



Posterior Root Medial Meniscus Tear With Medial Opening Wedge High Tibial Osteotomy: A Step-By-Step Systematic Arthroscopic Repair Technique

Surasak Srimongkolpitak, M.D., and Bancha Chernchujit, M.D.

Abstract: Medial meniscus root repair is often combined with correction of knee varus alignment by performing an opening wedge high tibial osteotomy (HTO) in patients with varus knee malalignment, particularly in those with suspected long-term medial meniscus root tear (MRT). Before planning a corrective alignment treatment, radiographic imaging of the knee alignment is recommended to assess a medial joint space and the tibiofemoral axis. Because HTO can reduce pressure on the repair site, new alignment may promote healing in the attachment of the MR repair. When HTO is used with meniscus root repair (MRR), the tunnel convergence remains a major concern. We describe an arthroscopic technique for treating chronic MRT with knee malalignment using the technique of arthroscopic posterior MRR with HTO. This approach was used to enhance anatomic healing of the meniscus root, decrease the load to the medial knee compartment to achieve MRR, and stop progressive osteoarthritis of the medial knee compartment.

Introduction

Meniscus root tear (MRT) is one of the most commonly overlooked or misdiagnosed causes of chronic knee pain. Most people delay getting treatment, resulting in cartilage loss and the development of osteoarthritis in the knee.¹ It tends to occur after low-energy trauma such as squatting, missed steps going down stairs, and twisted knees. Radiographs of the knee can reveal abnormalities from chronic injury;² thus, the rate of MRT repair has increased significantly. However, the outcomes of the surgery can be worsened if the patient presents to the doctor very late in the process. Assuming that degenerative joint disease exists in that area (i.e., high-grade cartilage pathology

and knee malalignment, especially a varus knee),³ the surgical treatment has been a meniscus root repair, in consideration of the following indications. Acute or chronic MRT and healthy articular cartilage, assessment of knee joint deformity (malalignment), joint space narrowing, and ligament injury determined to have been present before treatment. Joint space narrowing, a malalignment greater than 5 degrees, or a BMI larger than 30 kg/m² constitute a relative contraindication for MRR surgery, resulting in a high rate of failure.⁴ The transtibial pull-out method was the first and most widely used method of MRR. High mechanical strength was unnecessary for using the specialized equipment.⁵ Lee et al.⁶ reported that peak contact pressures returned to normal levels after transtibial-pullout repair, suggesting the role of the MR in meniscal function. A higher risk of tunnel convergence or jamming would also be present if other surgical techniques were required, such as high tibial osteotomy or ligament reconstruction.

High tibial osteotomy was initially developed to treat varus osteoarthritis by reducing the pressure on the medial compartment. Some studies have found that it causes articular cartilage remodeling, which they explain by the lower contact stress in adapting to changes in the weight-bearing axis.⁷ Authors frequently combine MR repair with correction alignment by performing HTO in patients with knee malalignment. Particularly in those with suspected

From the Department of Orthopedics, Faculty of Medicine, Queen Savang Vadhana Memorial Hospital, Thailand, and the Department of Orthopedics, Faculty of Medicine, Thammasat University, Thailand.

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Address correspondence to Surasak Srimongkolpitak, M.D., Department of Orthopedics, Faculty of Medicine, Queen Savang Vadhana Memorial Hospital, 209 Jernjornpol Road, Si Racha District, Chon Buri Province, Thailand 20110. E-mail: mikemiky88@gmail.com

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long-term MRT, this approach is expected to improve the rate of MR healing after repairing and decreasing axial load-bearing stress in the medial compartment (which may heal posterior medial MRT in some patients, like remodeling of articular cartilage).⁸ Hyun et al.⁹ proposed that the healing potency of a posterior root rupture of the medial meniscus and a chondral lesion was low, even after a medial open wedge high tibial osteotomy with no attempt at meniscal therapy or chondral resurfacing. The correlation between cartilage regeneration and clinical outcomes has been a point of conflict. This technique aims to prevent tunnel jamming between the transtibial pull-out bone tunnel and HTO. It includes a screw cut through the suture and osteotomy site, which is commonly found in the single-stage procedure (transtibial pull-out MRR with HTO).

