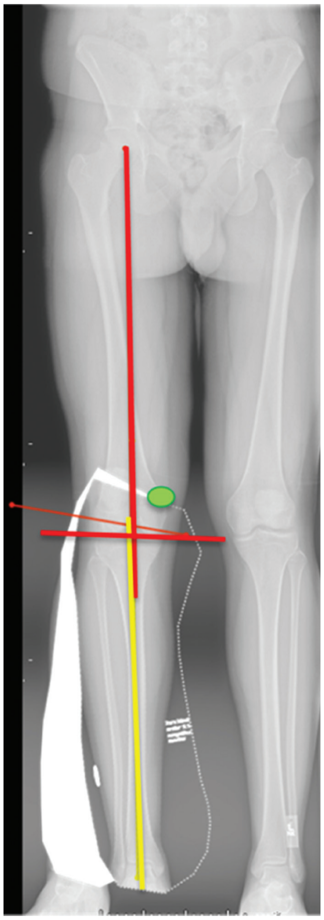

Figure 6. *Preoperative template of the deformity correction with an oblique osteotomy to improve overall mechanical axis alignment.*

but a sterile tourniquet can be placed to control bleeding as indicated. The operative leg is raised on a sterile rectangular bump to facilitate access to the distal femur and ease of orthogonal imaging without undesired flexion of the knee. The bump is removed when checking the final deformity correction and the new mechanical axis.

Operative Technique

Lateral Opening Wedge Osteotomy

The level and trajectory of the osteotomy is marked on the skin using fluoroscopic imaging based on the preoperative template (Figure 7A). A lateral longitudinal incision is created extending from the lateral femoral condyle to 4 cm proximal to the osteotomy site. The iliotibial band is split longitudinally and the vastus lateralis is elevated anteriorly prior to performing a subperiosteal exposure of the distal femur. With Hohmann retractors in place to protect the quadriceps anteriorly and the neurovascular bundle posteriorly, a 1.6 or 2.0 mm K-wire is inserted from proximal lateral to distal medial matching the preoperative plan for the osteotomy. A second wire may be placed parallel but more posterior to the first wire to control flexion and extension while performing the osteotomy. The oblique orientation of the osteotomy allows adequate fixation of the distal fragment with locking screws while hinging on the medial distal femur cortex as close to the bisector line as possible for more accurate correction. An oscillating saw is used to start the osteotomy paralleling the K-wires. A wide osteotome or saw may complete the osteotomy leaving the medial cortex intact. A varus force is applied to the knee and a lamina spreader inserted to gap open the osteotomy site until the desired correction is achieve. The bump is removed, and the hip and knee placed in 0 degrees of extension. The new mechanical axis is evaluated by placing a straight grid line or electrocautery cord at the center of the hip and ankle and checking the position of the same grid line at the knee (Figure 8). Adjustments are made to the osteotomy until the mechanical axis passes through the center of the knee joint. The maximum lateral opening is measured and a structural allograft or tricortical iliac crest autograft wedge is cut to support the defect. A lateral distal femur locking plate is secured to the bone and fixation completed (Figure 7C-E). The implant may not fit the contour of the lateral cortex following the osteotomy, indicating use of some locking fixation.

What to Avoid

Failure to create a proper preoperative plan may lead to inaccurate deformity correction and misaligned proximal and distal femur axes. Be careful to avoid the patellofemoral joint with the osteotomy by starting more proximally on the lateral cortex and aiming towards the distal medial physeal scar. Use fluoroscopic guidance while performing the osteotomy to avoid violation of the medial cortex which will create a more

