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Technical Notes

A new double level osteotomy procedure to restore a joint line and joint angles in severe varus osteoarthritis. - Double level osteotomy associated with tibial condylar valgus osteotomy (DLOTO) -

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ABSTRACT

High tibial valgus osteotomy (HTO) is a well-established surgical procedure to correct a varus malalignment and treat medial compartment osteoarthritis. Recently, double level osteotomy (DLO) recommended for extensive varus knees as a single level osteotomy (SLO) approach may create an excessive joint line obliquity and eventually result in a new bony deformity. However, a severe varus knee in cases of advanced osteoarthritis involves not only a bony deformity (extra-articular deformity) but also a medial joint space narrowing with a widened lateral joint space (intra-articular deformity). A DLO alone cannot reduce this intra-articular deformity. However, tibial condylar valgus osteotomy (TCVO) can complement DLO as to reduce this intra-articular deformity. This technical note describes a novel modified DLO procedure associated with TCVO which can restore a normal alignment and a joint line and achieve joint preservation even in cases of extensive varus osteoarthritis.

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Introduction

There has been a modern resurgence of interest in osteotomy surgery¹ in both Europe and Asia. The core principle underlying an osteotomy around the knee is to shift the load to the intact compartment with the aim of improving symptoms and postponing or avoiding arthroplasty. Open wedge high tibial valgus osteotomy (OWHTO) is a well-established surgical procedure performed in patients with varus malalignment and medial compartment osteoarthritis.^{2–4} However, in cases of an extensive varus knee, the use of a double level osteotomy (DLO), which is OWHTO associated with distal femoral osteotomy (DFO), is recommended⁵ because both the femur and tibia are usually involved in the deformity. A single level osteotomy (SLO) in such cases may create

an excessive joint line obliquity⁶ thereby increasing the shear stress at the joint surface,⁷ and finally resulting in a new bony deformity. The advantage of using DLO for a varus deformity is its ability to unload the affected joint compartment by normalizing the knee joint angles and their orientation.^{7–9} DLO has become more popular recently, especially in Germany where the number of procedures is increasing continuously, and also in Japan.^{5,10} Notably also, DLO has been conducted in some centers that have reported good results from this procedure in cases of extensive varus deformity involving the femur and tibia.^{5,6,10,11} The survival rate for cases with an adequate correction by DLO is reported to be 100% after 10 years, which is superior to most of the long-term results described for HTO.^{11,12}

Knee osteoarthritis is a progressive degenerative disease characterized by a gradual loss of articular cartilage around the knee. Accordingly, a severe varus deformity in patients with knee osteoarthritis is formed not only by the bony deformity but also by the medial joint space narrowing with a widened lateral joint space.

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This results in an increased joint line convergence angle (JLCA). In such knees involving both an intra- and extra-articular deformity, an osteotomy is not capable of reducing the intra-articular deformity even if a DLO is used and the load is shifted to a healthy compartment.¹³ By contrast, tibial condylar valgus osteotomy (TCVO), which was developed in Japan in 1990 and reported by Chiba et al.,¹⁴ can reduce an intra-articular deformity by elevating the medial tibial plateau, despite the limited amount of valgus correction.¹⁴ We thus developed a novel DLO approach to correcting a severe varus deformity with an intra-articular deformity by incorporating the TCVO surgical technique.

This technical note by a novel technique describes our novel technique which involves a modified double level osteotomy associated with TCVO (DLOTO) to restore a normal alignment and a joint line in patients with severe osteoarthritis in the knee.

Surgical indications

Indications for DLOTO include a symptomatic severe varus malalignment and medial compartment osteoarthritis. As to patient selection, patients who are less than 60 years old, active and desire knee joint preservation are preferable, regardless of gender. All of our patients treated with DLOTO to date were active despite their osteoarthritis. The range of motion should be more than a 20° extension and more than a 100° flexion. A DLO has usually been considered in the past if the simulation of an open wedge HTO resulted in a medial proximal tibial angle (MPTA) of more than 94°, or if the deformity analysis revealed a mechanical lateral distal femoral angle (mLDFA) > 90° combined with a MPTA < 87°. Further, if a JLCA of more than 6°¹³ or if a total tibial plateau inclination (TTPI), which is the sum of the medial tibial inclination (MTPI) and lateral tibial plateau inclination (LTPI) (Fig. 1a and b), of

less than -10° and an LTPI of more than 5° was evident, DLOTO should be considered to restore both the preoperative JLCA and the total alignment. A JLCA of more than 6° or a TTPI of less than -10°, but a LTPI of less than 0° (pagoda type), is also an indication for a DFOTO procedure (DFO associated with isolated TCVO) (Fig. 1c). That is, the difference in these surgical indication between DLOTO and DFOTO come from the difference in the morphology of the proximal tibia, if LTPI increased and MTPI decreased, which involves both extra-articular and intra-articular deformity in the proximal tibia, adding OWHTO to TCVO (DLOTO) should be considered (Fig. 1d). A decision tree was shown in Fig. 2.