A plain radiographic (a scanogram of both knees) was performed preoperatively to assess the result of varus tibiofemoral alignment and the medial narrowing joint space (Fig 1). Magnetic resonance imaging of the affected knee was requested to evaluate the status of the menisci (cleft sign) representing the posterior medial MRT (Fig 2).

Surgical Technique

Patient Positions

After a spinal or general anesthesia (depending on the patient's preference), they are positioned supine with the affected leg hanging over the edge of the operating table and the posterior thigh supported with



Fig 1. Right knee scanogram showing medial narrowing joint space and varus knee (yellow circle).



Fig 2. Right knee magnetic resonance image (MRI) showing posterior medial meniscus root as a cleft sign (MRI T2FS, coronal view; red circle).

a paddle underneath the tourniquet cuff. The contralateral leg is placed in a lithotomy stirrup (Fig 3). This position allows a "figure 4" position and semi flexion with valgus of the knee. A well-padded pneumatic tourniquet is applied to the upper thigh. After surgical site preparation and exsanguination, the tourniquet is inflated.

Standard Diagnostic Arthroscopy

Following the anesthetic examination, a routine arthroscopic examination is performed through the standard anterolateral and anteromedial portals to detect the diagnosis and inspect the integrity of other intra-articular structures' pathology (particularly anterior and posterior cruciate ligament injuries, which are frequently associated with meniscal injuries). The prepatellar fat pad is debrided to improve intraarticular visualization.

Inspection of Medial Compartment of the Right Knee

If the other ligaments in and around the knee are healthy, the valgus knee position may not be enough to open up the medial compartment. In tight medial knees, visualizing and repairing tears arthroscopically in the posteromedial corner of torn menisci is also challenging, especially in cases of posterior medial MRT (Fig 4). Iatrogenic chondral lesions (which can be caused by an arthroscopic device in a narrow space) and residual unrepaired tears (arising from an insufficient view in a tight space) can result in substantial morbidity and long-term pain problems.



Fig 3. Patient shown in the supine position, with right leg hanging and the contralateral leg in lithotomy position.

The percutaneous release of the MCL¹⁰ is a technique used to increase the medial tibiofemoral joint space during arthroscopy, in order to use instrumentation and improve visualization without causing iatrogenic cartilage damage. Thus, we routinely release the posteromedial fibers of the MCL using the subcutaneous penetration technique or the magic point. The knee is flexed to 20° while applying valgus force on the tibiofemoral joint and external rotation of the foot. The landmark draws a posterior edge of the tibia, intersects with the joint line, and draws the point up to approximately 1.2 cm. A No. 18G needle is then used to puncture this point in a extension position and then apply enough valgus force to produce a “popping” sound (Fig 5).

Right Posterior Medial Meniscus Root Repair

In cases of posterior medial MRT that require repair, accessory mid-medial portals are created (Fig 6). Their advantages include the following: (1) insertion of other instruments is easier because stay close the posterior MMR; (2) fat tissue is not an obstacle during performing the procedure; and³ damage to a medial femoral condyle cartilage is avoided while inserted a repairing device. Using a ring curettage, the footprint of the MR

was debrided, and the cartilage removed until the subchondral bone was seen (Fig 7). The low-profile aiming device (The Acuflex Director Drill Guide, Smith-Nephew) was guided via an accessory, mid-medial portal (Fig 8). The distal aiming device was pointed from the anterolateral proximal tibia to the posterior MR footprint. The guided wire was drilled until the tip to the subchondral bone meniscus footprint appeared, and drill bit reaming (4.5 mm) drilled via guide wire, with the cartilage protecting by using round curettage coverage while penetrating the joint. PDS No. 2-0 (PDS® II [polydioxanone] Suture 2-0, Ethicon) was inserted from the cortex anterolateral proximal tibia to the undersurface of the posterior medial MR via a drill bit reaming. A loop of the above suture was withdrawn from the anteromedial portal for preparing to tie the knot at the anterolateral proximal tibia. The FirstPass Mini Suture Passer (Smith-Nephew) was used to suture, along with the shuttle relay method by Ethibond No. 2 (Ethibond Sutures USP 2-0, Ethicon; Fig 9). The fiber tape (Ultratape, Smith-Nephew), and a horizontal loop was prepared and attached to the anteromedial portal (Fig 10). A vertical loop was made, 7–9 mm and 5–7 mm medial to the torn edge of the meniscus. Ethibond No. 2 was used to make a cross-shaped loop (Mason Allen suture technique; Fig 11). All suture strands were retrieved to the anteromedial portal and inserted into the PDS loop (PDS® II [polydioxanone] Suture 2-0, Ethicon). All PDS sutures were pulled out through the tibial tunnel and the meniscus root stability was rechecked. The drill bit was turned reaming side to handle side and the PDS No. 2 loop (PDS® II [polydioxanone] Suture 2-0, Ethicon) inserted into the handle side. All suture strands were put into the drill bit again and then inserted into the tibial tunnel with the handle side of the drill bit. Arthroscopy was confirmed when the drill bit appeared underneath the meniscus root. The drill bit was applied to protect the suture from

