Technical Note

Medial Gradual Opening Osteotomy of the Tibia With Monolateral External Fixator for Correcting the Varus Deformity of the Tibia

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Abstract: Correction of the varus deformities in the tibia is necessary because of the excessive pressure exerted on the medial compartment of the knee, which intensifies the degenerative process. Correction strategies encompass a variety of approaches and depend on the patient's individual characteristics, age, soft tissue condition, and the orthopaedic surgeon's experience with different surgical materials. Size and location of the deformity, whether gradual or acute, play crucial roles in choosing the most appropriate material and shape. The gradual correction is especially indicated for patients with severe deformities, soft tissue involvement, and a history of bone infections. This study aimed to introduce a gradual correction technique for varus deformities in the tibia using a unilateral external fixator and to describe the postoperative follow-up. This technique offers notable advantages, including accurate correction, better patient acceptance, lighter assembly, less risk of pseudarthrosis, and shorter distraction process owing to the use of a single piece. In addition, the operated limb can support the load on the day after surgery, and dynamic follow-up is performed on an outpatient basis.

In genu varum deformities, owing to alteration of the mechanical axis, the load is transferred to the medial compartment of the knee, leading to an increase in load and deterioration of joint of the medial compartment.[1]

Alteration of the mechanical axis of the lower limbs not only causes damage to the knee cartilage but also affects the outcome of a possible knee ligament reconstruction surgery; therefore, correction of the varus knee deformity is important before reconstruction of the anterior cruciate ligament.[2]

There are different techniques for the correction of varus knee deformities, including gradual or acute correction with external circular or monolateral fixation and acute correction with opening or closing wedges and internal fixation.[3]

Gradual opening osteotomy is an appropriate procedure for correcting genu varum deformities to correct mechanical axis deviation. The procedure relieves pain in patients with osteoarthritis of the medial compartment of the knee.[4] In addition, because it is gradual, it allows fine adjustments after surgery, avoiding under- or overcorrection, which is not possible in acute correction with internal fixation. Gradual distraction of the bone callus with subsequent consolidation results in a low possibility of pseudarthrosis.[5]

The degree of pain relief experienced after varus deformity correction depends on the accuracy of deformity correction. Inaccurate correction can cause persistent pain, and surgery may not have an effective result.[6]

Monolateral fixation has advantages in relation to circular fixation, including being more comfortable for the patient, who adapts better to daily life; has greater

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simplicity in the user-fixator interface; and presents a much lower cost when compared with hexapodal fixation.

Surgical Technique

Positioning

After anesthesia, the patient is placed in the supine position with the operated limb positioned in the distal region of the radiolucent operating table (Table 1).

All individual parts of the single-sided ProCallus Fixator (Orthofix) with a self-centering body necessary for correct assembly must be separated (Fig 1).

Under fluoroscopic guidance, the apex of the deformity is marked with a Kirchner wire to indicate the correct point on the external fastener hinge. The distances from the apex to the articular surface of the tibia and the articular line of the ankle are compared with the cuff sizes to determine the best choice (straight or T clamp of ProCallus Fixator; Orthofix) (Fig 2 A and B, Video 1).

Surgery

The surgical area is accessed using a scalpel of approximately 1 cm in the anteromedial space of the proximal portion of the tibia. Dissection of the muscular and subcutaneous planes is performed using Metzenbaum scissors.

Under intraoperative fluoroscopic guidance, the 4.8-mm drill is positioned inside the drill guide in contact with the anteromedial cortical bone of the tibia, and the first perforation is performed, through which the pin is inserted into the epiphyseal region parallel to the tibial articular surface, approximately 1.5 to 2 cm below this surface; a 6.0-mm external fixator conical pin is placed using the T-key. The epiphyseal bony pins are inserted parallel to the articular surfaces. Once inserted, the pin should not be returned because of the tapered thread; any attempt to pull it out or backward will cause it to become loose (Fig 2 C and D).

The distal pin is placed distally, delimiting the size of the device in relation to the tibia, parallel to ankle articular surface (Fig 2E). An additional pin is placed close to the distal clamp, causing the fixator body to be parallel to the longitudinal axis of the bone (Fig 2F).

Then, 1 more proximal pin is inserted, following the same pattern and being parallel to the articular surface (Fig 2G). However, the surgeon may choose to make 2 proximal and distal pins or make first proximal, first distal and then second proximal and second distal.

Once this is complete, the main body of the fastener is fully closed. Thus, the distractor device will enter completely closed, making it possible to gain the length of the axis of the main body during distraction. Subsequently, an external fastener with a self-centering monolateral body and previously defined clamp is mounted. It should always be positioned on the medial part of the leg and never on the anteromedial part, so that the deformity begins to correct at the opening.

