Technical Note

A Right Angle Guide for Distal Tuberosity Osteotomy With Medial Open Wedge High Tibial Osteotomy for Varus Knee Osteoarthritis

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Abstract: Medial open wedge high tibial osteotomy (OWHTO) is usually performed with proximal tuberosity osteotomy or setting the osteotomy line proximal to the tuberosity. However, OWHTO can result in patellofemoral complications due to postoperative patella infera. A new OWHTO technique, biplanar osteotomy with a distal tuberosity osteotomy, was reported in 2004 to prevent postoperative patella infera. To ensure that the 2 osteotomy lines maintain perpendicular, we describe the OWHTO procedure with a distal tuberosity osteotomy technique using a TriS Medial HTO Plate System (Olympus Terumo Biomaterials Corp., Tokyo, Japan) and a right angle guide we developed. In this Technical Note, we describe the procedure and advantages, risks, and limitations, as well as the pearls and pitfalls based on our experience.

High tibial osteotomy (HTO) is recognized as a very useful treatment option for varus knee osteoarthritis in prolonging the life of the native knee joint.[1] Although medial open wedge high tibial osteotomy (OWHTO) recently has become more common[1-4] than traditional lateral closed wedge osteotomy, conventional OWHTO with proximal tuberosity osteotomy (PTO)[1,3,4] or setting the osteotomy line proximal to the tuberosity[2] has been reported to result in patellofemoral complications due to postoperative patella infera because the tuberosity remains attached to the distal tibia.

A new OWHTO technique, biplanar osteotomy with a distal tuberosity osteotomy (DTO), was reported to prevent postoperative patella infera by Gaasbeek et al.[5] in 2004. Since the inception of this new technique, many authors have pointed out that patella height was not altered as compared with the conventional procedure.[5-13] In addition, Stoffel et al.[14] experimentally revealed that OWHTO with DTO maintained normal patellofemoral joint biomechanics with no significant increase in patellofemoral cartilage pressure. However, setting the DTO (the second osteotomy) line perpendicular to the OWHTO (the first osteotomy) line, which prevents creating a gap at the DTO site, is quite difficult during the actual procedure due to the triangular shape of the proximal tibia. Therefore, in this Technical Note, we describe the OWHTO procedure with the DTO technique using a TriS Medial HTO Plate System (Olympus Terumo Biomaterials Corp., Tokyo, Japan) and a right angle guide we developed to accurately maintain the 2 osteotomy lines perpendicular to one another. In addition, the advantages, risks, and limitations, as well as the pearls and pitfalls, are discussed.

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Surgical Technique

Indications for the OWHTO Procedure With the DTO Technique

The OWHTO procedure with the DTO technique is indicated for patients with medial-sided knee pain and varus knee alignment due to osteoarthritis of the medial knee compartment (grade II or greater based on

the Kellgren–Lawrence classification) and spontaneous osteonecrosis of the medial femoral condyle. Patients with inflammatory arthritis, ligamentous instability, and flexion contracture $\geq 15^{\circ}$ are excluded. Since September 2018, all OWHTO procedures have been performed with the DTO technique independent of the valgus correction angle.

The TriS Medial HTO Plate System

The TriS Medial HTO Plate System used in this procedure is composed of a locking plate with 8 holes (A-D in the proximal part and I-IV in the distal part) (Fig 1) and cannulated locking screws. Special instruments required for the use of this system include a radiolucent retractor, a parallel guide, 5 osteotomes of various widths (10-25 mm), an HTO opener set, and a metal alignment rod (Olympus Terumo Biomaterials Corp.) (Fig 2).

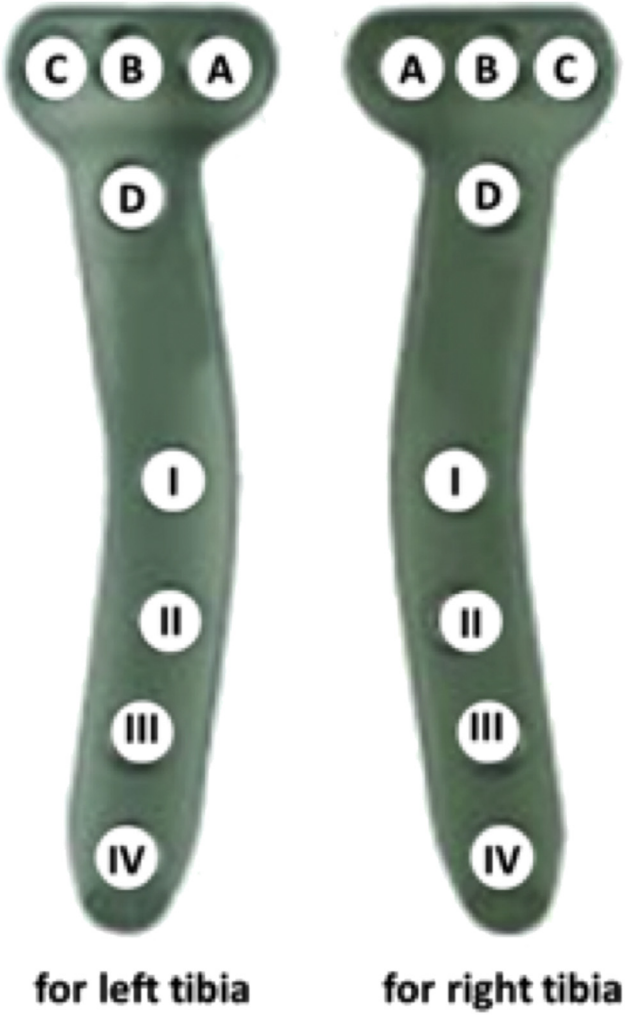

Fig 1. The TriS Medial HTO Plate System is composed of a locking plate with 8 holes (A-D in the proximal part and I–IV in the distal part) and cannulated locking screws. Left (right) side plate is for the left (right) tibia.

Right Angle Guide (an Instrument We Developed)

The instrument we developed, named "right angle guide" (Olympus Terumo Biomaterials Corp.), is also included in the TriS Medial HTO Plate System. It consists of two 1-mm thick stainless-steel plates (Plate I and Plate II) that are joined together at a right angle. The 2 ends of Plate I are referred to as the right and left wings (Fig 3A). By inserting the right or left wing of Plate I into the first osteotomy line of the right or left tibia, respectively, the upper surface of Plate II now represents the second osteotomy line. Thus, the second osteotomy can be performed perpendicularly to the first. A scale is marked on the upper surface of Plate II so that the surgeons can determine the length of the second osteotomy line (Fig 3B).

