Technical Note

Restoration of the Knee Medial Collateral Ligament and Complete Soft-tissue Coverage After Medial Open-Wedge High Tibial Osteotomy

Mikiko Handa, M.D., Tsuneari Takahashi, M.D., Ph.D., Yukinori Hayashi, M.D., Ph.D., and Katsushi Takeshita, M.D., Ph.D.

Abstract: High tibial osteotomy (HTO) is used in the treatment of knee osteoarthritis. This surgical procedure is indicated in patients with medial osteoarthritis who are relatively young and active and have a good range of motion. In most medial open-wedge HTO cases, the fascia, medial collateral ligament (MCL), and part of the knee joint capsule are carefully separated and moved to expose the osteotomy site, but many patients experience postoperative swelling and pain in the affected limb due to bleeding from the osteotomy site and MCL failure. We have developed a method of osteotomy followed by a restoration of the MCL to its anatomic position and complete soft-tissue coverage of the osteotomy. This Technical Note aims to provide a comprehensive description of the employment of a soft-tissue envelope for the MOW-HTO protection.

High tibial osteotomy (HTO) is used in the treatment of knee osteoarthritis. It alleviates pain by correcting medial deformity of the tibia, thereby reducing the load on the medial compartment of the knee joint.[1-3] This surgical procedure is indicated in patients with medial osteoarthritis who are relatively young and active and have a good range of motion.[1] The HTO may be performed using an open- or closed-wedge method. However, the closed-wedge approach has several disadvantages, including difficulty achieving accurate correction, neurovascular complications, and a risk of accidental osteotomy of the fibula, with potential bone loss.[4] Medial open-wedge (MOW)-HTO is widely used because it allows intraoperative determination of the osteotomy gap. Fixation using a locking plate allows micromotion and promotes bone healing.[5] The osteotomy can be fixed without friction between the bone and the plate, preventing interference with periosteal blood flow. In addition, the use of a long plate increases the screw pull-out strength and provides long-axis stability.[6,7] The periosteal blood vessels are especially important postoperatively, as they restore blood flow to the fracture site and facilitate the influx of osteogenic cells.[8] To minimize the MOW-HTO soft-tissue damage, we have developed a technique in which an envelope of soft tissue is used to protect the osteotomy site. This is achieved using a TOMOFIX (DePuy Synthes, Solothurn, Switzerland) anatomical medial high tibial plate. The successful use of this device requires a complete understanding of the technique involved. Hence, this Technical Note aims to provide a comprehensive description of the employment of a soft-tissue envelope for the MOW-HTO protection.

Surgical Technique (With Video Illustration)

This technique can be carried out under local or general anesthesia and does not require a pneumatic tourniquet. The patient is placed in the supine position on a radiolucent table with lateral thigh support. The affected lower limb is sterilized, and standard anterolateral and anteromedial portals are created for

From the Department of Orthopedic Surgery, Ishibashi General Hospital (M.H., T.T.); and Department of Orthopedic Surgery, Jichi Medical University (Y.H., K.T.), Shimotsuke, Japan.

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Address correspondence to Tsuneari Takahashi, M.D., Ph.D., Department of Orthopedic Surgery, Ishibashi General Hospital, Shimotsuke, 1-15-4 Shimokoyama, 329-0502, Japan. E-mail: tsuneari9@jichi.ac.jp

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a routine arthroscopic evaluation. The concomitant meniscal and chondral injuries are treated. The knee joint line is identified by palpation and a curved oblique skin incision is made, extending from the posteromedial corner of the proximal tibia to the insertion site of the pes anserine tendon. The skin incision is curved rather than straight as this helps to reduce the risk of postoperative infection.[9] Care is taken to detect all branches of the descending genicular artery. These are cauterized during the separation of subcutaneous tissue and sartorius fascia. The affected knee is placed in a slightly flexed position to maximize the visibility of the lateral joint line. The gracilis and semitendinosus tendons are then identified and scooped with a Kelly clamp and wet gauze. The distal attachments of these 2 tendons are left connected to the proximal tibia. The periosteum and medial collateral ligament (MCL) are partially detached dorsally from the border of the knee joint capsule to preserve them during the osteotomy (Fig 1). They will later be returned before plate fixation. A retractor is inserted between the MCL and the proximal tibia to protect the neurovascular bundles (Fig 2). The tip of the first Kirschner wire is inserted 4 to 4.5 cm below the medial joint line between the 2 tendons (Fig 3). A second Kirschner wire is inserted parallel to the first under fluoroscopic guidance (Fig 4).[10] To create a lateral bone hinge, a cut is made with a bone saw that is 5 mm less than the depth of the wires. Furthermore, it is important to ensure that there is sufficient cranial space for the locking bolts of the plate fixator. At this point, an anterior ascending osteotomy is performed at an angle of 110° to the horizontal saw cut. The osteotomy ends behind the patellar tendon insertion. The width of the tuberosity segment is set to at least 1.5 cm (Fig 5).[11] The horizontal osteotomy is gradually opened to the desired correction angle (Fig 6).[12] To minimize tibial slope alteration, a spreader is inserted as close to the posterior cortex as possible. With the spreader in place, the Mikulicz line is checked using a long alignment rod to determine the correction angle. Axial pressure is applied to the calcaneus to reproduce loading conditions. A β-tricalcium phosphate (β-TCP) block is cut into a trapezoid shape to a size appropriate to the amount of correction needed at the osteotomy site (Fig 7).[13] The detached MCL and the hamstring tendons are replaced in their original anatomical