Table 1. Step-by-Step Surgical Procedure

Step	Description
1	The patient is positioned supine after being anesthetized.
2	The apex of the deformity is marked with Kirchner wire.
3	First perforation is performed at the first perforation is made on the anteromedial cortical of proximal tibia, 1.5 to 2 cm below this surface. With a T-key, the first 6.0-mm conical external fixator pin is placed.
4	First distal pin is inserted parallel to the ankle articular surface using same drill.
5	One more proximal pin and 1 distal pin are inserted parallel to the articular surface.
6	Under fluoroscopy guidance, anterior access of approximately 5 cm is made with partial osteotomy of the tibia, anteromedial portion, preserving the lateral cortex.
7	The distractor device is responsible for distracting the external fixator. An L-key is used to perform an approximately 1-cm distraction, which is then checked by direct focus viewing and fluoroscopy.

Osteotomies

After the distal pins are fixed, the entire appliance is removed for osteotomy of the metaphyseal region. However, a practical method to select an osteotomy site is to take advantage of the fact that the fixator is temporarily mounted and pass a pin or trocar through the cam from the articulated body to the bone surface. This will allow the identification of the osteotomy area to allow for the optimal opening of the deviation.

The center of the tibial deformity is marked under fluoroscopic guidance with an anterior access of approximately 5 cm.

The subcutaneous and muscular planes are divulsed and separated using 2 Hohmann-type retractors. With visualization of the tibia, a partial osteotomy is performed, sparing only the lateral cortical bone of the tibia, which functions as a hinge. Osteotomy is performed on the medial, anterior, and posterior cortices and should preserve the integrity of the lateral cortex. Drilling is carried out close to each other using the drill bit and 4.8-mm drill guide. The osteotomy is extended to the anterior, posterior, and medial cortices until a satisfactory opening is achieved. The lateral cortical bone cannot be ruptured because it functions as an axis of correction of angulation. Again, the main body of the fastener is positioned, and the entire appliance and universals are tightened (Fig 2H).

Opening the Osteotomy

The distractor device is responsible for distracting the external fixator. An L-key is used to perform an approximately 1-cm distraction, which is then checked by direct-focus viewing and fluoroscopy. Hemostasis is reviewed, and both surgical sites are closed using a 2-0

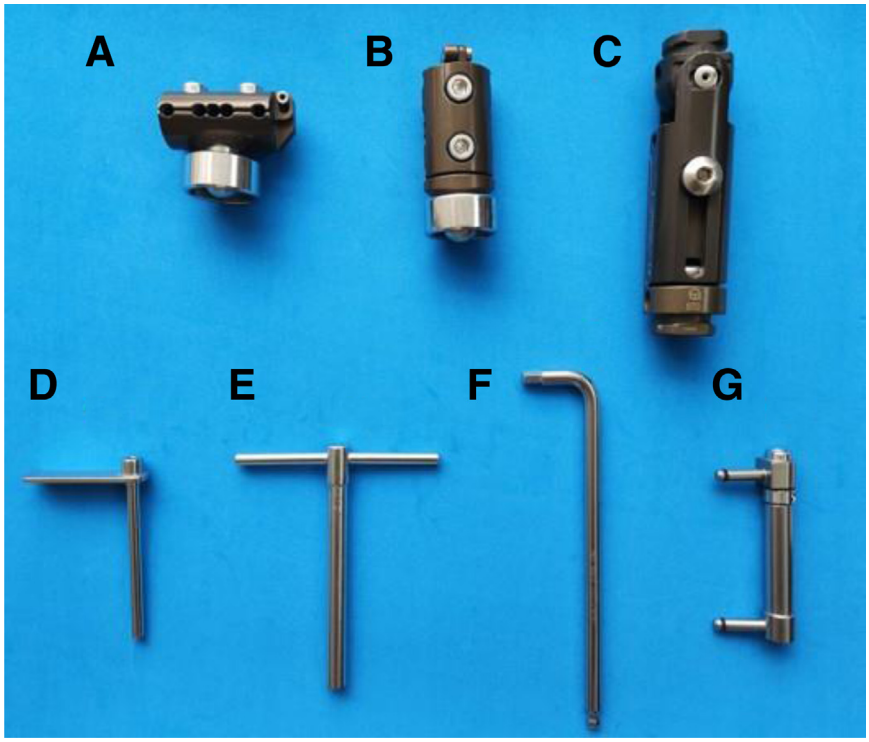

Fig 1. ProCallus Fixator Orthofix pieces (Orthofix). (A) T clamp. (B) Straight clamp. (C) Self-centering fixator body. (D) Drill guide. (E) T-key. (F) L-key. (G) Distractor device (Orthofix).

