Technical Note

Combined Biplanar Medial Closing-Wedge Distal Femoral Osteotomy and Quadriceps Tendon Medial Patellofemoral Ligament Reconstruction

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Abstract: Lateral patellofemoral instability is multifactorial in etiology, with bony and soft-tissue factors contributing. Coronal plane alignment, in particular genu valgum, is important to consider when evaluating lateral patellofemoral instability. When genu valgum is present and thought to be a significant contributing factor, we typically address this with an extra-articular, biplanar, medial closing-wedge distal femoral osteotomy (DFO). This can be combined with a medial patellofemoral ligament reconstruction using a partial-thickness quadriceps tendon graft via the same incision. A medial closing-wedge DFO with locking plate fixation affords a highly stable construct suitable for early weight-bearing. The locking plate is less prominent as compared with a lateral opening-wedge DFO, and it does not irritate the iliotibial band or cause tightening of the illiopatellar expansion. The biplanar nature of the osteotomy prevents extension of the osteotomy into the proximal trochlear, helps to control rotation in both axial and sagittal plane after wedge removal, and increases the bony surface area for healing. The quadriceps tendon medial patellofemoral ligament reconstruction allows a graft that can be tailored in terms of length and diameter, does not require an anchor on the patellar, and can be performed through the same incision as for the DFO.

Lateral patellofemoral instability (LPI) is multifactorial in etiology, with bony and soft-tissue factors contributing. Medial patellofemoral ligament (MPFL) reconstruction has become a mainstay of treatment for many cases of LPI; however, this does not address contributing bony morphologic factors. Patella alta and trochlear dysplasia are examples of contributing bony factors and need careful assessment and management. Coronal plane alignment, in particular genu valgum, is also a critical bony factor to consider when evaluating LPI, with important implications on the force vectors of the patellofemoral joint. When genu valgum is present (Fig 1) and thought to be a significant contributing factor, we typically address this with an extra-articular, biplanar medial closing-wedge (MCW) distal femoral osteotomy (DFO). A MCWDFO with locking plate fixation affords a highly stable construct suitable for early weight-bearing. The medial locking plate is less prominent as compared with a lateral opening-wedge DFO, the latter often causing irritation of the iliotibial band and/or tightening of the illiopatellar expansion. The biplanar nature of the osteotomy prevents extension of the osteotomy into the proximal trochlear, controls rotation in both the axial and sagittal planes after wedge removal, and increases the bony surface area for healing.[1] An MCWDFO can be combined with an MPFL reconstruction through the same incision using various graft options, including hamstring tendon autograft, allograft, or ipsilateral quadricep tendon graft (Video 1). The quadriceps tendon MPFL reconstruction allows a graft that can be tailored in terms of length and diameter, does not require an anchor on the patellar, and can be performed through the same incision making it our preference in this scenario.

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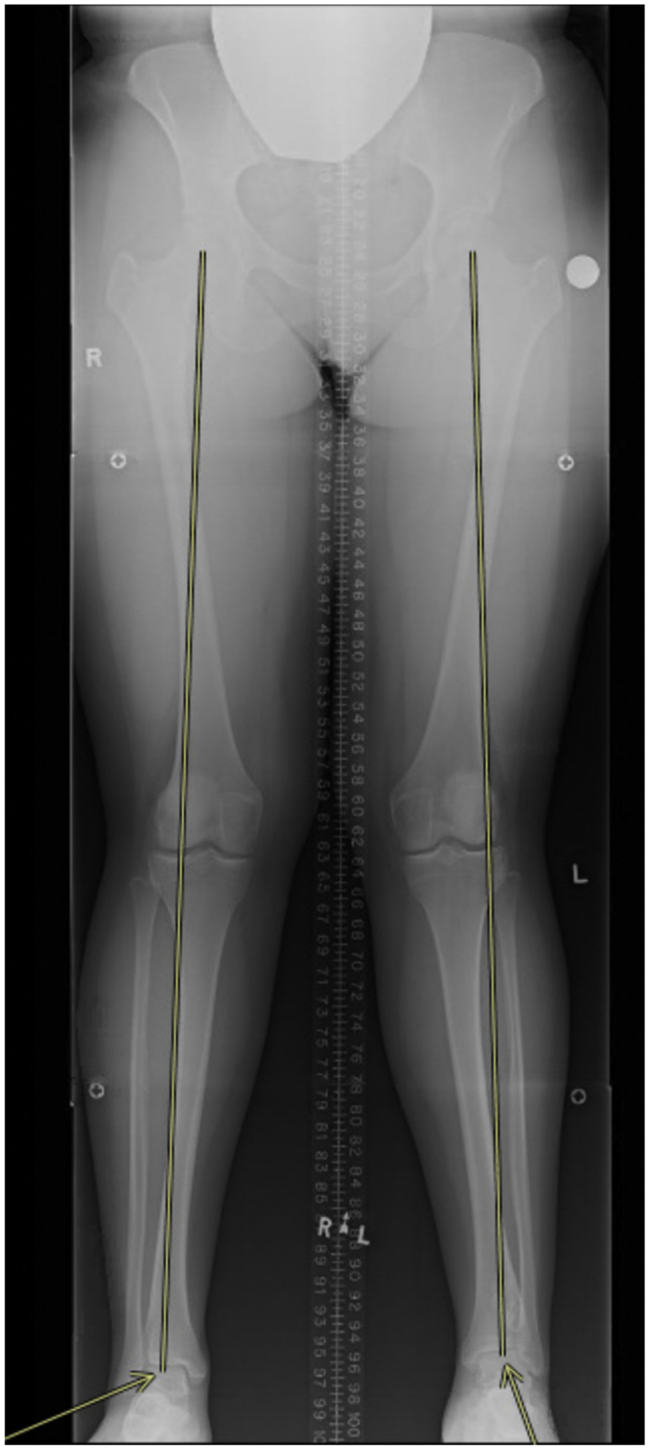

Fig 1. Long-leg alignment films demonstrating bilateral genu valgum. The weight-bearing axis is passing well lateral to the center of the knee.

