TECHNICAL NOTE

How to Perform an Accurate and Safe Medial Open Wedge High Tibial Osteotomy; A Technical Note

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Abstract

Medial open-wedge high tibial osteotomy (MOWHTO) is increasingly recognized as the preferred treatment option for active patients with varus malalignment and medial compartment osteoarthritis of the knee. This procedure aims to delay the degenerative process while alleviating pain and dysfunction. In this technical note, we aim to describe the tips and tricks for performing a safe MOWHTO, drawing on recent literature.

Level of evidence: V

Keywords: Genu varum, High tibial osteotomy, Knee osteoarthritis, Open wedge

Introduction

Medial open-wedge high tibial osteotomy (MOWHTO) is a well-established treatment option for correcting varus knee deformity in relatively young and physically active patients with medial compartment osteoarthritis (OA) or lateral trust during gait.[1] The primary objective of high tibial osteotomy (HTO) is to redistribute loads across the joint, thereby offloading the medial compartment, reducing pain, slowing OA progression and delaying the need for joint replacement surgery.[2,3] MOWHTO has gained popularity due to its simplicity, accuracy and minimally invasive nature. The purpose of this technical note is to provide guidance to orthopedic surgeons on performing a safe and precise MOWHTO.

The main indication for valgization HTO is a relatively young and active patient who presents with medial compartment OA and varus malalignment of less than 15°, along with normal or near-normal lateral and patellofemoral compartments and a full range of motion in the knee.[2,4] Additionally, in cases of varus malalignment, HTO is an effective treatment option for patients with medial meniscus deficiencies, including degenerative meniscus tears, posterior root tears, subtotal or total meniscectomies, as well as those who have undergone medial meniscus repair or transplantation and medial compartment cartilage repair.[3,4]

In the past, only patients aged between 40 and 60 years were considered for osteotomy.[2,5] However, recent research suggests that physiological age is more significant than chronological age.[3,4] An active patient over 60 years old with mild OA, should not be excluded based solely on age.[3,4] Furthermore, symptomatic younger patients exhibiting early radiographic changes of medial compartment OA should not be overlooked.[5]

Contraindications for MOWHTO are relative and should be considered on an individual basis.[3] These contraindications include smoking, body mass index (BMI) > 30, inflammatory arthritis, ROM < 120°, flexion contracture > 15° and extension deficit > 10°.[2,3] Traditionally, lateral compartment OA has been considered a contraindication; however, findings show that even in cases of asymptomatic subtotal single or kissing cartilage lesions in the lateral compartment of the knee, HTO can lead to reduced pain and improved functional outcome scores.[6] Although Kellgren-Lawrence (KL) Grade IV medial compartment OA should not be considered as an absolute contraindication, patient satisfaction is only favorable in 58% of patients who exhibit a bone on bone appearance in preoperative radiographs.[3,4]

Pre-operative radiographs should include weight-bearing anteroposterior (AP), lateral, and skyline views.[2,5] A Rosenberg view (a 45-degree flexion, weight-bearing postero-anterior view) is particularly sensitive for detecting joint space narrowing and should be routinely requested.[5] The weight-bearing alignment view

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is considered the gold standard for assessing coronal plane deformities of the lower limb.[5] MRI is often necessary to assess the medial, lateral, and patellofemoral compartments, as well as cruciate ligaments and meniscal pathologies.[4,5]

Recently, an individualized approach has been recommended for the degree of correction based on the severity of OA. Correction to neutral alignment is preferred for patients with no or mild OA, while the Mikulicz line (limb mechanical axis) in patients with more severe OA is adjusted further into the lateral compartment.[4,5]

The correction angle is determined using the Miniaci method [7] [Figure 1]. Line CM (corrected mechanical axis) is drawn from the center of the femoral head, passing through the desired correction point at the knee and extending to the height of the ankle joint (the center of the desired ankle joint). The hinge point (H) is defined at the lateral cortex of the tibia, approximately 1.5 cm distal to the joint line. Two lines (A and B) are then drawn to the center of the ankle joint and the end of line CM. The angle between lines A and B is referred to as the correction angle (α).[7] The height of the osteotomy gap can be determined using Hernigou's trigonometric chart, which takes into account the mediolateral diameter of the osteotomy and the desired correction angle.[8]