Nylon thread. Follow-up radiography is performed at the end of the procedure. The compression-distraction unit is used to ensure that the osteotomy opens unilaterally and that correction is possible.

After the opening of the osteotomy is certified, the appliance is closed again with a waiting period of 10 to 14 days before starting gradual correction itself.

Postoperative Orientation and Rehabilitation

On the first postoperative day, the patient is encouraged to walk with the help of crutches. The total length of the hospital stay is usually 1 to 2 days.

Each participant returns after 14 days of surgery to receive an L-key of the same model used during the operation and is taught how to distract the device (a quarter turn every 6 hours, 1 mm/d), using Ilizarov's concept.

The patient should return weekly for updated radiographs of the leg, and loading should be stimulated in the operated limb. The weekly evaluation considers visual inspection of the limbs, radiologic pattern of correction, and bone formation at the osteotomy site, as well as skin conditions and hygiene of the device, in addition to reinforcing the correct way to perform the distraction (Fig 3).

If satisfactory clinical correction is achieved and radiologically confirmed by correction of the proximal and distal joint angles on anteroposterior leg radiographs, distraction is paused. The consolidation phase of regeneration is initiated. However, if overcorrection occurs, leading to valgus deformity of the tibia, it is possible to compress the distractor to the angle-correction position on the new radiographs. Ultimately, under- and overcorrections can be corrected on an outpatient basis.

Discussion

Gradual opening osteotomy allows for greater correction of varus deformities of the knee with osteotomy of the tibia, followed by distraction with gradual opening through hemicalotasis.[7] Thus, the use of a monolateral external fixator with the technique presented above involves minimally invasive surgical access; simpler external fixator assembly; easier cleaning and fewer transfixing structures; less physical effort for the patient when walking; partial osteotomy, leading to better patient acceptance and less postoperative pain; stimulation of an early return to daily activities; and fewer postoperative complications (Table 2).[8]

In contrast, osteotomies performed with bone plates and grafts, although effective for deformities of lower angulation, present risks of nonunion in more severe cases.[9] Nonunion can lead to surgical readmissions and prolong the recovery process.[9] Therefore, medial opening wedge osteotomy should be performed if the involved extremity is shortened by 2 cm or more in relation to the contralateral extremity.[10] This procedure may also be indicated in patients with laxity of the medial collateral ligament or combined deficiency of the anterior cruciate ligament.[11]

