Medial Closing-Wedge Distal Femoral Osteotomy with Medial Patellofemoral Ligament Imbrication for Genu Valgum with Lateral Patellar Instability

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Abstract: A varus-producing distal femoral osteotomy (DFO) is an effective technique for the treatment of lateral patellar instability (LPI) in patients with concomitant moderate to severe valgus malalignment. Patellar maltracking and subluxation are corrected via neutralization of some of the laterally directed forces on the patella due to the valgus deformity. This can be accomplished with a distal femoral lateral opening-wedge or medial closing-wedge osteotomy and medial soft tissue stabilization. A medial closing-wedge osteotomy offers the advantages of immediate weight bearing and a single incision in cases requiring patellofemoral soft tissue stabilization. In this article, we describe our preferred operative technique for a medial closing-wedge DFO using a femoral locking plate and medial patellofemoral ligament imbrication for the correction of LPI.

Genu valgum is a risk factor for lateral patellar instability (LPI).[1] Valgus malalignment increases the quadriceps (Q) angle, which contributes to patellar lateralization and maltracking.[2,3] In the skeletally mature patient with refractory LPI and concomitant valgus malalignment, a varus-producing distal femoral osteotomy (DFO) decreases the Q angle and improves patellar tracking via relative medialization of the tibial tubercle.[4]

A varus-producing DFO can be accomplished with a lateral opening-wedge or a medial closing-wedge technique. A lateral opening-wedge osteotomy offers the ability to fine-tune the intraoperative correction, but a medial closing-wedge osteotomy provides the advantage of immediate weight bearing and knee range of motion as a result of the inherent stability of direct bony apposition. A closing-wedge osteotomy also negates the need for bone grafting, and the hardware is usually not as symptomatic as the lateral opening-wedge plate underneath the iliotibial band.

Osseous realignment and soft-tissue stabilization may be required to prevent further LPI in cases of severe patellar maltracking with valgus deformity. This can be accomplished with medial patellofemoral ligament (MPFL) imbrication or a formal MPFL reconstruction after the DFO has been performed. We present a technique for distal femoral medial closing-wedge osteotomy using a precontoured femoral locking plate and MPFL imbrication for recurrent LPI in a patient with valgus malalignment (Video 1).

Surgical Technique

Preoperative Planning and Radiograph Templating

DFO is indicated for patients with recurrent LPI and concomitant genu valgum who have failed nonoperative management. A DFO can also be used for the treatment of isolated lateral compartment valgus gonarthrosis and cartilage lesions in young patients (Table 1), and some patients will present with recurrent LPI and symptomatic lateral compartment arthrosis.

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Table 1. Indications and Contraindications of Distal Femoral Varus Osteotomy

Indications	Absolute Contraindications
• Lateral patellar instability with valgus malalignment >5°	• Symptomatic or severe medial compartment disease
• Lateral compartment mild to moderate osteoarthritis	• Tricompartmental osteoarthritis
• Lateral condyle cartilage lesions	• Inflammatory arthritis
• Cartilage restoration surgery	• Severe osteoporosis
• Lateral meniscal transplants	Relative Contraindications
• Age <55 years	• Symptomatic or severe patellofemoral osteoarthritis
• Desire to participate in activities with heavy functional loading	• Knee range of motion <90°
	• Age >55 years
	• Elevated body mass index
	• Nicotine use

DFO is contraindicated in patients with medial compartment osteoarthritis or inflammatory arthritis.

Osteotomy correction is planned using preoperative standing hip to ankle radiographs. The weight-bearing line drawn from the center of the femoral head to the center of the talus should pass through the center of the knee. If the weight-bearing line passes through the lateral compartment, limb alignment is classified as valgus. A DFO is considered to restore a neutral mechanical axis for patients with valgus deformity greater than 5°. Lines are drawn from the center of the femoral head and the center of the talus to the center of the intercondylar notch. The resultant angle is the degree of correction needed to restore neutral mechanical alignment (Fig 1). The wedge size to achieve the desired angle of correction is then calculated using the geometric triangle method by measuring the width of the femur at the level of the proposed osteotomy using size-calibrated radiographs (Fig 2).[4]

Patient Positioning

The patient is positioned supine on a radiolucent table making sure that the ipsilateral hip, knee, and ankle joints can be visualized with the image intensifier. The operative leg can be raised on a bone foam ramp to facilitate access to the medial distal femur and for intraoperative imaging. The operative extremity is prepped and draped in the usual fashion. A sterile tourniquet is placed and raised prior to incision (Table 2).

