

Original article

Role of the Ilizarov fixator in high tibial osteotomy

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The Ilizarov fixator is extensively used for deformity correction. Medial compartment osteoarthritis (MCOA) of the knee usually presents with a varus deformity in the lower limb. Varus leads to excessive loading of the medial compartment of the knee joint. Corrective osteotomies enable the weight-bearing line or the mechanical axis¹ to pass through the center of the knee or a little beyond² through the lateral compartment to unload the medial compartment of the knee joint.

The varus deformity may arise from the upper tibia, lower femur, or in the knee joint itself. Varus arising from the lower femur is measured by mL DFA. Large Varus deformities in femur are relatively uncommon and present as part of bowleg deformity. Though knowledge of double level osteotomies of femur and tibia is growing, commonly performed osteotomies for varus correction are in the upper tibia or within the knee.

Medial Proximal Tibial Angle (MPTA) measures the varus arising from upper tibia. The varus may either be mild moderate or severe. Mild deformities are easy to correct using an opening wedge osteotomy, fixed with a Tomofix plate. Correcting moderate to large varus deformities acutely with an open wedge may cause delayed healing or create complications relating to the patella-femoral joint, knee or ankle joint line orientation.

Correcting moderate or large varus deformities arising from upper tibia can create problems either with opening wedge or closing wedge osteotomies.

This is where the Ilizarov fixator comes in handy with its ability to gradually correct large deformities. We have used the Ilizarov fixator for the last 32 years to correct moderate to large varus deformities in osteoarthritis of the knee. We have used it in three differing clinical situations.

1. Ilizarov Focal Dome osteotomy

It is especially useful for correcting moderate to severe deformities arising from the upper tibia. The Ilizarov fixator is best performed in combination with the focal dome osteotomy. The surgery is minimally invasive and causes less bleeding and tissue trauma. The fixator is strong and permits early and full weight-bearing. The patient resumes activities and gainful employment rather soon. We can apply sustained compression at the osteotomy site to ensure early healing. We can fine tune correction after surgery to achieve either more or less valgus. The Ilizarov fixator maybe used by itself for correction of moderate and large varus deformity is when performed with a focal dome osteotomy. Fig. 1(a–g). A focal dome osteotomy is based on rule two of deformity correction.³

The deformity can be resolved with its apex somewhere near the articular surface of the knee joint. The osteotomy is performed below the tibial tuberosity. Performing the semicircular or arcuate and distally convex osteotomy has two main advantages. Firstly, a mild lateral translation of the distal fragment occurs which enables the lateral translation of the mechanical axis at the knee. Secondly, the arcuate shaped bone osteotomy has a very large area of bone contact which ensures early healing. Additional correction of rotation or limb length is also easily possible with the circular Ilizarov fixator. The circular rings enable 360° control and strong fixation of the fragments. Hinges and connections enable lateral translation and external rotation of the distal fragment and full correction into valgus. The osteotomy is percutaneous and causes little blood loss and has no incidence of compartment syndrome in my experience.

1.1. Surgical Technique

There are three ways to apply the Ilizarov fixator while

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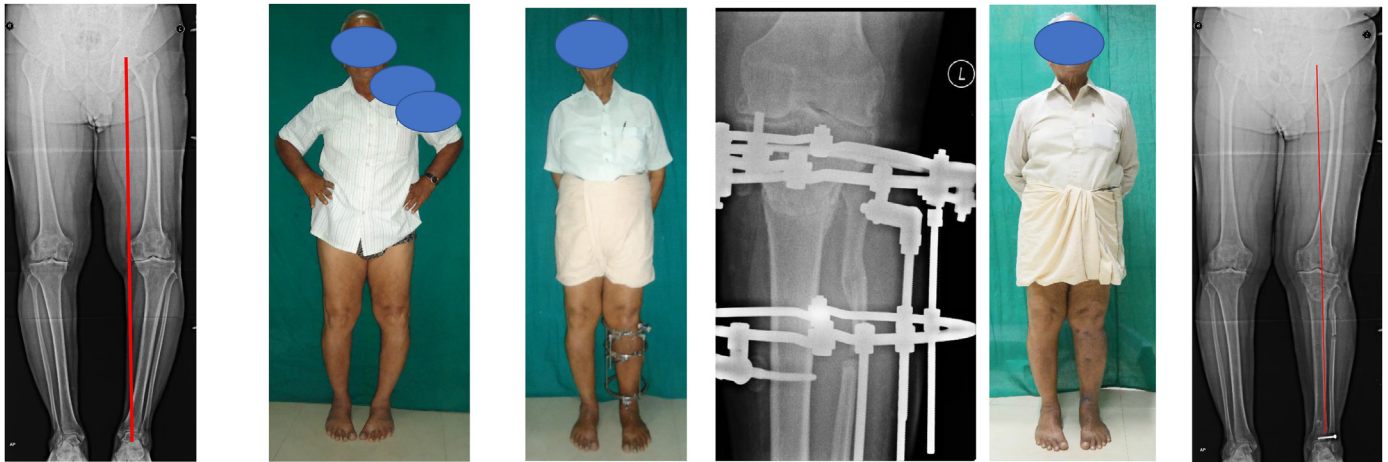