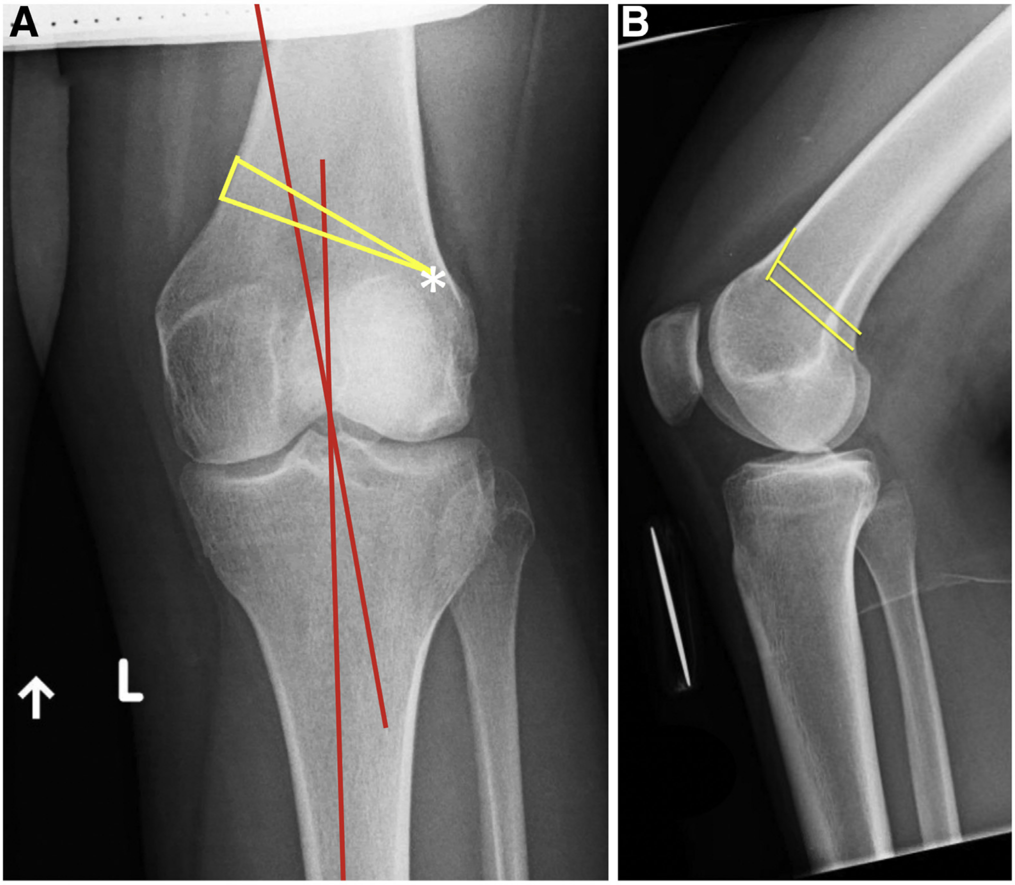

Fig 2. Preoperative templating of a left-sided medial closing wedge distal femoral osteotomy. (A) The red lines extend from the center of the femoral head and center of the talar dome and meet at the desired point for the postoperative weight-bearing axis. The acute angle subtended by the 2 red lines is transposed from the desired hinge point (*) to the medial femoral cortex. Note this is an isosceles triangle and therefore when the wedge is removed, there will be no cortical step off. The distance at the medial femoral cortex is recorded and used intraoperatively to space the guidewires. (B) A lateral radiograph demonstrating the planes of the cuts for the osteotomy. Note the anterior cut plane helps ensure the osteotomy plane does not enter the proximal trochlear.

Surgical Technique (With Video Illustration)

Pearls and pitfalls for this technique are listed in Table 1.

Templating the Osteotomy

We template the osteotomy using a technique based on that described by Dugdale et al.[2] (Fig 2). Of note, this original description was for a high tibial osteotomy and when adapting it for a DFO, there is a tendency for overcorrection. This is because the correction is calculated at the joint line; however, the osteotomy is performed above the joint line and therefore the angular correction is applied over a longer distance. A small adjustment can be made to accommodate for this by reducing the correction down to the nearest millimeter. High-quality long-leg alignment films are mandatory, and particular attention should be paid to rotational positioning of the limb. Lateral patellar subluxation is often present in this scenario, and a true anteroposterior view of the distal femur may have the patella laterally positioned. A point for the desired weight-bearing axis after the osteotomy is selected (Fig 2A). We typically aim for a neutral postoperative alignment and select a point between the tibial spines. Lines from the center of the femoral head and middle of the talar dome intersect at this point. The acute angle subtended by these lines is the desired angular correction. This is angle is transposed from the desired hinge point to the medial femoral cortex (Fig 2A and Fig 3A). The distance between these lines at the medial femoral cortex is measured in millimeters and used intraoperatively (Fig 4).

Patient Positioning

The patient is positioned supine on a radiolucent table with a high thigh tourniquet, lateral thigh support, and single foot rest placing the knee at 60° of flexion. The image intensifier is set perpendicular to the table from the ipsilateral side, and the surgeon operates from the contralateral side of the table. Prepping and draping must be as proximal as possible to allow adequate exposure especially in patients of short stature.