Patient Positioning and Anesthesia

Both epidural anesthesia and general anesthesia are usually employed. After induction of general anesthesia in the supine position, a tourniquet (Portable Tourniquet System PTSII; Delfi Medical Innovations, Inc., Vancouver, British Columbia, Canada) is secured around the upper thigh. The leg is then prepared and draped with a sterile fashion. The tourniquet is inflated to approximately 250 mmHg and 2 sterilized soft bumps are placed under the lower leg to elevate the lower leg to facilitate the osteotomy procedure. The knee can be either extended or slightly flexed by changing the height of the bumps.

Surgical Technique (With Video Illustration)

With the patient in the supine position, an arthroscopic examination is usually performed. Moreover, arthroscopic surgery is performed before osteotomy if necessary. Partial medial meniscectomy, resection of the osteophyte anterior to the tibial insertion of the anterior cruciate ligament, which blocks full knee extension, and microfracture of the eburnated subchondral bone of the medial compartment are often performed.

The OWHTO procedure with the DTO technique on the right tibia is shown in Video 1. A skin incision is made on the medial surface of the proximal lower leg that starts 3 to 4 cm distal to the tibial tuberosity and near the tibial crest and continues proximally and posteriorly 1 to 2 cm distal to the knee joint line (Fig 4A). After retraction of the skin and subcutaneous fatty tissue, the deep fascia, together with the semitendinosus and gracilis tendons, is then incised in an L-shaped fashion. The distal border of the incision is along the inferior border of the semitendinosus tendon. The incised fascia is reflected proximally to expose and completely release the superficial layer of the medial collateral ligament (Fig 4B). After releasing the posterior periosteum of the tibia with a Cobb-type spinal elevator (Mizuho Medical Innovation, Tokyo, Japan), a

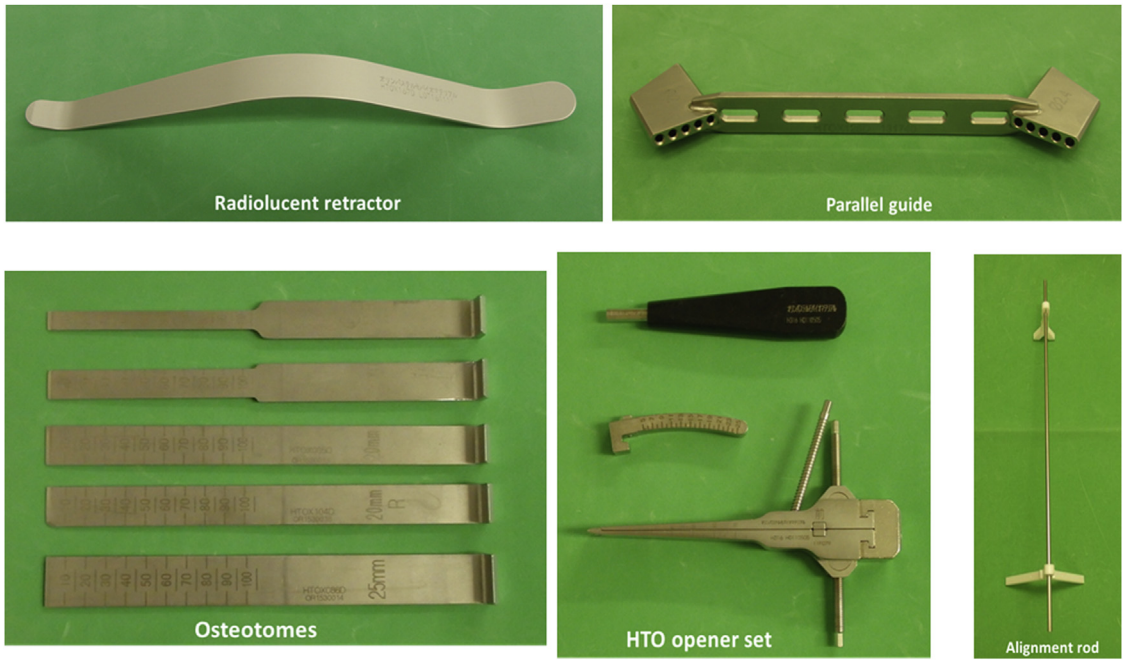

Fig 2. Special instruments required for the use of the TriS Medial HTO Plate System include a radiolucent retractor, a parallel guide, 5 osteotomes of various widths (10-25 mm), an HTO opener set, and a metal alignment rod.

radiolucent retractor is then subperiosteally inserted just posterior to the tibia to protect the popliteal neurovascular structures.

Before the first osteotomy, 2 Kirschner wires (diameter, 2 mm) are inserted in parallel to serve as guide pins using a parallel guide under anteroposterior