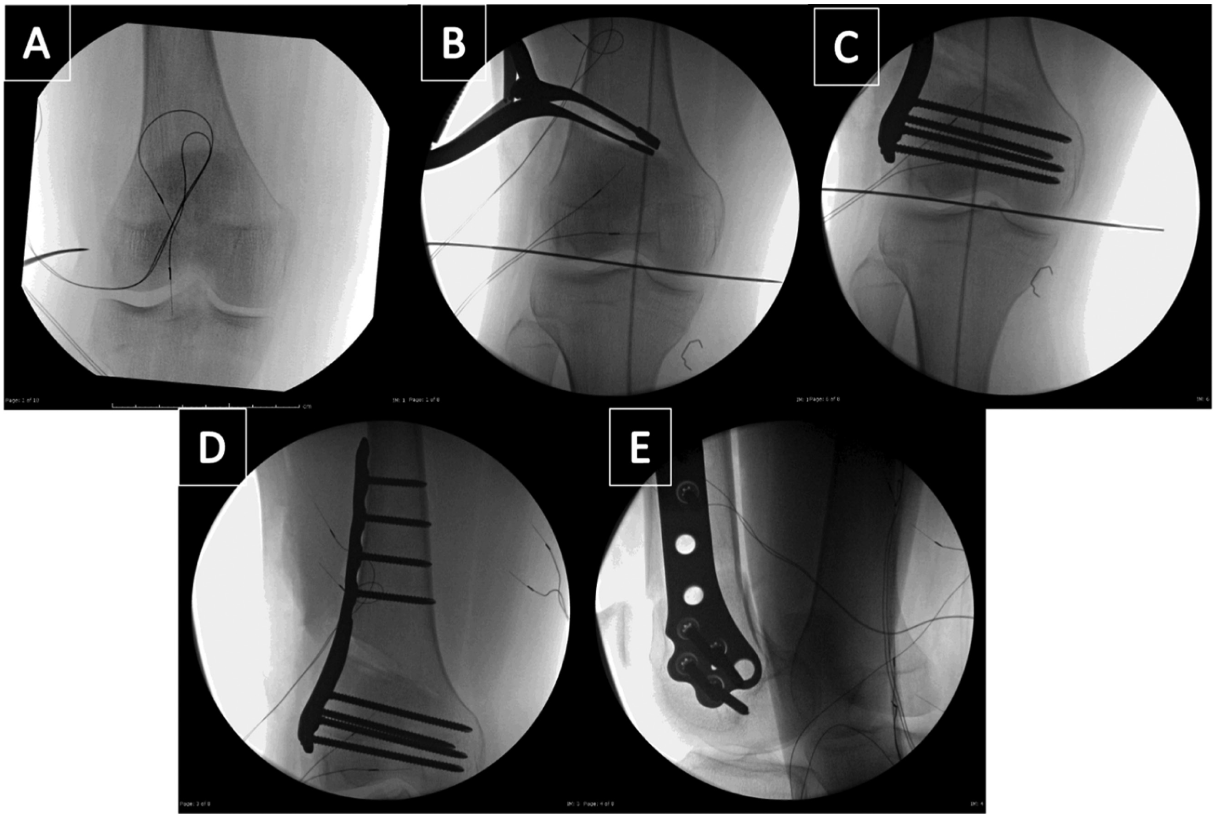

Figure 7. *A) Assessment of the deformity to mark osteotomy site. B) Laminar spreader is used to begin deformity correction after osteotomy. C-E) Assessment of alignment after fixation is placed.*

unstable osteotomy. Keep the saw blade perpendicular to the shaft of the femur to prevent inducing flexion or extension deformity. Soft tissue retractors reduce the risk of neurovascular injury when completing the osteotomy.

While the peroneal nerve is more forgiving near the femur, larger valgus corrections with an opening wedge technique may risk injury to the peroneal nerve. Consider intraoperative neuromonitoring of the peroneal nerve for deformity corrections exceeding 10°-15° or prophylactically decompressing the nerve as described by Nogueira et al.[13]

External Fixator Assisted Osteotomy

Temporary external fixation is a valuable way to stabilize and fine tune correction prior to placement of final fixation. It is particularly helpful when one considers intramedullary fixation as the final construct.