Fig. 1. a, b. 70-year-old bodybuilder had a large varus deformity with intorsion of the tibia. The mechanical axis has deviated to less than 0%. c, d. A hybrid Ilizarov fixator with half-pin fixation was done. A proximal fibulectomy is necessary. A curved Focal Dome osteotomy with a distal convexity is performed. Proximal fixation is with one ring with a half-pin proximal and distal to the ring. A plain wire ensures parallelism to the joint. Distal fixation is with two rings and two half pins. Angulation is achieved with multi-plane hinges. More valgus can be achieved by compressing lateral struts. Uniform compression achieves better bony contact and reliable healing. e, f. accurate correction without causing overcorrection to enable the mechanical axis to pass just lateral to the midline. Has given lasting pain relief for more than seven years now.

performing the high tibial osteotomies. Essentially, we have been using the hybrid Ilizarov fixator which has a combination of half-pins and wires since many years.

1.1.1. Preconstruction

The frame is constructed around the leg before surgery either using x-rays or a C-Arm before surgery. HTO needs one ring at the upper metaphysis and two rings for fixation of the distal tibia. It is possible to mimic the varus deformity by angulating the rings with help of hinges. The fibula osteotomy is performed first. A frontal plane K wire is passed at level of fibular head, parallel to the knee joint. The assembled rings are slid on to the limb and upper ring attached to this K wire. Distally, a K wire parallel to the ankle joint is inserted distal and parallel to lower ring and attached with wire fixation bolts. Remaining fixation is performed with Half pins. Two are attached to upper ring, one from lateral side and one from medial side, subtending an angle as close to 90° as possible.

The middle ring will have one HP perpendicular to the tibial face and the distal ring has a HP inserted a little more antero-posterior direction, medial to the Tibialis anterior tendon and the Saphenous vein. The osteotomy can be outlined by drill holes below the tuberosity before mounting the rings and completed with an osteotome after stable fixation.

1.1.2. Progressive Construction

This method is used by surgeons familiar with the fixator. The focus is on fixing the upper ring first after inserting the wire and HP. This is fixed and made stable. Next the attention is shifted to the middle ring and finally to the lower ring. This method is flexible and especially useful in presence of large deformities, including internal rotation of distal fragment.

1.1.3. Peri construction

All wires and HP are inserted after performing the fibular osteotomy. The rings are assembled and fixed at each level. This method is more practical and allows one to finish one task at a time, and may save operative time for an experienced team.

Ilizarov Focal Dome osteotomy: Surgical Technique^{4,5}

The Focal Dome Osteotomy enables correction of all varus deformities, especially the moderate to large ones with simultaneous correction of any sagittal plane or rotational or axial deformities.

The Patellofemoral joint is addressed by performing a medial and lateral retinacular release.^{4,5} We start the surgery with a proximal fibular osteotomy. Resection of a small piece helps avoid impaction of tibial osteotomy caused by correction into valgus. Outline the shape of the osteotomy, just below the tuberosity either with a jig or freehand. Make two small oblique incisions over the medial and lateral cortices. Drill holes outline the two cortices at tibial tuberosity. Rest of the holes describe a distally convex arc. The fixator is now assembled in one of the three ways outlined above: Preconstruction, Peri construction or Progressive Construction. The proximal fragment has a 1.8 mm wire that passes just below the flare of the tibial head. A lateral half-pin is inserted at the Gerdy Tubercle passing from antero-lateral to posteromedial. The ring is usually placed below both. The distal half pin is inserted at least 10 mm distal to the wire and should subtend a right angle with the proximal half pin. It goes from medial face of tibia to its posterolateral cortex. Rancho cubes attach these half pins attached to the ring and give a stable fixation. The distal block of two rings is constructed distally with at least 15 cm between the rings. The middle ring has one half-pin perpendicular to the medial face of the tibia and distal ring has a wire parallel to the ankle and an anteroposterior half-pin. The distal block may be placed at a varus angle compared to the proximal ring. It may also be translated minimally medial to the proximal ring.

The osteotomy is performed by connecting the dots of the previously outlined drill holes. A 6.5 mm or 10 mm osteotome can be used. Plunging beyond the posterior cortex can be prevented by checking with the C-Arm. When the osteotomy is complete, twist the osteotome to laterally translate the distal fragment.

After the osteotomy is complete, with only straight connecting rods we can ensure correction of distal fragment into valgus with a mild lateral translation. Optionally we can use multi-plane hinges to ensure this correction. It is not necessary to complete the correction on the table. Fine tuning can be performed once the patient starts walking and we can gauge correction of the static and dynamic varus as well. Full length x rays gauge correction of static varus by measuring mechanical axis deviation a little lateral to the midpoint of the knee. Dynamic Varus is easy to observe. Achieve additional valgus by compressing the lateral struts and distracting the medial ones. Once correction is satisfactory, uniform compression enables better stability and early healing at osteotomy

site.^{6,7}

Advantages of the Ilizarov fixator and fixation of the focal dome osteotomy.