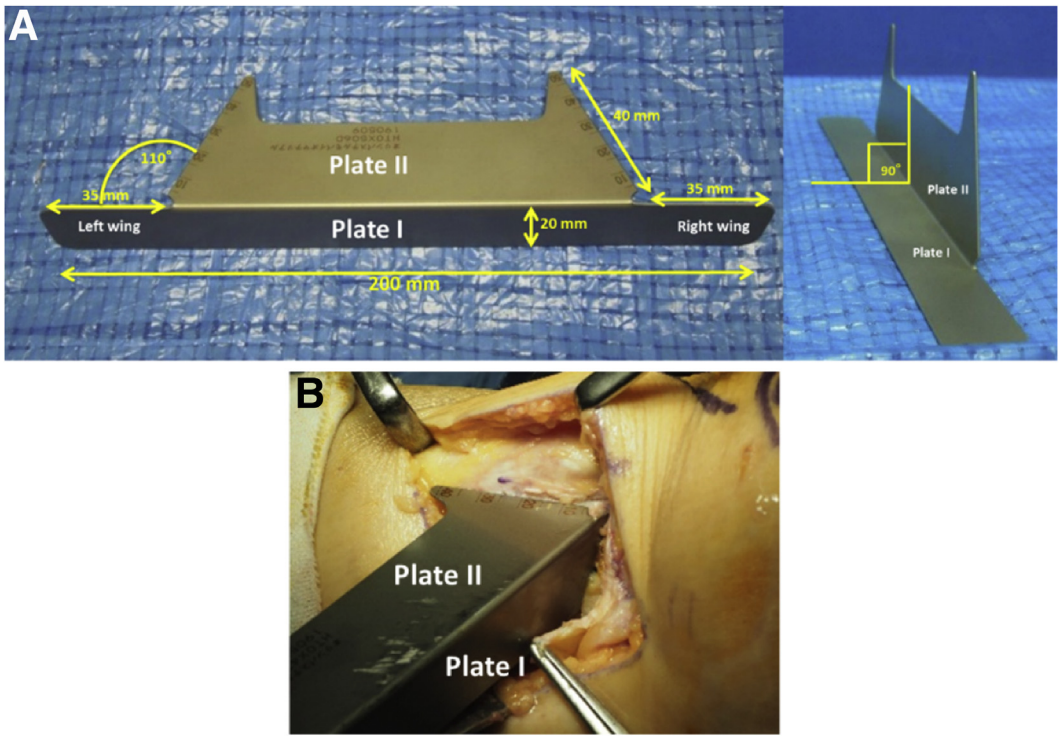

Fig 3. The right angle guide consists of two 1-mm thick stainless-steel plates (Plate I and Plate II) that are joined together at a right angle. The 2 ends of Plate I are referred to as the right and left wings (A). By inserting right or left wing of Plate I into the first osteotomy line of the right or left tibia, respectively, the upper surface of Plate II now represents the second osteotomy line. A scale is marked on the upper surface of Plate II so that the surgeons can determine the length of the second osteotomy line. This is the right tibia (B).

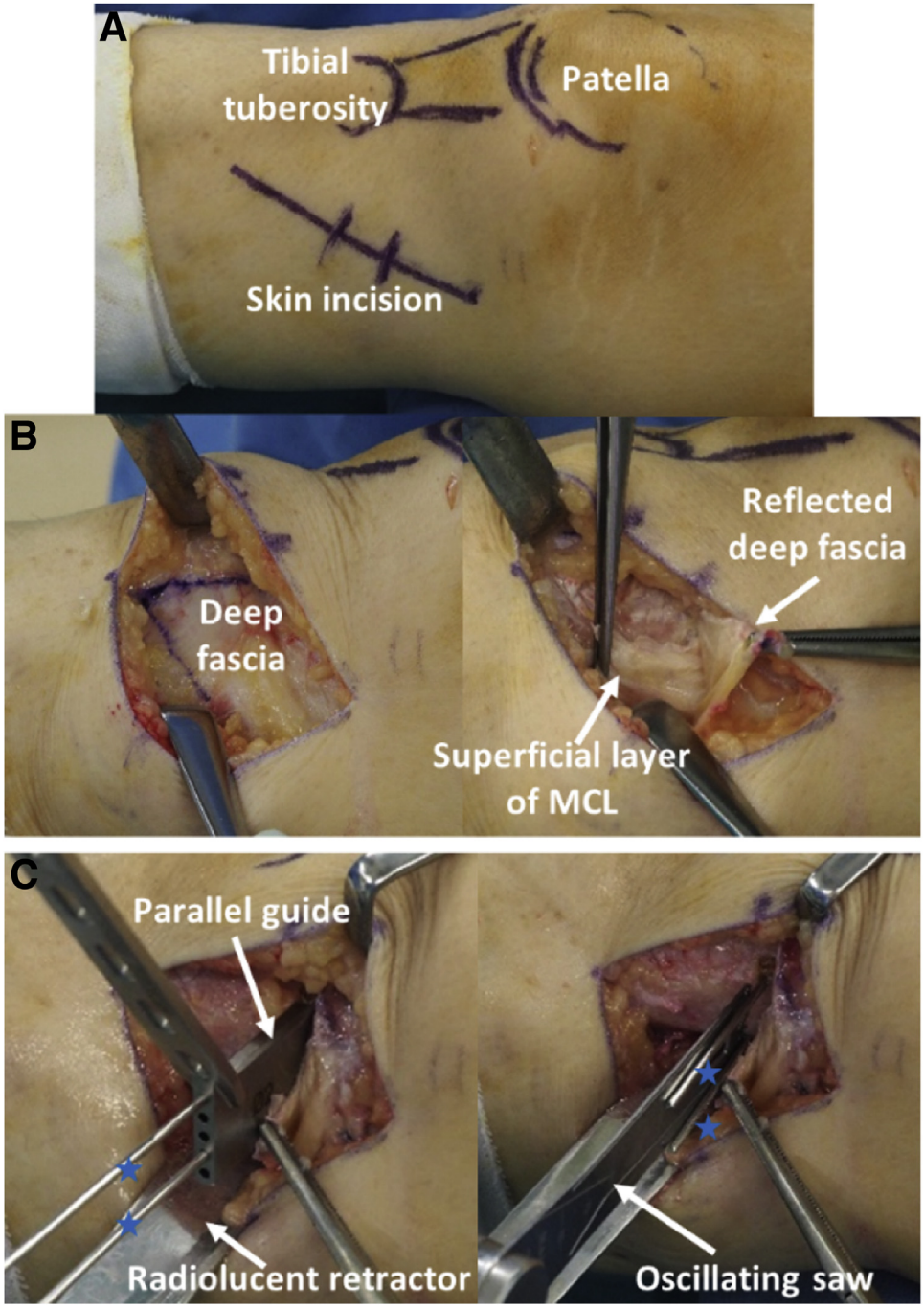

Fig 4. Medial side of the right tibia is shown. With the patient in the supine position, a skin incision starts 3 to 4 cm distal to the tibial tuberosity and near the tibial crest and continues proximally and posteriorly 1 to 2 cm distal to the knee joint line (A). The deep fascia, together with the semitendinosus and gracilis tendons, is incised in an L-shaped fashion. The distal border of the incision is along the inferior border of the semitendinosus tendon. The incised fascia is reflected proximally to expose and completely release the superficial layer of the medial collateral ligament (B). After releasing the posterior periosteum of the tibia, a radiolucent retractor is subperiosteally inserted just posterior to the tibia. Before the first osteotomy, 2 Kirschner wires (blue asterisk) are inserted in parallel using a parallel guide under fluoroscopic control. The first osteotomy is performed using an oscillating saw and osteotomes inserted along the distal surface of the 2 Kirschner wires (blue asterisk) (C). (MCL, medial collateral ligament.)