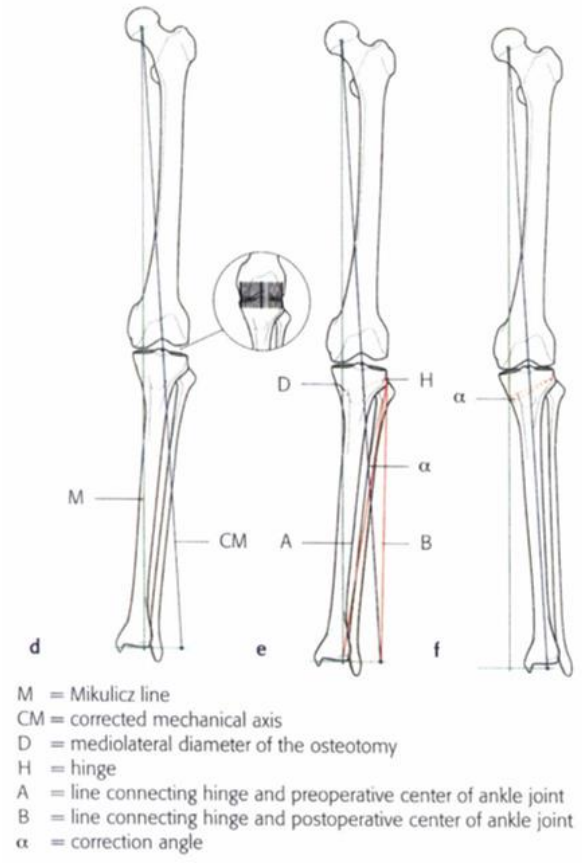

Figure 1. Determination of correction angle using Miniaci technique

Surgical Technique

Diagnostic arthroscopy is not routinely performed; however, it should be conducted in cases of concomitant meniscal injury or doubtful findings on MRI prior to osteotomy.[4] A longitudinal skin incision is made approximately 1 cm below the medial joint line, extending distally to the midpoint between the posteromedial and anterior borders of the tibia.[9] The infrapatellar branch of the saphenous nerve should be preserved. The pes tendons are retracted distally using a blunt retractor, which exposes the superficial fibers of the medial collateral ligament (sMCL). The anterior border of the sMCL is then raised with a scalpel and carefully peeled away from the medial cortex of the tibia using a periosteal elevator, without detaching the distal insertion. A distal release is unnecessary; instead, only peeling off the proximal 3-4 cm of sMCL fibers and inserting a Hohmann retractor is adequate to relieve tension of sMCL.[9] The osteotomy pattern should be marked with an electrocautery, with the posterior part (horizontal cut) parallel to the tibial slope and just above the superior border of the pes tendons. There should be enough space to insert four screws in the proximal segment. The horizontal cut could be localized by placing the plate on the tibia, which is usually about 4 cm distal to the medial joint line. The anterior part (sagittal cut) runs at an angle of 100 - 110° to the posterior part, ending behind the patellar tendon insertion. The tuberosity segment diameter should be at least 10-15 mm to avoid possible tuberosity fracture during the osteotomy. While the leg is held in extension, under an image intensifier, a 2.5 mm guide pin is inserted from the intersection of the sagittal and horizontal cuts, aiming towards the downslope of the fibular head in the proximal tibiofibular joint.[10] The second guidewire is inserted about 2 cm posterior and a little distal (to be parallel with the medial tibial slope) and parallel to the first one in the anteroposterior direction. Guidewires should end at the lateral tibial cortex [Figure 2], because penetration of this cortex increases the possibility of peroneal nerve injury. Using the third pin with the same length, the tibial diameter is measured according to the length of the posterior pin. The depth of the horizontal osteotomy should be about 5-10 mm less than the guidewire length to prevent hinge fracture, and this length is marked on the saw blade. Insertion of an additional guidewire that intersects the cutting plane at the theoretical lateral hinge location (Hinge K-wire) could prevent the hinge fracture by increasing the mechanical resistance and limiting the cut depth.[11]

