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...
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 4A-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.

### 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.
(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 \(\times\) 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). 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. Although Staubli and Jacob reported that OW-HTO could be performed with the TomoFix plate (Synthes, Oberdorf, Switzerland) without any implantation, the use of bone substitute wedges in OW-HTO also showed acceptable clinical, radiologic,

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**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.

**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.
and histologic outcomes. Lash et al. reviewed the role of autologous bone grafting as compared with both $\beta$-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. reported that when union rates were compared, patients with $\beta$-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. reported that the use of $\beta$-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. 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 $\beta$-TCP. Second, the operating time—which is usually increased when adjusting the width of $\beta$-TCP wedges to match the size of the osteotomy gap—was decreased. The metallic block...
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. 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 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
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.

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**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.

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

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