fluoroscopic control. Although it is usually recommended that the insertion point of the Kirschner wires is approximately 3.5 cm distal to the knee joint line, we usually fit the trial locking plate to the tibia and place the insertion point between holes D and I under fluoroscopic control. The direction of the wires is the proximal tibiofibular joint. The first osteotomy is also performed under fluoroscopic control using an oscillating saw with a 1.27-mm thick blade (CONMED, Largo, FL) and osteotomes inserted along the distal surface of the 2 Kirschner wires (Fig 4C). The first osteotomy line can be seen along the distal surface of the 2 Kirschner wires (Fig 5A). The end of the first osteotomy is about 5 mm medial to the lateral tibial cortex. The 2 Kirschner wires are then removed. Next, the right or left wing of Plate I is inserted into the first osteotomy line of the right or left tibia, respectively, and then the second osteotomy is performed along the upper surface of Plate II using an oscillating saw with a 1.27-mm thick blade, a reciprocating saw with a

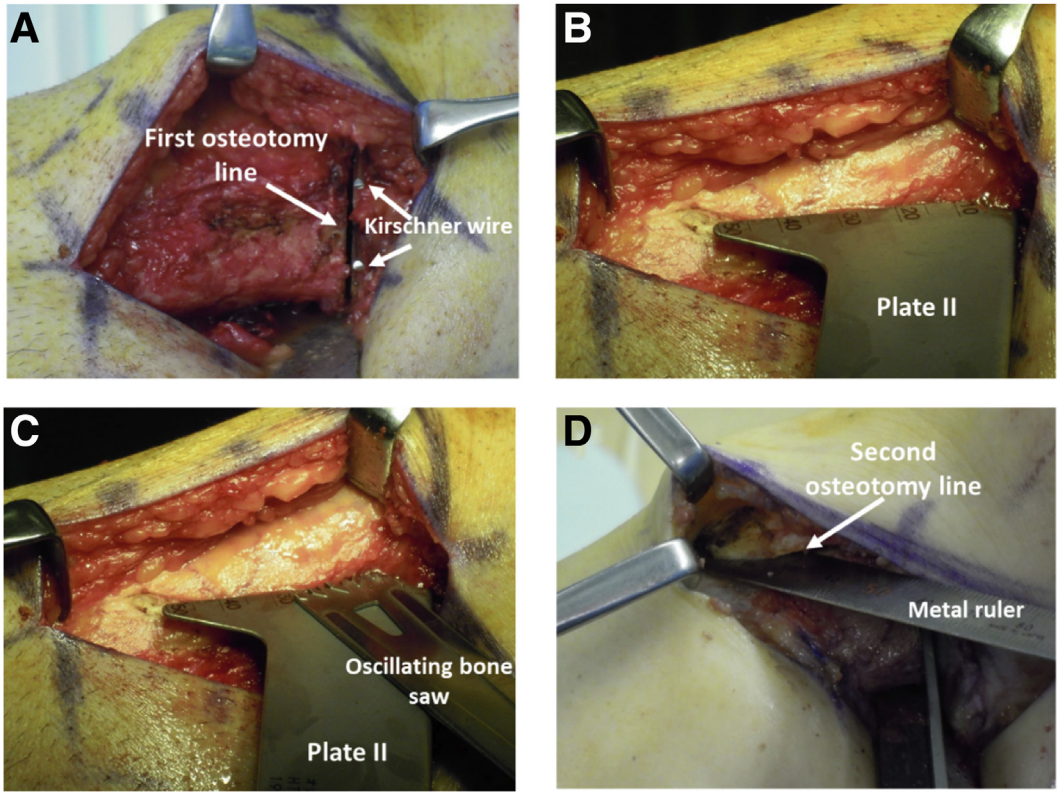

Fig 5. Medial side of the right tibia is shown. The first osteotomy line can be seen along the distal surface of the 2 Kirschner wires (A). Right wing of Plate I is inserted into the first osteotomy line, and the second osteotomy is performed along the upper surface of Plate II using an oscillating saw, a reciprocating saw, and osteotomes (B, C). The completion of both the first and second osteotomies is confirmed with the use of a metal ruler (D).

0.8-mm thick blade (CONMED), and osteotomes (Fig 5 B and C). The second osteotomy is performed while, at the same time, ensuring that the osteotomized tuberosity is at least 1 cm thick and at least 4 cm in length. After completion of both osteotomies, which is confirmed with the use of a metal ruler (Fig 5D), the first osteotomy site is opened. At first, 5 osteotomes are inserted one by one to gradually open the osteotomy site; afterward, an HTO opener is inserted to further open the site to the desired distance as preoperatively calculated. When opening the first osteotomy site, it is necessary to check whether a gap had formed or not at the second osteotomy site. The accuracy of the acquired coronal alignment is determined under fluoroscopic control as to whether the mechanical axis (from the center of the femoral head to the center of the ankle joint) passes through a point of 60% to 70% of the medial to lateral width of the tibia,[1,15] which is examined using a metal alignment rod.

Then, an artificial bone, β-tricalcium phosphate (β-TCP) (OSferion; Olympus Terumo Biomaterials Corp.), is inserted into the first osteotomy site. At first, a 10-mm long β-TCP wedge with 60% porosity and an appropriate width (equal to the osteotomy gap) is inserted into the posterior and peripheral part of the first osteotomy gap (Fig 6A). Next, the second osteotomy site is fixed with a 4-mm diameter cannulated cancellous screw and a washer (MEIRA Corporation, Seki, Gifu prefecture, Japan) (Fig 6B). β-TCP granules with 75% porosity are then stuffed into the osteotomy gap. Finally, a β-TCP wedge with 60% porosity of an appropriate width and 10 mm in length is inserted at the anterior and peripheral part of the osteotomy gap (Fig 6C). The released superficial layer of the medial collateral ligament is not sutured but is rather only repositioned onto the tibial surface (Fig 6D). The reflected deep fascia is sutured to the surrounding soft tissue to cover the first osteotomy gap and to repair the semitendinosus and gracilis tendons (Fig 6 E and F).

Finally, the first osteotomy site is fixed with a locking plate and 8 cannulated locking screws (Fig 7). Upon completion of the procedure, an aspiration device (SB VAC; Sumitomo Bakelite, Co., Ltd., Tokyo, Japan) is set and the subcutaneous fatty tissue and skin are closed. Representative pre- and postoperative radiographs are shown in Figure 8.

