



## Distal Tibial Tuberosity Arc Osteotomy in Open-Wedge Proximal Tibial Osteotomy to Prevent Patella Infra

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**Abstract:** Open-wedge high tibial osteotomy is considered to be an effective surgical intervention for medial compartmental knee osteoarthritis. However, patella infra, which has been reported to be a result of tuberosity distalization after open-wedge high tibial osteotomy, changes the native patellofemoral biomechanics. This could raise abnormal patellofemoral contact stresses, which might be the trigger of patellofemoral arthrosis. To minimize the reduction in patellar height, we have developed a technique called open-wedge distal tuberosity tibial osteotomy. The benefits of this technique include increased bone-to-bone contact of the distal tuberosity cut surface after correction by cutting an arc osteotomy around the hinge position, which is the center of rotation. This technique also provides cortical support at the anterior osteotomy site without additional bone defect and, therefore, may be advantageous against weight-bearing stress on the osteotomy site. In all, open-wedge distal tuberosity tibial osteotomy could potentially be a unique open-wedge osteotomy that eliminates the risk for postoperative patellofemoral osteoarthritis and also could theoretically encourage rapid healing of the osteotomy, which could lead to early return to full physical activity.

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The authors report the following potential conflicts of interest or sources of funding: Olympus Termo Biomaterials provided manuscript preparation, English proofreading service, and video narration. T.A. has consulted with and been a paid speaker for Olympus Termo Biomaterials. K. Okazaki has been a paid speaker for Olympus Termo Biomaterials. Full ICMJE author disclosure forms are available for this article online, as [supplementary material](#).

Received February 11, 2019; accepted February 21, 2019.

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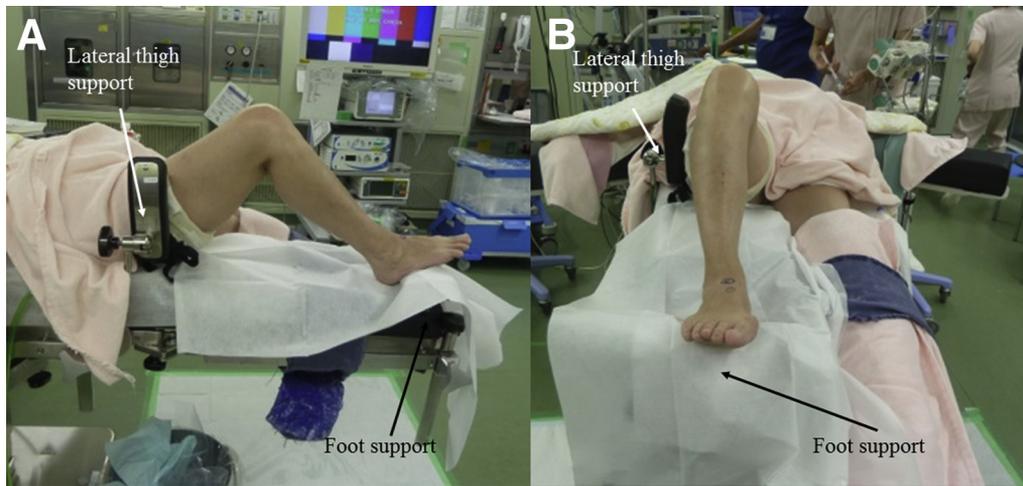
2212-6287/19167

<https://doi.org/10.1016/j.eats.2019.02.011>

High tibial osteotomy (HTO) is effective in patients with unicompartmental knee osteoarthritis (OA) with associated varus deformity and abnormal load through the medial compartment.<sup>1</sup> Because closed-wedge HTO needs to be accompanied by an additional osteotomy of the fibula, with potential risk for complications such as peroneal nerve injury, open-wedge HTO (OWHTO) has gained popularity with its favorable radiographic, biomechanical, and clinical results.<sup>2-4</sup>

As potential drawbacks of OWHTO, patella infra and patellofemoral malalignment have been reported to result from the tibial tuberosity distalization that is part of the OWHTO procedure.<sup>5-9</sup> Increased patellofemoral joint pressure and contact forces after patella infra carry a risk for the onset or progression of patellofemoral OA.<sup>10-12</sup> Goshima et al.<sup>9</sup> have reported progression of patellofemoral OA in 27% of cases by radiographs and of chondral damage in 45% of cases by arthroscopy.

