Technical Note

Minimally Invasive Double Level Osteotomy in Severe Knee Varus: Pearls and Pitfalls

Pierre Sautet, Kristian Kley, Raghbir Khakha, and Matthieu Ollivier

Abstract: Minimally invasive double-level osteotomy (DLP) surgery is performed in severe knee varus, when extra-articular deformity is identified in both the distal femur and proximal tibia. The main advantage is to maintain a horizontal joint line and avoid creating secondary anatomic deformities. This article considers the pearls and pitfalls in performing minimally invasive DLO surgery.

Through the ages, osteotomy has been widely accepted as an effective treatment for deformity correction and osteoarthritis of the knee.[1] Today, we see a trend toward functional osteotomy treatments where the aim is to correct the limb alignment axis without adversely effecting normal anatomical parameters and achieve physiological gait patterns. These advances have been able to therefore provide a higher satisfaction rate with a sustained survivorship of the treatment.[2]

Surgical Indications

Indications for a double-level osteotomy (DLO) in severe knee varus include a change in the mechanical lateral distal femoral angle (mLDFA°) and medial proximal tibial angle (MPTA) that reaches values of more than 3° from normal.[3] DLO should be considered when the MPTA exceeds 94°, resulting in an abnormal joint line obliquity, when a simulating of isolated open-wedge high tibial osteotomy (HTO) (Table 1).[3] Increased joint line obliquity >4° results in excessive shear forces on the articular surface, with resulting poor functional results.[4] The purpose of this study is to show the pearls and pitfalls of minimally-invasive DLO for correction of deformity in severe varus.

Preoperative Planning

To evaluate the source of the deformity in a malaligned lower limb, analysis and planning are key to determine the required course of action. The degree of varus/valgus malalignment is defined in Fig 1:

- Mikulicz line[5]: A line drawn from the center of the femoral head to the center of the ankle joint in a weightbearing long leg alignment radiograph with appropriate orientation at the knee joint (centered patella)
- mLDFA: The angle formed between the line of mechanical axis of the femur and the distal femur joint line
- MPTA: The angle formed between the mechanical axis of the tibia and the proximal tibial joint line
- Joint line convergence angle: The angle formed between the distal femur and proximal tibia that addresses the deformity at the level of the joint and the influence of the soft tissue structures supporting the knee

Surgical Technique

The patient is positioned supine on a radiolucent table (Video 1). The leg is draped up to the level of the iliac crest. A tourniquet may be considered, but in our

From the Institut du Mouvement et de l'Appareil Locomoteur, Hôpital Sainte-Marguerite, Aix-Marseille Université (P.S., M.A.), Marseille, France; Orthoprofis Hannover (K.K.), Hannover, Germany; and the London Knee Osteotomy Centre, Orthopaedic Specialists, Harley Street Specialist Hospital (R.K.), London, United Kingdom.

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Address correspondence to Corresponding author: Pierre Sautet, Institut du Mouvement et de l'Appareil Locomoteur, Hôpital Sainte-Marguerite, Aix-Marseille Université, 270 Boulevard Sainte-Marguerite, 13009 Marseille, France. E-mail: sautetp@gmail.com

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Table 1. Indications of Double Level Osteotomy in Severe Knee Varus

mLDFA >90°
MPTA<84°
Planned correction of isolated open wedge HTO result in MPTA>94°

mLDFA, mechanical lateral distal femoral angle; MPTA, medial proximal tibial angle; HTO, high tibial osteotomy.

experience it is not required. Usually the distal femoral osteotomy (DFO) is performed first.

DFO

A bolster is used to support the femur to prevent undue stress across the hinge point when the osteotomy has been performed because of the weight of the limb. For global varus malalignment correction, our preferred correction is a lateral femoral closing wedge osteotomy. A direct lateral approach is used. A mini-invasive subvastus approach is performed. To achieve full cortical support in closing wedge DFO, the resected wedge has to describe as an isosceles triangle. The long limbs of the triangle are of equal length resulting in lateral cortical contact after closure of the osteotomy without any steps.[6] To achieve this, the first step is to identify the hinge point. This is positioned directly on top of the contralateral condyle approximately 1 cm away from the contralateral cortex. Two K-wires are the positioned at the lateral cortex a pre-determined separation distance to achieve a desired correction. The 2 wires are then passed in a convergent fashion so that they meet at the hinge point. Before the cut is performed, a third K-wire may be used as a hinge wire to protect the hinge of the femur (Fig 2).[7] This K-wire not only protects the mobile hinge but acts like a saw stop to not accidently cut through the hinge point. Next the posterior $^3/_4$ anteroposterior thickness of the femur is cut under posterior neurovascular protection using a radiolucent retractor (Newclip Technics, Nantes, France); care is taken to preserve the anterior biplanar part of the osteotomy. Once the biplanar osteotomy is complete, the wedge is removed. To close the osteotomy, gentle pressure is applied on the foot in an axial direction until there is cortical contact on the lateral side. The osteotomy plate, usually a fixed angle locking device, is applied (Video 1).