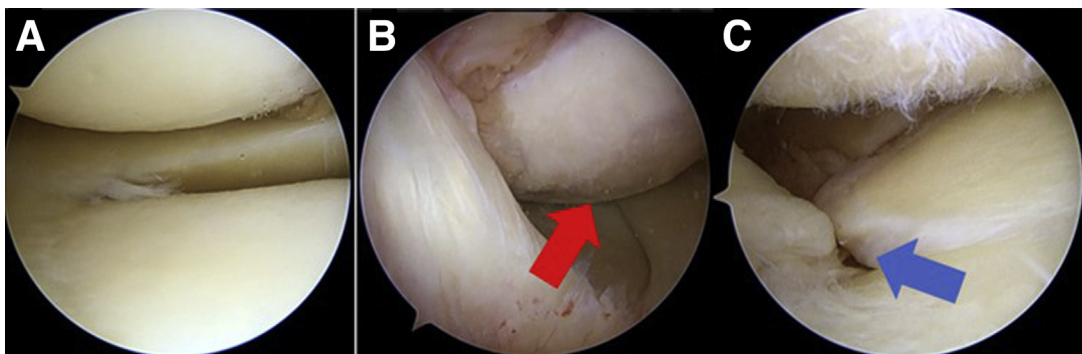


Fig 4. Images showing the intra-articular finding from the anterolateral viewing portal of the right knee, supine position, with 90° of knee flexion. (A) Posterior lateral meniscal root and lateral tibiofemoral cartilage intact. (B) Cartilage lesion at right medial femoral condyle (Outerbridge Grade IV; red arrow). (C) A posterior medial meniscal root was completely torn (blue arrow).

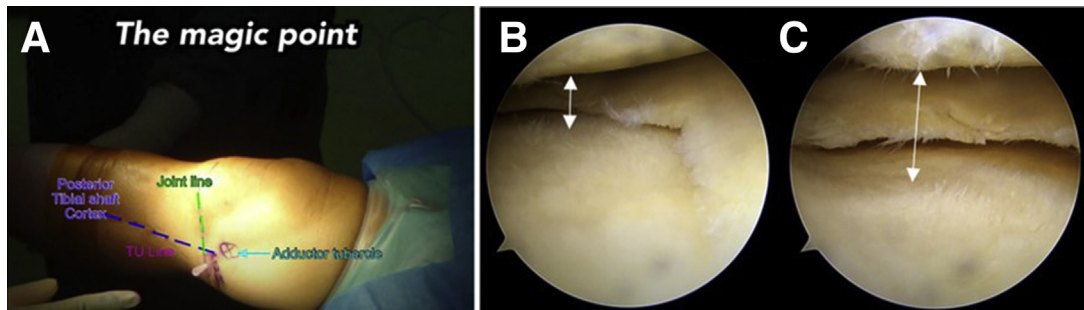


Fig 5. (A) Landmark of the magic point released at the right knee. (B) The working room space was inspected before the medial collateral ligament (MCL) is released via the anterolateral viewing portal. (C) Post-MCL release showing easier access to the posterior medial meniscus via the anterolateral viewing portal.

sawing bone in the osteotomy site of the proximal tibia; however, the drill bit must always remain underneath the meniscus root or be rechecked by fluoroscopy when cutting at the osteotomy site.