To minimize patellar height reduction, several studies<sup>13-15</sup> have recommended OWHTO be performed below the tibial tuberosity for patients requiring a large degree of valgus correction; the descending incision begins distally in the frontal plane from the most



**Fig 1.** Patient's positioning on the operating table (right knee). With lateral thigh and foot supports, the operative knee (left, A) is placed in 90° of flexion during the procedure. The opposite leg (right, B) is placed lower than the operative leg.

anterior point of the transverse incision such that it is posterior to the tuberosity directed toward the anterior tibial crest. However, the plane of such an incision involves a wide area of cortical bone and lacks anterior cortical support; it may be associated with a risk for slower bone healing and biomechanical weakness at the fixation site. Thus, additional bicortical screw fixation is needed from the distal part of the tuberosity to the tibia.<sup>14-18</sup>

Here, we present a technique for medial compartmental knee OA treatment: open-wedge distal tibial tuberosity osteotomy (OWDTO). This method prevents patella infra and maintains anterior cortical contact with the tibial crest, thereby providing potentially secured fixation that could lead to rapid bone healing after osteotomy.

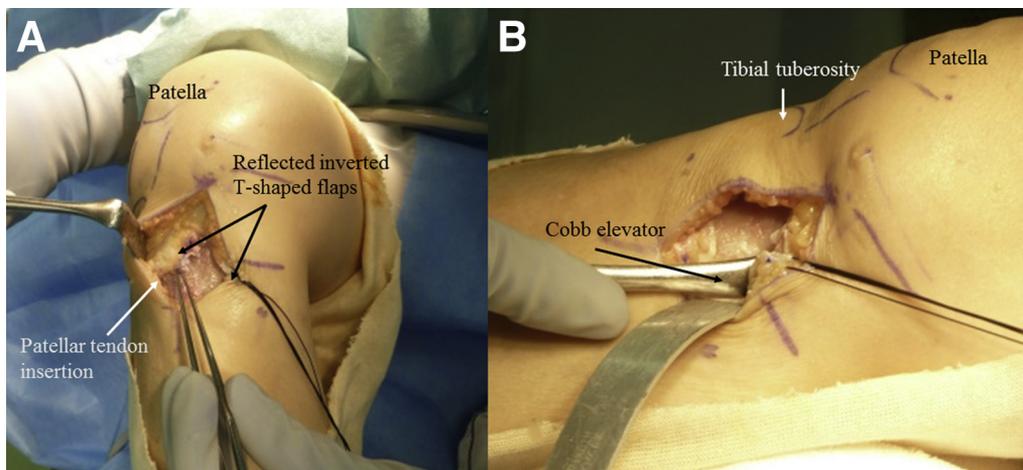
## Technique

### Indications

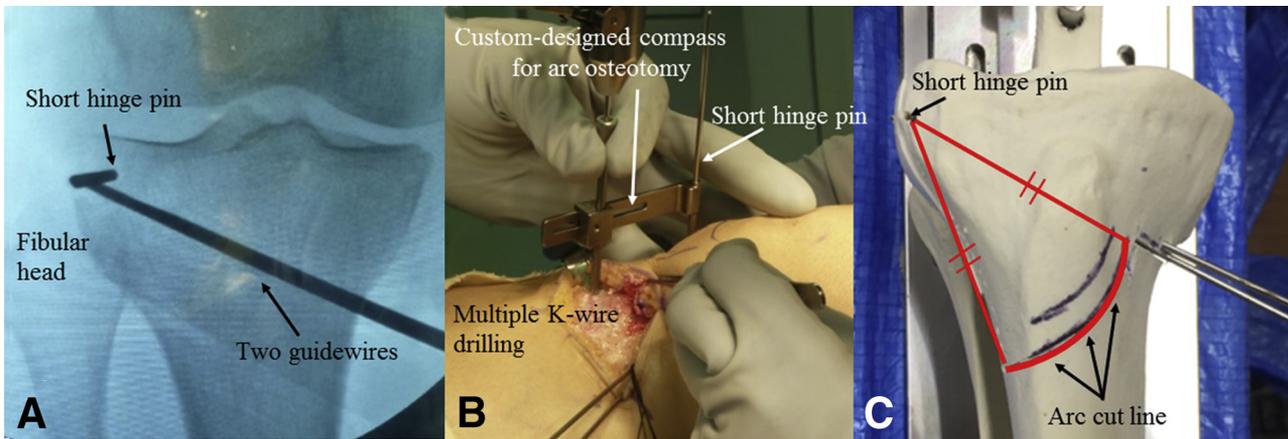
Indications for this technique include medial compartmental knee OA of Kellgren–Lawrence OA grade  $\geq 2$ , osteonecrosis of the medial femoral condyle, no symptomatic patellofemoral compartmental OA, no lateral compartmental OA, and no systemic inflammatory arthritis.