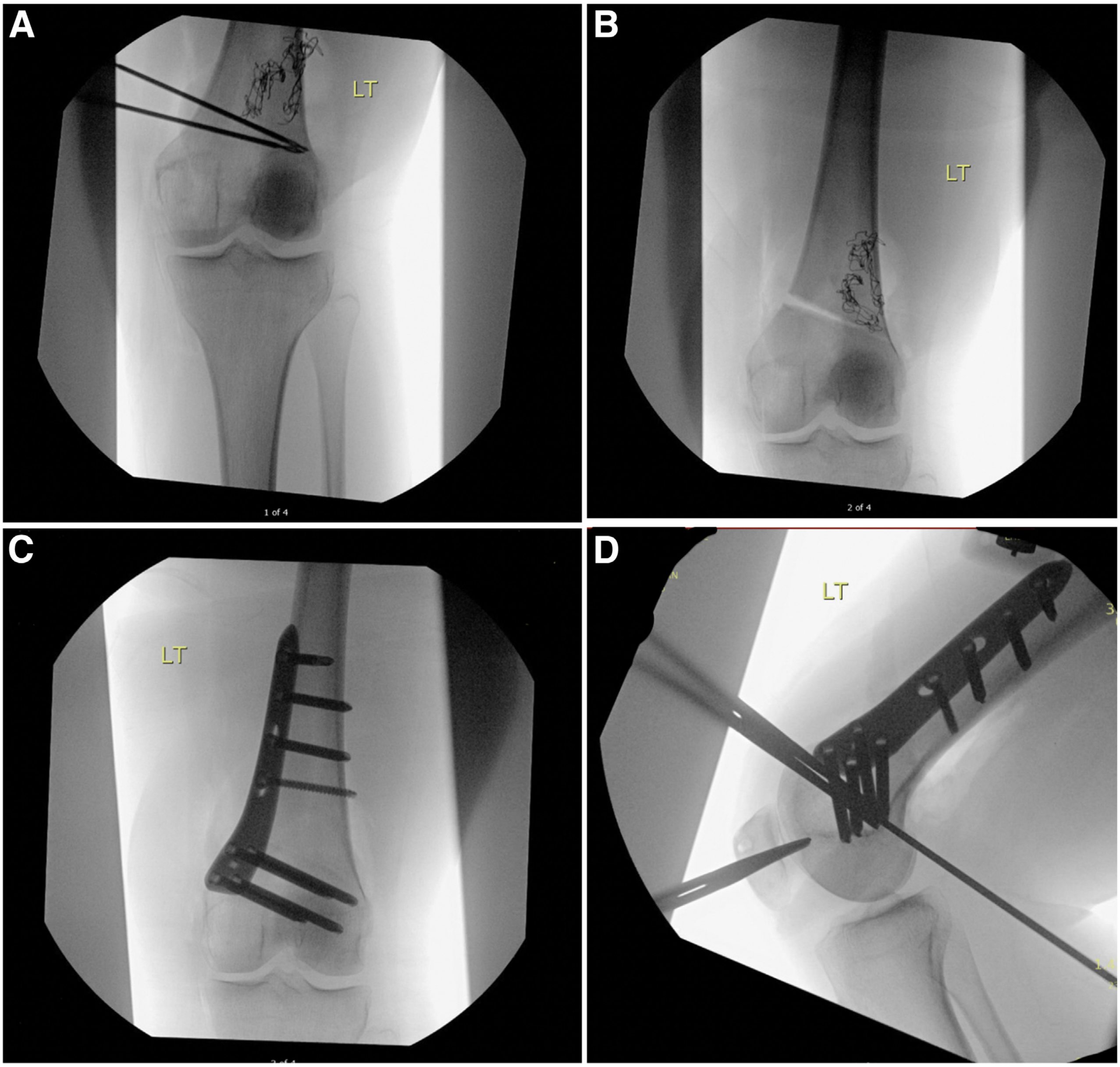

Fig 3. A composite of intraoperative fluoroscopic images from a left biplane medial closing wedge distal femoral osteotomy. (A) Guidewires are placed as per the preoperative templating. Note the radiolucent wire in the surgical pack placed posterior to the femur to help protect the neurovascular bundle. (B) The osteotomy has been completed and beginning to close. (C) An anteromedial locking plate holds the osteotomy after the wedge has been closed. The bi-cortical non-locking screw (4th from the top) is used to gain compression at the osteotomy site. (D) Lateral image after the osteotomy with the beath pin at Schottle's point. A Kocher is attached to the Beath pin to localize its position on the medial femoral cortex. The Beath pin can be angled to avoid the plate/screw construct.

Examination Under Anesthesia and Arthroscopic Evaluation

An examination under anesthesia of the knee and in particular patellofemoral joint is performed. An arthroscopy is performed to address any intra-articular pathology with particular attention paid to the lateral femoral condyle and medial patellar facet chondral surfaces.

Performing the Osteotomy

A 15-cm longitudinal para-midline incision is made, centered over the desired osteotomy site. The fascia over the vastus medialis is identified and elevated. Importantly, developing this subfascial plane protects the saphenous nerve, which remains superficial to it. A blunt Hohmann retractor can be used to elevate the vastus medialis obliquus. Diathermy is used to release