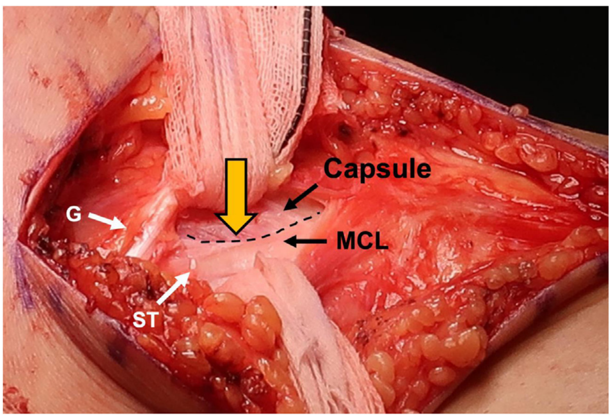

Fig 1. The patient with left knee osteoarthritis is placed in the supine position on a radiolucent table. After skin incision, the sartorius fascia is unfolded, and the gracilis (G) tendon and semitendinosus (ST) tendon are identified. Wet gauze is applied over the G and ST tendons to expose the shallow layer of the medial collateral ligament (MCL) and the joint capsule. We enter the shallow layer of MCL at the border between the joint capsule and the MCL. White arrows indicate G and ST tendons. Dotted line indicates the border between the joint capsule and the MCL. Yellow arrow indicates entry point. Black arrows indicate MCL and joint capsule.

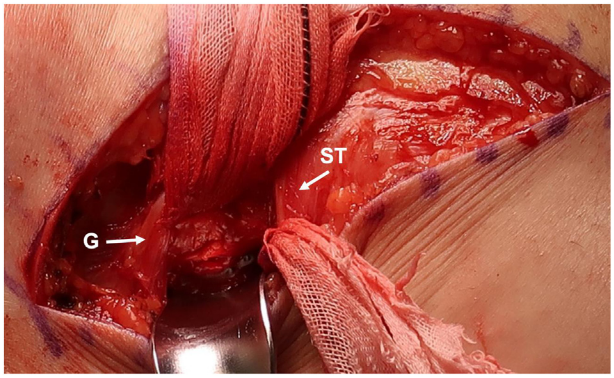

Fig 2. Avoiding the shallow layer of the left medial collateral ligament, a retractor is inserted dorsally into the posterior cortex of the left tibia. White arrows indicate G tendon and ST tendon. (G, gracilis; ST, semitendinosus.)

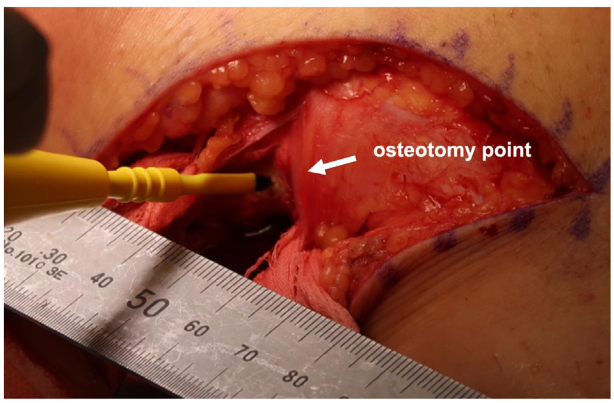

Fig 3. Under fluoroscopic guidance, a metal ruler is aligned with the joint plane to mark the point 45 mm distal to it. This will be the osteotomy line. White arrow indicates osteotomy point.

