Technical Note

Intraoperative Laximetry-Based Selective Transtibial Anterior Cruciate Ligament Reconstruction Concomitant With Medial Open Wedge High Tibial Osteotomy for Treating Varus Knee Osteoarthritis With Anterior Cruciate Ligament Deficiency

Tsuneari Takahashi, M.D., Ph.D., Mikiko Handa, M.D., Yuya Kimura, M.D., and Katsushi Takeshita, M.D., Ph.D.

Abstract: High tibial osteotomy (HTO) is used in the treatment of varus knee osteoarthritis (KOA) in young and active patients. At times, a concomitant anterior cruciate ligament (ACL) deficiency is found, and there is no conclusive evidence comparing the osteotomy options for an ACL-deficient knee despite the popularity of medial opening-wedge (MOW) HTO in varus KOA with ACL deficiency. To minimize the incidence of an unnecessary ACL reconstruction with MOW-HTO, we developed an intraoperative laximetry-based selective technique for transtibial ACL reconstruction concomitant with MOW-HTO using a sterilizable metal laximeter. To successfully use the device required for this procedure, surgeons must understand the proper techniques. Hence, this Technical Note aims to give a comprehensive description of the technique.

Introduction

High tibial osteotomy (HTO) is used for the treatment of varus knee osteoarthritis (KOA) in young and active patients. HTO realigns the mechanical axis of the lower limb and unloads the affected medial compartment by transferring weight-bearing forces to the lateral knee compartment.[1] Primary medial KOA in an anterior cruciate ligament (ACL)-intact knee usually involves the anteromedial aspect of the knee and is accordingly termed as anteromedial osteoarthritis (OA).[2] On the other hand, ACL-deficient patients typically exhibit a more extensive wear pattern of the medial compartment involving the posterior aspect as well, appropriately termed as posteromedial OA.[3] Although both lateral closing-wedge and medial opening-wedge (MOW) HTOs can be performed in varus KOA with ACL deficiency, there is a paucity of evidence comparing these osteotomy options for the ACL-deficient knee.[4]

To minimize the unwarranted application of a concomitant ACL reconstruction with MOW-HTO, we developed a technique for intraoperative laximetry-based selective transtibial ACL reconstruction concomitant with MOW-HTO. This Technical Note aims to guide surgeons through the appropriate use of this technique using a Rolimeter (Aircast, Europe).[5]

Surgical Technique

The technique can be carried out under regional or general anesthesia without a pneumatic tourniquet. The patient is positioned supine on a radiolucent table in the orthopedic theater and subjected to the anterior drawer test immediately after administering the anesthesia (baseline). The test is repeated three times using a nonsterilized Rolimeter in 30° knee flexion (Fig 1) to apply a manual maximum anterior force to the tibia relative to the femur. The side-to-side difference (SSD)

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

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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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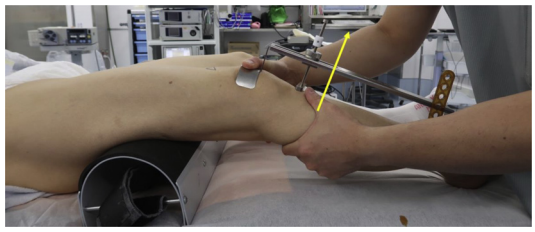

Fig 1. The patient with right varus knee osteoarthritis with anterior cruciate ligament deficiency is positioned supine on a radiolucent table in the orthopedic theater and subjected to the preoperative measurement of anterior drawer test immediately after administering the general or regional anesthesia using a nonsterilized Rolimeter in 30° knee flexion for baseline measurement. The maximum manual force is applied to the tibia relative to the femur both anteriorly and posteriorly. The anteroposterior laxity is calculated as the difference in average anterior and posterior laxities, according to the manufacturer's instructions. Yellow arrow indicates the force direction when anterior force is applied to the tibia.