HTO

A longitudinal 5 cm incision in line with the anterior boarder of the medial collateral ligament (MCL), starting 1 to 2 cm below the joint-line up the upper border of the pes anserinus is made. A space is created between the pes anserinus and the MCL, by placing a curved clip in this interval and opened along the length of the pes. In doing so, this “auto-dissects” the MCL bluntly and grants exposure to it. In the anterior part, the medial insertion of the patella tendon is identified and acts as a landmark for the anterior biplanar ascending osteotomy. Next, the anterior and posterior border of the

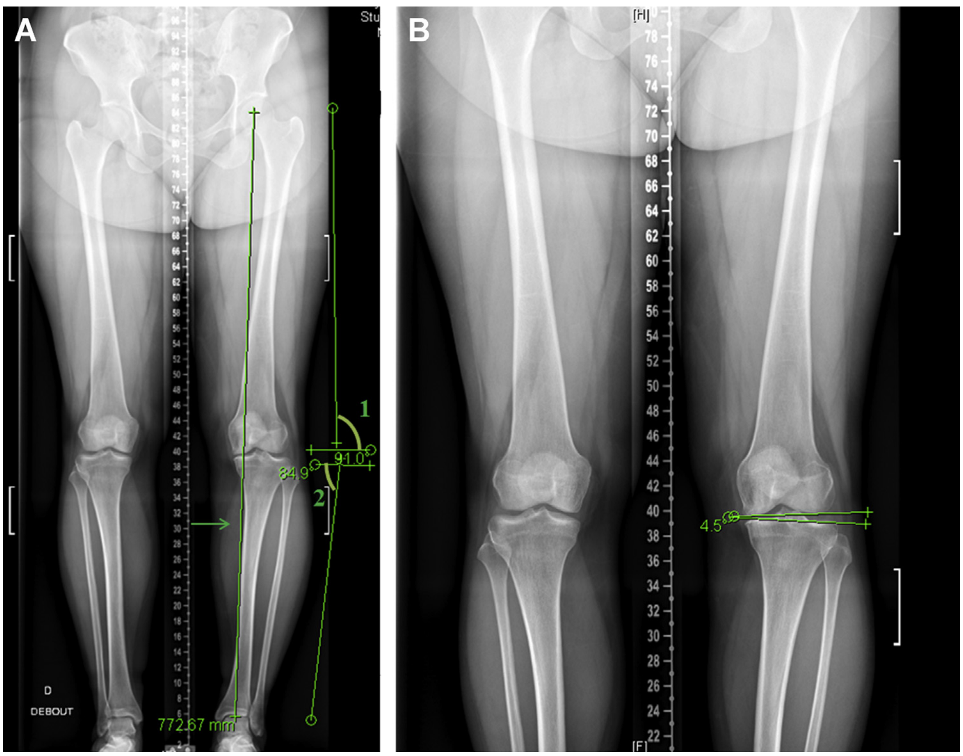

Fig 1. Full-length standing anteroposterior radiograph with measurements of the left lower extremity demonstrating the Mikulicz line (*arrow*), the mechanical lateral distal femoral angle (*1*), medial proximal tibial angle (*2*), and the joint line convergence angle.

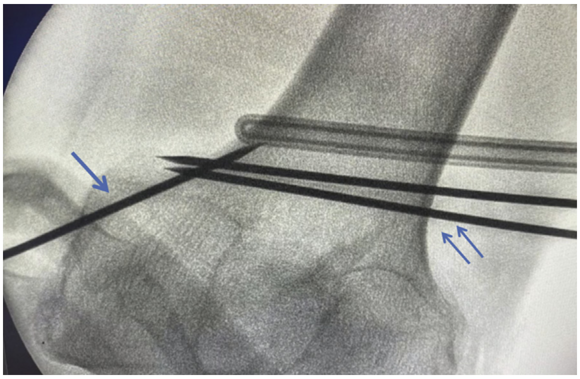

Fig 2. Perioperative radiograph showing two K-wires defining the osteotomy wedge (*double arrow*) during closing distal femoral osteotomy and the K-wire hinge protection (*arrow*).

MCL is defined and at the level of pes crossing. The MCL is released off the tibia at this level using a narrow periosteal elevator (narrow Cobb), avoiding any distal release. With the distal fibers attached, using the same elevator, the posterior border of the posteromedial tibia is identified. A window posterior to the MCL is created and using blunt dissection along the posterior cortical surface of the tibia, a pocket is created to place a neurovascular protector in the form of a radiolucent Hohmann. With the posterior radiolucent Hohmann in place, a second mini-Hohmann is used to retract the MCL and grant exposure to the anteromedial tibial surface.