High Tibial Osteotomy

Anatomical landmarks on the surface were identified and noted. A 5–7 cm long vertical incision was made 4 cm distal to the medial joint line. The *pes anserinus* was identified. The superficial medial collateral ligament was found when a deep incision was made just above the *pes anserinus* insertion. To relieve medial compartment pressure, the superficial medial collateral ligament was partially released. To protect the neurovascular structures, a blunt Hohmann retractor was introduced into the posteromedial side of the proximal tibia. Subsequently, the patellar insertion side was identified. Under fluoroscopy, two 2.5-mm, threaded Kirschner wires were placed 4 cm distal to the joint line at the medial cortex of the proximal tibia and pointed to the tip of the fibular head at the lateral cortex of the proximal tibia. Then the medial open-wedge osteotomy was performed via biplanar osteotomy. An initial, oblique osteotomy began at the upper

margin of the *pes anserinus* (approximately 40 mm distal to the medial proximal tibial joint surface) and ended 10 mm from the lateral cortical margin at the upper level of the proximal tibiofibular joint, while a second, frontal osteotomy began 10 mm or more proximal (biplanar osteotomy) (Fig 12). The bone oscillating saw and osteotome were used just distal to the Kirschner-guided wires from the tibia's medial to lateral cortex, preserving the lateral hinge of the proximal tibia. At the anterior, medial, and posterior cortex of the proximal tibia, the chisels were slightly cut until anterior, medial, and posterior cortex were completely cut. The lamina spreader was placed at the posteromedial edge of the osteotomy gap and spread gently to open the medial gap until the desired opening was achieved, as planned. A TomoFix medial high tibial plate (TomoFix, DePuy Synthes) was placed into a subcutaneous tunnel over the soft tissues on the anteromedial portion of the tibia and secured in place with 8 locking screws. Locking screws were inserted in all of the proximal parts of the TomoFix plate, as the lateral cortex of the proximal tibia could have been broken and more displacement ensued if a compression screw had been used at its distal part. However,

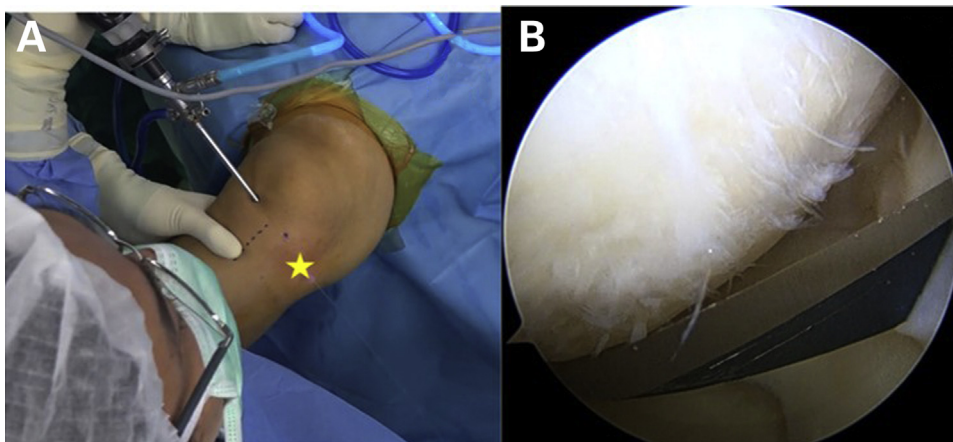


Fig 6. (A) Accessory mid-medial portal made at the middle part of the medial meniscus at the right knee (yellow star). (B) The mid-medial portal was created by vertical stab incision, avoiding injured cartilage and meniscus via the anterolateral viewing portal.