Surgical technique

Distal femoral osteotomy

Distal femoral osteotomy procedures were performed under general anesthesia without an air tourniquet and using single dose antibiotics and tranexamic acid. To facilitate bone healing after a lateral closed wedge osteotomy at the distal femur, the lengths of the proximal and distal cut of the osteotomy should be equal to avoid overstuffing of the lateral cortex.¹⁵ The double plane lateral closed wedge osteotomy was performed to achieve an intact hinge point at the medial cortex. The minimally invasive subvastus-approach for the lateral closed wedge DFO, which was modified by the AO Joint Preservation and Osteotomy Group was used.⁵ This method involves a 5–7 cm longitudinal skin incision after which the vastus lateral muscle is retracted to the anterior and the dorsal septum was dissected to a length of 3 cm in order to position a radiolucent retractor in the back to protect the neurovascular structures. Four 2.4 mm osteotomy guide pins (AR-13303-2.4; Arthrex GmbH, Naples, FL) were positioned according to this

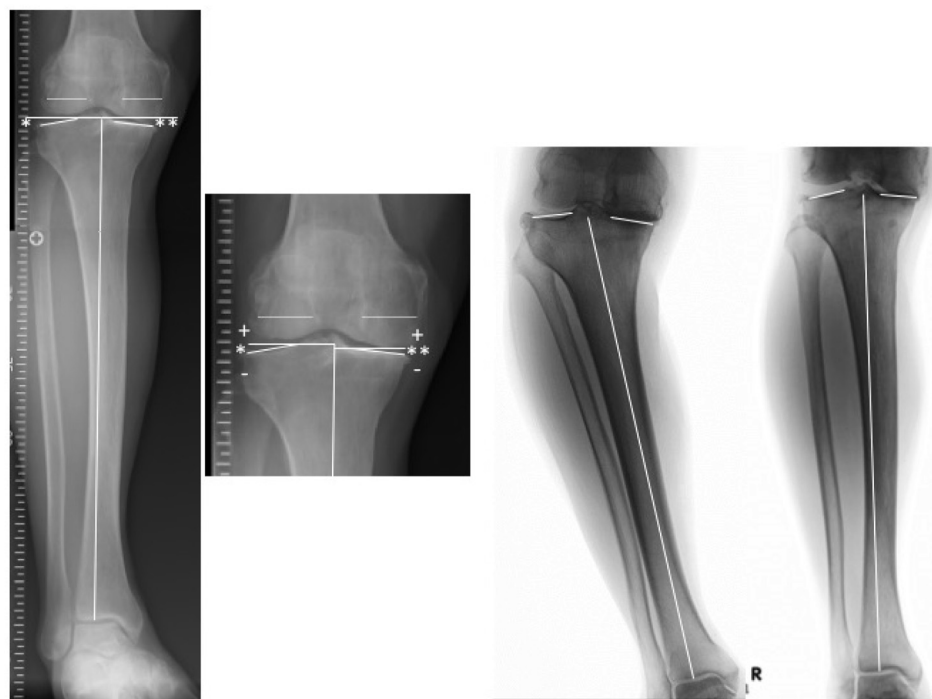


Fig. 1. ab) Measurement of tibial plateau inclination. a) *: lateral tibial plateau inclination (LTPI), **: medial tibial plateau inclination (MTPI), the length of LTPI and MTPI was defined as the same width of femoral condyle. b) the value of Inclination with respect to the perpendicular line to the tibial mechanical axis is expressed as the value with plus or minus, The formula for total tibial plateau inclination (TTPI) was calculated as $TTPI = MTPI + LTPI$. cd) different type of morphology of tibial plateau inclination. c) both medial and lateral plateau varus deformity was a good candidate for TCVO + OWHTO. d) “Pagoda type” deformity was a good candidate for TCVO.