Diagnostic Arthroscopy

A diagnostic arthroscopy is performed to assess the status of the patellar and trochlear articular cartilage, remove chondral loose bodies, address any meniscoligamentous pathology, and ensure that there are no contraindications to DFO such as severe medial compartment arthrosis.

Exposure and Osteotomy Site Preparation

A 10-cm longitudinal skin incision extends from the medial epicondyle to the joint line with the knee in full extension. Dissection is carried through the subcutaneous tissue to the vastus medialis fascia, which is incised in line with the skin incision. The vastus medialis is reflected anteriorly from the intermuscular septum using electrocautery to expose the distal medial femur (Fig 3A). Care should be taken to cauterize and/or ligate all perforating vessels. A precontoured TomoFix locking femoral plate (DePuy Synthes, Warsaw, IN) is positioned on the distal medial femur. The osteotomy site is marked at the metaphyseal-diaphyseal junction to reduce the risk for condylar fracture and ensure that a minimum of 4 cortices of fixation can be obtained in the distal segment. Biplanar fluoroscopy is used to confirm the osteotomy site and

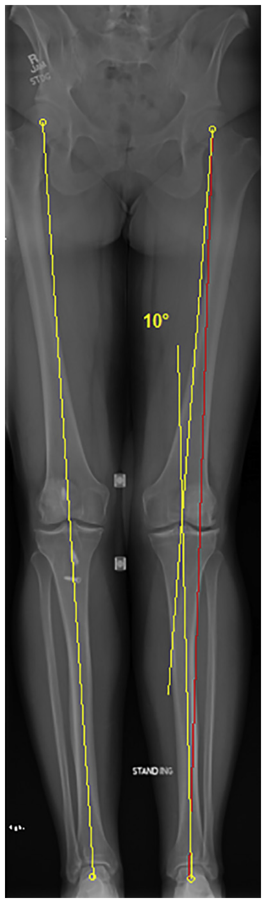

Fig 1. Preoperative planning of the osteotomy correction. A standing hip to ankle radiograph is used to calculate the mechanical axis of the lower limb and determine the desired degree of correction. A line is drawn from the center of the femoral head to the center of the intercondylar notch, and another line is drawn from the center of the intercondylar notch to the center of the ankle. The angle formed by the intersection of these 2 lines is the degree of correction needed to restore neutral mechanical alignment.

