Technical Note

Combination of Cylindrical Autologous Bone Grafting Technique With a Metallic Block Insertion in Open-Wedge High Tibial Osteotomy

Jong Hyun Kim, M.D., Ph.D., Woon Hwa Jung, M.D., Seung Soo Jeon, M.D., and Jae Hyoung Kim, M.D.

Abstract: Open-wedge high tibial osteotomy (OW-HTO) is an effective surgical intervention for medial-compartment knee osteoarthritis. However, the osteotomized gap might be a disadvantage in OW-HTO because it can cause problems such as delayed bone union or loss of correction. These issues can be minimized by using autologous bone graft in the osteotomized gap, which is known to be the fastest and most clinically satisfactory gap filler. The primary mechanical stability of the osteotomy site in OW-HTO is essential for early weight bearing after surgery. Therefore, we introduce the combination of a cylindrical autologous bone grafting technique and a metallic block insertion for faster bone union and better primary stability of the site in OW-HTO. We expect that the described procedure will enable early postoperative weight bearing and, thereby, allow an early return to normal function.

High tibial osteotomy (HTO) is an effective surgical treatment for patients with medial knee osteoarthritis and varus malalignment.[1] Because closed-wedge HTO has several disadvantages, such as a fibular osteotomy with the potential risk of neurovascular complications and bone stock loss,[2-4] open-wedge HTO (OW-HTO) has gained popularity with its favorable radiographic, biomechanical, and clinical results.[5-7] However, the osteotomized gap might be a disadvantage in OW-HTO because the gap can cause problems such as delayed bone union or loss of correction.[8,9] To resolve those issues, a variety of gap fillers, such as autologous iliac crest, autologous osteophyte, and allogeneic bone grafts, as well as bone graft substitutes, such as β−tricalcium phosphate (β-TCP) and hydroxyapatite, have been used.[7,10-12] The results of recent studies have shown that autologous bone graft is the fastest and most clinically satisfactory gap filler.[13]

Additionally, the primary mechanical stability of the osteotomized site is essential for early full weight bearing.[7] In this regard, it has been reported that the insertion of bone substitutes such as β-TCP wedges and structural triangular bone allografts was likely to improve it.[14-16]

We present the combination of a cylindrical autologous bone grafting technique with a metallic block insertion in OW-HTO (Video 1). The pearls and pitfalls of this technique are shown in Table 1.

Surgical Technique

Indications

The indications for our technique include knees with symptomatic, isolated medial-compartment osteoarthritis and osteonecrosis of the medial femoral condyle with varus deformity. Patients with severe patellofemoral arthritis, systemic inflammatory arthritis, or knee contracture of more than 15° are excluded.

Preparation

The patient is placed supine, with the knee extended, on a radiolucent operating table to allow fluoroscopic

From Samsung Orthopaedic Clinic, Chungju, Republic of Korea (J.H.K.); Department of Orthopaedic Surgery, Murup Hospital, Masan, Republic of Korea (W.H.J.); Department of Orthopaedic Surgery, Koggiry Hue Hospital, Gwangju, Republic of Korea (S.S.J.); and Department of Orthopaedic Surgery, Woori Hospital, Suwon, Republic of Korea (J.H.K.).

The authors report no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received June 9, 2020; accepted October 9, 2020.

Address correspondence to Jong Hyun Kim, M.D., Ph.D., Samsung Orthopaedic Clinic, 33, Jungang-ro, Chungju-si, Chungcheongbuk-do 27406, Republic of Korea. E-mail: jhkim1406@gmail.com

2212-6287/201015

https://doi.org/10.1016/j.eats.2020.10.012

Table 1. Pearls and Pitfalls

Pearls
Harvested bone grafts should be packed adequately into the lateral cortex of the tibia.
The surgeon should choose the metallic block that matches the height of the osteotomy gap.
The plate should be placed over the metallic block to reduce the possibility of its displacement.
The soft tissue should be repaired as much as possible to cover the metallic block, which can minimize the displacement of the inserted block.
Pitfalls
The surgeon must be careful not to cause a fracture of the medial femoral condyle during insertion of the OATS donor cutting tube.
The size of the first cylinder is approximately 8 mm × 20 mm; the other cylinder is usually smaller than the first.
The surgeon should be careful not to allow hematoma formation around the bone graft donor site.