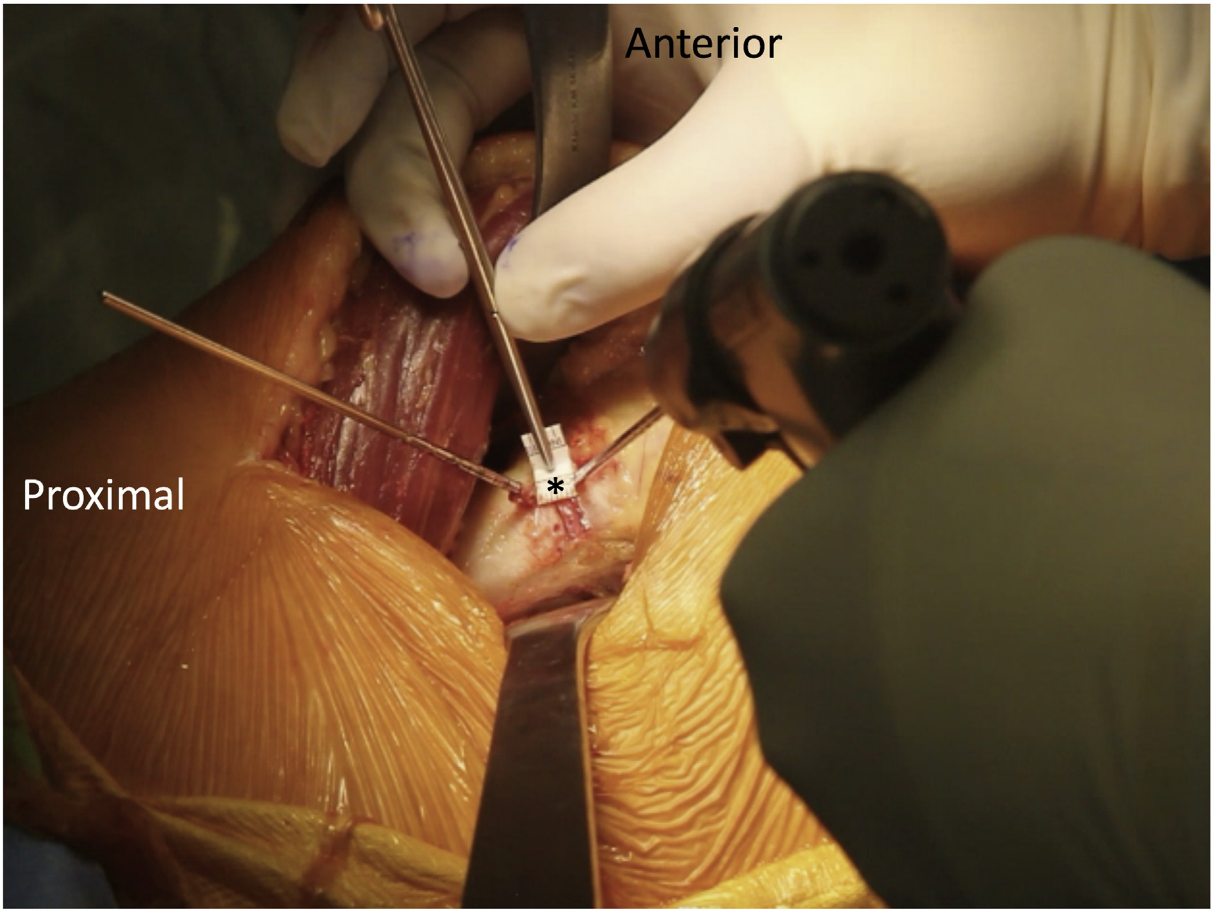

Fig 4. A sterile ruler cut to size (*) and held on an artery forceps is used to guide the guidewire separation as per the preoperative templating. This is the medial aspect of the left knee with the proximal limb to the left and the distal limb toward the right.

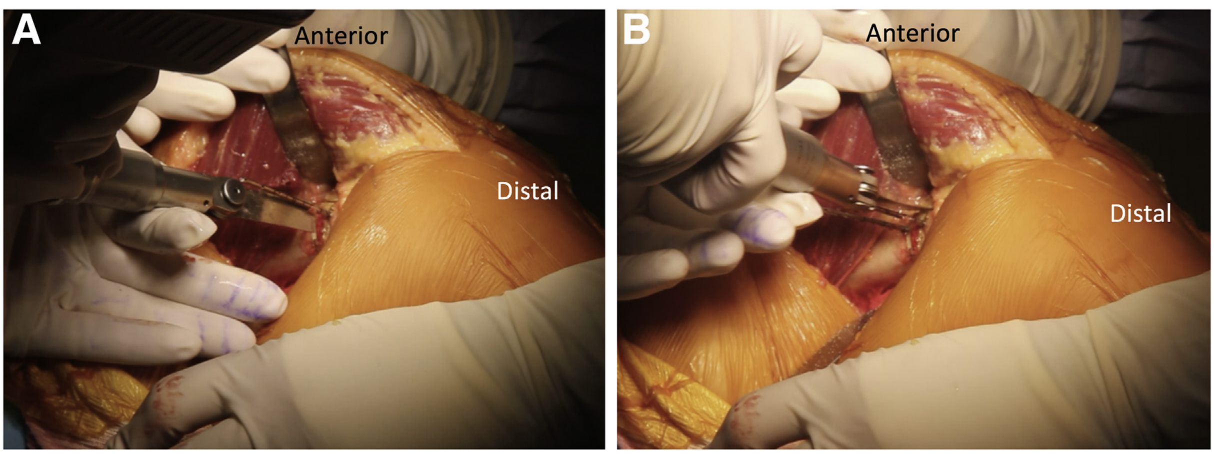

Fig 5. The axial (A) and coronal (B) plane cuts are performed with an oscillating saw during a medial closing wedge distal femoral osteotomy. This is a left knee with the proximal limb to the left and the distal limb towards the right.