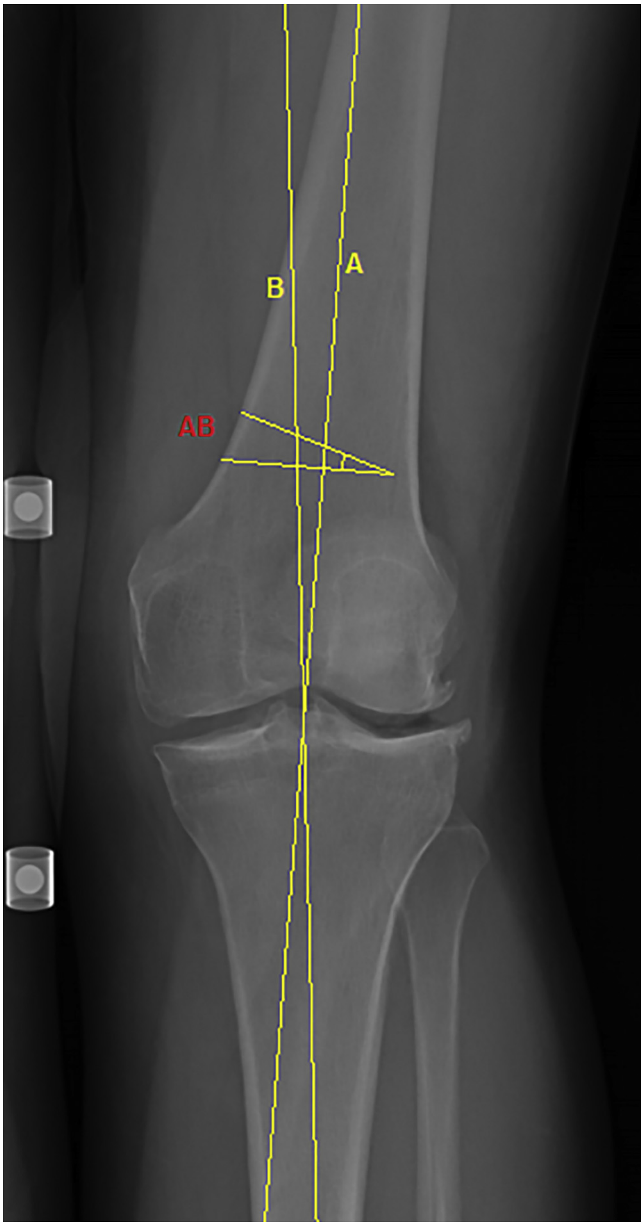

Fig 2. Calculation of the wedge size. Once the desired angle of correction is determined by drawing 2 lines (line A from the center of the femoral head to the center of the intercondylar notch, and line B from the center of the intercondylar notch to the center of the ankle), the wedge size is calculated using the geometric triangle method. The apex of the osteotomy is marked 5 mm from the lateral cortex in the metadiaphysis. Two lines are then drawn toward the medial cortex diverging at the angle calculated (AB). The distance between these lines on the medial femoral cortex (C) represents the wedge resection size.

plate position (Fig 3B). The periosteum is incised transversely using electrocautery at the osteotomy site. Malleable retractors are placed anteriorly and posteriorly to protect the quadriceps and neurovascular structures, respectively.

Osteotomy and Plate Fixation

Two guide pins are inserted through the medial cortex meeting at an apex 5 mm from the lateral cortex at the desired osteotomy site (Fig 4A). The distance between the insertion points of the 2 pins at the medial cortex corresponds to the preoperative calculation (Fig 2). These pins serve as a guide for the osteotomy and also help avoid a rotational deformity when closing the osteotomy following wedge removal. An oscillating saw is passed along each pin to cut the anterior and posterior cortices while preserving a lateral cortical hinge (Fig 4B). Copious irrigation is used while sawing to avoid thermal injury to bone. The bone wedge is removed and the osteotomy is closed by applying careful manual compression under fluoroscopic guidance (Fig 4C). Additional release of the anterior and posterior cortex with an osteotome may be required to close the osteotomy. The osteotomy site may be temporarily stabilized using crossed pins that do not interfere with application of the plate. The metal alignment rod is positioned from the center of the femoral head to the center of the talus to verify that the weight-bearing axis passes directly through the center of the knee joint (Fig 5). The medial distal femoral locking plate is then applied with the solid segment at the osteotomy site. The plate is temporarily secured by placing a pin in both a distal and proximal hole. Four cancellous self-tapping unicortical locking screws are inserted into the distal holes. The osteotomy is then compressed by applying an oblique 4.5-mm cortical screw through the most distal combination hole in a slightly proximal and lateral direction. This will also compress the lateral cortex if violation occurred during the osteotomy creation. The remaining 3 proximal holes are then filled with unicortical locking screws (Fig 6). Following plate fixation, the vastus medialis is reattached to the intermuscular septum using No. 0 Vicryl sutures.

MPFL Imbrication and Closure

The tourniquet is then deflated and the MPFL imbrication is performed. The patella is centered in the trochlear groove by flexing the knee to 30°. The MPFL is identified distal to the vastus medialis, coursing from its femoral origin (at the medial femoral condyle between the adductor tubercle and the medial epicondyle) to its insertion along the superomedial border

Table 2. Special Equipment/Instrumentation

- Basic knee arthroscopy set
- TomoFix locking femoral plate system (DePuy Synthes)
- Kirschner wires
- Oscillating saw
- Fluoroscopy
- No. 1 Ethibond suture