OATS, Osteochondral Autograft Transfer System.

evaluation from the hip to the ankle under general or spinal anesthesia. A tourniquet is inflated to 280 to 300 mm Hg. The other leg is positioned lower to provide an easier approach to the medial aspect of the operative knee during the surgical procedure (Fig 1).

Diagnostic Arthroscopy and Concomitant Procedures

Diagnostic arthroscopy is carried out in all cases prior to OW-HTO with standard anterolateral and anteromedial portals to check the status of the cartilage and meniscus. Concomitant procedures are performed to address medial-compartment chondral or meniscal disease.

Open-Wedge HTO

A 6- to 7-cm longitudinal oblique incision is made midway between the tibial tuberosity and the posteromedial border of the tibia (Fig 2A). The tendons of the pes anserinus and the superficial medial collateral ligament (sMCL) are sharply incised into an L shape and reflected as a flap. Under fluoroscopic control, 2 guidewires are inserted parallel to each other from the starting point of the osteotomy at the medial cortex of the tibia until the tip of the fibular head (Fig 2B). The osteotomy site is approximately 35 mm distal to the medial proximal tibial joint surface line. A radiolucent retractor is placed between the sMCL and the posterior cortex of the tibia. Sagittal osteotomy is performed in the posterior two-thirds of the tibia along the guidewires using an oscillating saw. This section of the osteotomy should end approximately 1 cm medial to the lateral tibial cortex. Then, the second, coronal ascending osteotomy is carried out with a small, thin oscillating saw to create a biplanar osteotomy (Fig 2C). Under fluoroscopic guidance, the sagittal osteotomy site is opened with a bone spreader after the insertion of several chisels until the mechanical axis of the corrected knee passes through 62% of the tibial plateau.

Cylindrical Autologous Bone Graft Technique in Combination With Metallic Block Insertion

When the desired alignment of correction is achieved, the surgeon chooses the Ohtofix metallic block (OhtoMedical, Goyang, Republic of Korea) that matches the height of the sagittal osteotomy gap. The metallic blocks are rectangular and are assembled with a handle. They vary in height from 6 to 16 mm (Fig 3). The metallic block is inserted in the posteromedial osteotomy site of the tibia (Fig 4 A-D). The soft tissue is repaired as much as possible to cover the metallic block (Fig 4E). Cylindrical autologous bone grafts are then harvested. This technique was described by Jung et al.[13] Cylindrical autologous bone grafts are extracted using the donor cutting tubes

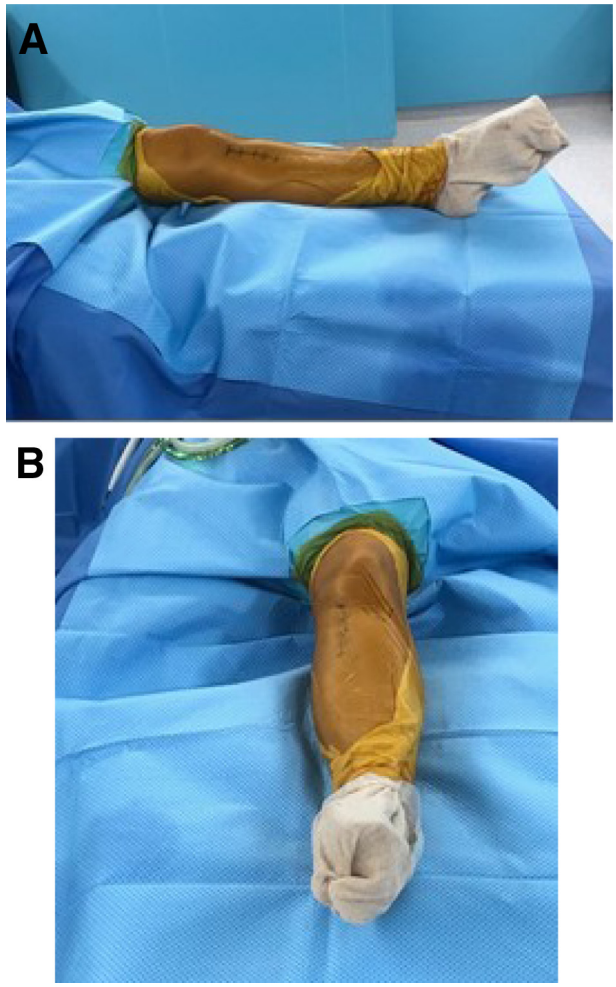

Fig 1. Patient positioning on operating table (left knee). (A) The patient is placed supine, with the knee extended, on a radiolucent operating table. (B) The opposite leg (right) is placed lower than the operative leg.