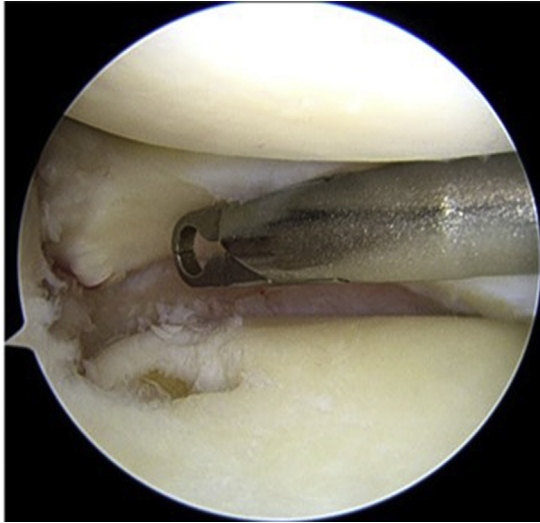


Fig 7. A ring curettage removed cartilage until a subchondral bone was reached via the accessory mid-medial working portal (i.e., the anterolateral viewing portal at the right knee).

one proximal locking screw may not have penetrated the lateral cortex, due to tibial tunnel jamming caused by the drill bit protecting the suture strands (Fig 13). One locking screw which jams the transtibial tunnel can avoid inserting the proximal part of the TomoFix plate, and the author has yet to find a patient whose implant fixation had failed or had been affected by postoperative rehabilitation.

Anterior Tibial Cortex Fixation

All the suture limbs are then pulled with adequate tension and secured to the anterolateral cortex of the

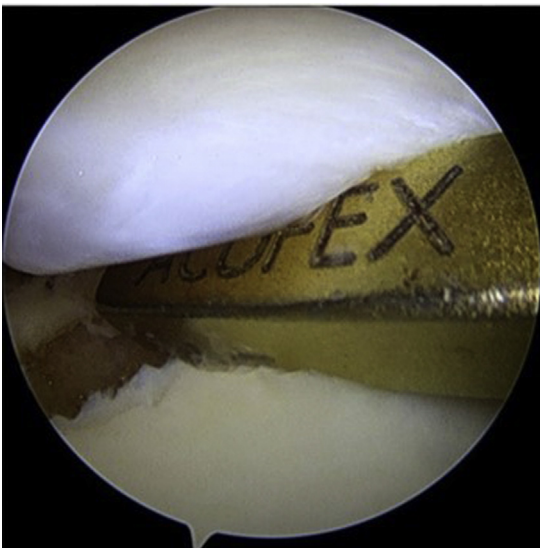


Fig 8. The low-profile aiming device (Acufex Director Drill Guide; Smith-Nephew) used to create a tibial tunnel via the anteromedial working portal (the anterolateral viewing portal) at the right knee.

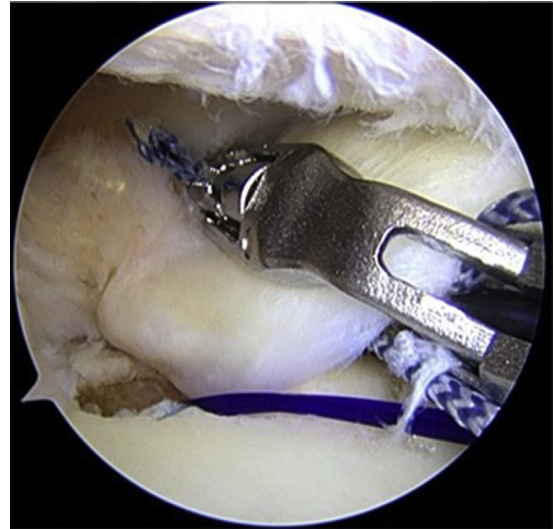


Fig 9. A FirstPass Mini suture passer (Smith-Nephew) sutured the medial meniscus root, with fiber tape shuttling (Ultratape, Smith-Nephew) done in a horizontal loop via the anteromedial working portal (the anterolateral viewing portal at the right knee).

tibia with the suspensory fixation (EndoButton CL Ultra, Smith-Nephew) (Fig 14).

Postoperative Rehabilitation

Postoperatively, isometric exercises commence immediately. For the first 2 weeks, the patient is ambulated via protected weight-bearing, with the knee immobilized in full extension via a hinge knee brace (Fig 15). Range-of-motion exercises begin 2 weeks postoperatively, while the patient carries on with the isometrics. Often, they can perform a straight-leg raise at 2 weeks post-operatively. The patient is followed up at 2 and 6 weeks, 3 and 6 months, 1 year, and 2 years. Postoperative magnetic resonance imaging is done at 12 and 24 weeks. Active rehabilitation exercise commences at 6 months postoperatively.