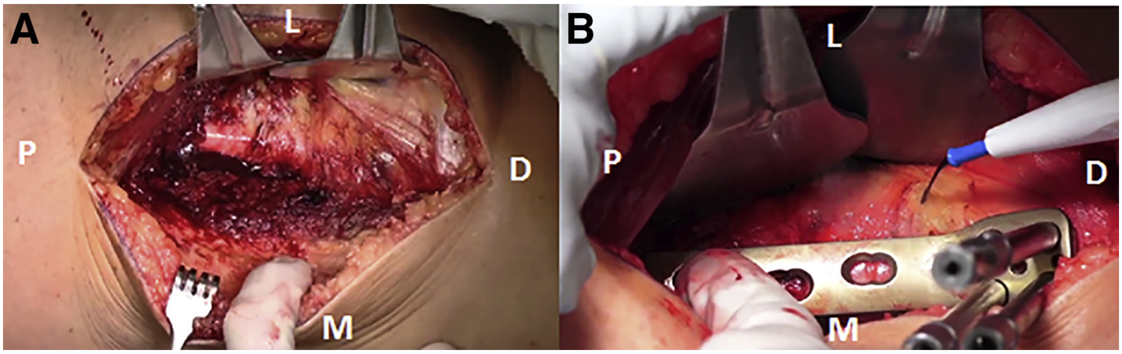

Fig 3. (A) Exposure for planned osteotomy. The vastus medialis muscle is released and elevated anteriorly from the intermuscular septum exposing the distal medial femur. (B) Planning of the osteotomy site. The precontoured locking distal femoral plate is placed over the distal medial femur. The osteotomy site is marked at the metaphyseal-diaphyseal junction proximal to the distal locking screws using electrocautery. (D, distal; L, lateral; M, medial; P, proximal.)

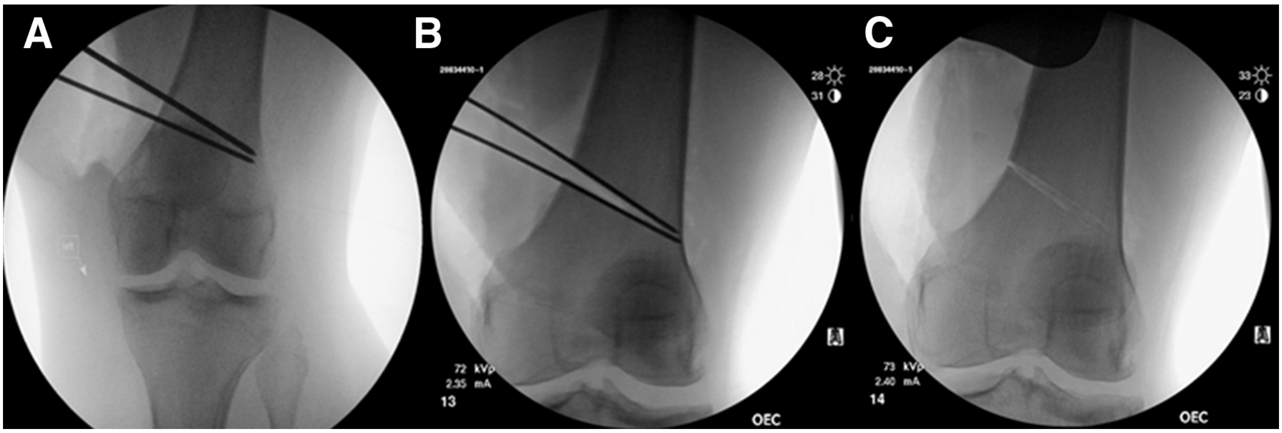

Fig 4. (A) Outlining the medial closing-wedge osteotomy. Two Kirschner wires are inserted in a sagittal direction proximally and distally outlining the medial closing wedge according to the preoperative plan. The osteotomy is planned to end approximately 5 mm before the lateral cortical bone, leaving a lateral hinge. (B) Osteotomy completion. An oscillating saw is used to complete the osteotomy along the anterior and posterior cortices preserving the lateral femoral cortex. (C) Osteotomy closure. The osteotomy is closed with manual compression to the lateral lower limb while stabilizing the knee joint.