### Preparation

The patient is placed supine on the operating table under general or spinal anesthesia. A tourniquet is inflated to 280-300 mm Hg. The knee is positioned using lateral thigh and foot supports. The other leg is positioned lower to provide an easier approach to the



**Fig 2.** Reflected inverted T-shaped flaps involving the pes anserinus tendon, and underlying periosteum (right knee). (A) The patellar tendon insertion is exposed. (B) The starting point of the osteotomy is exposed using a Cobb elevator.



**Fig 3.** Preparation of the arc cut (right knee). (A) Fluoroscopic image after the insertion of a short hinge pin. (B) This hinge pin serves as an axis for a device that acts as a compass for arc osteotomy. The compass is used to describe a drill-marked arc with a radius of approximately 50 mm. Multiple 2-mm holes are then drilled along the arc line. (C) A model bone showing the arc cut line around the short hinge pin.

medial aspect of the operative knee during the surgery (Fig 1).

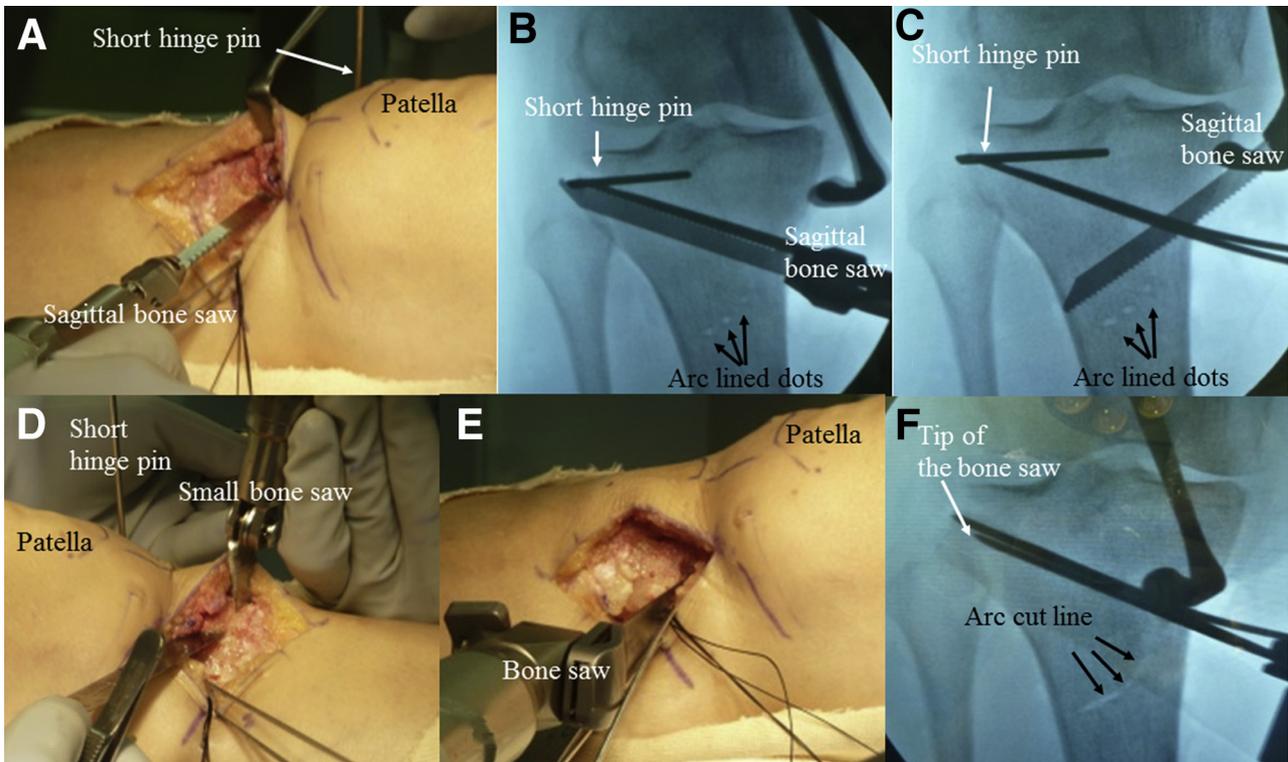
#### Arthroscopic Technique

Knee arthroscopy is performed to evaluate articular surface at all the joint compartments. Arthroscopic debridement, including meniscectomy or synovectomy,

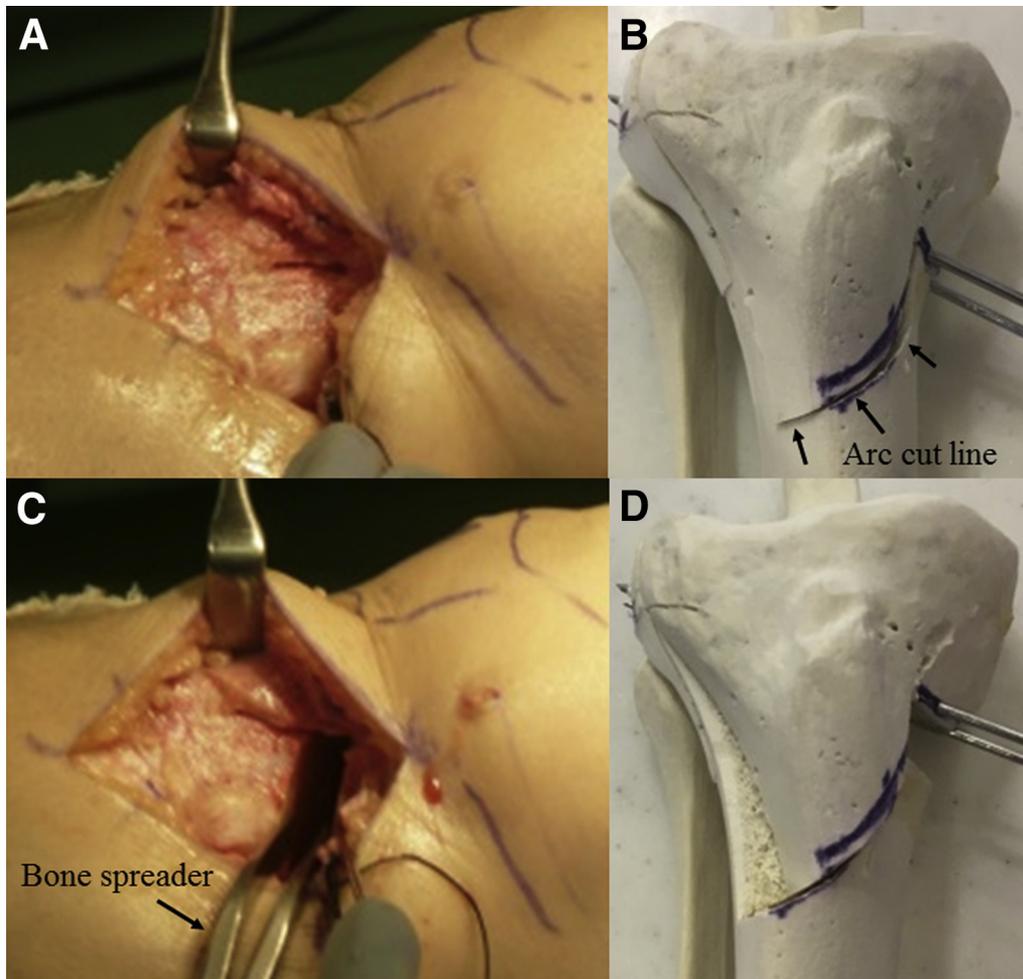
is performed if necessary. Simultaneously, osteophytes are arthroscopically harvested for the subsequent implantation into the gap formed by the OWDTO.<sup>19</sup>