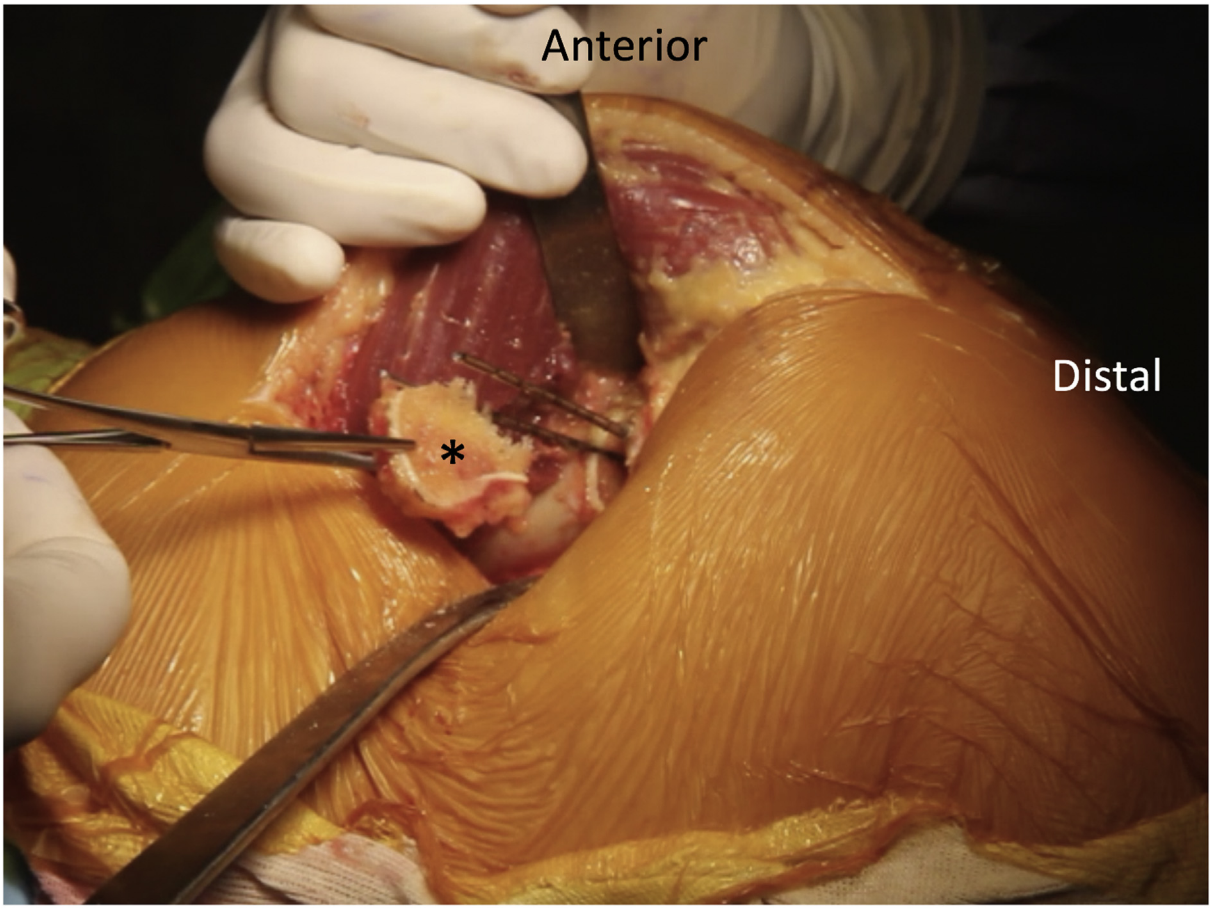

Fig 6. The bone wedge (*) is removed from the osteotomy site during a closing wedge distal femoral osteotomy. This is the medial aspect of the left knee with the proximal limb to the left and the distal limb toward the right.

the intermuscular septum from the femur. A surgical pack can be packed behind the femur and, along with a posterior Hohmann retractor, protect the posterior neurovascular bundle. A guidewire is placed under image intensifier guidance as per templating (Fig 3A). A sterile ruler can be cut to size (as per templating) to allow for an accurate positioning of the second wire (Fig 4). Care is taken for the wires (and therefore osteotomy plane and hinge point) to be proximal to the lateral femoral condyle. If the wires are equidistant from the medial femoral cortex to the hinge point, after the wedge is removed there will be no step in the cortex when the osteotomy is closed down. The osteotomy plane is marked with cautery. The wires can be bent or shortened for improved maneuverability around them with the oscillating saw. The coronal plane cut is performed first (Fig 5A) and then the converging axial plane cuts (Fig 5B), initially with the saw and completed with osteotome. Care is taken to ensure the axial cuts are removing the same amount of bone anteriorly as posteriorly so as not to add undesired flexion or extension into the osteotomy.

The bone wedge is removed (Fig 6), and the osteotomy is completed with an osteotome. A Kerrison rongeur is helpful to safely remove posterior cortical bone. Drilling of the medial hinge (controlled osteoclasis) with a 2-mm K wire can aid in plastic deformation when closing the wedge. The osteotomy is closed by manipulation of the leg or positioning it in the figure-of-4 position. If this does not close immediately, further completion with an osteotome and Kerrison is performed. An anteromedial precontoured locking