Discussion

The medial MRT with varus knee alignment is overlooked by physician leading to misdiagnosis and mistreatment. Despite normal radiography of the knee, the patient still has knee pain and swelling. A few research papers have addressed the steps to repair and correct knee alignment for those conditions at the same time (Table 1). The means of fixing those structures simultaneously has been controversial, and no consensus exists on the surgical procedure. We proposed systematic surgical steps and techniques to manage posterior medial MRT with varus knee alignment. HTO and medial MRR procedures can be performed simultaneously, as we believe that if HTO was performed particularly, the medial compartment of the

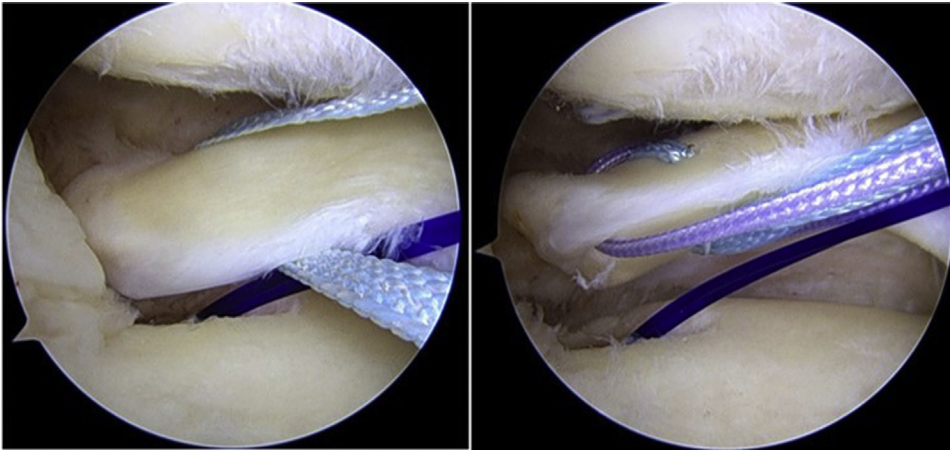


Fig 10. A vertical loop was also sutured (Ethibond Sutures USP 2-0, Ethicon) via the anterolateral viewing portal at the right knee.

knee would be unloaded from the contact stress and the medial tibiofemoral cartilage would be restored, allowing the meniscus to heal optimally and return to its hoop stress function. The advantages of this procedure and its limitations or disadvantages are summarized in [Table 2](#).

Hyun et al.¹¹ said to be that HTO alone without specific meniscus treatment can provide some posterior medial MR healing by itself; however, the degree of healing was variable. Because the HTO procedure reduces stress on the load-bearing cartilage in the medial compartment, root healing might occur through a mechanism similar to articular cartilage remodeling, and HTO could allow for increased potential healing of both cartilage regeneration and meniscus root healing.

The medial osteoarthritis of the knee and varus knee malalignment combined with medial MRT means the

stress is localized in the medial compartment, leading to difficult healing after repair. Normal peak contact pressures are restored after suture or pullout repair (suggesting the role of the meniscal roots in meniscal function),¹² while MMR repair is also necessary to reduce the extruded meniscus. Medial meniscus extrusion (MME) is a major risk factor for cartilage degeneration, and MME greater than 3 mm has been related to chondral lesions and OA knee.¹³

At the midterm follow-up of 66.4 months, the modified Mason–Allen suture technique combined with HTO for medial meniscus posterior root tears significantly improved clinical outcomes and reduced OA progression. Furthermore, during the second-look arthroscopy, this surgery resulted in a 64.7% full healing rate of the restored meniscus root function.¹⁴



Fig 11. All suture strands were withdrawn into the tibial tunnel by PDS No. 2-0 (PDS® II [polydioxanone] Suture 2-0, Ethicon), followed by a Mason Allen suture (the anterolateral viewing portal was at the right knee).



Fig 12. The medial open-wedge high tibial osteotomy with the Tomofix medial high tibial plate (DePuy Synthes) was done as a planned osteotomy gap at the right knee.

Fig 13. A drill bit (4.5-mm cannulated Smith-Nephew) prevented all sutures during the osteotomy cutting, and the drill bit tip was always observed at the posterior medial meniscus root repair site by arthroscopy or fluoroscopy during osteotomy cutting at the right knee.