Rehabilitation After Surgery

The patients are encouraged to start a passive and active range-of-motion exercise and 2-crutch gait with

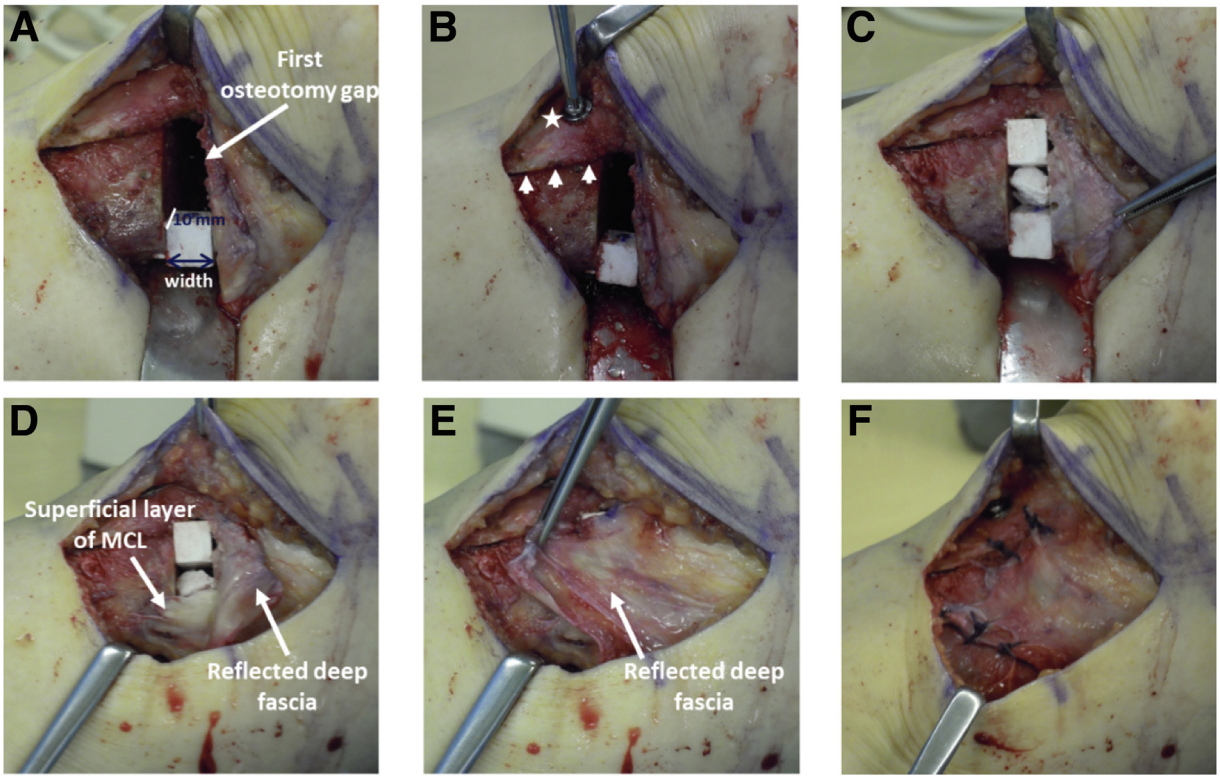

Fig 6. The medial side of the right tibia is shown. After opening of the first osteotomy site, a 10-mm long β-TCP wedge with 60% porosity and an appropriate width (equal to the osteotomy gap) is inserted into the posterior and peripheral part of the osteotomy gap (A). The second osteotomy site (arrowheads) is fixed with a 4-mm diameter cannulated cancellous screw and a washer (white asterisk) (B). β-TCP granules with 75% porosity are stuffed into the osteotomy gap. An appropriate width and 10-mm long β-TCP wedge with 60% porosity is inserted at the anterior and peripheral part of the osteotomy gap (C). The released superficial layer of the medial collateral ligament is only repositioned onto the tibial surface (D). The reflected deep fascia is sutured to the surrounding soft tissue to cover the osteotomy gap and to repair the semitendinosus and gracilis tendons (E, F). (β-TCP, β-tricalcium phosphate; MCL, medial collateral ligament.)

no weight-bearing on postoperative day 1. This should be followed by a straight leg raising exercise 1 week after surgery. Partial and full weight-bearing gait are allowed 2 to 3 weeks and 4 weeks after surgery, respectively.

Discussion

OWHTO with PTO[1,3,4] or setting the osteotomy line proximal to the tuberosity[2] for valgus correction of varus knee osteoarthritis has recently become more common. However, a few problems associated with this procedure have been recognized, especially patellofemoral degenerations due to postoperative patella infera.[1-4] In 2004, Gaasbeek et al.[5] developed a new DTO technique during OWHTO to prevent patella infera. This technique offers 2 advantages over PTO. First, the tibial tuberosity, which is the insertion site of the patellar tendon, remains attached to the proximal part of the tibia; thus, the patellar height is unchanged after opening of the first osteotomy site. Second, the DTO technique can be performed without touching the patellar tendon, thereby avoiding shortening of the

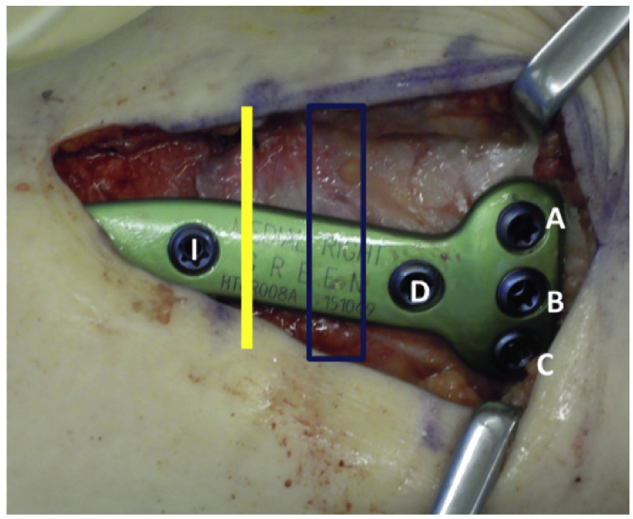

Fig 7. The medial side of the right tibia is shown. The first osteotomy site is fixed with a locking plate and eight cannulated locking screws. Holes A-D and I can be seen. Yellow line shows the location of a 4-mm diameter cannulated cancellous screw which fixed the second osteotomy site. Blue rectangle represents the location of the first osteotomy gap.