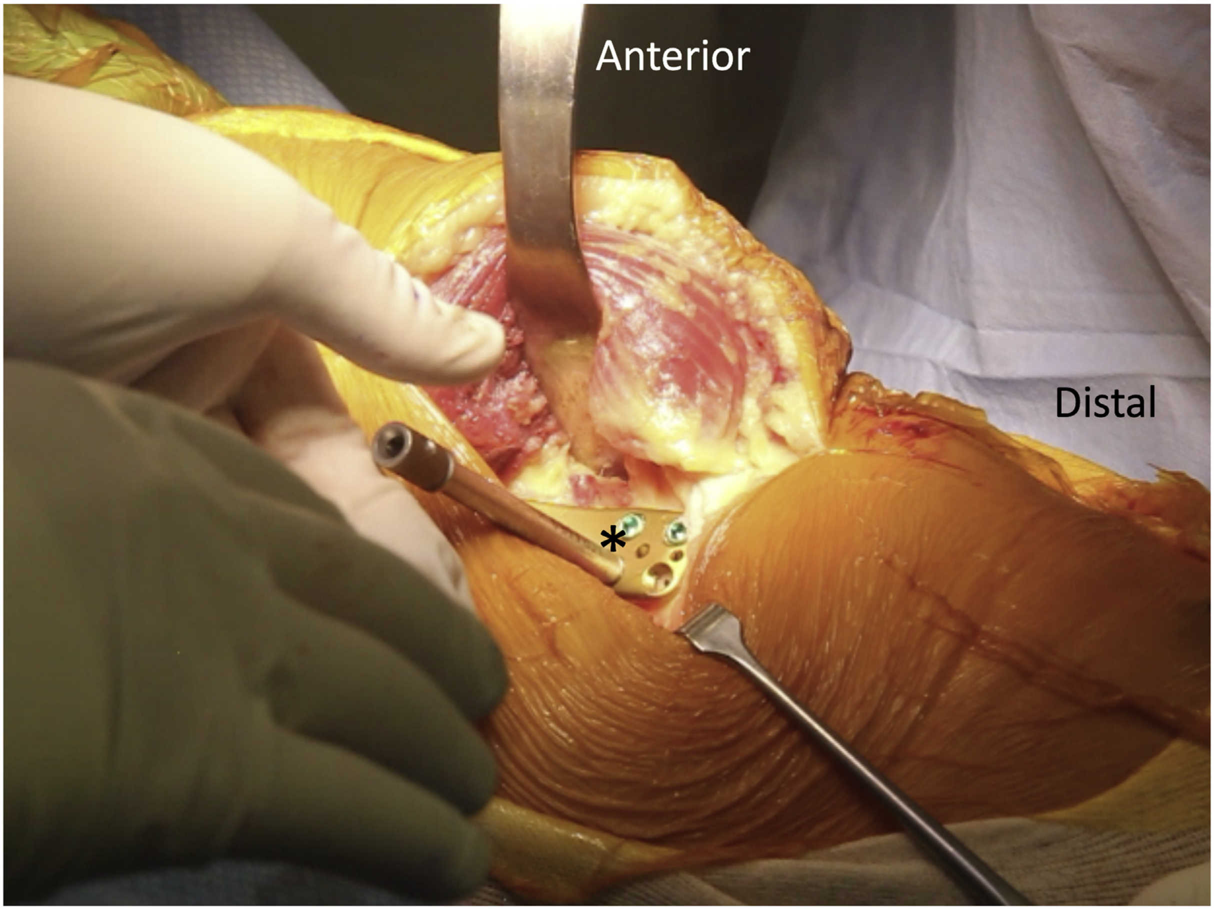

Fig 7. A precontoured antero-medial locking plate (*) is applied after the medial closing wedge distal femoral osteotomy is closed. The distal locking screws are placed first as shown, and the an eccentrically drilled bi-cortical nonlocking screw is used to gain compression at the osteotomy site. This is the medial aspect of the left knee with the proximal limb to the left and the distal limb toward the right.

plate (TomoFix; DePuy Synthes, Raynham, MA) is applied with distal fixation completed first (Fig 7). Then, an eccentrically drilled 3.5-mm bicortical compression screw is inserted proximally to gain compression at the osteotomy site via the plate. Of note, the tendency of the plate is to sit off anteriorly on the proximal segment. The remaining proximal holes are filled with locking screws.

Autologous Quadriceps Tendon Medial Patellofemoral Ligament Reconstruction

Through the same incision, dissection is carried out anteriorly to expose the quadriceps tendon. Quadriceps tendon length can be measured to confirm there is adequate length with an ipsilateral hamstring tendon being the alternate option. Scissors and a 15 blade or a commercially available 8- or 10-mm 'catamaran' blade (Karl Storz, Tuttlingen, Germany) is used to harvest a partial-thickness quadricep tendon graft from the medial side of the tendon (Fig 8). The attachment to the superomedial pole of the patella is left in continuity. The free end is tubularized and whipstitched with a 1 VICRYL suture (Ethicon Inc., Somerville, NJ). A Beath pin (Smith & Nephew, Andover, MA) is placed in the region of Schottle's point[3] (Fig 9) and the position is confirmed on a true lateral fluoroscopic image (Fig 3D). The position for the femoral MPFL tunnel is evaluated by wrapping the graft around the Beath pin and cycling the knee while monitoring tension of the graft and knee range of motion. The aim is to create a check reign to lateral patella translation from 0 to 30° of flexion. The graft should slacken in deeper flexion when the bony constraints (femoral trochlear) become the primary restraint to LPI.