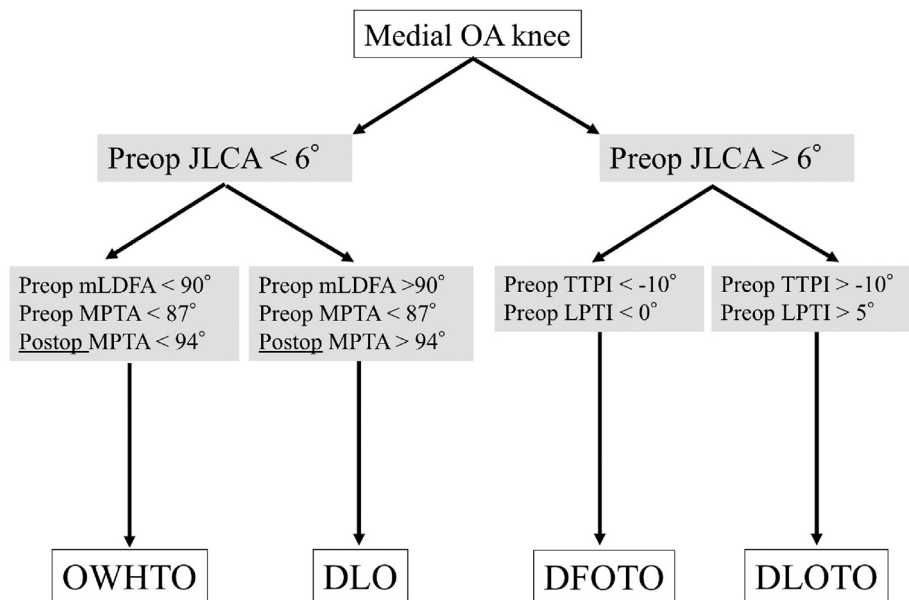


Fig. 2. A flow chart for the indication of DFOTO or DLOTO based on deformity analysis.

planning after the distance between them was measured with a precision calliper (Calliper for corpectomy, short, No 324.060; DePuySynthes, Solothurn, Switzerland). The transversal cut was made prior to the ascending cut using a Stryker Precision™ Oscillating Tip Saw (Stryker Surgical, Kalamazoo, MI). The wedge could subsequently be removed and grafted into the following tibial osteotomy. The osteotomy could then be closed slowly protecting the hinge under valgus stress.

A TomoFix MDF plate (DePuySynthes, Solothurn, Switzerland) from the contralateral side was bent and put on the lateral aspect of the distal femur. Initially, the 5.0 locking screws fixed the plate to the distal femur after temporary 2 mm K-wire fixation. Under valgus stress, a bicortical hole was eccentrically positioned in the combi-hole of the TomoFix MDF plate to provide more compression to the osteotomy. Using a proximal stab incision at the level of the proximal holes, the drilling sleeve could be inserted through a PassPort Button Cannula (8 mm ID*5 cm, AR-6592-08-50; Arthrex GmbH) and the 5.0 locking screws could be positioned. Before completing the plate fixation, the bicortical screw which compressed the osteotomy was replaced to a bicortical angular locking screw. The drain was then placed and the layers were closed. The alignment was controlled and compared to the preoperative planning.⁵ If hinge fracture occurred in distal femur, double plating at contralateral side should be considered. The surgery was completed with isolated TCVO only or TCVO combined with OWHTO.

Proximal tibial osteotomy

A 5-cm longitudinal incision sited distal to the medial joint line at the level of the pes anserinus, facilitated dissection that would expose the medial tibia. Two guide pins were placed in the tibia at the metaphyseal flare parallel to the tibial slope and aimed towards the tibiofibular joint tip as in the OWHTO technique after release of a superficial layer of medial collateral ligament.^{16,17} Two antero-posterior guide pins were then inserted from the medial border of patella tendon to an insertion of the posterior cruciate ligament to enable intra-articular osteotomy (Fig. 3ab). The transverse plane osteotomy was made to within 5 mm of the lateral cortex with the