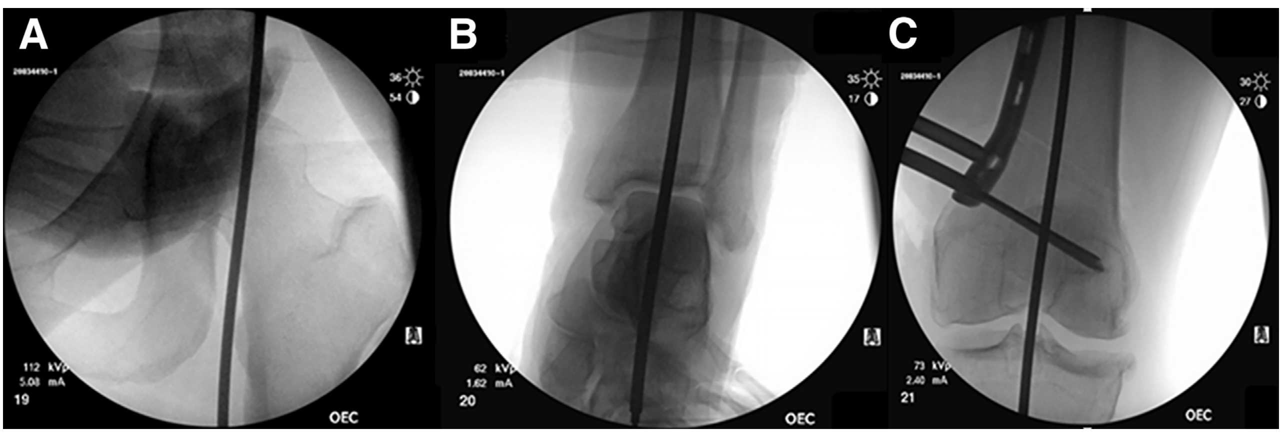

Fig 5. Fluoroscopic verification of mechanical axis correction. The alignment rod is used to verify that the corrected weight-bearing axis from the center of the femoral head (A) to the center of the talus (B) now passes directly through the center of the knee joint (C).

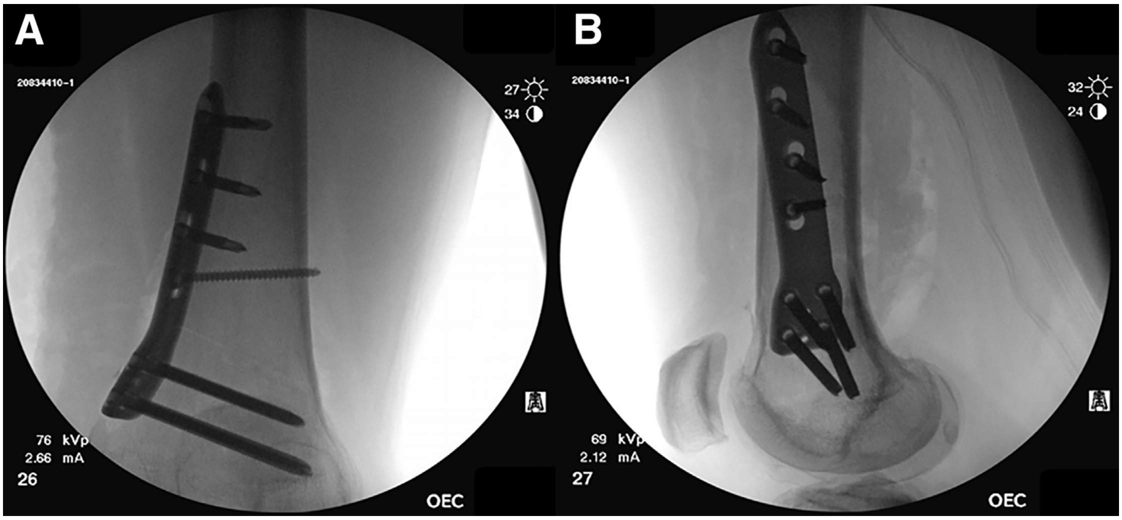

Fig 6. Final anteroposterior (A) and lateral (B) radiographs after locking plate application. Four cancellous self-taping unicortical locking screws are placed on the distal holes. An oblique 4.5-mm compression screw is then inserted aiming slightly proximal to achieve best interfragmentary compression. The remaining 3 proximal holes are then filled with unicortical locking screws.

of the patella (Fig 7A). Using a sharp blade, the MPFL is transected longitudinally (Fig 7B). Using No. 1 Ethibond sutures, the superior and inferior margins of the transected MPFL are tagged. Tension is applied to these sutures, bringing the superior margin over the inferior margin to determine the extent of imbrication required to reproduce a one and one-half quadrant lateral patellar glide and normal patellar tracking throughout knee range of motion (Fig 8A).

The imbrication is then performed using No. 1 Ethibond sutures starting at the inferior margin of the MPFL. Two passes are done, bringing the suture from inside-out and then outside-in. A total of 3 sutures are placed. The sutures are then advanced to the superior margin so that the superior margin drapes over the inferior margin in a pants-under-vest fashion (Fig 8B). A free needle is used to pass the free ends of the sutures. The tagging sutures are then removed. Adequate tensioning is reassessed by taking the knee through a full range of motion. The knee is then flexed to 60° and the sutures are tied. This is done to avoid overtensioning. Repair of the medial retinaculum is completed with a running locked No. 0 Vicryl suture (Fig 9).