The joint line and level of the osteotomy are marked on the skin using fluoroscopic imaging based on the preoperative template. The temporary monolateral external fixator is placed on the medial aspect of the femur using 6 mm half pins. The distal pin is placed proximal to Blumensaat's line and anterior to the posterior cortex (Figure 9A). The proximal half pin is placed in the femoral shaft close to the osteotomy site. The monolateral frame is assembled. A distal lateral longitudinal incision is created extending from the femoral condyle to the osteotomy site. The iliotibial band is split longitudinally, and the selected implant is placed submuscularly.
The level of the osteotomy is confirmed with plate in position to ensure adequate fixation in both segments. A complete subperiosteal exposure is not necessary with this technique. A low energy osteotomy is created using multiple drill holes with a 4.5-5.0 mm drill bit entering the lateral cortex and exiting three times on the medial

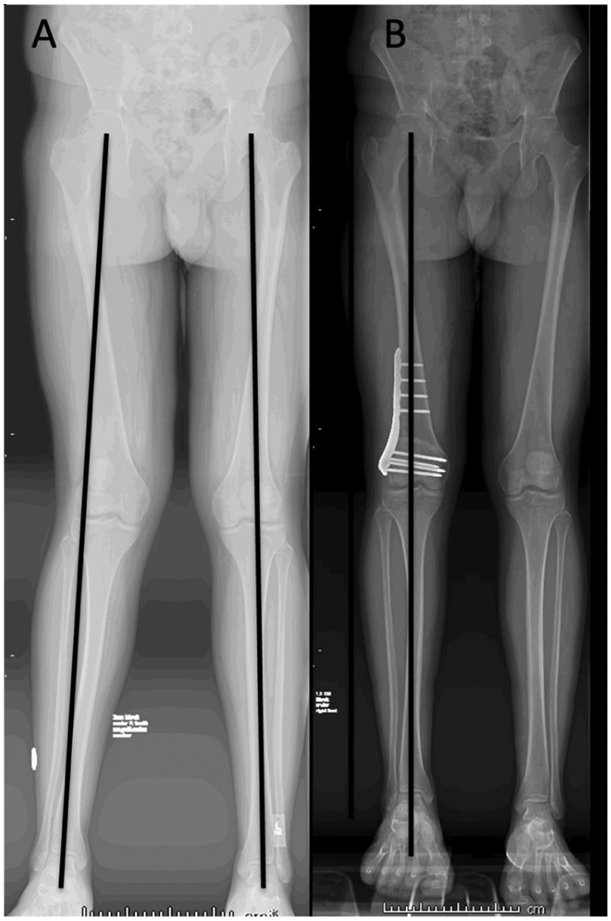

Figure 8. *A) Preoperative and B) Postoperative radiographs showing complete realignment of the valgus deformity.*

cortex with each pass. A final drill hole is made in the posterior cortex from lateral to medial. An osteotome is used to complete the osteotomy with the external fixator slightly loosened to facilitate movement of the fragments. The distal fragment is first translated and then angulated to match the preoperative plan. The pins can be used to manipulate the bone (Figure 9B, C). The external fixator is secured. The sagittal alignment is checked with fluoroscopic imaging. A second monolateral external fixator can be placed anteriorly to control the sagittal plane if necessary. The new lateral distal femur angle can be measured using an electrocautery cord placed over the center of the hip and knee and a K-wire placed parallel to the femoral condyles. Adjustments are made until the desired lateral distal femur angle is achieved based on the preop plan. A lateral distal femur locking plate is secured to the bone and position confirmed with orthogonal imaging. The plate is initially fixed to the distal segment with a nonlocking screw. The implant typically does not fit the contour of the lateral cortex proximally and requires locking fixation in this segment. The proximal fixation is placed percutaneously using the locking guide. The external fixator is removed once the fixation is complete. Final images confirm that the mechanical axis passes through the center of the knee joint using a radiolucent grid or electrocautery cord extended over the lower extremity (Figure 10).

Postoperative Care

A knee immobilizer or hinged knee brace locked in extension may be placed to promote knee extension for 2 weeks at the discretion of the surgeon. Knee range of motion and isometric quad sets can begin 2 weeks postop. Patient remains non-weight-bearing or touch down weight-bearing until satisfactory radiographic healing, typically between 6 and 12 weeks. Standing hip to ankle radiographs are obtained 3 months after surgery to evaluate correction of the deformity.

