**Technical Note**

Interlocking Closed-Wedge High Tibial Osteotomy Modified With Oblique Osteotomy Lines and a Locking Plate Fixation

Ken Okazaki, M.D., Ph.D.

**Abstract:** Closed-wedge high tibial osteotomy (CWHTO) is more advantageous over open-wedge high tibial osteotomy in the following viewpoints: (1) compression force from the patellar tendon to the osteotomy site contribute to its stability, (2) patellar baja less likely occurs, and (3) hardware implant is placed under the thick muscle, which could prevent risk of irritation and infection. Although conventional CWHTO resects the wedge bone, including the anterior and posterior cortices, interlocking CWHTO preserves them while performing osteotomy for the anterior or posterior cortex with only the proximal or distal osteotomy line, respectively. When the wedge is being closed, the distal fragment is internally rotated overlying the anterior and posterior cortices on the proximal and distal cortices, respectively. As a result, good rotational stability and anterior advancement of the tibial tubercle are obtained. Interlocking CWHTO can be applied for patients with moderate patellofemoral osteoarthritis. Adopting an oblique osteotomy line enables secure multiple screw fixations for a long locking plate with a good fitting, allowing early postoperative weightbearing.
on the lateral cortex (Fig 2). Informed consent was obtained from the patient for the presentation in this article.

Preoperative Planning

A standard preoperative planning for CWHTO is conducted using a weightbearing long-leg radiograph and a targeted weightbearing line running on 65% of the tibial joint surface from its medial edge (Fujisawa point). The correction angle, length of the proximal osteotomy line from the hinge point (15 mm distal from the medial edge of the joint) to the 40 mm distal from the lateral joint surface, and distance between the two osteotomy lines on the lateral wall of the tibia are measured (Fig 3).

Surgical Techniques

Fibular Osteotomy (Video)

Fibular osteotomy is performed at the mid portion of the diaphysis, from the posterior margin of the peroneus longus muscle to the posterior edge of the fibula with a caution not to injure the superficial peroneal nerve. The fibula must be exposed in the periosteal fashion with caution not to injure the fibular artery and
vein located just behind the fibula. Osteotomy is made either with bone fragment resection for 15 mm or an oblique transection (Fig 4). Fibular osteosynthesis is not necessary.

Tibial osteotomy (Video)
A curved incision is made from above of the fibular head to 3 cm distal to the tibial tubercle. The fascia of the tibialis anterior is incised, and the muscle is detached from the lateral wall of the tibia. The posterior wall of the tibia is exposed under the periosteal fashion, and a radiolucent Hohman retractor is placed behind the targeted distal osteotomy line. The periosteum is incised at the lateral edge of the tibial tubercle to expose the proximal border of the patellar tendon insertion.

A 2-mm K-wire is inserted under a fluoroscopic guidance at 40 mm distal from the lateral joint surface on the lateral wall of the tibia to 15 mm distal from the medial edge of the joint. The insertion length (l') is measured and compared with preoperative planning (l) to adjust the distance on the lateral edge of the tibia (d'). Another 2-mm K-wire is inserted at the adjusted distance (d') away from the previous K-wire and placed across the previous wire at the medial edge of the tibia (Fig 5).
A rectangular-shaped cortex is removed from the lateral wall of the tibia. Depending on the bone size, a 15- to 20-mm chisel is used to cut the bone inside the two K-wires parallel to each other and perpendicular to the posterior wall of the tibia. Depending on the distance between K-wires, a 5- to 10-mm chisel is used to cut the bone at the anterior and posterior edges of the lateral wall. Then, a rectangular-shaped cortex is removed. Next, a wedge-shaped cancellous bone is removed between K-wires. Under fluoroscopic guidance, a 15- to 20-mm chisel is inserted into the cancellous bone inside with the K-wires until the tip reaches the medial cortex. After removing the wedge-shaped cancellous bone, the residual cancellous bone on the anterior and posterior cortices is completely scraped out using a bone curette (Fig 6).

For the posterior cortex, a radiolucent Hohman retractor is placed behind the distal osteotomy line, and a single-edged reciprocating saw is inserted into the wedged bone space along the distal osteotomy line until the tip reaches the medial cortex under fluoroscopic guidance. The distal osteotomy line on the posterior cortex is cut (Fig 7).

A small Hohman retractor is placed under the patellar tendon to expose the proximal edge of the patellar tendon insertion. The saw is inserted along with the proximal osteotomy line until the tip of the saw reaches the medial cortex. Osteotomy of the anterior cortex is performed in an oblique direction toward the proximal edge of the patellar tendon insertion (Fig 8).

When closing the wedge, the lower leg is internally rotated so that the anterior cortex of the wedge overlies the anterior cortex of the proximal fragment and the posterior cortex overlies the posterior cortex of the distal fragment (Fig 9).

Osteosynthesis is performed using an anatomically shaped locking plate for the proximal lateral tibia with 8 screws, such as the Tomofix Lateral High Tibial Plate (DePuy Synthes, West Chester, PA) or TriS Lateral HTO Plate (Olympus Terumo Biomaterials, Tokyo, Japan) (Fig 2).

**Postoperative Rehabilitation**

Active range of motion exercises are started the next day. Partial weightbearing is allowed from 1 week after operation, and the weight is gradually increased up to full weightbearing as tolerated.