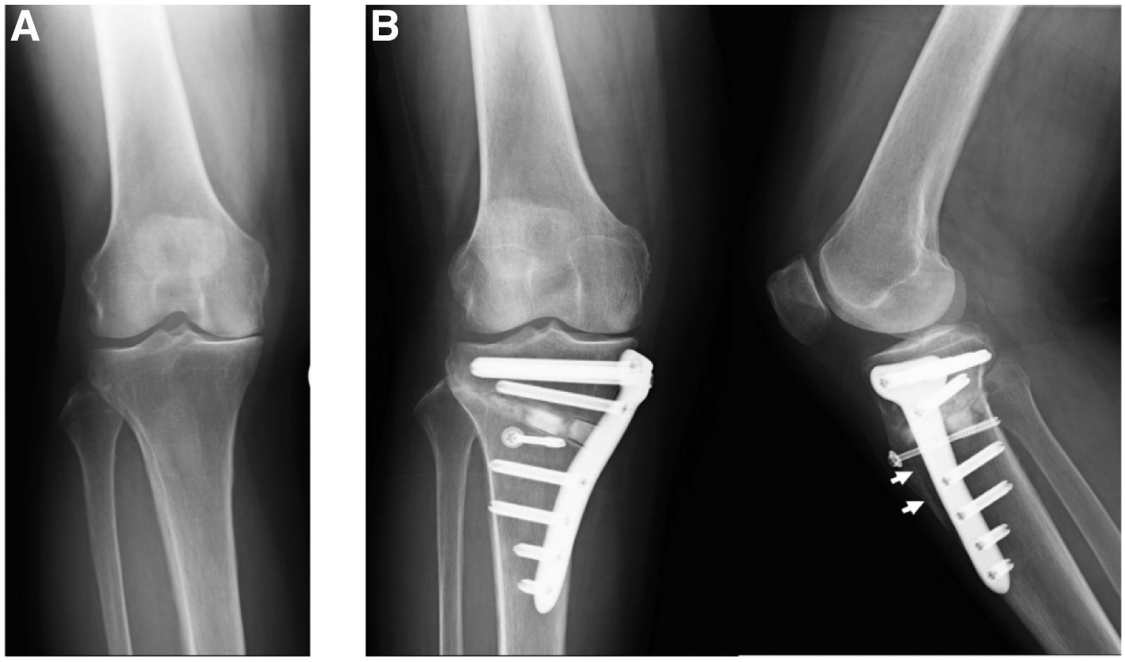

Fig 8. Preoperative (A) and postoperative radiographs (B) of the right knee. Arrows shows the second osteotomy line (B).

patellar tendon by scarring, which is a known cause of patella infera.[5,7] The superiority of Gaasbeek et al.'s technique with DTO, as compared with PTO, has been reported.[5-13] However, since it is sometimes difficult to set the DTO line perpendicular to the OWHTO line due to the triangular shape of the proximal tibia, we

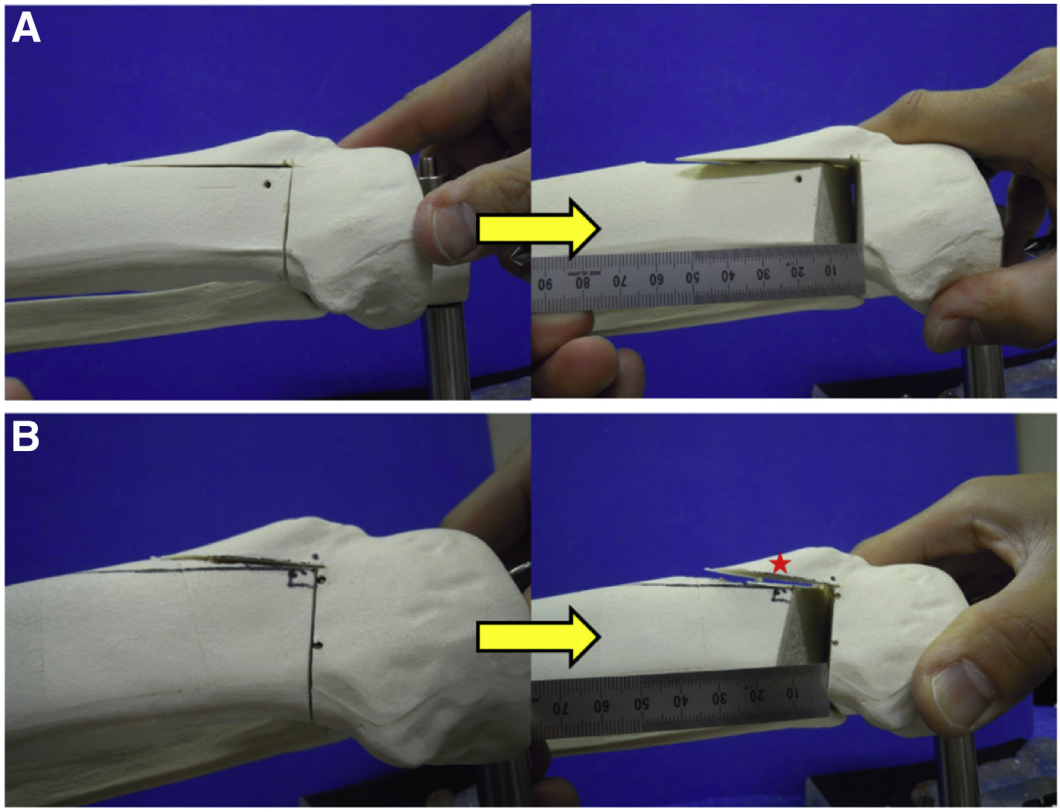

Fig 9. A bone model of the right tibia is shown. Setting the second osteotomy line perpendicular to the first one prevents gap formation at the second osteotomy site (A). A gap (red asterisk) will form if the angle between the first and second osteotomy lines is obtuse (B).

Table 1. Risks and Limitations of This Technique and Possible Addresses

Risks and Limitations	Addresses
Damage to the popliteal neurovascular structures.	The posterior periosteum of the tibia should be clearly released and a radiolucent retractor should be inserted subperiosteally.
Fracture of the osteotomized tuberosity.	The tuberosity should be at least 1 cm thick. The tip of the osteotomized tuberosity should be completely released from the surrounding soft tissue.
Insufficient screw fixation of the osteotomized tuberosity.	The length of the tuberosity should be planned to overlap the distal tibia by at least 2 cm after opening of the first osteotomy site.
There is controversy regarding the selection of the second osteotomy technique, PTO or DTO.	The use of the DTO technique, rather than the PTO, for all OWHTO procedures is recommended because the presented right angle guide can facilitate and improve the accuracy of the DTO technique.

