

Anterior Proximal-to-Posterior Distal Oblique Proximal Tibial Osteotomy

Jinzhong Zhao, M.D.



Abstract: High tibial osteotomy is a common procedure to address unicompartment knee osteoarthritis and other conditions. Regarding the specific surgical methods, medial open wedge osteotomy and lateral close wedge osteotomy are the most used. Both methods have a common disadvantage in that they are not so suitable to correct a severe deformity. Thus, we would like to introduce an anterior proximal-to-posterior distal oblique proximal tibial osteotomy technique, which is especially suitable to correct severe tibial deformity. The most critical point of this technique is to create an osteotomy plane from the most proximal posterior site of the tibial tubercle posteriorly and distally to the posterior cortex of the tibia, with each horizontal osteotomy maneuver in the coronal plane. Combined fibular osteotomy is always needed, and better results can be obtained when it is combined with arthroscopic debridement of the knee. We consider the introduction of this technique will provide a useful option when tibial osteotomy is needed to preserve the knee, especially for a great deformity correction.

High tibial osteotomy (HTO) is a common orthopaedic procedure¹⁻³ that includes medial open wedge osteotomy, lateral closed wedge osteotomy, arch osteotomy, and oblique osteotomy, of which the most used are the former 2 techniques.⁴ However, both techniques are disadvantageous to correct a severe deformity because enormous bone grafting is required in medial open wedge osteotomy and there is a high possibility of nonunion and correction loss; in addition, enormous tibial height loss is inevitable in lateral close wedge osteotomy. Posterior proximal-to-anterior distal oblique proximal tibial osteotomy (PTO) has been reported but seldom used in large series, with the main

disadvantage being that the osteotomy site of the posterior tibial cortex is too close to the joint line and a high risk of the posterior neurovascular structure injury.⁵ Polyzois et al.⁶ reported a slightly anterior proximal-to-posterior distal (AP-PD) oblique HTO, which we consider just suitable for minor deformity correction. Thus, we would like to introduce an AP-PD oblique PTO technique to address the need for a great deformity correction and decrease the risk of posterior neurovascular injury. The main indication of this technique is medial compartment osteoarthritis with varus knee caused mainly by tibial deformity (Table 1).

Surgical Procedures (With Video Illustration)

Preoperative Planning and Preparation

The range of motion of the knee is examined preoperatively to exclude patients with obvious flexion contracture. The stability of the knee is examined to exclude patients with obvious laxity of the medial stability structures.^{7,8}

The mechanical axis of the lower leg is measured on the radiography in weight-bearing position, where the location and the amount of deformity of the tibia, the femur and the joint are determined. On the femoral side, a 90° mechanical lateral femur angle is considered as normal and less than 5° varus is considered acceptable (when the varus degrees reach 5° on the femoral side, distal femur osteotomy should be considered). On

From the Department of Sports Medicine, Shanghai Sixth People's Hospital, Shanghai Jiao Tong University, Shanghai, China.

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Address correspondence to Jinzhong Zhao, M.D., Department of Sports Medicine, Shanghai Sixth People's Hospital, Shanghai Jiao Tong University, 600 Yishan Rd., Shanghai 200233, China. E-mail: zhaojinzhong@vip.163.com or jz Zhao@sjtu.edu.cn

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Table 1. Indication and Contraindications of Anterior Proximal-to-Posterior Distal (AP-PD) Oblique Proximal Tibial Osteotomy (PTO)**Indications**

1. For either varus or valgus knee, when the deformity occurs mainly on the tibial side, total knee deformity is over 5° , and there is combined cartilage lesion on the over-weight bearing compartment or overloading signs on imaging examination, AP-PD oblique PTO is indicated.
2. AP-PD PTO can be used as a primary or adjuvant treatment for varus instability or posterolateral structural injury of the knee.
3. Anterior cruciate ligament injury with varus knee is not a contraindication for surgery. We suggested that the valgus osteotomy should be performed first to relieve the pain. If the patient has sports requirements and feels joint instability in the later stage, ligament reconstruction can be performed.