What to Avoid

Failure to create a proper preoperative plan may lead to inaccurate deformity correction and misaligned proximal and distal femur axes. Place the temporary half pins in the zone of the implant to reduce risk of a stress riser and peri-implant fracture from a half pin site adjacent to the plate. To avoid injury of the femoral artery in the adductor canal, bluntly dissect the soft tissues anterior to midline until the cortex is encountered. Drill and place the half pin using a soft tissue protector. Be careful not to plunge deeply with the drill bit or osteotome medially and posteriorly while performing the osteotomy. The leg is placed on a bump intraoperatively to allow orthogonal imaging. Avoid flexion of the knee which may induce sagittal deformity when performing corrective maneuvers. Do not attempt angular correction until the distal segment is first translated. Confirm acceptable alignment with orthogonal imaging before fixing the implant. While the peroneal nerve is more forgiving near the femur, larger valgus corrections with an opening

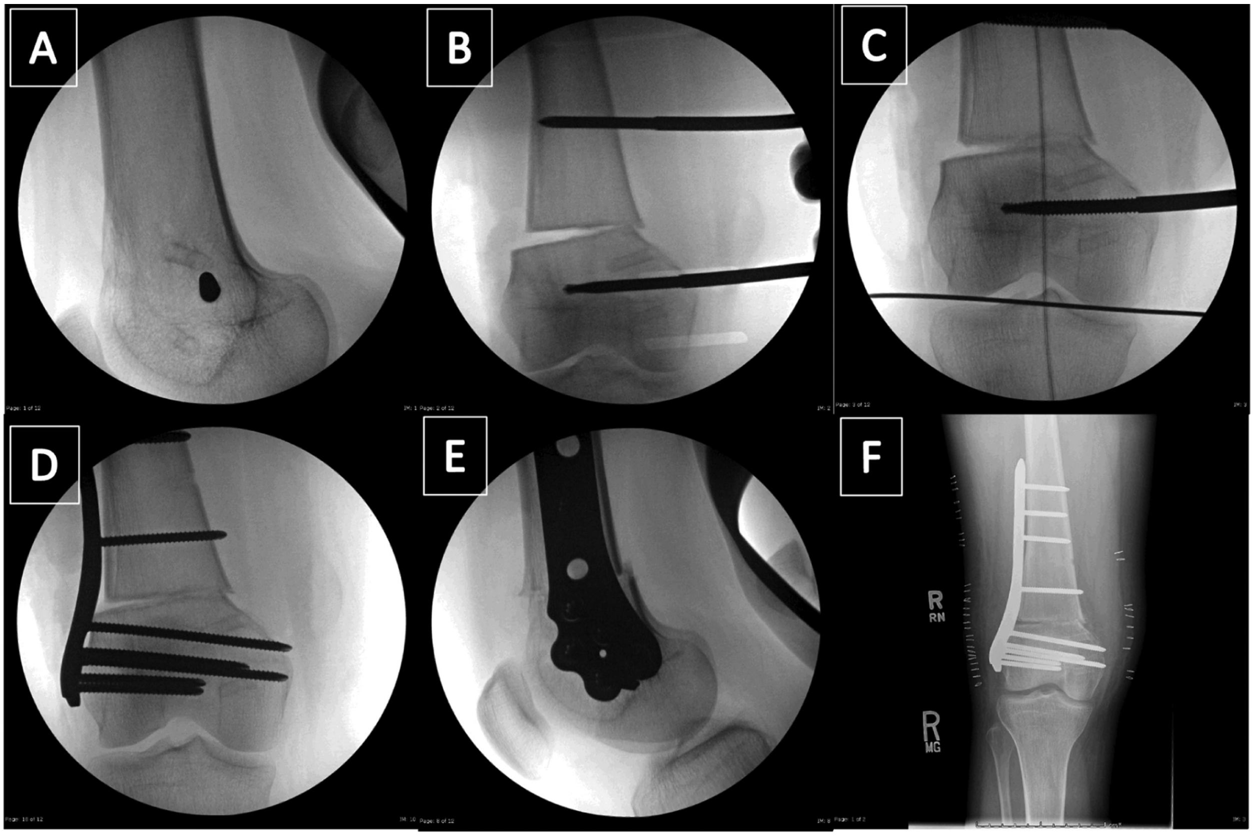

Figure 9. *A) Placement of the distal half pin. B, C) Deformity correction using the external fixator. D, E) Fixation of the correction with a laterally based locking plate. F) Final image of deformity correction.*