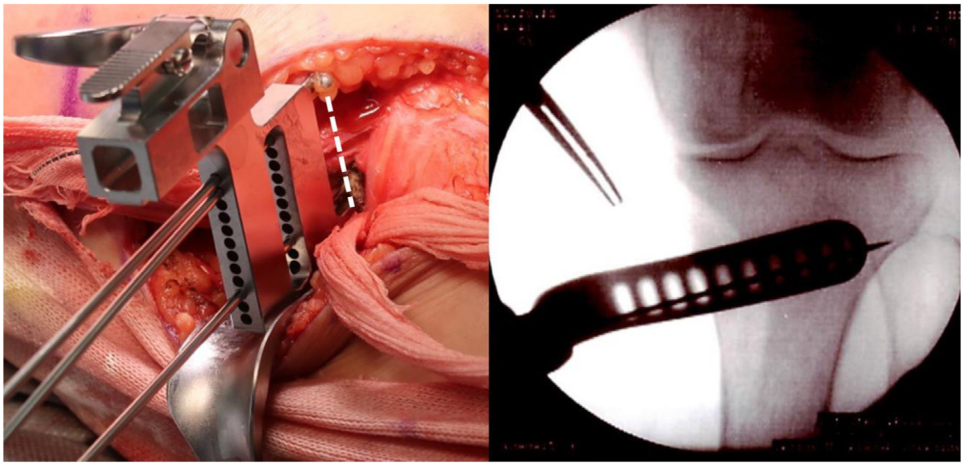

Fig 4. Two Kirschner wires are inserted to fix the guide to the marked osteotomy site. The wire is used to make a hole in the cortical bone to create the osteotomy line. Dotted line indicates osteotomy line.

positions. The fascia and hamstring tendons are sutured in place to completely cover the osteotomy site (Fig 8). A TOMOFIX (DePuy Synthes) medial high tibial plate is applied to the medial side of the proximal tibia and the intraoperative mechanical axis of the lower limb is set at 55% and checked using a long alignment rod (Fig 9 and Video 1).[14,15] Finally, each layer of soft tissue and skin is closed. The advantages and disadvantages of this technique are shown in Table 1.

Postoperative Rehabilitation

Subsequent to this procedure, a postoperative rehabilitation protocol must be instigated. This begins with muscle-strengthening exercises, including quadriceps settings and straight leg lifts. These are begun immediately and gradually increased over time. Range-of-motion exercises are allowed a day after surgery. Partial weight-bearing is allowed at 2 weeks and full weight-bearing without crutches 4 weeks postoperatively. Jogging is permitted after 12 weeks. Squatting and sporting activities are not permitted until at least 6 months after surgery.

Discussion

In this Technical Note, we have described a MOW-HTO technique in which the osteotomy site is enveloped in soft tissue. This is achieved by

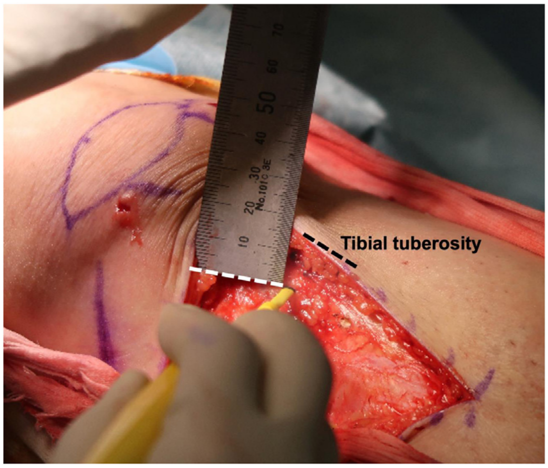

Fig 5. The anterior ascending osteotomy line is marked 15 mm posterior to the left tibial ridge. Black dotted line indicates tibial tuberosity. White dotted line indicates anterior ascending osteotomy line.

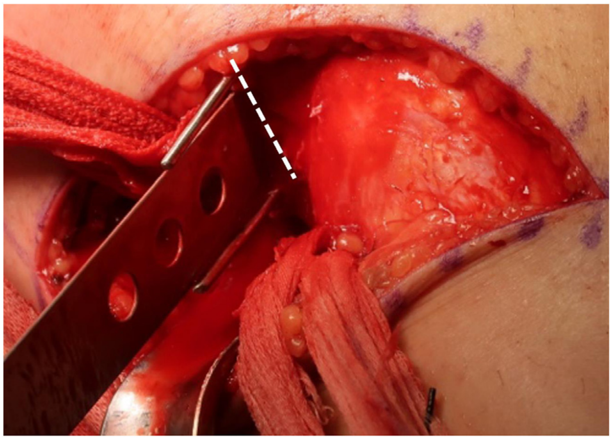

Fig 6. The osteotomy is performed proximal to the guide pin. The guide pin is removed before using the bone saw. After confirming by fluoroscopy that the bone saw is correctly placed, the osteotomy is performed carefully. White dotted line indicates osteotomy line.