Threshold of deformity correction

1. Our indication for AP-PD PTO is generally over 5° varus knee in above-mentioned indicated patients.
2. For patients with recalcitrant symptoms that severely affect daily life and obvious over-loading signs in imaging examinations, we consider valgus osteotomy even if the varus deformity is not over 5° .

Contraindications

1. Isolated osteotomy should be contraindicated in patients with obvious flexion contracture (e.g. over 10° flexion contracture).
2. If there is medial side instability due to trauma or inflammation, valgus osteotomy is contraindicated.
3. In AP-PD PTO, the osteotomy plane goes across the site of physis. Thus, it is unsuitable to be used in skeletally immature patients. Teenagers with congenital developmental abnormalities are contraindication.
4. Varus knee without medial compartment osteoarthritis or signs of overloading is not an indication for posterodistal PTO.
5. For medial compartment traumatic arthritis, if there is no alignment abnormality, it is still unknown whether it is suitable to relieve the pain of a single compartment by changing the alignment. In this case, it may be more suitable for single condyle replacement theoretically.
6. Patients who are 70 years or older are a relative contraindication.
7. If the patient is overweight, weight should be lost preoperatively. If the weight is not reduced, the long-term effect of AP-PD PTO must be poor.
8. The goal of AP-PD PTO is to reload part of the medial compartment to the lateral compartment. The medial compartment must also be used. Osteotomy is contraindicated if the medial compartment is severely damaged, or if the defect is so severe that it is not useful.

the tibial side, the mechanical lateral tibial angle is also measured with a 90° mechanical lateral tibial angle as normal. The degree of correction is the sum of the varus degrees of the lower leg plus 5° , with the purpose to get a mechanical axis of approximately 5° valgus in the middle-aged or elder patients.

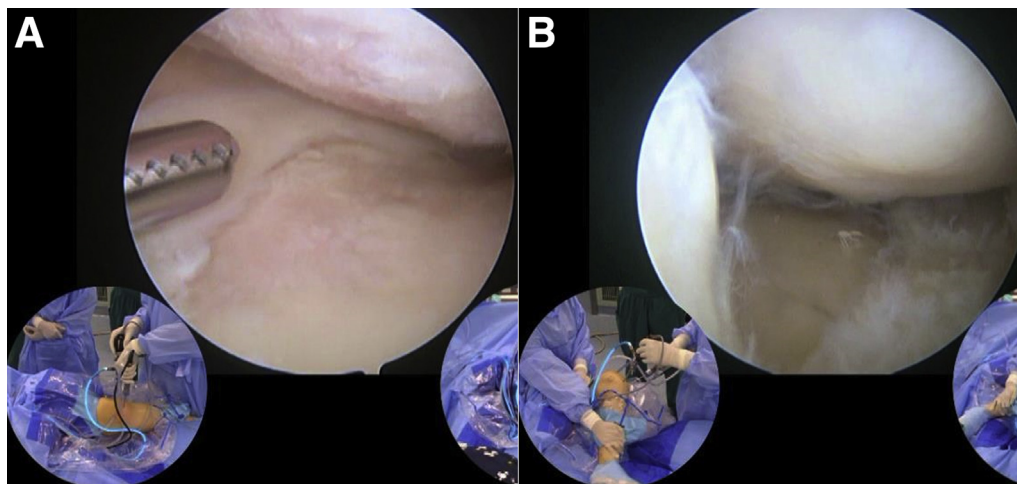
Patient Position

The patient is placed in the supine position. An inflatable tourniquet is placed at the proximal thigh. General or regional anesthesia is taken. The operative limb is disinfected, and a sterile towel is laid as in the routine knee surgery. The foot is draped with a thin sterile towel to facilitate the adjustment of ankle flexion

and determine the position of the toes for alignment judgment. The leg is exsanguinated, and the tourniquet is inflated.