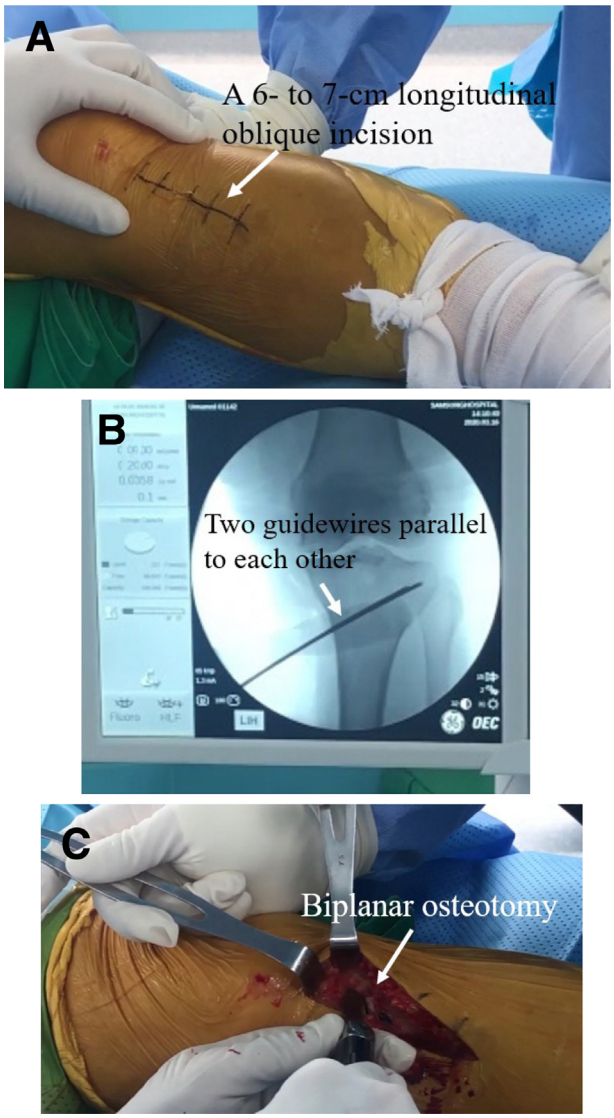

Fig 2. (A) A 6- to 7-cm longitudinal oblique incision is made in the left knee. (B) Two guidewires are inserted parallel to each other from the starting point of the osteotomy at the medial cortex of the tibia until the tip of the fibular head. (C) A biplanar osteotomy is carried out with a small, thin oscillating saw.

(8 mm in diameter) of the Osteochondral Autograft Transfer System (OATS; Arthrex, Naples, FL). Through the skin incision measuring 15 mm, an OATS donor cutting tube is inserted into the medial femoral condyle at the level of the adductor tubercle (Fig 5). Two cylindrical bone grafts are easily obtained (Fig 6 A and B). The size of the first cylinder is approximately 8 mm × 20 mm; the other cylinder is usually smaller than the first. Figure 6C shows the cylindrical autologous bone grafts immediately after being harvested. The osteotomy gap is filled with the 2 harvested cylindrical bone grafts. The bone grafts should be inserted adequately into the lateral cortex of the tibia (Fig 7).

Fixation With Locking Plate and Screws

The Ohtofix HTO plate (OhtoMedical) is fixed with 7 locking screws and 1 cortical screw (Fig 8A).[17] The plate should be placed over the metallic block to reduce the possibility of its displacement (Fig 8 B and C). The pes anserinus and sMCL are approximated with the remnants of the periosteum over the osteotomy gap. This procedure could minimize the displacement of the inserted block at the osteotomy gap. The wound is closed with the placement of a surgical drain.