DTO, distal tuberosity osteotomy; OWHTO. open wedge high tibial osteotomy; PTO, proximal tuberosity osteotomy.

developed a right angle guide to perpendicularly set the 2 osteotomy lines.

The main advantage of this guide is the ability to accurately set the second osteotomy line perpendicular to the first, thereby preventing gap formation at the second osteotomy site (Fig 9A). If the angle between the first and second osteotomy lines is obtuse, a gap will form (Fig 9B).

The risks and limitations of this technique, along with how to address each, are summarized in Table 1. First, the foremost prominent risk is damage to the popliteal neurovascular structures. Therefore, the posterior periosteum of the tibia should be clearly released, and a radiolucent retractor should be inserted subperiosteally. Second, there is a risk of fracture or insufficient screw fixation if the osteotomized tuberosity is too thin or too short, respectively.[5] Gaasbeek et al.[5] recommend that the tuberosity should be at least 1 cm thick and that the length should be planned to overlap the distal tibia by at least 2 cm after opening the first osteotomy site. Meanwhile, McNamara et al.[1] reported that the tuberosity osteotomy was at least 1 cm thick at the proximal portion and at least 5 cm in length. In one of our cases, the proximal part of the tuberosity was fractured while opening the first osteotomy site. Fortunately, there was little displacement, and bone union was achieved 3 months after surgery with standard postoperative rehabilitation (Fig 10). Hence, it is necessary to completely release the distal tip of the osteotomized tuberosity from the surrounding soft tissue. Lastly, as a limitation to OWHTO with biplanar osteotomy, there is controversy regarding the selection of the second osteotomy techniques, PTO or DTO. Generally, OWHTO with the PTO technique is recommended for lower valgus correction, whereas the DTO technique should be used only for cases that require higher valgus correction of $>10°$,[5] >12.5 mm[1], or >12 mm.[9] Actually, Longino et al.[6] reported the occurrence of patella

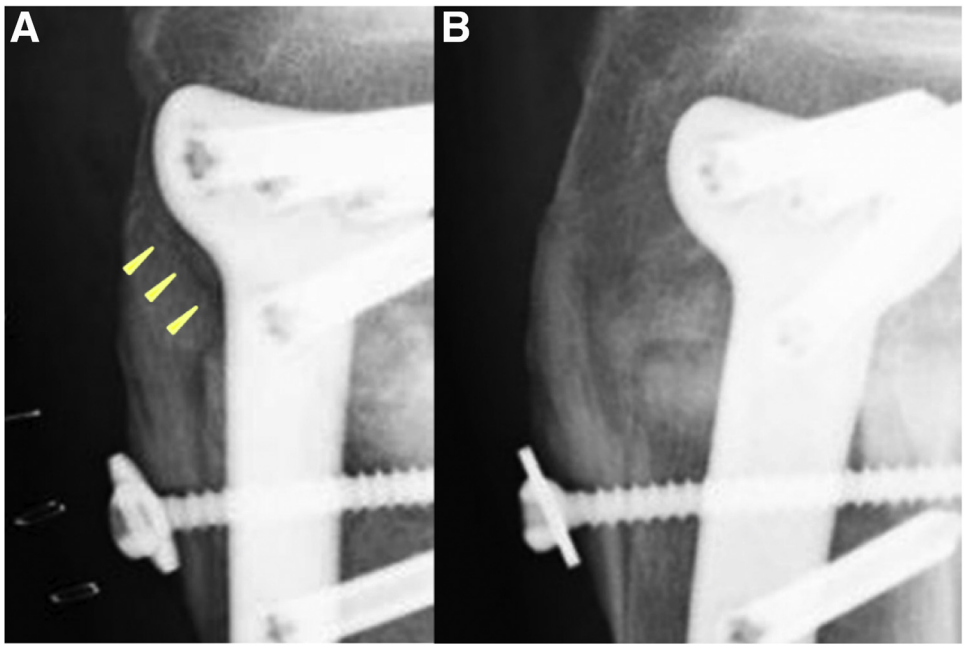

Fig 10. The proximal part of the tuberosity was fractured while opening the first osteotomy site. There was little displacement (yellow arrowheads) (A), and bone union was achieved 3 months after surgery (B).

Table 2. Pearls and Pitfalls of This Technique

Pearls	Pitfalls
Knee flexion of approximately 90° and external rotation of the hip relax the gastrocnemius muscle, which is useful when releasing the posterior periosteum of the tibia and determining whether the posterior tibial cortex is completely cut.	While performing the first osteotomy, an oscillating saw and osteotomes should be inserted along the distal surface of the 2 Kirschner wires to prevent advancement toward the knee joint line.
It is important to clearly visualize the medial tibial plateau under anteroposterior fluoroscopic control by changing the height of the 2 bumps and altering the knee flexion angle. If the 2 Kirschner wires are inserted without divergence under fluoroscopic control, the first osteotomy line can be set parallel to the medial tibial plateau in the sagittal plane.	If the second osteotomy line is too long, the first osteotomy should be advanced anteriorly.
Internally rotating the lower extremity is recommended to clearly determine the proximal tibiofibular joint on the fluoroscopic image.	It is dangerous to open the first osteotomy site when the first and second osteotomies are not yet completed. We confirm whether both osteotomies are complete or not by inserting a metal ruler into the osteotomy lines.
When deciding the starting point of the first osteotomy, we recommend fitting the trial locking plate to the tibia and then choosing an insertion point between holes D and I. In addition, it is imperative to confirm that there exists sufficient space between the first osteotomy line and hole I for insertion of a screw to fix the second osteotomy site.	Gap formation and insufficient screw fixation at the second osteotomy site may complicate bone union at the first osteotomy site. Setting the knee joint either fully extended or slightly hyperextended by changing the height of the 2 bumps is recommended to achieve firm contact at the second osteotomy site.

infera after OWHTO with the PTO; however, this complication did not result in poorer patient-reported outcomes at 24 months after surgery. In addition, Goshima et al.[4] reported the progression of radiologic and arthroscopic patellofemoral osteoarthritic changes in some cases after OWHTO with PTO, although these changes did not affect the clinical outcomes at 58.2 months after the surgery. Nonetheless, the long-term outcomes of OWHTO with PTO have not yet been clarified. McNamara et al.[1] do not recommend the DTO technique for cases that require lower valgus correction due to increased technical demands. However, we recommend the use of the DTO technique, rather than the PTO, for all OWHTO procedures because the presented right angle guide can facilitate and improve the accuracy of the DTO technique.