Hemostasis is attained and the wound is thoroughly irrigated. The superficial and deep soft tissues are injected with a solution of 0.2% Ropivacaine. The subcutaneous tissue is closed with No. 2-0 Monocryl sutures, and the skin with a running 2-0 Quill subcuticular suture. A Prineo occlusive dressing is applied along with sterile gauze, Soft-Roll, and an elastic wrap.

Postoperative Care and Rehabilitation

The patient is instructed on partial weight bearing with the rehabilitation brace locked in full extension and knee motion to 90° of maximum flexion for

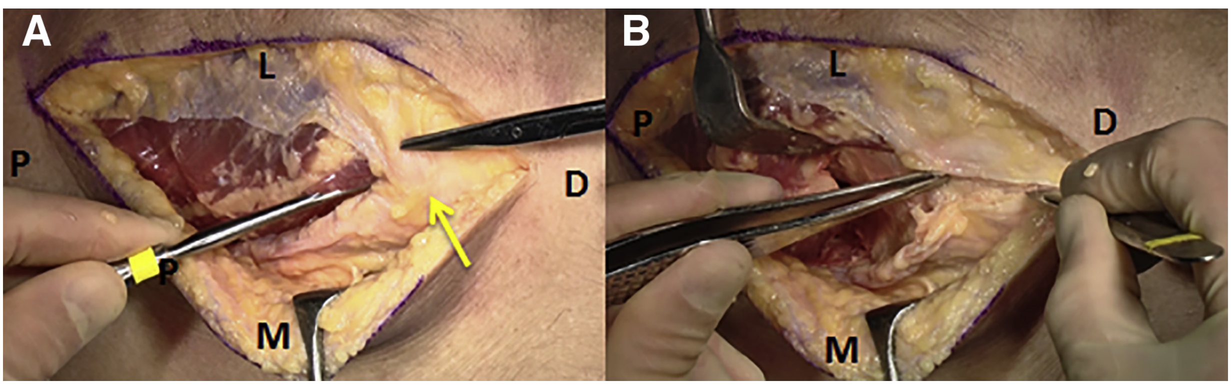

Fig 7. (A) Medial patellofemoral ligament (MPFL) identification. The knee is flexed to 30° and the MPFL is identified distal to the vastus medialis (yellow arrow). (B) MPFL transection. The MPFL is transected longitudinally using a sharp blade. (D, distal; L, lateral; M, medial; P, proximal.)

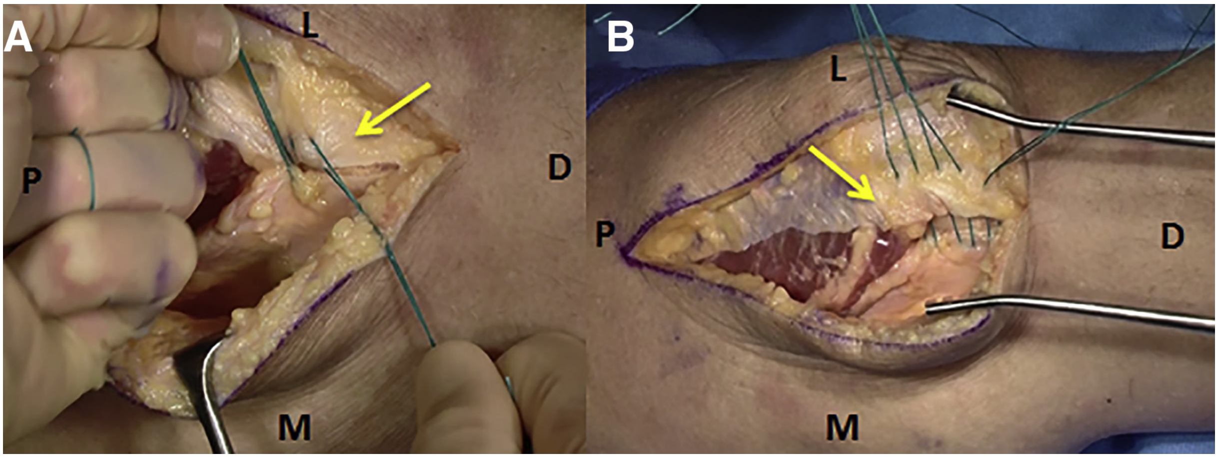

Fig 8. (A) MPFL tensioning. The superior and inferior margins of the transected MPFL are tagged with No. 1 Ethibond sutures. The superior margin (yellow arrow) is brought over the inferior margin to assess adequate tensioning and extent of imbrication required to reproduce a one and one-half quadrant lateral patellar glide and normal patellar tracking throughout the knee range of motion. (B) MPFL imbrication. Using 3 No. 1 Ethibond sutures, the MPFL is imbricated starting at the inferior margin and advancing the sutures to the superior margin so that the superior margin (yellow arrow) drapes over the inferior margin in a pants-under-vest fashion. A free needle is used to advance the free ends of the sutures. The knee is then flexed to 60° and the sutures are tied. (D, distal; L, lateral; M, medial; P, proximal.)