Discussion

It has been a longstanding debate whether an osteotomized gap needs to be filled up with autologous bone graft or any other spacer to accelerate the bone-healing process.[6,7,18] Although Staubli and Jacob[19] reported that OW-HTO could be performed with the TomoFix plate (Synthes, Oberdorf, Switzerland) without any implantation,[6] the use of bone substitute wedges in OW-HTO also showed acceptable clinical, radiologic,

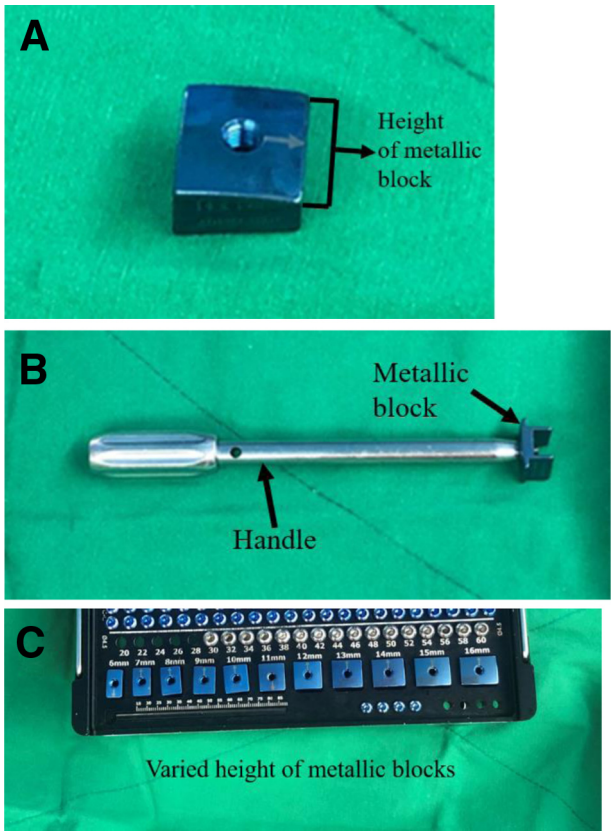

Fig 3. Ohtofix metallic block. (A) Rectangular metallic block. (B) The metallic block is assembled with a handle. (C) The metallic blocks vary in height from 6 to 16 mm.