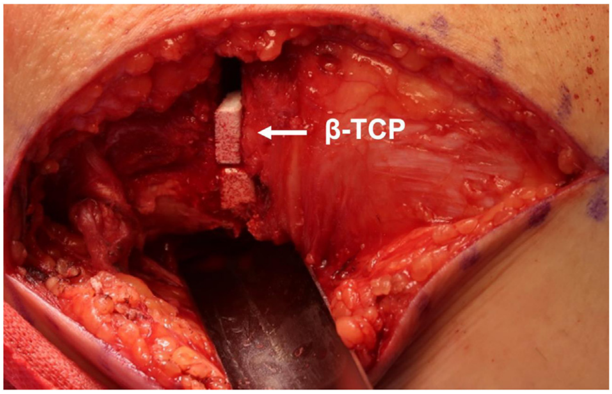

Fig 7. After the osteotomy, fluoroscopy was used with a long alignment rod to ensure correct alignment. Two β-TCP blocks of the appropriate size for the amount of correction required were inserted. White arrow indicates β-TCP. (β-TCP, β-tricalcium phosphate.)

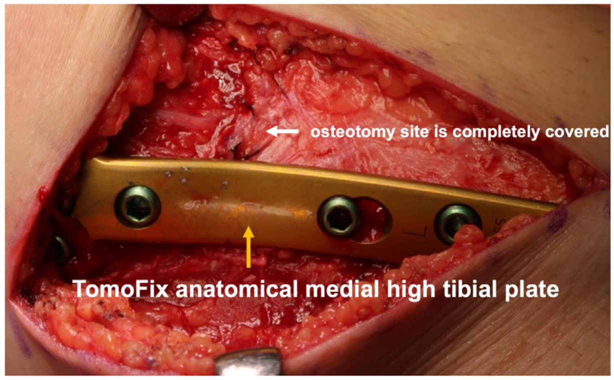

Fig 9. A cross-linked plate is placed over the periosteum and fixed with 8 locking screws. The osteotomy site is completely covered by the periosteum, and periosteal blood flow is preserved. White arrow indicates completely covered osteotomy site. Yellow arrow indicates TOMOFIX anatomical medial high tibial plate.

separating the shallow layer of the MCL before osteotomy, protecting it while the osteotomy is performed, and then suturing the MCL back into position, covering the osteotomy site.

The HTO is an effective surgical treatment for relatively young patients with knee osteoarthritis. The procedure uses osteotomy of the tibia to correct the Mikulicz line. This reduces medial compartment pressure on the knee joint and alleviates pain. In most MOW-HTO cases, the fascia, MCL, and part of the knee joint capsule are carefully separated and moved to expose the osteotomy site. Releasing or resecting the shallow layer of the MCL allows alignment to be corrected.[16] Yet, despite the advantages, many patients experience postoperative swelling and pain in the affected limb due to bleeding from the osteotomy site. There have also been cases reported in which excessive intraoperative release of the MCL has resulted in postoperative MCL insufficiency and external deformity due to altered collateral ligament balance.[17] Sasaki et al.[18] have described a similar technique in which the osteotomy site is covered using the deep fascia. Our surgical technique involves repairing not only the deep fascia, but also the pes anserinus and the shallow MCL layer. Maximum possible soft-tissue repair reduces postoperative swelling of the affected limb and promotes long-term bone healing by preventing bleeding from the osteotomy site. This also helps to maintain periosteal blood flow.[19,20] This method cannot be used in cases in which the soft tissue around the pes anserinus is severely damaged intraoperatively or the correction angle is great. In future research, we hope to determine the maximum correction angle at which soft tissue repair and full coverage are possible.

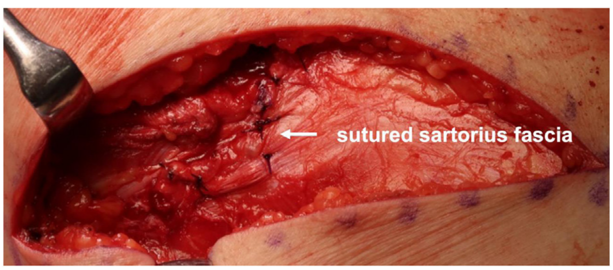

Fig 8. After insertion of the beta-tricalcium phosphate blocks, the left shallow layer of the medial collateral ligament, and then the G tendon and ST tendon, are replaced in their original positions and sutured with absorbable thread. The osteotomy site is then completely covered by the periosteum. White arrow indicates sutured sartorius fascia. (G, gracilis; ST, semitendinosus.)

Table 1. Advantages and Disadvantages of Intraoperative Soft-Tissue Envelopment for the Preservation of Medial Open-Wedge High Tibial Osteotomies

Advantages
• Allows adequate dissection of the sartorius fascia
• Separates the shallow and deep layers of the MCL
• Sutures can be placed with the shallow layer of the MCL pulled up
• Maintains periosteal blood flow
• Reduces postoperative wound swelling and pain
Disadvantages
• Soft-tissue damage may occur during osteotomy
• Risk of postoperative MCL insufficiency

MCL, medial collateral ligament.

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