Two K-wires are positioned to mark the upper border of the osteotomy, aiming for the tip of the fibular head on a true anteroposterior x-ray film.[8] The knee is held in slight flexion to achieve an x-ray film that projects the tibial surface as a single line to account for the tibial slope. In this position, x-ray films are sequentially taken to achieve a saw blade image that is parallel to the x-ray films (saw blade at its thinnest appearance on radiography).

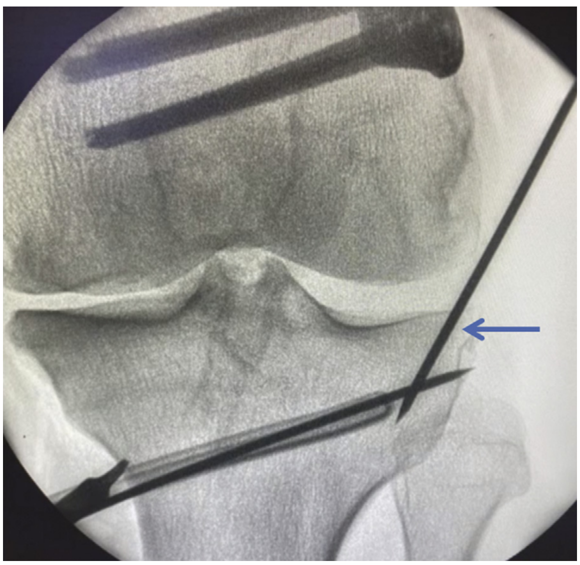

Fig 3. Perioperative radiograph showing 1 K-wire defining the osteotomy plan during high tibial osteotomy and the K-wire hinge protection (*arrow*).

This cut now fixes the orientation of the blade and one K-wire is enough to guide it to the hinge. The cut, as mentioned, should be performed distal to the wire to avoid deviating towards the joint and is in biplanar fashion carried out in the posterior $^3/_4$ of the tibia. During this process the posterior retractor remains in place, finding its way through the posterior surgical

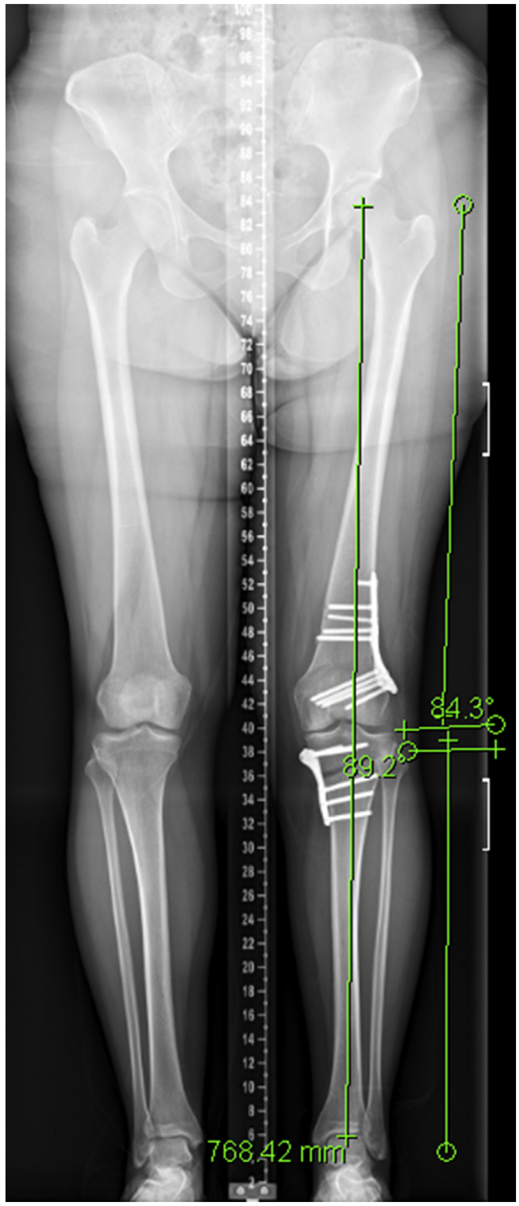

Fig 4. Postoperative radiographs at 6 months show neutral alignment with correction of mechanical lateral distal femoral angle and medial proximal tibial angles.

