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

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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. 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). 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 postero medial OA. 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.

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).

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)
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.\textsuperscript{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 \( 4 \text{ to } 4.5 \text{ cm} \) below the medial joint line (Fig 2). A second K-wire is inserted parallel to the first wire under fluoroscopy.\textsuperscript{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.\textsuperscript{8} 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,\textsuperscript{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.\textsuperscript{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 preservation are performed as much as possible.\textsuperscript{14} The graft is introduced; turn-buckle stapling
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.

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
advantage of the intraoperative laximeter is that it provides a可靠 measurement of the anteroposterior translation. This is an economic option that can be sterilized, is simple to use, and is portable. However, the Rollimeter is suitable for assessing knee laxity in the clinical setting as it is time-consuming and requires radiation exposure to the patient. The intertester and intrater reliability is also high when used with the same examination technique. These advantages enable the surgeon to compare preoperative and intraoperative change in evidence supporting the indications and benefits of ACL reconstruction concomitant with HTO remains inconclusive. Valgus HTO is known to increase the posterior slope of the proximal tibia. Therefore, surgeons should be cautious to place the spreader as close to the posterior cortex as possible to avoid disturbing the tibial slope.

The Rollimeter 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 Rollimeter is suitable for assessing knee laxity in the clinical setting as it is time-consuming and requires radiation exposure to the patient. The intertester and intrater reliability is also high when used with the same examination technique. These advantages enable the surgeon to compare preoperative and intraoperative change in evidence supporting the indications and benefits of ACL reconstruction concomitant with HTO remains inconclusive. Valgus HTO is known to increase the posterior slope of the proximal tibia. Therefore, surgeons should be cautious to place the spreader as close to the posterior cortex as possible to avoid disturbing the tibial slope.

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correction accuracy in open-wedge high tibial osteotomy. Arthroscopy 2021;37:3297-3306.

9. Staubli AE, De Simoni C, Babst R, Lobenhoffer P. Tomo-Fix: A new LCP-concept for open wedge osteotomy of the medial proximal tibia—early results in 92 cases. Injury 2003;34:B55-B62 (Suppl 2).

10. Katagiri H, Nakagawa Y, Miyatake K, et al. Short-term outcomes after high tibial osteotomy aimed at neutral alignment combined with arthroscopic centralization of medial meniscus in osteoarthritis patients. J Knee Surg In press. https://doi.org/10.1055/s-0041-1731738.

11. Wu K, Zeng J, Han L, Feng W, Lin X, Zeng Y. Effect of the amount of correction on posterior tibial slope and patellar height in open-wedge high tibial osteotomy. J Orthop Surg (Hong Kong) 2021;29:23094990211049571.

12. Rangger C, Daniel DM, Stone ML, Kaufman K. Diagnosis of an ACL disruption with KT-1000 arthrometer measurements. Knee Surg Sports Traumatol Arthrosc 1993;1:60-66.

13. Takahashi T, Saito T, Kubo T, et al. Evaluation of tibial tunnel location with the femoral tunnel created behind the resident’s ridge in transtibial anterior cruciate ligament reconstruction. J Knee Surg In press. https://doi.org/10.1055/s-0040-1722568.

14. Takahashi T, Takeshita K. Remnant tissue preserved transtibial anterior cruciate ligament reconstruction with femoral tunnel created behind the resident’s ridge. Arthrosc Tech 2021;10:e2501-e2506.

15. Ajuied A, Wong F, Smith C, et al. Anterior cruciate ligament injury and radiologic progression of knee osteoarthritis: A systematic review and meta-analysis. Am J Sports Med 2014;42:2242-2252.

16. O’Neill DF, James SL. Valgus osteotomy with anterior cruciate ligament laxity. Clin Orthop Relat Res 1992:153-159.

17. Jin C, Song EK, Jin QH, Lee NH, Seon JK. Outcomes of simultaneous high tibial osteotomy and anterior cruciate ligament reconstruction in anterior cruciate ligament deficient knee with osteoarthritis. BMC Musculoskelet Disord 2018;19:228.

18. LaPrade RF, Oro FB, Ziegler CG, Wijdicks CA, Walsh MP. Patellar height and tibial slope after opening-wedge proximal tibial osteotomy: A prospective study. Am J Sports Med 2010;38:160-170.

19. Muellner T, Bugge W, Johansen S, Holtan C, Engebretsen L. Inter- and intratester comparison of the Rolimeter knee tester: Effect of tester’s experience and the examination technique. Knee Surg Sports Traumatol Arthrosc 2001;9:302-306.