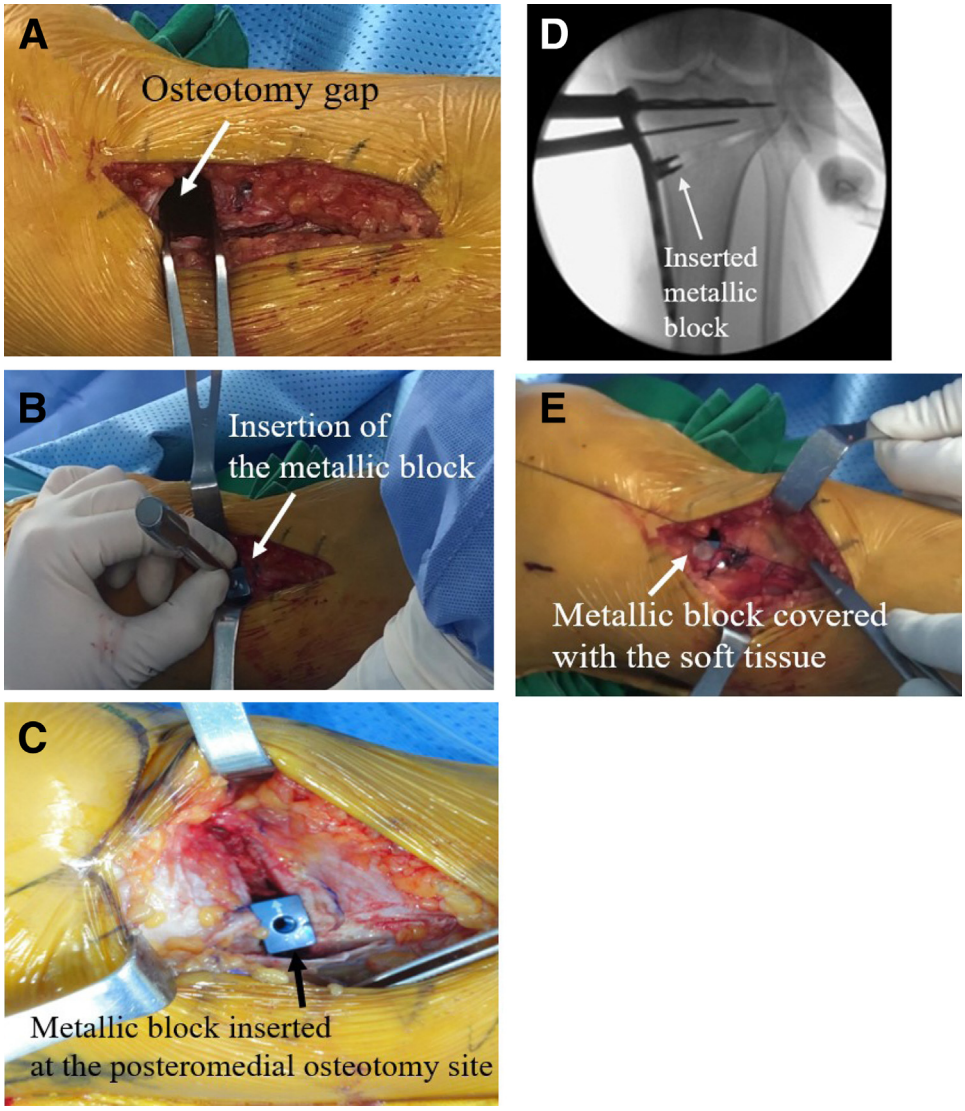

Fig 4. Ohtofix metallic block insertion. (A) Measurement of height of sagittal osteotomy gap. (B) Insertion of metallic block with handle. (C) The metallic block that matches the width of the sagittal osteotomy gap is inserted at the posteromedial osteotomy site of the tibia. (D) A fluoroscopic image shows the metallic block inserted in the osteotomy gap. (E) The soft tissue should be repaired as much as possible to cover the metallic block to minimize its displacement.

and histologic outcomes.[14,20] Lash et al.[21] reviewed the role of autologous bone grafting as compared with both β-TCP and no defect filling in OW-HTO. They concluded that autologous bone grafting had a definitive advantage over any other gap fillers. Recently, Jung et al.[13] reported that when union rates were compared, patients with β-TCP, no fillers, and autologous grafting achieved union at a mean duration of 8.3, 7.2, and 3.4 months, respectively.

For early weight bearing after OW-HTO, the primary stability of the osteotomy site is one of the most important factors. In a biomechanical study, Takeuchi et al.[15] reported that the use of β-TCP wedges and the TomoFix plate was likely to improve the primary stability at the osteotomy site in comparison with methods that leave the osteotomy gap open. The biomechanical, comparative, experimental study reported that the bone substitute grafts inserted into the osteotomy site significantly decreased the load stress on the plate and on the lateral cortex compared with when bone substitute grafts were not used.[6,15] These results indicated that the bone substitute grafts were able to bear loads and therefore reduce stress on the plate.

We used the metallic block for 2 purposes: First, the metallic block was stronger than β-TCP. Second, the operating time—which is usually increased when adjusting the width of β-TCP wedges to match the size of the osteotomy gap—was decreased. The metallic