Arthroscopic Surgery

The anterolateral and anteromedial portals are created. The osteoarthritis of the medial compartment and the healthier status of the lateral compartment are confirmed (Fig 1, Video 1). The synovium with inflammatory manifestations and marked hyperplasia is removed. Meniscus lesions are addressed. Free bodies are removed. Osteophytes that cause impingement to the anterior cruciate ligament or extension limitation are removed. For patients with severe posterior capsule

**Fig 1.** Arthroscopic examination revealing the osteoarthritic status of the medial compartment (A) and the healthier status of the lateral compartment (B) (arthroscopic view of left knee through the anterolateral portal).

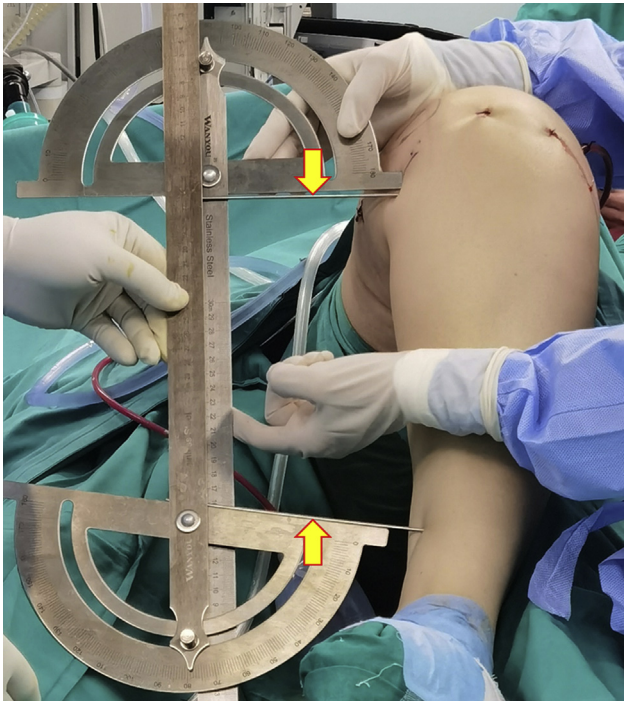


Fig 2. Two reference K-wires (arrows) are drilled into the tibia with an angle equal to the to be corrected angle (left leg).

contracture, posterior capsule release is performed through the posteromedial and posterolateral portals. In case of patellofemoral osteoarthritis, patella plasty, lateral retinaculum release, and femoral trochlea denervation are performed.

Placement of Reference K-Wires

The knee is flexed at 90° . The ankle is placed at neutral position in flexion–extension. The joint line of the knee is identified. A K-wire, which is used as a proximal reference wire, is drilled into the tibia in the coronal plane from the medial to the lateral side, parallels as far as possible and at a level approximately 1 cm distal to the joint line. Another K-wire, which is used as a distal reference wire, is drilled into the distal tibia also in the coronal plane. During drilling of the distal K-wire, the angle between the 2 K-wires (K-wire angle) is controlled with 2 costumed protractors to as equal as the to-be-corrected angle (Fig 2). Equality of the angle between the 2 reference K-wires and the to-be-corrected angle indicates when the 2 reference K-wires are adjusted to parallel status after osteotomy, the varus tibia is adjusted to expected alignment (Table 2).

Marking the Osteotomy Line

A line is drawn on the skin of the medial side of the proximal leg from the site corresponding to the most proximal and posterior site of the tibial tubercle going in a posterodistal direction with 30° angulation to the tibial axis to a site that is at the posteromedial ridge of the tibia. A longitudinal incision is made along the midline of the medial tibial surface, with both ends at levels abreast the 2 ends of the scheduled osteotomy line. The pes anserinus is peeled off from its tibia insertion. A K-wire is placed at the most proximal posterior site of the tibial tubercle to define the osteotomy line, which goes in an AP-PD direction, with

Table 2. Step-by-step Procedure of Anterior Proximal-to-Posterior Distal (AP-PD) Oblique Proximal Tibial Osteotomy (PTO)