wedge technique may risk injury to the peroneal nerve. Consider a neutral wedge osteotomy that does not add length, intraoperative neuromonitoring of the peroneal nerve for deformity corrections exceeding 10 degrees to 15 degrees or prophylactically decompressing the nerve as described by Nogueira et al.[13]

Complications

Complications may include peroneal nerve injury, vascular injury, under/overcorrection of the deformity, sagittal plane or rotational deformity, leg length inequality, delayed union, nonunion, symptomatic hardware, peri-implant fracture, and infection.

Summary

Genu valgum is a risk factor for patellar maltracking and recurrent instability, knee pain and, potentially, arthritis. A distal femur varus producing osteotomy is indicated in symptomatic patients with a LDFA <85 degrees and a normal MPTA. Preoperative weight bearing x-rays from hip to ankle allow assessment of deformity and planning of the correction. The laterally based opening wedge osteotomy is a fairly straightforward procedure that is technically easier than the medial closing wedge osteotomy. A controlled distal femur osteotomy that is perpendicular to the femur shaft helps prevent flexion/extension or rotational deformities. The fixator assisted distal femur osteotomy is an alternative technique to reduce soft tissue dissection while maintaining control of the bone segments for accurate deformity correction when the osteotomy is planned away from the level of deformity and translation is needed to restore the mechanical femur axis.

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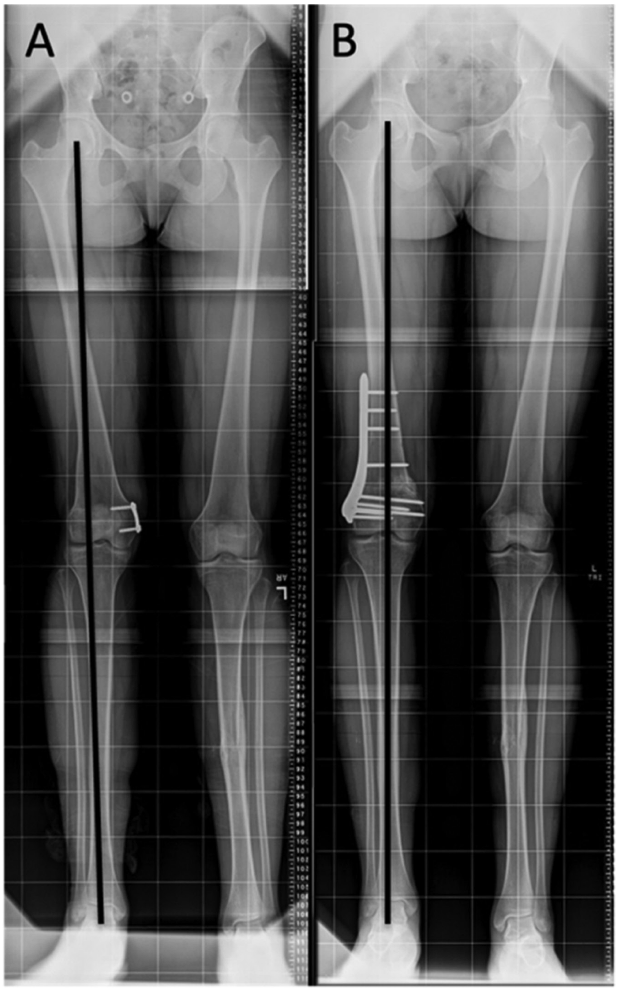

Figure 10. *A) Preoperative and B) Postoperative radiographs showing complete realignment of the valgus deformity using a fixator assisted technique.*

Scientific. S. Mathew and M. Young have no conflicts of interest to report.

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