Although rare, popliteal neurovascular bundle injury is the most catastrophic complication of HTO. The distance from the popliteal artery to the posterior cortex of the tibia increases with knee flexion, and the mean distance at 90° is significantly greater than at all other angles.[12,13] Therefore, the knee should be positioned at 90° of flexion during sawing to protect the popliteal artery. Furthermore, since the neurovascular bundle is located posterior to the popliteus muscle, a broad radiolucent retractor should be placed between the posterior tibial cortex and the popliteus muscle, and the saw blade should be angled at less than 30° towards the posterior tibial cortex in the coronal plane.[12] The horizontal cut should be performed carefully below the guidewires. To minimize the risk of neurovascular injury, the osteotomy of the posterior tibial cortex should be completed using osteotomes rather than a saw. Once the

horizontal cut is completed, by protection of patellar tendon insertion, the sagittal cut can be made with a narrow saw blade. when the osteotomy is finished, the knee should be gently brought back to extension, and a small bump should be placed under the patient's heel to prevent an increase in the posterior tibial slope during gap opening. Subsequently, three broad flat osteotomes from the osteotomy set should be placed one by one. After removing the stacked osteotomes, the gap should be opened gradually to the desired amount using a gap spreader available in the standard osteotomy set. Due to the thickness of the saw blade, the gap should be opened 2 mm more than the preoperatively calculated wedge height.

Figure 2.Two parallel guidewires are inserted aiming towards the proximal tibiofibular joint

When the desired gap height is achieved, a lamina spreader is placed in the posteromedial corner of the osteotomy to maintain the gap during the insertion of the plate and screws. Placing the lamina spreader in the posteromedial corner is crucial, as it prevents an increase in the posterior tibial slope (PTS). The PTS tends to increase in MOWHTO because the hinge is often placed in a slightly posterolateral position.[1,2,14-16] Normal PTS can be maintained if the anterior gap is approximately 50-67% of the posterior gap. This ratio is achieved only with a true lateral hinge position.[1] Additionally, complete sawing of the posterior tibial cortex is essential.[1,14] Trying to maintain or decrease the PTS without a true lateral hinge position or through incomplete osteotomy of the posterior tibial cortex may result in a fracture of the lateral tibial condyle or hinge. In summary, recommendations to avoid an increase in PTS include: complete osteotomy of the posterior tibial cortex,[1,14] maintenance of the optimal gap ratio,[1] placement of the lamina spreader in the posteromedial portion of the osteotomy,[17] positioning the plate as far posterior as possible[18] and keeping the limb in extension while opening the osteotomy gap.[1,14-16]

While the desired gap height is maintained with a lamina spreader, a long measuring rod or electrocautery wire is positioned at the center of the femoral head and at the center of the plafond under image intensification. In most young patients, we prefer that the desired Mikulicz line cross the center of the tibial plateau (between the medial and lateral tibial spines) [Figure 3]. Once the desired alignment is achieved, the stable angle locking T-plate (TomoFix, AO, specifically designed for MOWHTO) is inserted and fixed to the proximal segment with three locking screws of the T-arm [Figure 4].[17] Then, a lag screw is inserted perpendicular to the tibial cortex into the first hole distal to the osteotomy site (hole 1) to compress the lateral hinge by pulling the distal osteotomy segment toward the plate. If the lateral cortical hinge has fractured in the previous stages, the lag screw should be inserted distally (rather than perpendicular to the plate) to achieve better compression of the hinge. Next, the remaining three locking screws of the longitudinal arm and the locking screw proximal to the gap (hole D) are inserted. Finally, the lag screw in hole 1 is replaced with a bicortical locking screw. A supplemental percutaneous lag screw from the lateral cortex to the medial plateau may also be utilized to prevent or treat lateral hinge fractures, improve fixation stability, and prevent loss of reduction postoperatively.[19,20]

A variety of bone void filling materials and methods are available; however, research has shown no significant differences among them.[21] Regardless of the gap size, we routinely fill the osteotomy gap with impacted allograft cancellous bone cubes.

In the post-operative protocol, the use of an orthosis or brace is not required, and full range of active and passive motion is encouraged. Patients are allowed to start partial weight-bearing (15-20 kg) with underarm crutches immediately after surgery for a duration of four weeks. Between four to six weeks post-surgery, the amount of weight-bearing is gradually increased, and after six weeks, full weight-bearing is permitted.[22]

The steps of the MOWHTO technique are available in the attached video.