#### Exposure

An 8-cm longitudinal incision is made one-third of the way anteromedially between the tibial tuberosity and



**Fig 4.** Triplane osteotomy (right knee). (A) A small sagittal bone saw is used to perform the descending osteotomy at 15 mm posterior to the tibial tubercle. (B) Fluoroscopic image showing the upper limit of the descending osteotomy. (C) Fluoroscopic image showing the lower limit of the descending osteotomy. The lower limit is shown as the arc of dots. (D) The arc osteotomy using a small bone saw. (E) Transverse osteotomy. (F) Fluoroscopic image during the transverse osteotomy. The arc osteotomy line is identified.



**Fig 5.** After completion of triplane osteotomy (right knee). (A and B) Before opening. (C and D) After opening. Interfaces at the arc osteotomy site are slid in contact with each other along the cut line.

anteromedial tibial cortex. Tendons of the pes anserinus, superficial medial collateral ligament, and underlying periosteum are sharply incised into an inverted T-shape at their distal insertion through a periosteal incision, and the flap is reflected to the patellar tendon insertion (Fig 2A) and the starting point of the osteotomy, approximately 35-40 mm distal to the medial proximal tibial joint surface. Reflection of the superficial medial collateral ligament and underlying periosteum can be facilitated with a Cobb elevator (Fig 2B). Tissues are carefully preserved for use in subsequent repair.

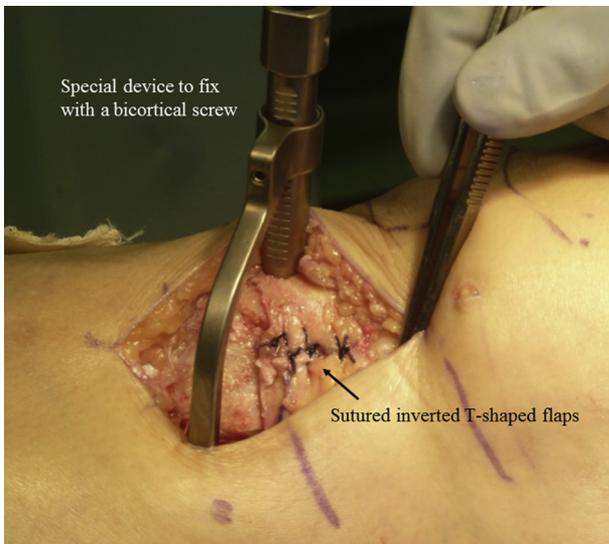
#### OWD TO Setup

Our technique is characterized by a triplane osteotomy comprising transverse, descending, and arc incisions. Like OWHTO, 2 guidewires are inserted in parallel and aimed toward the tip of the fibular head. The hinge position is defined 5 mm medial from the lateral cortical margin at the upper level of the proximal tibiofibular joint. Maintaining the neutral position of the knee joint, a short hinge pin is inserted into the hinge position in the

anteroposterior direction under fluoroscopy (Fig 3A). This pin serves as an axis for a custom-designed compass for arc osteotomy, which is used to produce a drill-marked arc with a radius of approximately 50 mm around a short hinge pin. Multiple 2-mm holes are then drilled along the arc line (Fig 3B and C).