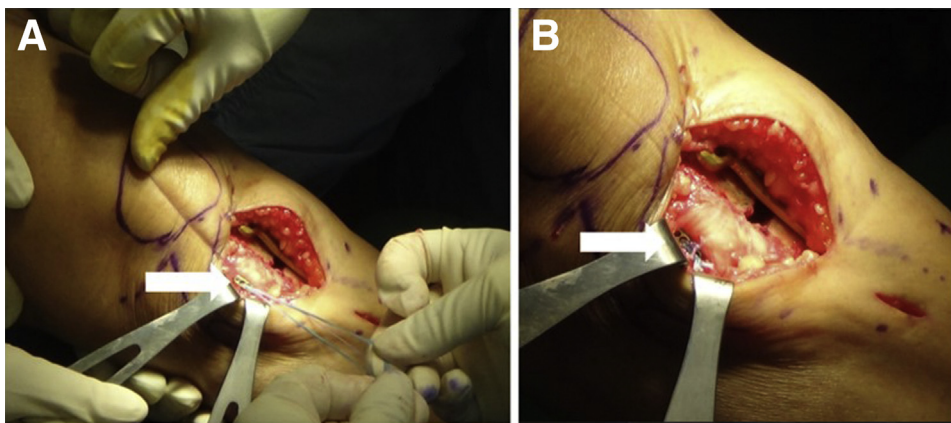
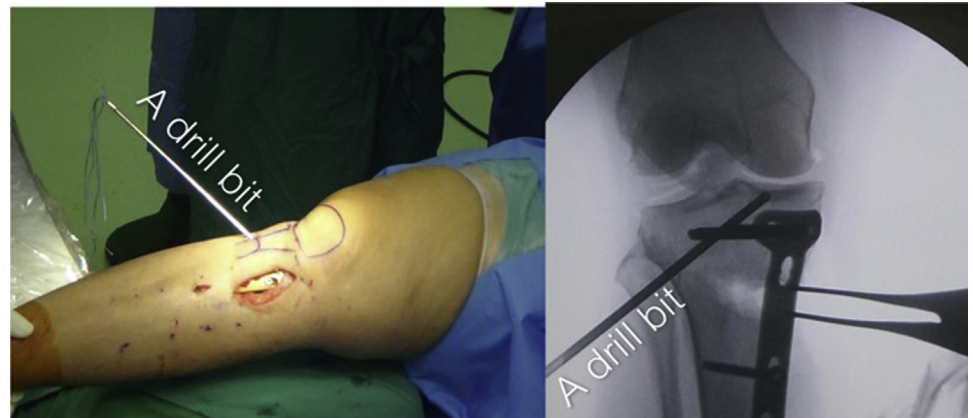


Fig 14. (A) With the suspensory fixation EndoButton (CL Ultra, Smith-Nephew), the 4 strands of sutures are pulled and secured to the anterolateral cortex of the proximal tibia at the right knee (white arrow). (B) Finished anterior cortical fixation with EndoButton at the right knee (white arrow).

HTO has a role for younger and more active patients, as it combines cartilage operations, meniscal allograft transplantation, and chronic instability into a single-stage procedure.¹⁵ The alignment must be corrected first (which includes medial MRR) for patients who arrive at the physician's surgery after the secondary varus knee malalignment has occurred.^{16,17} The author prefers to combine HTO and posterior meniscus root repair in a single-stage procedure to improve knee function and decrease deterioration of the medial knee compartment. The procedure must reattach the root anatomically, and the correction of varus malalignment should be considered. However, few studies have investigated and recommended the combined procedure of root repair and HTO.¹⁸

Despite failed healing and the fibrous tissue of the MMR, the healing status of the root meniscus during repair and HTO did not correlate with clinical results. Without the meniscal procedure, HTO leads only to cartilage regeneration at medial compartment knee, and MMR repair is unable to heal enough when compared with MRR. However, even altering the



Fig 15. Anteroposterior radiograph of the right knee joint in supine position showing the proper position of the anterior tibial fixation for medial meniscus root repair and TomoFix medial high tibial plate (DePuy Synthes), with a hinge knee brace in full extension.