6 weeks. The brace is then discontinued, crutches are weaned, and quadriceps strengthening and full knee range of motion with no knee loading beyond 90° of flexion are allowed. Standing hip to ankle radiographs are obtained 3 months after surgery to assess correction of the deformity. The patient may gradually return to activities as tolerated after 4 months.

Discussion

DFO has been effectively used as a joint-preserving alternative to arthroplasty for the treatment of isolated lateral compartment valgus gonarthrosis in the young patient.[5-9] Renewed interest in DFO has followed recent developments in cartilage and meniscal repair surgery as well as a better understanding of the relationship between malalignment and early ligamentous reconstruction failure. Patients also present with concomitant valgus deformity, LPI and early lateral compartment arthrosis. DFO is the best procedure to address symptoms from these combined pathoanatomic deformities.

DFO can be accomplished with either a medial closing-wedge or a lateral opening-wedge technique. Treatment of valgus lateral gonarthrosis with both procedures resulted in improved long-term patient reported-outcomes and no differences in complication or reoperation rates according to recent systematic reviews.[9,10] Medial closing-wedge osteotomy does not require bone grafting due to direct bony apposition and allows for immediate postoperative weight bearing and knee motion (Table 3). Moreover, in cases requiring a medial soft tissue stabilization procedure, it offers the advantage of a single incision that is more cosmetically aesthetic and can be incorporated into future surgical procedures. A medial closing-wedge osteotomy could theoretically result in less symptomatic hardware than a lateral opening-wedge osteotomy due to friction between the plate and the iliotibial band. Yet, similar rates of symptomatic hardware have been reported between these 2 techniques.[9,10] Potential surgical risks include under- or over-correction, intra-articular fracture, neurovascular injury, and postoperative knee stiffness[11] (Table 4). Ultimately, the osteotomy choice is surgeon dependent.

A varus-producing DFO can be considered for the treatment of LPI and associated valgus malalignment. Restoration of a neutral mechanical axis corrects maltracking and subluxation by decreasing lateral patellar forces. A recent case series of patients treated with a

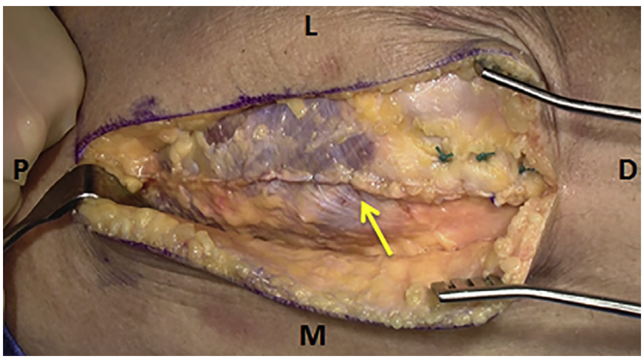

Fig 9. Completion of MPFL imbrication. With the knee in full extension, the medial retinaculum and superficial fascia (yellow arrow) are closed using a running locked No. 0 Vicryl suture. (D, distal; L, lateral; M, medial; P, proximal.)

Table 3. Advantages and Disadvantages of Medial Closing-Wedge Distal Femoral Osteotomy

Advantages	Disadvantages
■ Inherent stability allowing immediate postoperative functional loading ■ Early mobilization ■ Reliable bone healing without the need for bone grafting ■ Single incision when a medial soft tissue stabilization procedure is required	■ Less ability to fine-tune the intraoperative correction ■ Risk of neurovascular injury ■ More difficult access to the lateral compartment for concomitant procedures