in the anterior translation is calculated as the difference in average anterior laxity between both sides as per the manufacturer's instructions. After the baseline testing, the affected lower limb is sterilized, and standard anterolateral and anteromedial portals are made to perform the routine arthroscopic evaluation. The concomitant meniscal and chondral injuries are treated, and an ACL deficiency is diagnosed using probing. Next, 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 oblique skin incision is not used to avoid the risk of postoperative infection after HTO.[6] The starting point of the first Kirschner wire is approximately 2 cm medial to the medial border of the tibial tuberosity, i.e., the entry point is ~4–4.5 cm below the medial joint line (Fig 2). A second K-wire is inserted parallel to the first wire under fluoroscopy.[7] The depth of the saw cut is 5 mm less than the value measured against the wires to leave a lateral bone hinge to avoid unstable hinge fracture.[8] It is important to ensure that there is sufficient space cranially for the locking bolts of the plate fixator. After that, an anterior ascending osteotomy is made at an angle of 110° to the horizontal saw cut, ending behind the patellar tendon insertion. The width of the tuberosity segment is set to at least 1.5 cm. The horizontal osteotomy is gradually opened to the desired correction angle,[9] and the medial tibia is fixed with the TomoFix anatomical medial high tibial plate (DepuySynthes, Solothurn, Switzerland). To minimize tibial slope alteration, the spreader is placed close to the posterior cortex (Fig 3). The intraoperative mechanical axis of the lower limb is set at 55%[10] and checked using a long alignment rod (Fig 4).[11]

After temporary fixation of the medial high tibial plate, a second anterior drawer test for the affected side

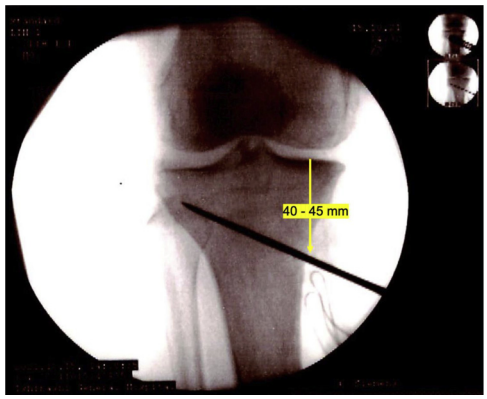

Fig 2. Fluoroscopic image of the right proximal tibia with first guidewire. The starting point of the first Kirschner wire is ~2 cm medial to the medial border of the tibial tuberosity. The entry point of this wire is approximately 4 to 4.5 cm below the medial joint line. Yellow arrow indicates the entry point. The depth of the saw cut is 5 mm less than the value measured against the wires to leave a lateral bone hinge to avoid unstable hinge fracture. It is important to ensure that there is sufficient space cranially for the locking bolts of the plate fixator.

only is performed using a sterilized Rolimeter (Fig 5). For an SSD <3 mm, ACL reconstruction is not performed; when the SSD is over 3 mm,[12] the ipsilateral semitendinosus tendon (and gracilis tendon if needed) is extracted using a tendon harvester (Smith & Nephew Endoscopy). The harvested graft is trimmed and quadrupled, then connected with a suspensory fixation device and the artificial ligament.[13] After tendon harvesting, the medial high tibial plate is fixed to the tibia using locking screws. Transtibial ACL reconstruction aimed at a femoral bone tunnel created behind the resident's ridge is performed (Figs 6 and 7). Remnant tissue preservations are performed as much as possible.[14] The graft is introduced; turn-buckle stapling

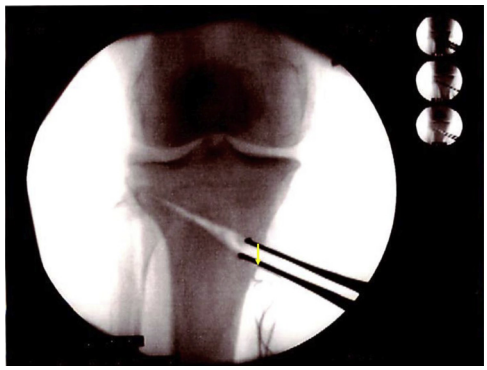

Fig 3. Fluoroscopic image of the spreader placement. The spreader is placed as close to the posterior cortex as possible to minimize tibial slope alteration while opening the horizontal osteotomy to the desired correction angle. Yellow arrow indicates the width of medial opening wedge.