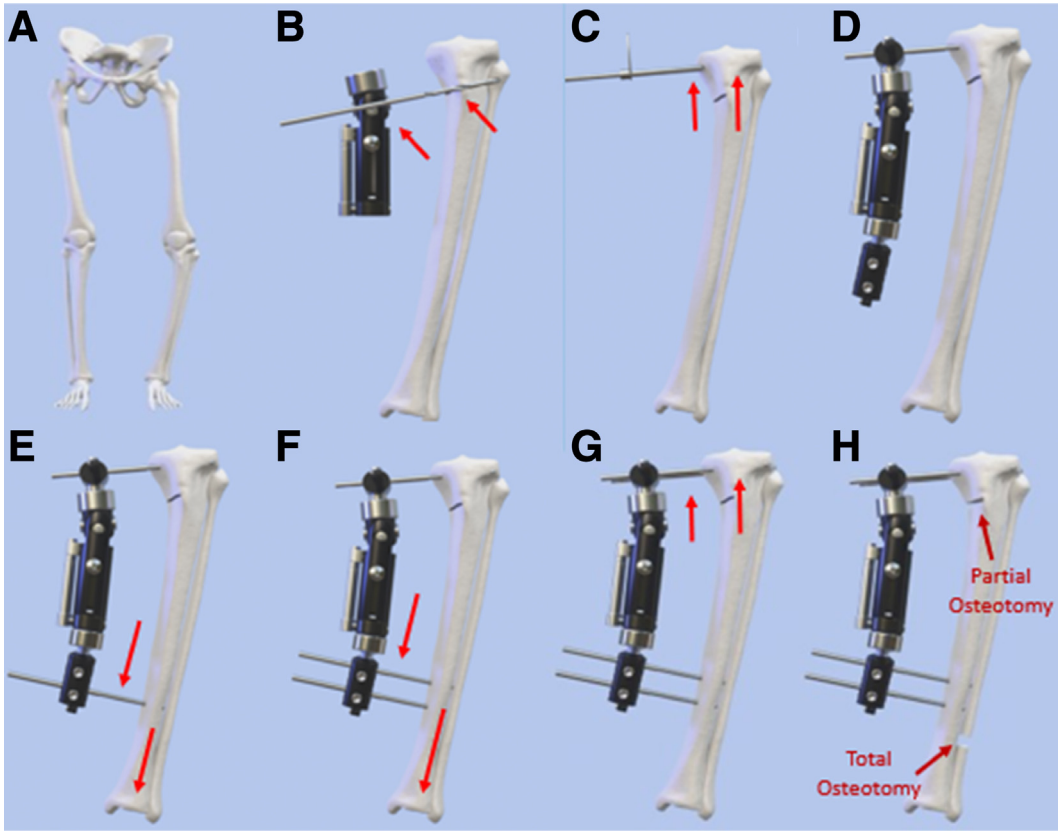

Fig 2. Step-by-step guide. (A) Varus deformity. (B) Hinge fastener on center of rotation angulation (location of tibia partial osteotomy). (C) Marking the first pin parallel to the proximal tibia articular surface. (D) First proximal pin with assembly. (E) First distal pin parallel to ankle surface. (F) Second distal pin parallel to first distal pin and ankle articular surface on coronal plane. (G) Second proximal pin parallel to first pin on axial plane and to proximal tibia articular surface on coronal plane. (H) Osteotomies—partial tibia osteotomy and total fibular osteotomy.

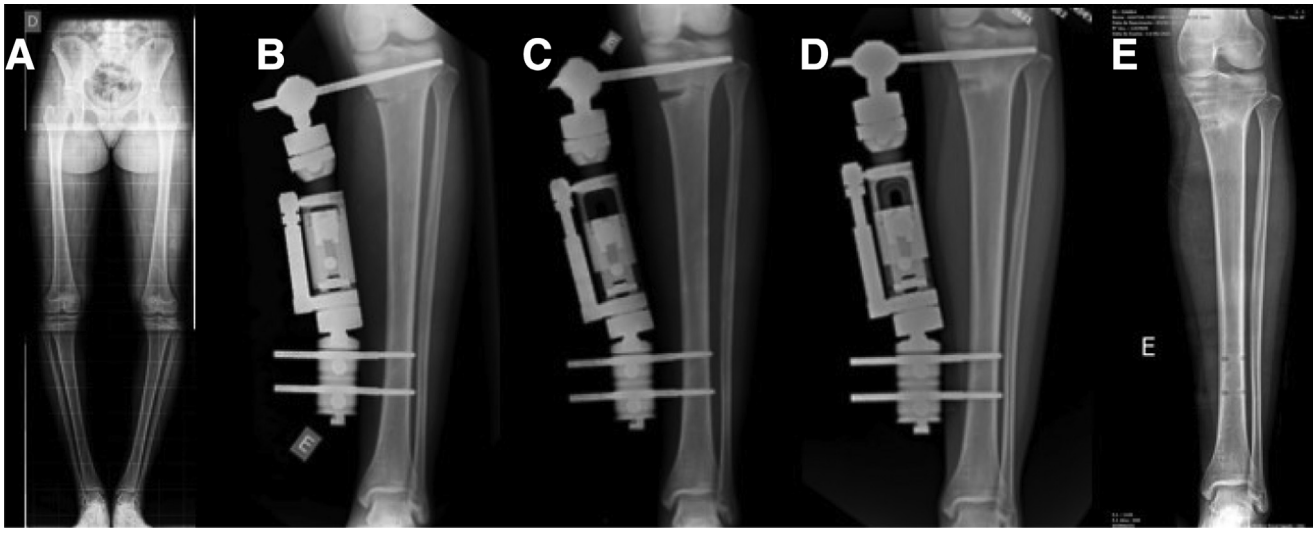

Fig 3. Varus gradual correction. (A) Deformity. (B) Immediately postoperative. (C) Six weeks postoperative. (D) Four months postoperative—final correction. (E) Five months postoperative.