biplanar ascending osteotomy created in the TCVO with OWHTO knees. The biplanar ascending osteotomy was created under the tibial tuberosity. In the knees in which an isolated TCVO only was planned, only the transverse plane osteotomy without a biplanar ascending osteotomy was made as far as the antero-posterior guide pins. The osteotomy was completed with the Stryker Precision™ Oscillating Tip Saw (Stryker Surgical). The osteotomy to the intercondylar eminence was achieved with a saw along the antero-posterior guide pins under a lateral view with a fluoroscope. These osteotomies were stacked and the gap was gently spread after applying the valgus stress using a spreader which was positioned at the posterior border of the transverse plane osteotomy. Valgus correction was controlled with the aim of achieving 65% of the mechanical axis with an alignment rod¹⁸ (Fig. 3c). After positioning of a locking plate (TomoFix anatomical; DePuySynthes) using a minimally invasive subcutaneous approach, a bony fragment of medial tibial plateau was temporary fixed with a couple of 2.0 mm K-wires (Fig. 3d). A bicortical temporary lag screw was then inserted in the first hole of TomoFix plate distal to the osteotomy in order to compress the lateral hinge and antero-posterior osteotomy, whilst maintaining the inclination of the medial tibial plateau (Fig. 3e). The remaining holes were filled with 5.0 mm locking screws before the bicortical lag screw and temporary K-wires were then replaced with a 5.0-mm locking screw. Iliac bone autograft or artificial bone materials should be put into any open space at this stage to avoid postoperative correction loss and facilitate bone healing. Finally, soft tissues were closed over a drain. Arthroscopy was performed to assess the cartilage and meniscus after the osteotomy had been completed.

Duration of all the procedure

All of procedure including distal femoral osteotomy, proximal tibial osteotomy and arthroscopy were performed under general anesthesia without tourniquet. The entire duration of the procedures was usually taken from 1.5 h to 2 h (distal femoral osteotomy: 40–50 min, proximal tibial osteotomy: 40–50 min, and arthroscopy: 10–20 min).

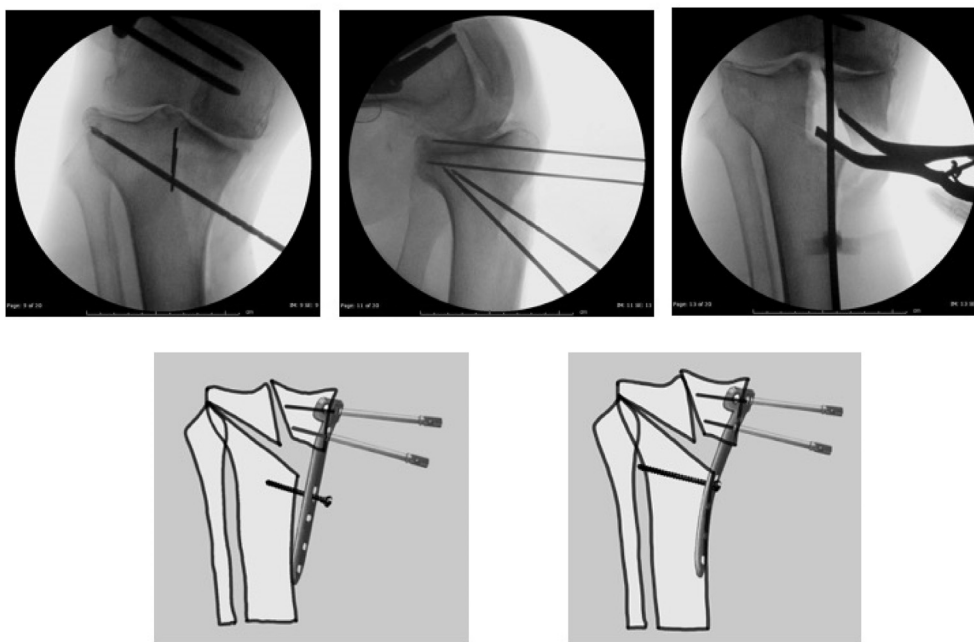


Fig. 3. Schema of osteotomy and fixation of proximal tibia.

a) anteroposterior view after insertion of guide pins. b) lateral view before starting osteotomy. c) if only TCVO could not shift the weight bearing line to lateral compartment (aiming point), perform additional OWHTO. d) after addition of OWHTO, while a TomoFix plate putting on the medial aspect of proximal tibia, the proximal medial bony fragment was fixed with temporary K-wires. e) according to a bicortical temporary lag screw was inserted in the first hole of TomoFix plate, a bony overhang created during both TCVO and OWHTO, then the lateral hinge and antero-posterior osteotomy were compressed by the plate. Because a few degrees of correction loss were often observed during this technique, a few more degrees of prior overcorrection than the aimed mechanical axis should be considered.