#### Triplane Osteotomy

The descending osteotomy is initiated 15 mm posterior to the tibial tubercle and parallel to the tibial shaft in the coronal plane using a sagittal bone saw after a starting cut with a small, thin oscillating saw; care is taken not to direct the cut in the posterolateral direction. Two guidewires and the arc of drilled holes allow fluoroscopic guidance of this descending osteotomy easily and accurately (Fig 4A-C). Thereafter, the arc osteotomy is performed using a small bone saw along the arc of drill holes (Fig 4D). The end of the arc cut is connected with the descending cut. Finally, the transverse osteotomy is performed along and below the guidewires using an oscillating saw (Fig 4E and F). After



**Fig 6.** Inverted T-shaped flaps are sutured and then covered over the osteotomy gap.

ensuring that these triplane cuts are completed with the hinge area intact, the transverse osteotomy site is opened using a bone spreader after the insertion of several chisels until the mechanical axis passes through 62% of the tibial plateau. While open, interfaces at the arc osteotomy site are rotated in contact with each other along the cut line, and those at the descending osteotomy site are also kept attached to each other (Fig 5A-D, Video 1).

### Implant Placement

The gap formed by the osteotomy is filled using harvested autologous osteophyte grafts.<sup>19,20</sup> After the

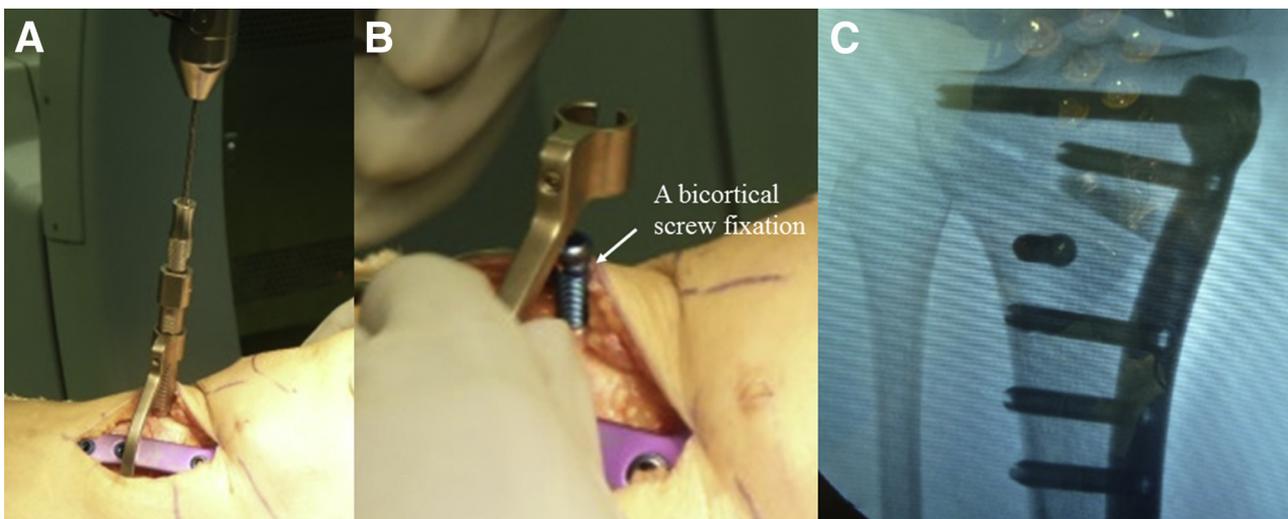
components of the descending osteotomy are compressed together using a tuberosity screw device of our own design for OWDTO, the reflected inverted T-shaped flaps are sutured and secured to each other, over the osteotomy gap (Fig 6). Fixation is accomplished using a plate and 8 screws, a TomoFix plate (Synthes, Paoli, PA), or a TRIS plate (Olympus, Tokyo, Japan), which is inserted into a subcutaneous tunnel formed on the medial aspect of the tibia. Finally, bicortical screw fixation from the tuberosity to the posterior tibia is performed using the tuberosity screw device that also shields the popliteal neurovascular bundle during this procedure (Fig 7A-C). The wound is closed after placement of a surgical drain. Pre- and postoperative radiographs are shown in Figure 8A-F. The pearls and pitfalls of this technique are shown in Table 1.