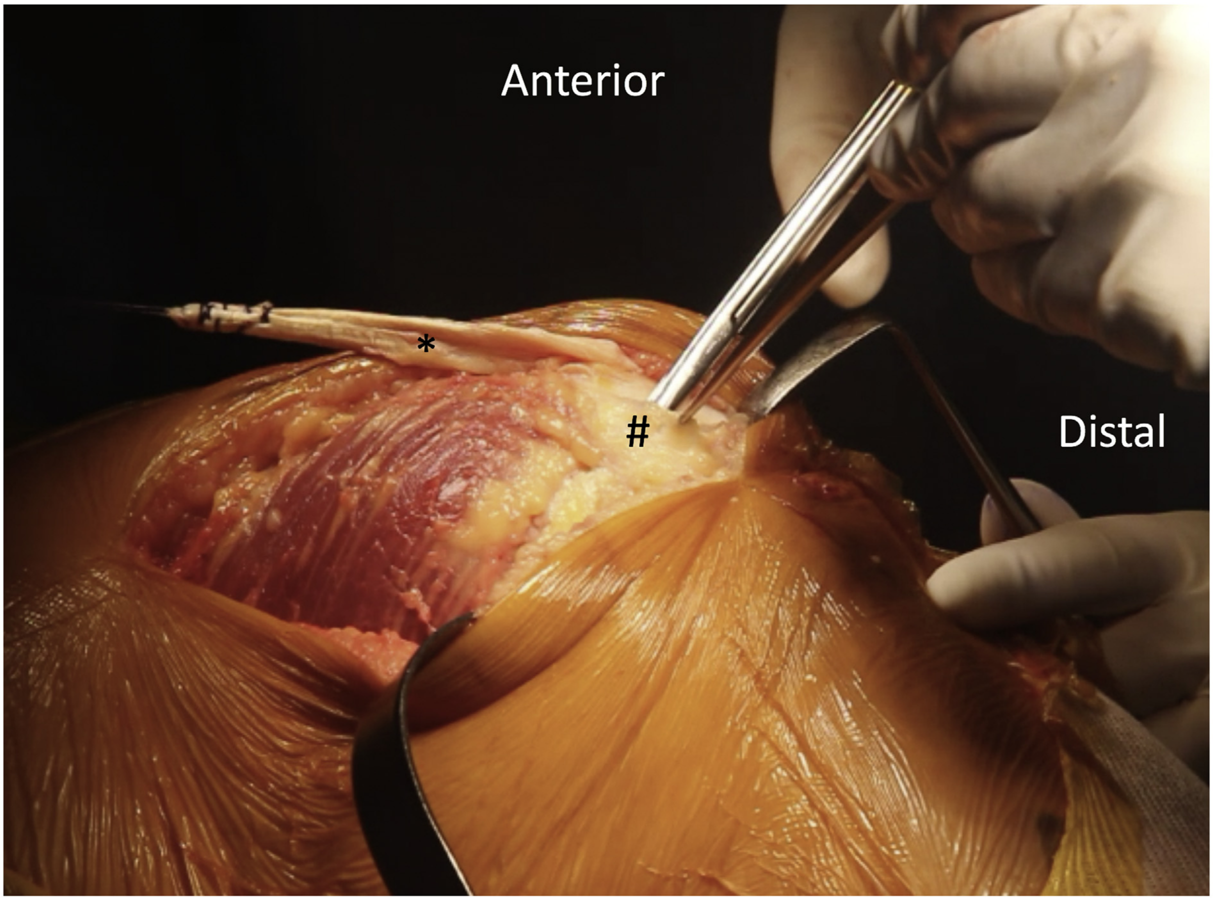

Fig 8. The partial-thickness quadricep tendon MPFL graft (*) is left attached to the superomedial border of the patellar and the free end is tubularized and whipstitched. The plane for the MPFL graft is being developed (#). This is the medial aspect of the left knee with the proximal limb to the left and the distal limb toward the right. (MPFL, medial patellofemoral ligament.)

When the desired MPFL femoral tunnel location is accepted, the Beath pin is advanced. This may need to be redirected on differing trajectories to avoid the plate and screws from the MCWDFO. A 6-mm cannulated reamer is used to drill a socket that will accommodate the graft length and the graft is docked into the tunnel. An extra-articular plane in layer 2 of the medial knee is developed and the quadricep tendon graft is passed (Fig 8). It is then docked into the femoral tunnel by the Beath pin and a 6-mm PEEK (polyether ether ketone) canulated screw (Smith & Nephew) is used to fix the graft at the appropriate tension.

Discussion

Addressing underlying bony and soft-tissue factors is important in the management of LPI. In the setting of predisposing genu valgum, this technique affords a stable construct ready for early weight-bearing and reduces hardware-related issues that are more commonly seen with a lateral opening wedge-distal femoral osteotomy (Fig 10).[4] This is particularly important in the context of LPI, where lateral retinacular tightness can be a contributing factor; an opening-wedge technique can potentially exacerbate this tightness due to the iliopatellar expansion of the iliotibial band. A

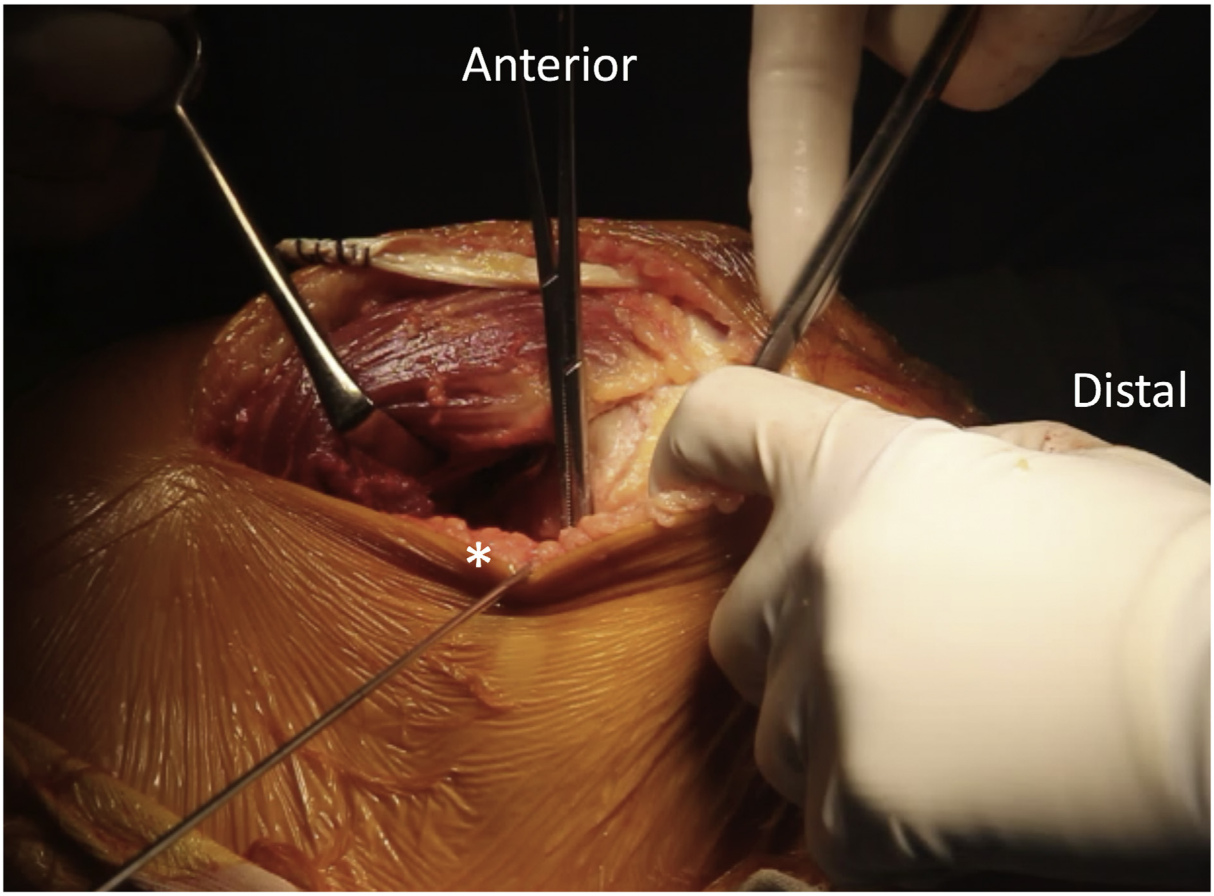

Fig 9. Schottle's point (*) has been identified and is being prepared for the femoral insertion of the medial patellofemoral ligament graft. A beath pin is placed at Schottle's point and a Kocher is used to help determine the position. This clinical image correlates with the fluoroscopic image in Figure 3D. This is the medial aspect of the left knee with the proximal limb to the left and the distal limb towards the right.