1. Arthroscopy is performed to confirm the osteoarthritis status of the medial compartment and the healthier status of the lateral compartment. Debridement and other indicated arthroscopic procedures are performed.
2. A K-wire is drilled in the coronal plane from the medial to the lateral side of the tibia at a level approximately 1 cm distal to the joint line, parallels the joint line as far as possible, and is used as a proximal reference wire.
3. Another K-wire is drilled into the tibia also in the coronal plane at a level in the distal one third of the leg and used as a distal reference wire. The angle between the 2 reference wires is controlled being equal to the to-be-corrected angle of the tibia as far as possible.
4. A longitudinal incision is made over the midline of the medial surface of the tibia. The pes anserinus is peeled off from its tibial insertion.
5. A K-wire is placed at the most proximal and posterior site of the tibial tubercle and an osteotomy line is marked posterodistally to the posteromedial ridge of the tibia with 30° angulation to the tibial axis in the sagittal plane. The posterior compartments are opened at the distal end of the osteotomy line.
6. A 2.5-mm K-wire is used to drill through the medial tibial cortex along the osteotomy line to make a line of holes with approximately 5 mm distance between each two neighboring holes.
7. An osteotome is used to cut the bone and connect the holes along the osteotomy line at the medial side of the tibia.
8. The lateral tibial cortex is drilled through the medial tibial fissure with each drilling maneuver along the coronal plane, to create a line of holes on the lateral side of the tibia.
9. The osteotome is put into the fissure at the medial side of the tibia to connect the holes on the lateral side of the tibia to create an osteotomy plane.
10. The distal posterior tibial cortex is cut along the osteotomy plane.
11. A K-wire is drill perpendicular to the coronal plane through the middle of the osteotomy plane.
12. The fibular osteotomy is performed at its middle point with a wire saw.
13. Valgus stress is applied to correct the varus deformity of the tibia until the 2 reference wires parallel to each other.
14. Two additional K-wires are placed across the osteotomy plane for temporary fixation of the fracture.
15. A tibial condyle plate is placed at the medial side of the tibia. Four self-locking screws are placed in respectively at the proximal and distal segments of the tibia for fracture fixation.
16. K-wires for temporary fixation and correction reference are removed.
17. A suction drainage is placed to the osteotomy site. The wounds are closed.

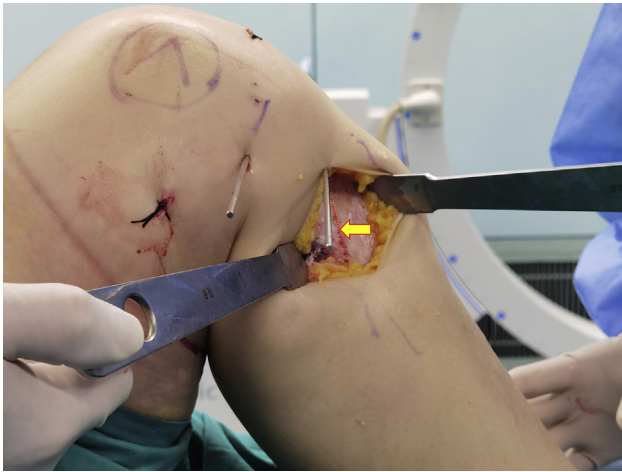


Fig 3. The osteotomy line (arrow) is angulate to the tibial axis in the sagittal plane at approximately 30°.

30° angulation to the tibial axis in the sagittal plane (Fig 3). The posterior osteofascial compartments are opened at the distal end of the osteotomy line.

A 2.5-mm K-wire is used to drill along the osteotomy line to make a line of holes with approximately 5-mm distance between each pair of neighboring holes. During each drilling maneuver, keep the K-wire parallel to the coronal plane and drill through only the medial cortex.

Tibial Osteotomy

An osteotome is used to cut the bone and connect the holes along the osteotomy line at the medial side of the tibia. Then the lateral tibial cortex is drilled through the osteotomy fissure in the medial tibial cortex, with each drilling maneuver parallel to the coronal plane.