Discussion

Despite advances in knee replacement techniques and prosthesis, it is wisely to perform joint-preserving surgeries in younger patients with isolated medial compartment arthritis to delay the need for future knee arthroplasty.[18] HTO was initially introduced in lateral closed-wedge manner. With improvements in implants and an array of allograft bone and bone graft substitute options, MOWHTO has gradually gained popularity as the technique of choice.[18] It offers several advantages over the lateral closed-wedge osteotomy including simplicity of the procedure, less invasive technique (one incision, one osteotomy, no fibular osteotomy, and no need for peroneal nerve exploration), less limb length alteration, shorter surgical duration, the ability to make gradual adjustments to correction during surgery, improved ability for biplanar corrections, preservation of tibial bone stock, and easier conversion to arthroplasty.[2,9,18] Potential disadvantages include a delayed time to full weight-bearing, higher risk of hardware failure, and the possibility of delayed union or nonunion.[18]

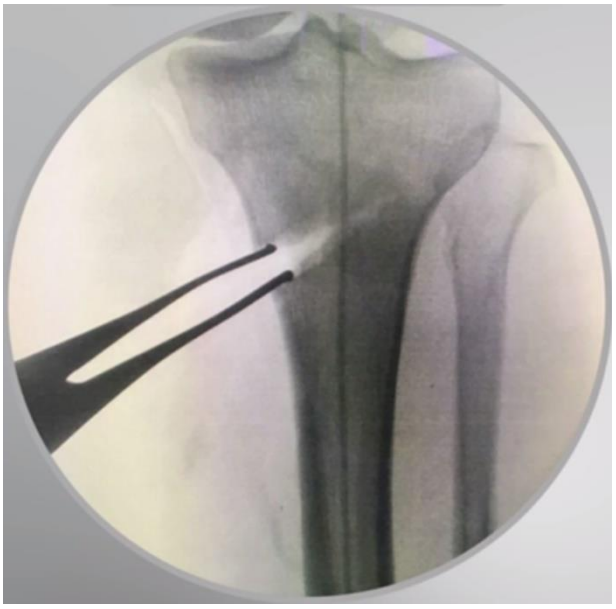

Figure 3.Intraoperative mechanical axis should cross the center of tibial plateau (between medial and lateral tibial spine)

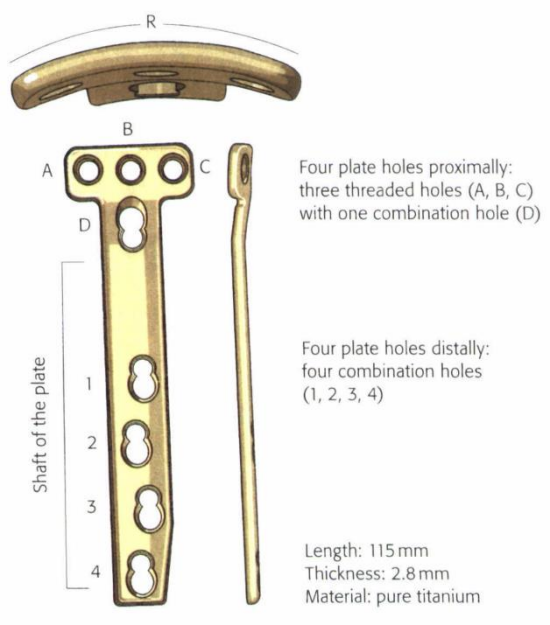

Figure 4 .Design of the TomoFix plate

Performing MOWHTO to treat symptomatic medial compartment osteoarthritis in carefully selected patients leads to a significant improvement in clinical outcome scores and a survival rate of up to 94% over a mean follow-up period of 3.6 years.[18] However, factors such as older age, larger corrections, female gender, higher BMI and more severe OA in the medial compartment are associated with poorer survivorship and an increased likelihood of conversion to arthroplasty.[23-25] In patients with bone on bone appearance in preoperative radiographs, the satisfaction rate is only 58%.[3,4] Therefore, we prefer to treat patients with KL grade IV OA with knee arthroplasty rather than performing MOWHTO.

The popularization of MOWHTO has led to significant innovations in surgical techniques. Recently, a three dimensional (3D) printed patient-specific technique has been introduced.[26,27] MOWHTO is simulated using computed tomography (CT) images, and a 3D model is designed and printed using biocompatible materials, which is then inserted into the osteotomy gap.[27] This technique enables surgeons to achieve a preoperative plan with a level of accuracy, especially in multi-planar angular deformities that is not possible with conventional techniques.[26,27]

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