Table 1. Pearls and Tips and Pitfalls in the Posterior root medial meniscus tear with medial opening wedge High Tibial Osteotomy

| Surgical Step | Pearls and Tips | Pitfalls |
|---|---|--|
| 1. Arthroscopic examination. | Always identified both posterior lateral and medial meniscus root tears. | Posterior medial compartment was narrow and difficult to access, leading to misdiagnosed posterior medial meniscus root injury. |
| 2. Magic point release. | Increased the working room, making it easier to access the posterior meniscus root site. | Released only the posterior part of the MCL. The excessive MCL released led to loss of valgus stability. |
| 3. Posterior root medial meniscus repair. | Use of the transtibial pull-out technique facilitated a precise anatomic attachment of the structure. The Mason Allen suture technique was used for the posterior medial meniscus root stump (Ethibond Sutures USP 2-0, Ethicon), along with Fiber Tape (UltraTape, Smith-Nephew). Retrieved all suture strands to the anteromedial tibial tunnel. The drill bit in the tibial tunnel protected all meniscus root suture repair while the tibial osteotomy was being performed. | Meniscal cut-through often occurs when there is a lot of suturing at the posterior meniscus root. |
| 4. High tibial osteotomy. | Unloaded the medial knee compartment. Improved functional outcomes in cases of medial knee osteoarthritis and increased chance of healing the posterior root medial meniscus repair. | Always confirm the tip of drill bit in the repair site by fluoroscopy or arthroscopy. Prevent drill bit migration until cutting all sutures while performing tibial osteotomy. |
| 5. Anterior tibial cortex fixation. | Inserted all suture strands in suspensory fixation (EndoButton CL Ultra, Smith-Nephew) in full extension as cortical fixation for meniscal root repair at anterior cortex of the proximal tibia. | Arthroscopic examination should be done while all sutures are tied, because too much tension will lead to suture cuts through the repair site. |

MCL, medial collateral ligament.

mechanical axis further from HTO without MRR could improve clinical symptoms. Improved clinical outcomes and radiological results were not related to cartilage and the healing condition of the MMR.⁹

Kyung et al. reported on 20 patients who had HTO for posterior medial MRT without a meniscectomy or pullout repair and were available for second-look arthroscopic surgery. The evaluation revealed a high rate of MMR healing following HTO with no attempt at repair. The degree of variable meniscus root healing was also not related to a better clinical outcome.¹¹

During short-term follow-up, the clinical and radiological outcomes were reported with concurrent medial MRR during HTO compared to HTO alone. During about 2 years of follow-up, the findings of the progressive OA showed no significant differences in the postoperative period. Further studies of the cartilage regeneration and disease progression after concurrent medial MRR during HTO remain controversial and should be reevaluated in a long-term follow-up period.¹⁹ Some evidence reports that concurrent medial MRR during HTO may not optimize the knee joints in terms of better tibiofemoral contact surface and the restoration of hoop tension.^{20,21}

Conclusion

Several studies do imply that meniscus root repair might not be required.¹⁹⁻²¹ HTO alone were not significantly different when compared with the HTO combine with

Table 2. Advantages, Limitations, and Disadvantages of High Tibial Osteotomy

| | |
|-------------------------------|--|
| Advantages | Provides adequate exposure during repair by use of the Magic point release technique. Creates good visualization for the injured structures. Provides both surface contact and repair site strength via Mason Allen suture technique. Permits a single-stage procedure. Makes it impossible to cut the suture strand while performing the tibial osteotomy Renders the trans-tibial pull-out repair technique cost effective, as special instrumentation is not needed. Increases the chance of meniscus root repair because the medial knee compartment is unloaded by HTO. |
| Limitations and disadvantages | Cannot be performed in cases of multiple knee compartment osteoarthritis or existing severe malalignment. Locking screws need to be spared if they penetrate into the tibial tunnel. Sutures tied too tightly at the anterior tibia cortex can cut through and lead to repair failure. |

HTO, high tibial osteotomy.

MMR. Otherwise, we recommend the combined meniscus root repair technique with HTO to enhance anatomic healing of the meniscus root and to decrease the load to the medial knee compartment, thus leading to improved MR repair and halting progressive osteoarthritis of the medial knee compartment.

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