Table 2. Pearls and Pitfalls of Double-Level Osteotomy

Pearls and Pitfalls DFO	Surgical solution
Hinge fracture	1. Hinge position: directly on femoral condyle, 5 to 10 mm from contralateral cortex 2. Hinge protection: hinge wire 3. Cut till the end by if necessary removal of inferior wedge K-wire and then place the hinge wire to limit the wedge towards hinge 4. Hinge closure under clearance with oscillating saw 5. Hinge stabilization with thigh pillow to prevent posterior fall back after osteotomy due to weight of limb 6. Do not accept macroscopic fractures, bilateral plating is safer
Neurovascular damage	1. Safe cutting due to posterior clearance with periosteal elevator 2. Finger guided saw blade 3. Special radiolucent retractors
Cutting precision	1. Placing only 1 K-wire for each wedge cut is sufficient and easier to aim 2. K-wires with drill tip 3. Wires need to be parallel (cave: parallax)
Rotational malalignment	Perform biplanar DFOs
Implant malpositioning	Perform a proximal and distal K-wire transfixation and check lateral x-ray film before screw insertion
Delayed union	Compress every closed wedge surgery
Pearls and Pitfalls HTO	**Surgical solution**
Hinge fracture	1. Hinge position in "safe zone" 2. Cut below the K-wire to avoid intraarticular Takeuchi 3 fractures 3. Avoid inferior saw-blade divergence from K-wire to prevent Takeuchi 2 fractures 4. Place a hinge wire to protect the hinge and prevent overcutting 5. Do not open against high restraint forces 6. Make sure to have cut the posterior cortex completely
Neurovascular damage	1. Place the retractor posterior to the MCP in a two-window technique 2. Check the retractor sits directly between dorsal cortex and popliteus muscle 3. Control the retractor alignment with regards to the K-Wire fluoroscopically
MCL over-tensioning	1. Place an osteotomy spreader dorsal to the MCL and check the MCL with forceps after opening the gap 2. Release if needed e.g. pie crust
Slope change	1. Avoid opening the osteotomy against the restraint from the MCL with the spreader anterior to it (Slope elevation-the reason for the often-accused change of slope in owHTO-technical error) 2. Create a triangular osteotomy gap with higher posterior opening

DFO, distal femoral osteotomy; HTO, high tibial osteotomy.

window behind the MCL. Before the biplanar osteotomy is executed, similar to the femoral osteotomy, a hinge wire may be used to protect the hinge point (Fig 3). The concept of a hinge wire was recently described and serves as an intraoperative protection device, that eventually may even be reinforced for postoperative protection.[7,9] After the biplanar cut is accomplished the osteotomy can be opened according to the preoperative planning. Many ways to perform this have been described. The most commonly used technique includes the use of gradual opening by alternating chisels brought in at different length. The opening can then be maintained by an osteotomy spreader through the same posterior window, being careful not to interfere with the MCL. In fine-tuning the amount of opening required, the tension off the posterior fibers of the MCL can be palpated. To prevent excessive MCL tension and adverse changes to the trapezoidal gap opening, the taut fibers can be released. The increase in slope after HTO surgery can occur as a result of a nonreleased MCL. An angle-stable plate fixator can then be applied. The resultant correction is double checked with an alignment rod under axial compression. A wedge of bone is then cut from the femoral head allograft to match the size of the correction and placed into the osteotomy (Video 1).

The patient is mobilized with partial weightbearing for 2 weeks. Range of motion is not restricted. The stitches are at 12 to 14 days after surgery. Clinical and radiographs exams are performed at 6 weeks, 3 months, and 1 year (Fig 4). The pearls and pitfalls of this technique are summarized in Table 2.

Discussion

The main advantage of DLO is to maintain an articular joint line that remains horizontal.[10] Excessive joint line obliquity is related to poor functional results.[4] Minimally-invasive DLO may be technically challenging surgery and requires a long learning curve. Correct indication and preoperative planning are the most important. Different groups of authors are agreed that indication of DLO is severe varus deformity with medial osteoarthritis with mLDFA $>90°$ and MPTA$<84°$ or if simulated planning correction of isolated open wedge HTO result in MPTA$>94°$.[3]

The use of a biplanar osteotomy technique is advocated as it shortens bone healing time when compared with a single plane technique.[11] Foremost, performing biplanar osteotomy avoid excessive malposition. With the use of locking plates, we are allowing weightbearing protected by crutches for a few weeks. Planning a DLO needs experience, and the use of software to help execute the plan could be useful.

Schröter et al.[3] in a retrospective study in 2018, showed that DLO in severe global varus osteoarthritis normalize alignment and improve functional knee scores. Although we do not routinely use patient-specific cutting guides, there may be a role to play for those at the start of their experience in DLO surgery. Grasso et al.[12] showed that the use of patient-specific cutting guides produced an accurate correction.

Complications of osteotomy around the knee include neurovascular lesions, hinge fracture, bone nonunion, and over- or undercorrection of the planning. Here, we have described the pearls and pitfalls that should help to decrease complications associated with DLO surgery and encourage this technique to be used in the correct patients to avoid secondary deformities.

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