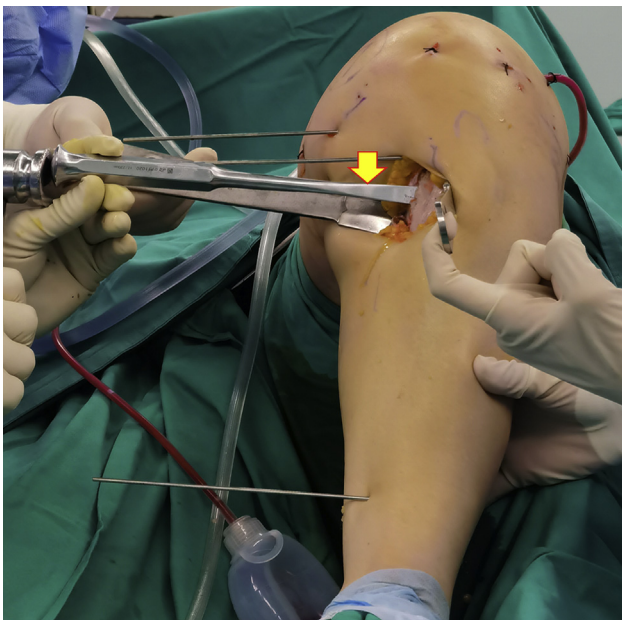


Fig 4. The osteotomy is performed along the coronal plane (arrow) when the knee is flexed (left leg).

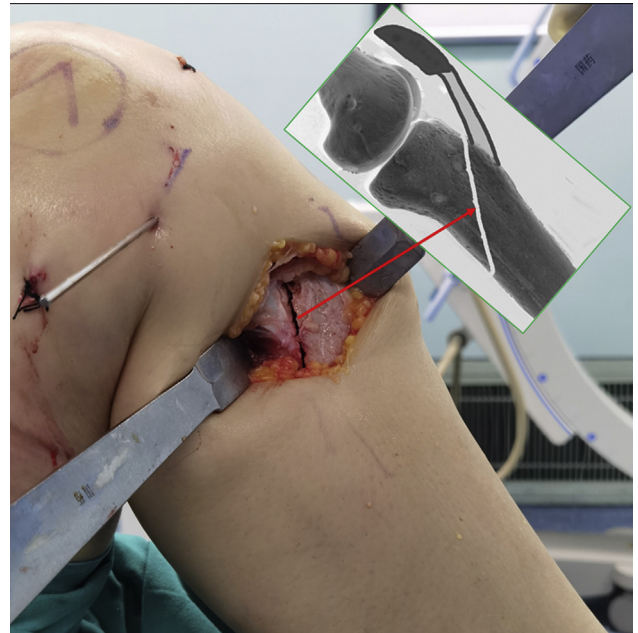


Fig 5. Photo with illustration indicating the osteotomy plane (arrow) (left leg).

Then, the osteotome is put into the fissure to connect the holes on the lateral side of the tibia to create an osteotomy plane (Fig 4). When cutting the lateral cortex of the tibia at the posterior distal part of the osteotomy plane, K-wires are inserted along the lateral side of the tibia at the corresponding level anterior-posteriorly to help to control the cutting depth and avoid vascular injury. Finally, the distal posterior tibial cortex is cut along the osteotomy plane (Fig 5). One K-wire is placed perpendicular to the tibial axis in the middle of the osteotomy plane.

Fibular Osteotomy

A 3-cm long longitudinal incision is made over the midpoint of the fibula, and the fibula is exposed



Fig 6. Fibular osteotomy is performed with a wire saw (arrow) (left leg).

Fig 7. Paralleling of the reference K-wires (arrows) indicating that the planned correction is achieved.



through layer-to-layer dissection. A fibula osteotomy is performed with a wire saw (Fig 6). Following osteotomy, the proximal bone end is checked to make sure it can be displaced completely medially.