Postoperative rehabilitation

Active physiotherapy and range of motion exercise using a continuous passive motion machine was started postoperatively after removal of the drain. Full weight-bearing and range of motion exercises were initially allowed from the day after surgery if the pain could be tolerated, although we advised to use two crutches without braces and casts 6 weeks after surgery. If a hinge fracture was observed intraoperatively and postoperatively, weight bearing was strictly controlled while observing pain and radiographs. Walking without crutch permitted 6–8 weeks after surgery. Bone union can be usually obtained by 3–6 months after surgery. Athletic activities were then permitted after the osteotomy gap is filled.

Long leg standing X-ray assessments in a representative case

A long leg standing X-ray of a patient revealed bilateral huge varus (Fig. 4a). A preoperative Rosenberg view revealed a bilateral “bone-on-bone” deformity (Fig. 4b). DLOTO with an iliac bone graft was performed in the right knee (Fig. 4c) and DLO with no grafting was done in the left knee. A postoperative long leg X-ray revealed normal alignment and physiological joint-line reacquired (Fig. 4d). Preoperative and postoperative deformity analysis was also conducted (Table 1). The bilateral extensive varus deformity in this patient was well corrected by the controlled osteotomy from the viewpoint of the deformity analysis in single staged surgery.

Discussion

The most important goal of an osteotomy around the knees is to restore the normal joint angles at the distal femur (mL DFA) and the proximal tibia (MPTA), to avoid joint line obliquity, and to ultimately achieve a normal alignment which results in a good clinical outcome. The aim of a DLO for varus deformity is a slight overcorrection with a hip-knee-ankle angle (HKA) of 0–2° valgus.⁵

However, with regard to varus osteoarthritis of the knee involving an intra-articular deformity due to a meniscus deficit, cartilage wear or bony deformity (usually with a large JLCA), neither a standard HTO nor a DLO will achieve a satisfactory change in the JLCA.¹³ On the other hand, a TCVO could alter JLCA in addition to the MPTA, making it suitable for treating cases with a large JLCA and widened lateral joint. However, a TCVO procedure was limited in terms of angle of valgus correction.¹⁴ The new surgical methodology we have here introduced that combines the DLO and TCVO procedures (DLOTO) can restore both an intra-articular and extra-articular deformity even when these are combined in the one patient (i.e. femur and tibia). However, the difficulties of this technique were to plan and conduct osteotomies to share the large amount of correction angle based on deformity analysis to restore physiological joint-line while preventing hinge fracture of femur and tibia. If they did not work, under-correction of weight bearing line and/or insufficient correction of inclination of medial tibial plateau fragment would adversely affect clinical outcomes. Most frequent complication was delayed union of proximal tibial osteotomy. From the perspectives of preventing correction loss after surgery, iliac bone autograft and artificial materials into the proximal tibia should be considered to obtain earlier bone healing. Moreover, our present findings are preliminary only and further follow-ups are necessary to properly determine the clinical benefits of our new technique. Nevertheless, the DLOTO approach can be readily performed by experienced operators because it combines the already established DLO and TCVO procedures. We believe that our new approach will prove to be effective in correcting large varus deformities associated with medial osteoarthritis.

Declaration of competing interest

The authors declare no conflicts of interest in relation to this study.



Fig. 4. X-ray assessments in a representative case a) a case of bilateral extensive varus deformity. b) Rosenberg view revealed severe osteoarthritis. c) DLO with TCVO was conducted in right knee. d) a postoperative long leg standing X-ray showed restored normal alignment.

Table 1
Pre and postoperative deformity analysis in a patient treated using DLOTO.

	R		L	
	Preop	Postop	Preop	postop
%MA	-66	50	1	48
HKA	-31	0	-13	-1
FTA	204	174	185	175
mLDFA	90	86	89	86
MPTA	69	88	83	89
JLCA	10	5	5	5
MTPI	-30	-2	-13	-2
LTPI	6	2	13	2
TTPI	-24	0	0	0

%MA, % mechanical axis; HKA, hip-knee-ankle angle; FTA, femoro-tibial angle; mLDFA, mechanical lateral distal femoral angle; MPTA, medial proximal tibial angle; JLCA, joint line congruence angle; MTPI, medial tibial plateau inclination; LTPI, lateral tibial plateau inclination; TTPI: total tibial plateau inclination.

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