### Postoperative Rehabilitation

Active and passive range-of-motion exercises, including continuous passive motion and quadriceps muscle strengthening exercises, are initiated 2 days postoperatively. Partial weight-bearing exercises using 2 crutches are allowed at 1 week and full weight-bearing exercises at 4 weeks postoperatively. Moderate sports activities, including jogging, are allowed at 3 months postoperatively.

### Discussion

This Technical Note describes a technique, OWDTO, performed with a triplane osteotomy (Fig 9A-C). The advantages of this technique involve cortical bone continuity of the tibial crest and an extensive cancellous bone contact area after the correction, provided by the arc and descending osteotomies (Table 2).



**Fig 7.** An additional bicortical screw insertion after plate and screw fixation (right knee). (A and B) Additional bicortical screw fixation from the tuberosity to the posterior tibia is performed using the tuberosity screw device. (C) Postoperative fluoroscopic image.



**Fig 8.** Pre- and postoperative plane radiographs (left knee). (A) Preoperative anteroposterior view. (B) Preoperative lateral view. (C) Preoperative whole leg standing view. (D) Postoperative anteroposterior view. (E) Postoperative lateral view. (F) Postoperative whole leg standing view.

Previous studies<sup>13-15</sup> on distal tuberosity osteotomy in OWHTO reported biplane osteotomies involving a descending cut in the frontal plane, from 1 cm behind the tibial tuberosity directly toward the anterior distal tibial cortex. On opening the osteotomy site in this procedure, the tuberosity fragment moved and protruded medially without cortical bone support. The larger correction angle led to a more medial protrusion of the distal tuberosity fragment, decreasing the contact area of cancellous bone and risking delayed union. In addition, this fragment

tended to move away from the osteotomy surface if the correction angle was larger because the opening direction along the tibial shaft was not parallel to the direction of the descending osteotomy in the sagittal plane. Moreover, fragment thickness <1 cm and imprecise screw fixation of the fragment were associated with increased risk for tuberosity fracture, necessitating precise additional bicortical screw fixation of this fragment.<sup>14,18</sup>

Conversely, our technique maintains the continuity of cortical bone around the arc osteotomy site with wide

**Table 1.** Pearls and Pitfalls

Pearls	Pitfalls
<ul style="list-style-type: none"> <li>• A more anterior skin incision is useful in approaching the area around the tibial tuberosity.</li> <li>• A short hinge pin is helpful to identify an accurate arc cut around the hinge point (the center of the arc) with a radius of approximately 50 mm.</li> <li>• The anteroposterior width from the tibial tuberosity to the starting point of the descending cut must be thick enough (15 mm) to minimize the risk for fracture.</li> <li>• Compression of the components of descending osteotomy together provides a wide cancellous bone contact surface.</li> <li>• An additional bicortical screw insertion after a plate and screw fixation ensures robust fixation of the osteotomy site.</li> </ul>	<ul style="list-style-type: none"> <li>• Care must be taken to prevent cutting along the posterolateral direction in the descending osteotomy.</li> <li>• All the triplane cuts must be checked to ensure that they are completed with the hinge intact to prevent iatrogenic fracture.</li> <li>• The risk for popliteal neurovascular bundle injury should be minimized using a radiolucent retractor when an additional bicortical screw is inserted from the tuberosity to the posterior tibia.</li> </ul>

cancellous bone contact surfaces, thereby providing anterior cortical support against weight-bearing stress. High stability and abundant blood supply are necessary for bone healing. Unlike the conventional technique, the anterior cortical support, wide cancellous bone contact surfaces, and additional use of a bicortical screw to fix this fragment may enhance stability and thus promote bone healing at the fixation site. Indeed, early bone healing in the arc and descending osteotomy sites was observed in most of our cases, which supports our hypothesis (Fig 8A-F, Fig 9A-C).