Tibial Deformity Correction and Fixation

Valgus stress is applied to correct the varus deformity of the tibia till the 2 K-wires parallel each other (Fig 7). When desired deformity correction has been reached, 2

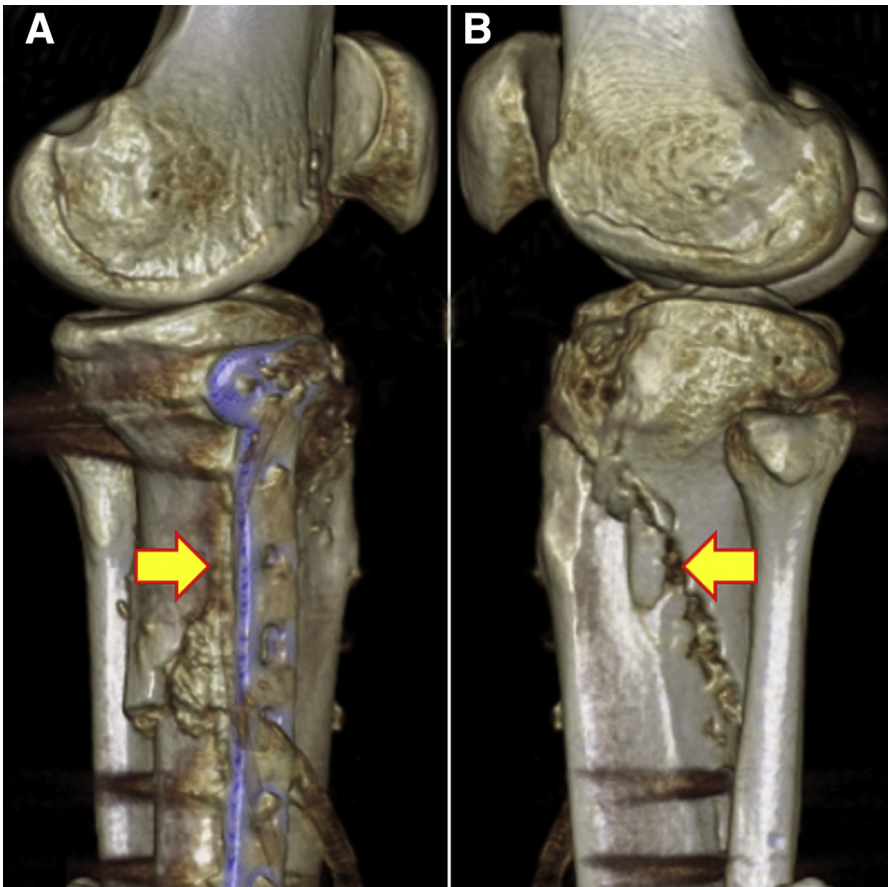


Fig 8. Postoperative computerized tomography indicating the osteotomy plane (arrows). (A) Medial side view of left leg. (B) Lateral side view of left leg.



Fig 9. Radiographs indicating the preoperative deformity (A) and postoperative alignment (B) of the left leg.

additional K-wires are placed across the osteotomy plane for temporary fixation of the fracture.

A tibial condyle plate is placed at the medial side of the tibia. Four self-locking screws are placed in respectively at the proximal and distal segments of the tibia (Fig 8 and 9). The K-wires for temporary fixation and reference for correction adjustment are removed (Fig 8).

A suction drainage tube is placed to the osteotomy site. The wounds are closed. Finally, an elastic bandage is used to compress the lower limb to the thigh.

Postoperative Management

Drainage is removed 24 hours after surgery and active knee range of motion exercise and muscle strengthening

begin immediately after operation. Partial weight-bearing activities begin 6 weeks after surgery, and full weight-bearing activities begin when radiography examination reveals complete healing of the tibial fracture.