Table 4. Pearls and Pitfalls

Pearls	Pitfalls
■ Two Kirschner wires are inserted prior to the osteotomy to serve as a guide for the osteotomy and also help avoid a rotational deformity when closing the osteotomy after wedge removal ■ The osteotomy is planned to end approximately 5 mm before the lateral cortical bone to leave a lateral hinge ■ Copious irrigation should be used while performing the osteotomy to avoid thermal injury ■ The osteotomy is closed by applying careful and continuous manual compression to the lateral lower limb while stabilizing the knee joint to avoid fracture	■ The quadriceps and neurovascular structures may be injured if malleable retractors are not placed both posteriorly and anteriorly ■ Undercorrection/malcorrection of the alignment by excessive/insufficient wedge resection ■ An osteotomy site that is too distal may lead to intercondylar fracture ■ Violation of the lateral cortex may lead to less stability of the osteotomy

lateral opening-wedge DFO and lateral retinacular release for LPI showed improved radiographic and patient-reported outcomes at a minimum follow-up of 2 years.[12] Medial soft-tissue attenuation may require imbrication or reconstruction in addition to realignment osteotomy to fully correct the patella maltracking. Prospective outcome data are lacking for this combined procedure, but several authors have reported success in cases of refractory LPI.[13-16]

In conclusion, a varus-producing DFO with MPFL imbrication is an effective treatment for recurrent LPI in patients with moderate to severe valgus deformity. We present our preferred surgical technique using a precontoured distal femoral locking plate and medial soft tissue stabilization.

References

1. Boden BP, Pearsall AW, Garrett WE Jr, Feagin JA Jr. Patellofemoral instability: Evaluation and management. *J Am Acad Orthop Surg* 1997;5:47-57.
2. Dejour D, Le Coultre B. Osteotomies in patello-femoral instabilities. *Sports Med Arthrosc* 2007;15:39-46.
3. McWalter EJ, Cibere J, MacIntyre NJ, Nicolaou S, Schulzer M, Wilson DR. Relationship between varus-valgus alignment and patellar kinematics in individuals with knee osteoarthritis. *J Bone Joint Surg Am* 2007;89:2723-2731.
4. Puddu G, Cipolla M, Cerullo G, Franco V, Gianni E. Which osteotomy for a valgus knee? *Int Orthop* 2010;34:239-247.
5. Backstein D, Morag G, Hanna S, Safir O, Gross A. Long-term follow-up of distal femoral varus osteotomy of the knee. *J Arthroplasty* 2007;22:2-6 (suppl 1).
6. Cameron JI, McCauley JC, Kermanshahi AY, Bugbee WD. Lateral opening-wedge distal femoral osteotomy: Pain relief, functional improvement, and survivorship at 5 years. *Clin Orthop Relat Res* 2015;473:2009-2015.
7. Kosashvili Y, Safir O, Gross A, Morag G, Lakstein D, Backstein D. Distal femoral varus osteotomy for lateral osteoarthritis of the knee: A minimum ten-year follow-up. *Int Orthop* 2010;34:249-254.
8. Wang JW, Hsu CC. Distal femoral varus osteotomy for osteoarthritis of the knee. *J Bone Joint Surg Am* 2005;87:127-133.
9. Wylie JD, Jones DL, Hartley MK, et al. Distal femoral osteotomy for the valgus knee: Medial closing wedge versus lateral opening wedge: A systematic review. *Arthroscopy* 2016;32:2141-2147.
10. Chahla J, Mitchell JJ, Liechti DJ, et al. Opening- and closing-wedge distal femoral osteotomy: A systematic review of outcomes for isolated lateral compartment osteoarthritis. *Orthop J Sports Med* 2016;4:2325967116649901.
11. Rosso F, Margheritini F. Distal femoral osteotomy. *Curr Rev Musculoskelet Med* 2014;7:302-311.
12. Swarup I, Elattar O, Rozbruch SR. Patellar instability treated with distal femoral osteotomy. *Knee* 2017;24:608-614.
13. Frosch KH, Schmeling A. A new classification system of patellar instability and patellar maltracking. *Arch Orthop Trauma Surg* 2016;136:485-497.
14. Kwon JH, Kim JI, Seo DH, Kang KW, Nam JH, Nha KW. Patellar dislocation with genu valgum treated by DFO. *Orthopedics* 2013;36:840-843.
15. Purushothaman B, Agarwal A, Dawson M. Posttraumatic chronic patellar dislocation treated by distal femoral osteotomy and medial patellofemoral ligament reconstruction. *Orthopedics* 2012;35:e1668-e1672.
16. Kitta Y, Niki Y, Udagawa K, Enomoto H, Toyama Y, Suda Y. Severe valgus deformity of the knee with permanent patellar dislocation associated with melorheostosis: A case report and review of the literature. *Knee* 2014;21:589-593.