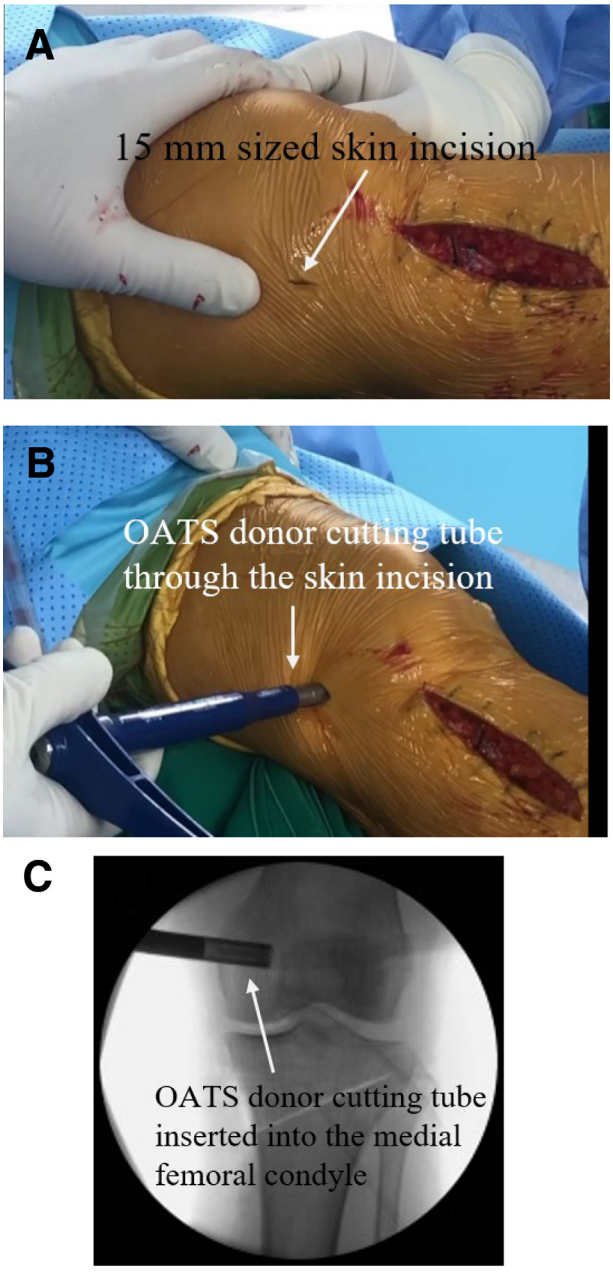

Fig 5. Cylindrical autologous bone graft harvesting (left knee). (A) Skin incision measuring 15 mm at level of adductor tubercle of medial femoral condyle. (B) Cylindrical autologous bone grafts are extracted with an Osteochondral Autograft Transfer System (OATS) donor cutting tube (8 mm in diameter) through the 15-mm skin incision. (C) A fluoroscopic image shows an OATS donor cutting tube that is inserted into the medial femoral condyle at the level of the adductor tubercle.

block was placed at the posteromedial site of the osteotomy gap because the posteromedial stability of the osteotomy site was effective in preventing an increase in the posterior tibial slope and the loss of correction after OW-HTO.[21-23] This technique was advantageous in shortening the bone-healing period and improving the primary mechanical stability after OW-HTO. Moreover, it required just a small additional skin incision in contrast to autologous iliac crest bone grafting. There was no associated postoperative donor-site morbidity, except for mild pain that required no intervention.[13]

Meanwhile, the risks and disadvantages of the described technique include the possibility of fracture of the medial femoral condyle during insertion of the