Table 2. Technical Advantages, Disadvantages, Risks, and Tips

Advantages	Disadvantages	Risks	Tips
Minimally invasive surgical access			
Monolateral assembly—easy cleaning, less effort for walking, immediate loading	Need for patient commitment		
Partial osteotomy—less pain		Fracture of lateral cortex Neurovascular injuries	Acute reduction and stabilization Use Hohmann-type retractor for protection
Precise control of correction	Need for patient commitment	Create a valgus deformity	Weekly radiographs

The gradual approach of the technique in question allows a progressive increase in correction and provides precise control over the corrective angles. This translates to more accurate and desired results.[12]

Schwartsman[13] discussed the use of the circular external fixator as a support after percutaneous tibial osteotomy distal to the tibial tuberosity. This approach allows for precise adjustments in the postoperative period, based on radiographs obtained under load.[14] He indicated that consolidation is more reliable after percutaneous corticotomy using an opening wedge as compared to an open osteotomy with a closing wedge.[13] He pointed out that osteotomy position below the tibial tubercle reduces the probability of developing a low patella and minimizes the loss of bone stock in the proximal region of the tibia, which could complicate future procedures such as total knee arthroplasty.[13]

Another point is the benefits offered by this approach, such as the ability to adjust the distal fragment to restore mechanical alignment, enhance fixation stability, allow immediate loading, and facilitate knee mobility from 0° to 90° through the circular system.[15] However, some disadvantages are associated with the Ilizarov technique for proximal tibial osteotomy, such as potential resistance to the use of the external fixator, which requires that patients perform several daily adjustments to the fixator, and the need for more transfixing structures, with more chance of pain and infection.[16,17]

Other osteotomy approaches have also been reported. Closed tibial lateral wedge osteotomy has several advantages, as it is less invasive, providing a direct approach and reducing complications compared with other techniques.[18,19] Partial resection of the fibular head, a smaller incision, and preservation of neurovascular structures are beneficial, along with customized adjustment of wedge width to correct deformities.[8] Fluoroscopic alignment assessment contributes to mechanical accuracy.[20] However, this technique has disadvantages, such as its complexity, which requires surgical skill; the need for fluoroscopy, which prolongs the time and increases radiation exposure; and a prolonged recovery period.[21]

The medial tibial open wedge osteotomy technique allows for accurate correction of incorrect alignment with intraoperative adjustments.[10] The technique involves only 1 osteotomy for deformities up to 15°, fibula osteotomy is not performed, and the tibiofibular joint, reducing associated risks, such as chronic pain, more than one surgical acess, and infection.[22] When the plate is used, it is positioned with the leg extended and fixed in place using screws, and a bone graft is also placed to aid in consolidation.[9] In the postoperative period, the leg is immobilized on a foldable knee support, with weightbearing on the toes, for 6 to 8 weeks.[8] The progression of weightbearing depends on the radiologic evidence of bone healing. An alternative approach involves external fixation devices. This can include biplanar external fasteners, semicircular external fasteners, or small guide holders.[14,17] The advantages of these distraction histogenesis techniques with external fixation basically consist of exact correction of the axis since it is possible to achieve the desired mechanical alignment with precision after distraction.[14,21-24]

Tibial dome osteotomy allows alignment corrections without affecting the length of the limb and avoids imbalances.[25] This allows anterior displacement of the tibial tubercle, reduces patellofemoral forces, and precisely corrects major deformities.[25] However, it is technically demanding and requires specialized surgical skills. The incidence of complications, including infections and healing problems, is higher.[26] There is a risk of peroneal nerve palsy owing to the complexity and manipulation of nearby structures.[26]

Therefore, the biggest advantage of the technique of gradual medial opening of the tibia with a monolateral external fixator is that there is a weekly increase in correction, and it is possible to follow the correction angle in a more accurate and desired manner.[27,28]

However, this technique has certain limitations. The main considerations relate to the use of an external fixation, which requires patient commitment; possible reduction of correction after removal of the external fixator; and pin site infection.[9,14] The manifestation of signs of infection frequently occurs when external fixation devices are used and can affect between 8% and 60% of patients, as reported by Pande.[7] However, it is important to note that up to 96% of these infections are of low severity. However, internal fixation does not allow for large-scale or complex multiplanar corrections and additional adjustments after surgery.[8,12,14,28]

Application of an external fixator for tibial osteotomy is considered a safe and straightforward procedure, with results comparable to those of other approaches.[8,12,14,28] Outcomes are satisfactory, especially in young and highly active patients who prefer to avoid the activity limitations associated with joint replacement.[12] In addition, gradual medial tibial opening osteotomy with a monolateral external fixator has emerged as a valuable therapeutic option for cases of severe genu varus.[14]

The benefits of the external fixator technique are remarkable, including the ease of correction at high angles and the ability to progressively increase correction.[8,12] In the context of tibial osteotomy, there are 4 main advantages to employing external fixation techniques. First, it is possible to correct even the smallest residual deformities and achieve the desired alignments during observation under load.[8,12,14,28] In addition, because of the phenomenon of hemostasis, there is no need for grafts.[7] In cases of more extensive corrections, an external fixator is recommended, eliminating the need for additional procedures to remove the fixation devices.[14,28]

Disclosures

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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