The pearls and pitfalls of this technique are described in Table 2. The first pearl is that knee flexion of approximately 90° and external rotation of the hip relax the gastrocnemius muscle, which is useful when releasing the posterior periosteum of the tibia and determining whether the posterior tibial cortex is completely cut after the first osteotomy. Second, before inserting the 2 Kirschner wires as guide pins for the first osteotomy, it is important to clearly visualize the medial tibial plateau under anteroposterior fluoroscopic control by changing the height of the 2 bumps and altering the knee flexion angle. If the 2 wires are inserted without divergence under fluoroscopic control, the first osteotomy line can be set parallel to the medial tibial plateau in the sagittal plane. Third, when the location of the proximal tibiofibular joint is obscure on the fluoroscopic image, internally rotating the lower extremity is recommended to clearly determine the joint line. Lastly, when deciding the starting point of the first osteotomy, we recommend fitting the trial locking plate to the tibia and then choosing an insertion point between holes D and I. In addition, it is imperative to confirm that there exists sufficient space between the first osteotomy line and hole I for insertion of a screw to fix the second osteotomy site.

There are also some pitfalls of this technique. First, while performing the first osteotomy, an oscillating saw and osteotomes should be inserted along the distal surface of the 2 Kirschner wires to prevent advancement toward the knee joint line. Second, if the second osteotomy line is too long after insertion of the right or left wing of Plate I into the first osteotomy line, the first osteotomy should be advanced anteriorly. Third, it is dangerous to open the first osteotomy site when the first and second osteotomies are not yet completed. We confirm whether both osteotomies are complete by inserting a metal ruler into the osteotomy lines (Fig 5D). Lastly, gap formation and insufficient screw fixation at the second osteotomy site may complicate bone union at the first osteotomy site. Setting the knee joint either fully extended or slightly hyperextended by changing the height of two bumps is recommended to achieve firm contact at the second osteotomy site.

In conclusion, although it is generally believed that the DTO technique is not always necessary for smaller corrections due to increased technical demands, the right angle guide presented here can facilitate and improve the accuracy of the DTO technique. Therefore, we recommend the DTO technique for all OWHTO cases.

References

1. McNamara I, Birmingham TB, Fowler PJ, Giffin JR. High tibial osteotomy: Evolution of research and clinical application—a Canadian experience. *Knee Surg Sports Traumatol Arthrosc* 2013;21:23-31.
2. Fowler PJ, Tan JL, Brown GA. Medial opening wedge high tibial osteotomy: How I do it. *Op Tech Sports Med* 2000;8:32-33.
3. Bode G, von Heyden J, Pestka J, et al. Prospective 5-year survival rate data following open-wedge valgus high tibial osteotomy. *Knee Surg Sports Traumatol Arthrosc* 2015;23:1949-1955.
4. Goshima K, Sawaguchi T, Shigemoto K, Iwai S, Nakanishi A, Ueoka K. Patellofemoral osteoarthritis progression and alignment changes after open-wedge high tibial osteotomy do not affect clinical outcomes at mid-term follow-up. *Arthroscopy* 2017;33:1832-1839.
5. Gaasbeek RDA, Sonneveld H, van Heerwaarden RJ, Jacobs WCH, Wymenga AB. Distal tuberosity osteotomy in open wedge high tibial osteotomy can prevent patella infera: A new technique. *Knee* 2004;11:457-461.
6. Longino PD, Birmingham TB, Schultz WJ, Moyer RF, Giffin JR. Combined tibial tubercle osteotomy with medial opening wedge high tibial osteotomy minimizes changes in patellar height: A prospective cohort study with historical controls. *Am J Sports Med* 2013;41:2849-2857.
7. Hopwood S, Khan W, Agarwal S. The biplanar open wedge high tibial osteotomy preserving the tibial tubercle. *J Orthop Sci* 2016;21:786-790.
8. Park H, Kim HW, Kam JH, Lee DH. Open wedge high tibial osteotomy with distal tubercle osteotomy lessens change in patellar position. *BioMed Res Int* 2017;2017:4636809.
9. Krause M, Drenck TC, Korthaus A, Preiss A, Frosch K-H, Akoto R. Patella height is not altered by descending medial open-wedge high tibial osteotomy (HTO) compared to ascending HTO. *Knee Surg Sports Traumatol Arthrosc* 2018;26:1859-1866.
10. Erquicia J, Gelber PE, Perelli S, et al. Biplane opening wedge high tibial osteotomy with a distal tuberosity osteotomy, radiological and clinical analysis with minimum follow-up of 2 years. *J Exp Orthop* 2019;6:10.
11. Akiyama T, Osano K, Mizu-Uchi H, et al. Distal tibial tuberosity arc osteotomy in open-wedge proximal tibial osteotomy to prevent patella infera. *Arthrosc Tech* 2019;8:e655-e662.
12. Horikawa T, Kubota K, Hara S, Akasaki Y. Distal tuberosity osteotomy in open-wedge high tibial osteotomy does not exacerbate patellofemoral osteoarthritis on arthroscopic evaluation. *Knee Surg Sports Traumatol Arthrosc* 2020;28:1750-1756.
13. Ogawa H, Matsumoto K, Yoshioka H, Sengoku M, Akiyama H. Distal tibial tubercle osteotomy is superior to the proximal one for progression of patellofemoral osteoarthritis in medial opening wedge high tibial osteotomy. *Knee Surg Sports Traumatol Arthrosc* 2020;28:3270-3278.
14. Stoffel K, Willers C, Korshid O, Kuster M. Patellofemoral contact pressure following high tibial osteotomy: A cadaveric study. *Knee Surg Sports Traumatol Arthrosc* 2007;15:1094-1100.
15. Fujisawa Y, Masuhara K, Shiomi S. The effect of high tibial osteotomy on osteoarthritis of the knee. An arthroscopic study of 54 knee joints. *Orthop Clin North Am* 1979;10:585-608.