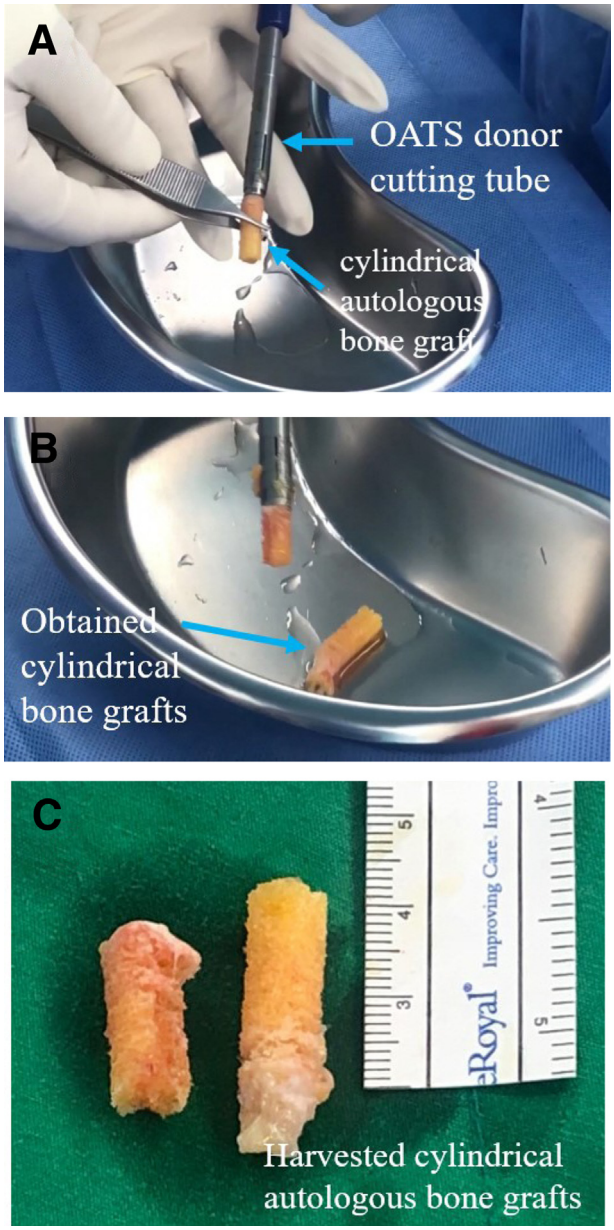

Fig 6. (A) Extraction of cylindrical autologous bone graft from Osteochondral Autograft Transfer System (OATS) donor cutting tube (8 mm in diameter). (B) Two cylindrical bone grafts are easily obtained. (C) Cylindrical autologous bone grafts immediately after being harvested.

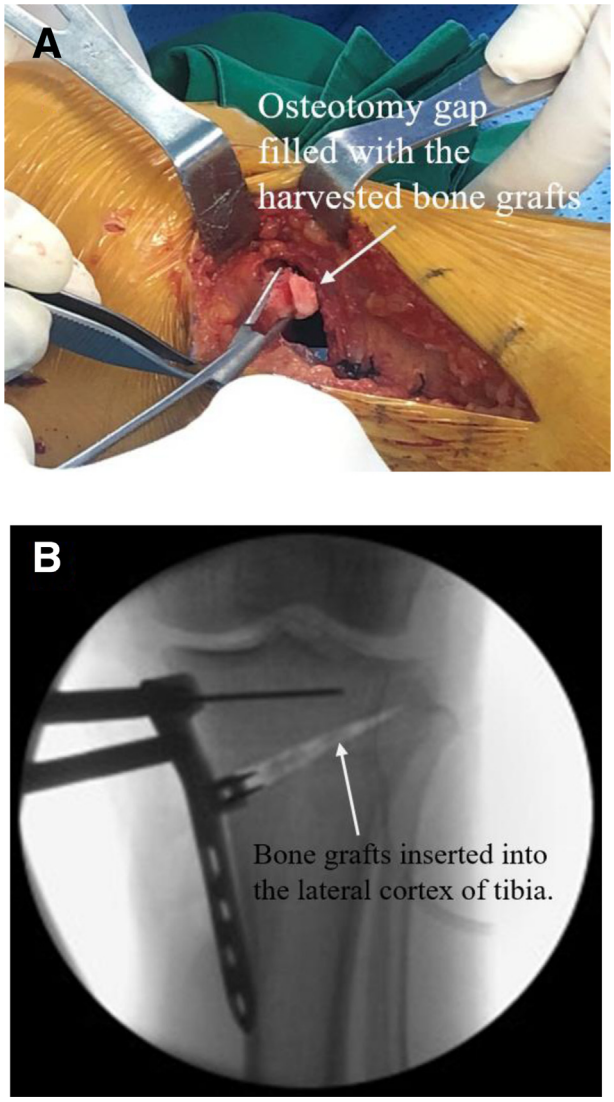

Fig 7. Implantation of cylindrical autologous bone grafts (left knee). (A) The osteotomy gap is filled with the harvested bone grafts. (B) The bone grafts should be inserted adequately into the lateral cortex of the tibia.

OATS donor tube system, hematoma formation, and mild postoperative pain around the bone graft donor site. There is a small possibility of displacement of the inserted metallic block at the osteotomy site. In addition, a small additional skin incision on the medial side of the distal femur is necessary to insert an OATS donor cutting tube. However, these complications can be minimized by performing the operation cautiously. To redress the limitations of our study, it is necessary to conduct a randomized controlled trial or a comparative study with other conventional techniques (Table 2).