Discussion

AP-PD oblique PTO is simpler than medial open wedge and lateral close wedge HTO. Because most of the osteotomy plane is located distal to the tibial tubercle, we named this procedure PTO instead of HTO. We prefer internal fixation with plate following correction of the deformity. However, if the soft-tissue condition is not so good, external fixation can be applied instead of a large plate, but with multiple lag

Table 3. Pearls and Pitfalls of Anterior Proximal-to-Posterior Distal (AP-PD) Oblique Proximal Tibial Osteotomy (PTO)

1. Age, the level of activity, lifestyle and overall health status should be considered when operative treatment is scheduled. Theoretically, if the patients have a certain life expectancy and an unicompartment osteoarthritis with varus knee, they are suitable for this procedure.
2. In younger patients, the goal of deformity correction is different from that in middle-aged or elder patients. In elder patients over correction may be accepted, but in younger patients, overcorrection should be avoided. The alignment needs to be accurately adjusted to normal.
3. Medial compartment osteoarthritis combined with patellofemoral arthritis is not absolutely contraindicated, but requires surgery related to patellofemoral arthritis.
4. In case of severe varus deformity associated with medial subluxation of the knee, deformity correction is suitable if stability reconstruction is followed.
5. In some cases, AP-PD PTO alone is difficult to satisfactorily relieve the symptoms of knee joint because many pain- or disability-causing factors in the joint cannot be eliminated through osteotomy. It is especially not helpful to relieve the limitation of knee extension, joint locking and reduce swelling. Simultaneous arthroscopic treatment can significantly improve the surgical results.
6. The key point of the operation is to make sure each osteotomy maneuver is parallel to the coronal plane. Otherwise, unexpected angulation or deformity will occur during the correction of the varus through lateral rotation of the distal tibia.
7. The osteotomy plane should be as flat as possible. Otherwise, separation of the bone fragment will occur following rotation of the distal tibia.
8. An osteotome is preferred to be used than an oscillating saw to reduce heat injury.
9. Before fibular osteotomy, a K-wire is placed across the osteotomy plane perpendicular to the tibial axis to prevent great fracture displacement and limb shortening.
10. The site of fibular osteotomy should not be too proximal. Otherwise, the risk of peroneus nerve injury will increase. However, it should not be too distal. Otherwise, the laterally rotated distal tibia will impinge on the proximal fibula. It is routinely located at the midpoint of the fibula when the correction degree is not large. However, when the correction degree is large, the site of fibular osteotomy is preferred to be located close to the junction of the proximal and middle one third.
11. When the correction range is small, the fibula osteotomy may not be needed.
12. The fibula fracture should be displaced once lateral rotation of the distal tibia is limited.
13. When minor correction of the posterior tibial slope is needed, the distal tibia can be elevated to create a separation purposely at the distal part of the osteotomy plane. However, bone grafting is needed in this case.

Table 4. Advantages and Disadvantages of Anterior Proximal-to-Posterior Distal (AP-PD) Oblique Proximal Tibial Osteotomy (PTO)**Advantages**

1. Great deformity correction can be realized with no need of bone grafting and no results of obvious limb shortening.
2. The AP-PD oblique PTO is simple, does not need special positioning, control instruments, and does not often need intraoperative radiograph monitoring.
3. In AP-PD oblique PTO, the tibial tubercle can be medialized, which is beneficial to relieve the symptoms of patellofemoral joint.
4. The height of the patella is not affected following AP-PD oblique PTO.
5. The contact surface of the broken ends resulting from AP-PD oblique PTO is large, which is beneficial to fracture healing.

Disadvantages

1. AP-PD oblique PTO results in an unstable fracture, weight-bearing should be strictly limited until the fracture heals.
2. The fracture may separate due to an uneven osteotomy plane.
3. Posterior tibial slope may be reduced due to inadvertent elevation of the distal part of the leg.

screws across the osteotomy plane to prevent fracture separation.

The pearls and pitfalls, and advantages and disadvantages of this technique are listed, respectively, in [Tables 3](#) and [4](#). The most critical point of this technique is to create an ideal osteotomy plane and to prevent separation of the bone fragment.

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