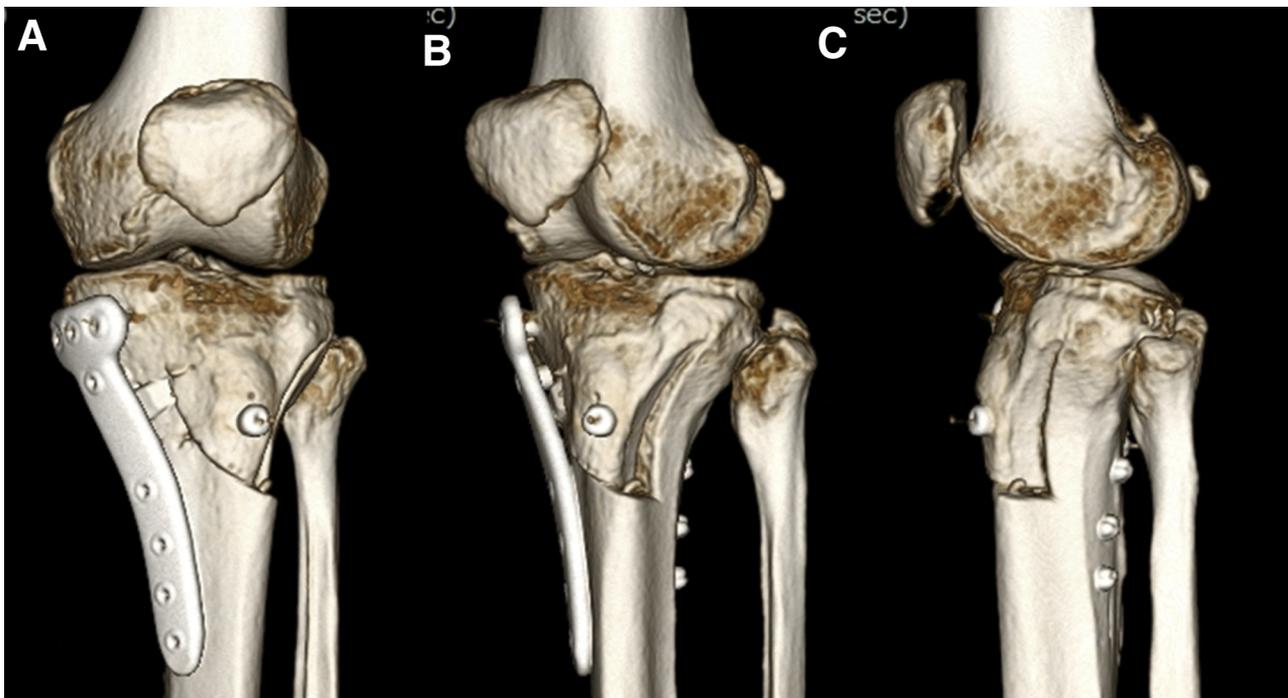
As a limitation of our study, we present only the concept and procedure of our osteotomy technique. To prove the significance of this procedure, it is mandatory to conduct a randomized controlled trial or a comparative study with the conventional technique.

## Conclusions

We introduce a surgical technique, OWDTO, as a triplane osteotomy that prevents patella infra and provides anterior cortical support without a bone defect in the tibial crest. This method could be an open-wedge osteotomy that minimizes the risk for patellofemoral pathology, with potentially good bone healing capacity. Randomized clinical trials with conventional OWHTO will be necessary to show the clinical significance of this procedure.

## Acknowledgments

The authors thank Shunsuke Nakamura and Kisato Saito for editorial assistance in the preparation of the article.



**Fig 9.** Three-dimensional computed tomography showing finished osteotomy, including the arc osteotomy (left knee). (A) Postoperative anteroposterior view. (B) Postoperative anterolateral oblique view. (C) Postoperative lateral view.

**Table 2.** Advantages, Risks, and Limitations of Open-Wedge Distal Tuberosity Tibial Osteotomy (OWDTO) in this Study**Advantages**

- Patella infra is prevented.
- Anterior cortical continuity on the tibial crest will enhance stability at the fixation site.
- A wide cancellous bone contact surface at the descending osteotomy site will promote bone healing.
- Improvement of knee range of motion is shortened after OWDTO.

**Risks and limitations**

- Operation time may be prolonged.
- An additional bicortical screw fixation may be necessary.
- Prospective randomized comparative studies are warranted in the future.

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