In conclusion, we have described a cylindrical autologous bone graft technique in combination with metallic block insertion in OW-HTO for faster bone union and better primary mechanical stability of the osteotomy site. We expect that the described procedure will enable early postoperative weight bearing and, thereby, allow an early return to normal function.

Acknowledgment

The authors thank E. H. Lee, S. M. Ji, J. M. Lee, and Lloyd Lee for editorial assistance in the preparation of the article.

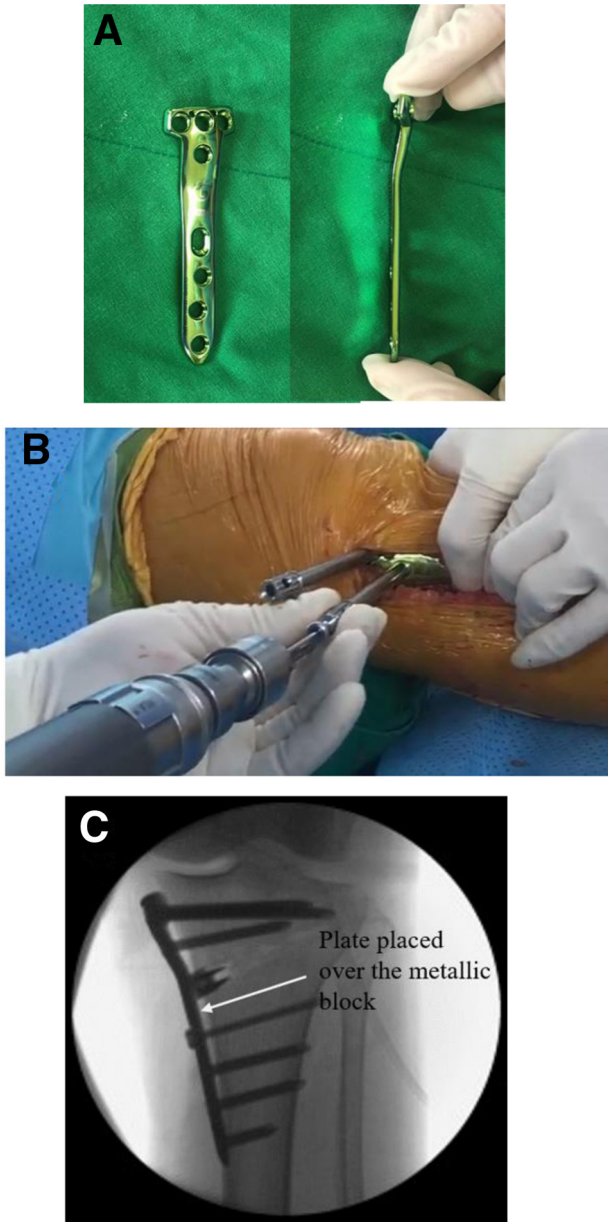

Fig 8. (A) Ohtofix high tibial osteotomy plate. (B) The plate should be placed over the metallic block to reduce the possibility of its displacement. (C) Fluoroscopic image showing plate placed over metallic block.

Table 2. Advantages, Disadvantages, and Limitations of Combination of Cylindrical Autologous Bone Grafting Technique With Metallic Block Insertion in OW-HTO

Advantages
Harvesting and implantation of cylindrical autologous bone grafts are simple and less time-consuming.
The osteotomy gap is filled with harvested autologous bone grafts.
The metallic block provides primary stability for the osteotomy site in OW-HTO.
Faster bone union is expected.
Early postoperative weight bearing is enabled.
Disadvantages and limitations
There is a possibility of fracturing the medial femoral condyle during insertion of the OATS donor cutting tube.
Hematoma formation and postoperative mild pain can occur around the bone graft donor site.
A small additional skin incision is necessary to insert the OATS donor cutting tube.
There is a possibility of displacement of the inserted metallic block.
A prospective, randomized, comparative study is necessary in the future to validate the results.

OATS, Osteochondral Autograft Transfer System; OW-HTO, open-wedge high tibial osteotomy.

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