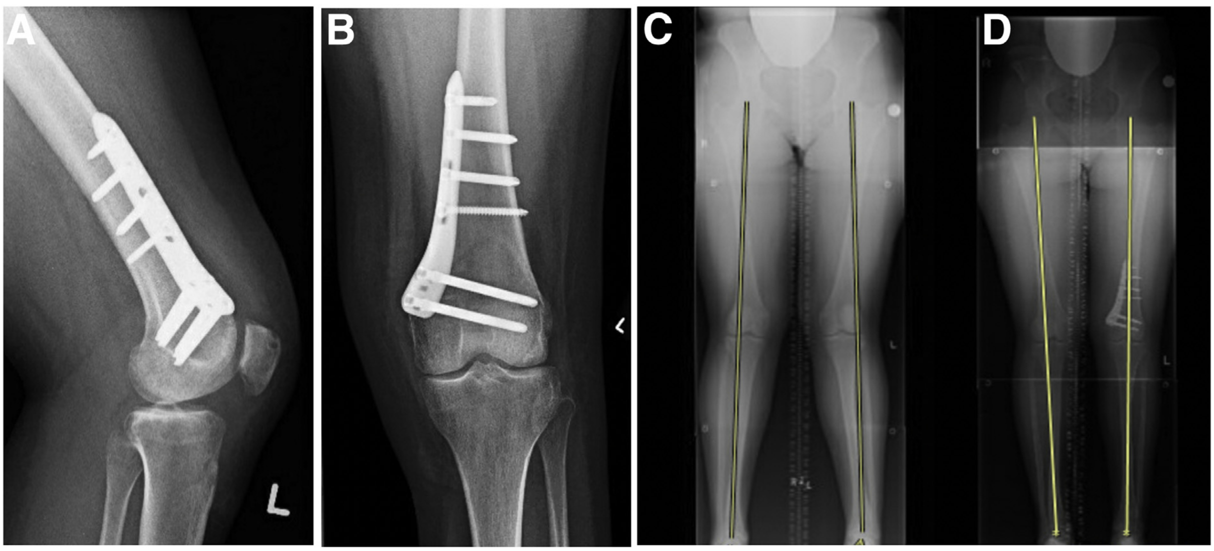

Fig 10. Postoperative radiographs (A and B) with preoperative (C) and postoperative (D) long-leg alignment films demonstrating correction to a near-neutral mechanical axis.

Table 1. Surgical Pearls and Pitfalls

Surgical Pearls	Surgical Pitfalls
• A subfascial approach will protect the saphenous nerve. • A surgical pack behind the femur is helpful to protect the posterior neurovascular bundles. • A sterile ruler cut to size on an artery forceps is helpful to execute the desired correction. • If the 2 guidewires are equidistant from the medial cortex to the hinge point, there will be no cortical step off when the osteotomy is closed. • A Kerrison rongeur is helpful to remove residual posterior bone. • Drilling the lateral hinge with K-wire can help aid in closing the osteotomy.	• Proximal dissection must be done carefully, as the femoral artery is in close proximity. • The wires and hinge point must be proximal to the lateral femoral condyle. • Residual posterior bone is a common reason the osteotomy will not close. • Fracture of the lateral hinge. Address with a lateral staple if there is concern for associated instability. • Complete the osteotomy before the MPFL; the tension in the MPFL graft would change if fixed before the DFO. • Beath pin passage past the DFO plate and screws can be difficult and require multiple attempts at differing trajectories. • Reinforcing the quadricep tendon grafts attachment to the superomedial patella can be done with a non-dissolvable suture if this becomes attenuated.

DFO, distal femoral osteotomy; MPFL, medial patellofemoral ligament.

MCWDFO also has been shown to reduce the tibial-tubercle to trochlear groove distance, which is another predisposing bony factor.[5] Meticulous preoperative templating is critical with a closing-wedge osteotomy, as there is less room for fine-tuning the degree of correction compared with an opening wedge. Closing the osteotomy and using the width of an oscillating saw blade can gradually increase the correction if required. Similarly, the wedge removed can be used to bone graft a void if too much is taken and the limb is overcorrected; however, these scenarios are best avoided with careful planning. Further advantages and disadvantages of this technique are summarized in Table 2.

Table 2. Advantages and Disadvantages of This Technique

Advantages	Disadvantages
• Stable construct allowing early weight-bearing • Rotational control is maintained with the biplanar osteotomy • The biplanar osteotomy also minimizes the chance of osteotomy extension into the joint and trochlea • No requirement for bone grafting or void filling as with LOWDFO • Lateral soft-tissue irritation (ITB) and tightening of the iliopatellar expansion associated with a LOWDFO is avoided • Quadricep tendon MPFL can be performed through the one incision • No requirement for implants on patellar side of the MPFL graft	• Proximity of femoral artery raise potential for vascular injury • Potential to slightly reduce leg length • More difficult to fine-tune or adjust degree of correction intraoperatively as compared to an opening-wedge osteotomy • Large corrections (>14 mm) are typically best performed with an opening-wedge technique • Inadequate length of quadricep tendon to reach Schottle's point is possible and should be assessed before harvesting

ITB, iliotibial band; LOWDFO, lateral opening-wedge distal femoral osteotomy; MPFL, medial patellofemoral ligament.

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