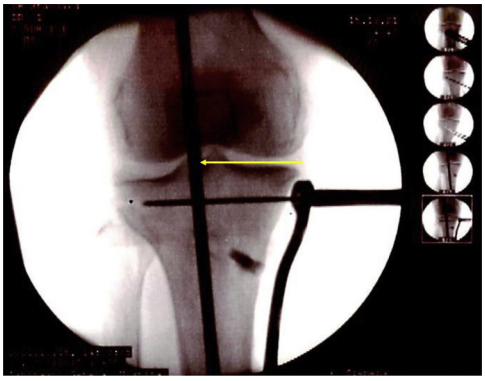

Fig 4. Intraoperative fluoroscopic evaluation of the mechanical axis of the lower limb set at 55% using a long alignment rod. The medial tibia is temporary fixed with the TomoFix anatomical medial high tibial plate (DepuySynthes, Solothurn, Switzerland). Yellow arrow indicates the long alignment rod from center of the femoral head to center of the talus.

is done, so that the two staples do not interfere with distal locking screws (Video 1). Detailed information about the pearls and pitfalls and the advantages and disadvantages of this technique are shown in Tables 1 and 2, respectively.

Postoperative Rehabilitation

A postoperative rehabilitation protocol starting with muscle strengthening exercises, including quadriceps setting and straight leg lifts, is carried out immediately postoperatively and gradually progressed. Eventually, range of motion exercises are started. Partial weight-bearing is allowed at 2 weeks, and full-weight-bearing without crutches at 4 weeks postoperation. Jogging is permitted after 12 weeks, while squatting and sports activities are allowed at least 6 months after surgery.

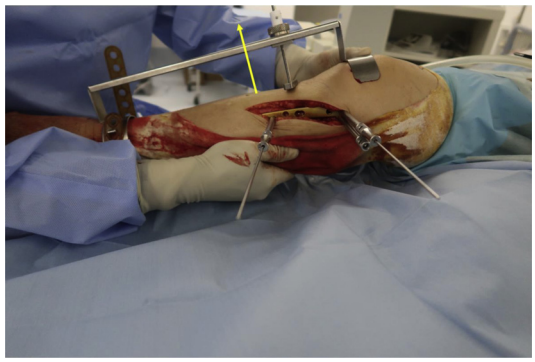

Fig 5. Intraoperative measurement of the anteroposterior laxity of the operated knee using the Rolimeter. Change in the side-to-side difference (SSD) is determined to consider performing an anterior cruciate ligament (ACL) reconstruction. For an SSD <3 mm, ACL reconstruction is not performed; when the SSD is over 3 mm, the ipsilateral semitendinosus tendon (and gracilis tendon if needed) is extracted using a tendon harvester. Yellow arrow indicates the force direction when anterior force is applied to the tibia.

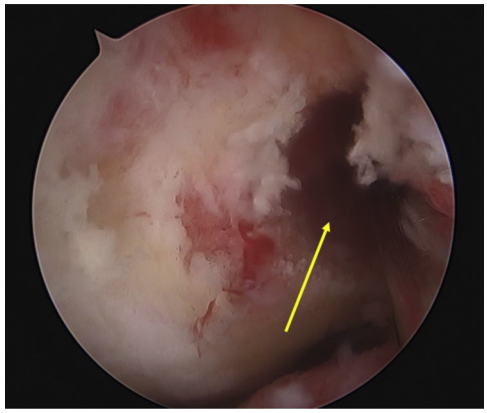

Fig 6. Arthroscopic image of the femoral bone tunnel of the right knee in the figure-four position from the anteromedial portal. Transtibial ACL reconstruction aimed at a femoral bone tunnel created behind the resident's ridge is performed to create the femoral tunnel with a diameter of 8.5 to 9 mm using an offset guide inserted through the tibial tunnel to prevent posterior wall blowout with a figure-four position so that the femoral bone tunnel is created lower and deeper, thus resulting in a placement behind the resident's ridge. Yellow arrow indicates a femoral socket-shaped tunnel with a diameter of 4.5 and 8 mm created behind the resident's ridge.

Discussion

The ACL-deficient knee frequently exhibits varus loading leading to instability and medial joint degeneration as a precursor to degenerative KOA.[15] ACL reconstruction with HTO is recommended as a salvage procedure in such cases for an ACL-deficient knee with anteromedial OA.[16] Despite its significance, the