**Discussion**

OWHTO has become the most popular surgical technique for proximal tibial osteotomy with the modern surgical technique consisting of a biplanar osteotomy and a rigid plate fixation. Nevertheless, OWHTO has several concerns such as postoperative patella baja, infection, increase of posterior tibial slope, and delayed union of the osteotomy site. CWHTO should be reconsidered, especially for patients with patellofemoral lesion, large correction, a risk of delayed union, or infection. Furthermore, IL-CWHTO with a long locking plate improves the fixation stability and patellofemoral kinematics.

Although the interlocking procedure improved the rotational stability, the original IL-CWHTO by Ogata used a step-shaped staple for fixation combined with a postoperative immobilization, and partial weightbearing was indicated for 6 weeks. The procedure was modified by adopting an oblique osteotomy line, enabling the use of 4 proximal screws for fixation eliminating a step-off of the lateral cortex at the osteotomy site that
improves fitting of an anatomic long locking plate. As a result, postoperative rehabilitation can be accelerated, allowing early full weightbearing as tolerated.

Ventralization, internal rotation, and proximal translation of the tibial tubercle are other attractive advantages of IL-CWHTO. Ogata \(^3\) reported a good clinical result of 36 knees. Although all knees had slight to severe degenerative changes of the patellar articular surface before surgery, the postoperative subjective assessment at 1 to 3 years after operation showed good results in 78\%, fair results in 22\%, and no poor result in terms of pain relief and walking tolerance. Improvement of the patellofemoral alignment in the skyline Merchant view of the radiograph is also presented.

Pitfalls and anticipated complications should be noted (Table 1). The medial hinge fracture sometimes occurs, especially in patients with hard bone quality. An incomplete osteotomy on the posterior cortex should be avoided by double checking if the osteotomy reaches the medially cortex under fluoroscopic guidance. The medial hinge is preserved and the lateral wall is continuous without a step-off. Fluoroscopic image of right knee is shown.

Fig 7. Osteotomy of the posterior cortex is performed only on the distal osteotomy line. A single-edged reciprocating saw is inserted into the wedged bone space along the distal osteotomy line until the tip reaches the medial cortex under fluoroscopic guidance. A retractor is placed under the posterior cortex to protect the popliteal neurovascular bundle. The distal osteotomy line is cut with the saw. Right lower leg is shown.

Fig 8. Osteotomy of the anterior cortex is performed only on the proximal osteotomy line. A small Hohman retractor is placed under the patellar tendon to expose the proximal edge of the patellar tendon insertion. The saw is inserted into the wedged bone space along with the proximal osteotomy line until the tip of the saw reaches the medial cortex under fluoroscopic guidance. Osteotomy of the anterior cortex is performed in an oblique direction toward the proximal edge of the patellar tendon insertion. Right knee is shown.

Fig 9. Closing the wedge. (A) When closing the wedge, the lower leg is internally rotated so that the anterior cortex of the wedge overlays the anterior cortex of the proximal fragment and the posterior cortex overlays the posterior cortex of the distal fragment. Right knee is shown. (B) Fluoroscopic image after closing the wedge. The medial hinge is preserved and the lateral wall is continuous without a step-off. Fluoroscopic image of right knee is shown.

In conclusion, IL-CWHTO provides firm rotational stability and improves patellofemoral kinematics. Adopting an oblique osteotomy line enables secure...
multiple screw fixations for a long locking plate with a good fitting. This procedure is beneficial for medial knee osteoarthritis with moderate patellofemoral degeneration, relatively large correction, and potential risks for complications, such as infection and delayed bone union.

Acknowledgment

The oblique osteotomy in IL-CWHTO was originated by Dr. Hideya Kawamura, Kagoshima, Japan.

References

1. Bonasia DE, Governale G, Spolaore S, Rossi R, Amendola A. High tibial osteotomy. *Curr Rev Musculoskelet Med* 2014;7:292-301.

2. Cheng XY, Liu FX, Xiong F, Huang YJ, Paulus AC. Radiographic changes and clinical outcomes after open and closed wedge high tibial osteotomy: a systematic review and meta-analysis. *J Orthop Surg Res* 2019;14:179.

3. Ogata K. Interlocking wedge osteotomy of the proximal tibia for gonarthrosis. *Clin Orthop Relat Res* 1984;186:129-134.

4. Staubli AE, De Simoni C, Babst R, Lobenhoffer P. TomoFix: 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).

5. 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.

6. Goshima K, Sawaguchi T, Shigemoto K, et al. Large opening gaps, unstable hinge fractures, and osteotomy line below the safe zone cause delayed bone healing after open-wedge high tibial osteotomy. *Knee Surg Sports Traumatol Arthrosc* 2019;27:1291-1298.

7. Woodacre T, Ricketts M, Evans JT, et al. Complications associated with opening wedge high tibial osteotomy—a review of the literature and of 15 years of experience. *Knee* 2016;23:276-282.

8. Lee SS, So SY, Jung EY, Kim HJ, Lee BH, Wang JH. Predictive factors for patellofemoral degenerative progression after opening-wedge high tibial osteotomy. *Arthroscopy* 2019;35:1713-1720.

9. Kaya H, Dastan AE, Bicer EK, Taskiran E. Posteromedial open-wedge high tibial osteotomy to avoid posterior tibial slope increase. *Arthroscopy* 2020;36:2710-2717.

---

**Table 1. Benefits, risks, and limitations of interlocking closed wedge high tibial osteotomy**

| Benefits | |
|---|---|
| Improved rotational stability |
| Increased contact area |
| Ventralization, internal rotation and proximal translation of the tibial tubercle |
| Locking plate fixation |
| Less risk of infections |

| Risks and Limitations | |
|---|---|
| Medial hinge fracture |
| Fibula osteotomy is necessary |
| Neurovascular injury including the peroneal nerve palsy |