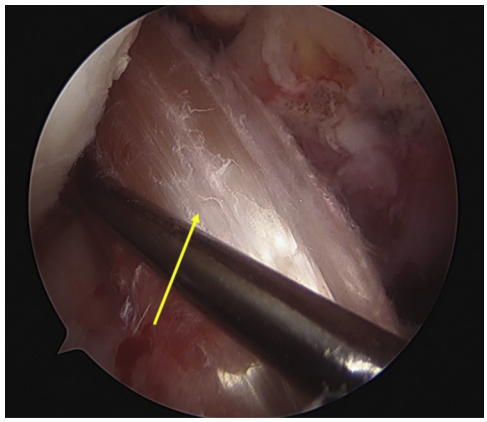

Fig 7. Arthroscopic image of the right knee in the hanging-leg position from the anterolateral portal. A quadrupled hamstring graft is introduced from the tibial tunnel to the femoral tunnel; turn-buckle stapling is done, so that the two staples do not interfere with distal locking screws. Yellow arrow indicates quadrupled hamstring graft.

Table 1. Pearls and Pitfalls of Intraoperative Laximetry-Based Selective Transtibial Anterior Cruciate Ligament Reconstruction Concomitant With Medial Open Wedge High Tibial Osteotomy

Pearls
• Hold the operative knee held in the extension position during osteotomy.
• Intraoperative fluoroscopic evaluation of mechanical axis of the lower limb to be set at 55% using long alignment rod.
• Intraoperative measurement of AP laxity of the operated knee using the Rolimeter to consider performing ACL reconstruction.
• Appropriate placement of the tibial guide creates a tibial tunnel.
• Hold the figure-four position when inserting the guide pin into the femoral ACL footprint.
Pitfalls
• Neurovascular damage due to inappropriate retractor use.
• Patellar tendon damage during ascending osteotomy.
• Hinge fracture during the opening of the horizontal osteotomy.
• Inadequate opening of horizontal osteotomy due to insufficient MCL release.
• Nonanatomic ACL femoral bone tunnel creation.
• Tibial cartilage injury and MCL injury resulting from creating the tibial bone tunnel too proximally and medially.

ACL, anterior cruciate ligament; AP, anterior-posterior; MCL, medial collateral ligament.

evidence supporting the indications and benefits of ACL reconstruction concomitant with HTO remains inconclusive.[17] Valgus HTO is known to increase the posterior slope of the proximal tibia.[18] Therefore, surgeons should be cautious to place the spreader as close to the posterior cortex as possible to avoid disturbing the tibial slope.

The Rolimeter is a manual laximeter that provides a reliable measurement of the anteroposterior translation. It is an economic option that can be sterilized, is simple to use, and is portable. The Rolimeter is suitable for assessing knee laxity in the clinical setting as it waves off the need for radiation exposure to the patient.[5] The intertester and intratester reliability is also high when used with the same examination technique.[19] These advantages enable the surgeon to compare preoperative and intraoperative change in SSD after HTO and decide on the need for ACL reconstruction while treating a patient with KOA with ACL deficiency.

Table 2. Advantages and Disadvantages of Intraoperative Laximetry-Based Selective Transtibial Anterior Cruciate Ligament Reconstruction Concomitant With Medial Open Wedge High Tibial Osteotomy

Advantages
• Able to evaluate the change of AP laxity before and after MOW-HTO.
• No need for an additional radiograph exposure to evaluate the change in AP laxity.
Disadvantages
• Not able to evaluate the change in rotatory stability before and after MOW-HTO.
• Need for sterilizing Rolimeter.
• Technical error and device problems.

AP, anterior-posterior; MOW-HTO, medial open high tibial osteotomy.

On the other hand, the conventional intraoperative rotatory stability evaluation is less reliable since the superficial medial collateral ligament (sMCL) is released before performing the horizontal osteotomy. In the transtibial technique, while aiming at the femoral bone tunnel created behind the resident ridge, the tibial tunnel inlet is placed at an average distance of 13.4 mm from the tibial tunnel inlet and 9.7 mm below the tibial joint line medial to the line of the tibial axis.[13] This position is above the horizontal osteotomy line and does not eliminate the sMCL. There is an additional concern about the risk of tibial cartilage and MCL injuries, which can occur if the tibial bone tunnel is created too proximally and medially; hence, an accurate understanding of the technique and precautions to be considered are prerequisite for the safety of ACL reconstruction through the tibial tunnel method.

In conclusion, beyond its risks and limitations, our technique enables intraoperative laximetry-based selective tibial tunnel ACL reconstruction concomitant with MO-WHTO for treating varus KOA with ACL deficiency, besides reducing the need for unnecessary surgical intervention and hamstring tendon harvest.

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