1. Ability to correct large deformities without reducing bony contact.
2. Ability to give sustained compression & get reliable union.
3. Better correction of mechanical axis by adding an element of lateral translation of distal fragment.
4. The dome is mostly infra-tuberosity and hence does not interfere with patellofemoral joint, such as creating patella Alta or Baja.
5. Ability to mobilize early and bear weight, resume work and gainful employment.
6. Prevents excess stretch on the medial collateral ligament.
7. Anatomy of proximal tibia is not altered and hence future TKA is not compromised.
8. Ability to fine tune the correction and overcorrect if needs be to correct dynamic varus deformity.
9. There is full control over 360° and have control over fragments in coronal and sagittal planes.
10. Ability to achieve rotational correction or lengthening or perform shortening if needed.
11. Ability to perform bilateral simultaneous correction and allow weight bearing mobilization.

Ideal Indications:

- * Large Varus deformities with associated sagittal, axial or rotational deformities.
- * Bilateral large varus with need for simultaneous correction.
- * Large varus deformity with fine-tuning to correct the Dynamic Varus deformity.
- * Younger patients.

Our Experience:

We have performed more than 250 of these osteotomies over the last 32 years. We performed all HTO's as an Ilizarov FDO for the first 15 years and thereafter we have reserved its use for only the ideal indications (Fig. 1). There have been no NonUnions or Neurovascular injuries or Compartment syndromes. Average fixator duration has been 14 weeks (range 11–22 weeks). Only five patients needed more than five months for union and fixator removal. All these patients had premature consolidation of the fibular osteotomy which prevented compression and union at the tibial osteotomy. 15% of the patients have had overcorrection of Mechanical axis beyond 70% of the joint width. Vast majority of these have not suffered from symptoms due to overcorrection as this extent was necessary for overcoming the dynamic varus. Two patients developed a procurvatum deformity due to comminution of the posterior cortex and mild instability.

In the early phase of our experience, we have had two patients above age 70 who did not tolerate the fixator due to our use of fine wires in the proximal ring. Since 1993 we have been using only half-pins and since 2001 only Titanium half-pins which have led to less infections and intolerance of the fixator.

10% of the patients complained of pain in the patello-femoral joint in the post-operative phase. Hence, we have added a Patello-Femoral Retinacular release to all patients since 2004, especially when they have Patello-femoral tenderness.

2. Ilizarov fixator assisted plating of a focal dome osteotomy

The second use of the Ilizarov Fixator is as an intra-operative tool for accurate correction of large deformities. The osteotomy is

then fixed with a locking plate and the fixator is removed at the end of surgery.⁸ A patellar retinacular release can be done for patello-femoral pain. A fibulectomy is needed to allow large correction and minimal lateral translation of the distal fragment. Release of the superficial medial collateral ligament can be done, and the plate is inserted medially to fix the osteotomy once alignment is verified. A TSF fixator is an excellent tool to achieve pre-determined correction. However, taking special x-rays and using the web-based software in the operation theatre can take a little longer. Fig. 2.

Ideal Indications: Older patients & ladies fulfilling indications of Ilizarov FDO, but not accepting an external fixator.

Our Experience: we have performed 68 of Fixator assisted focal dome high tibial osteotomies using a Tomofix plate since 2005. The last 14 of these have been inserted medially. 54 were performed with a lateral Tomofix plate. 10% had a overcorrection beyond 70% MAD. Since we switched to inserting a locking plate medially, we have been able to better correct the varus and release the superficial medial collateral ligament gain a more accurate correction. We have also corrected sagittal plane fixed flexion deformity by compressing the osteotomy more anteriorly. This is possible in the focal dome without removing bone. Patello-Femoral retinacular release was performed in most patients.

With increasing experience, we find that large varus deformities are usually accompanied by either a lower femoral or an intra-articular deformity and hence our use of this modality is reserved for fewer cases.

3. Ilizarov for double osteotomy of Tibia (intra & extra-articular correction)

The third use of the Ilizarov fixator in High Tibial osteotomies is for the fixation of double osteotomies of the tibia.⁹ The medial tibial condyle elevating Tibial Condylar Valgus Osteotomy (TCVO)^{10,11,12,13} is an intra-articular osteotomy. By elevating the medial tibial condyle when performed as a L-shaped osteotomy medial to the patellar ligament, it allows simultaneous contact of both the tibial condyles with both the femoral condyles. It is fixed acutely with cancellous screws. The TCVO by itself cannot correct the mechanical axis up to 50%. Excess correction can cause stuffing the joint or splaying & separation of the condyles and distortion of the joint lead to stiffness. A second osteotomy is performed in the diaphysis distal to the condylar osteotomy, and further corrects the extra articular varus deformity to well beyond the midline of the knee. The second osteotomy can be gradually corrected and fine tuned to allow proper correction of mechanical axis.

The L shaped intraarticular osteotomy is fixed with one cancellous screw and by two half pins from either side. The intervening space between the upper and lower osteotomies is fixed with two vertical pediatric tapering thin half pins. All four of these pins are attached to the proximal ring. Two rings distal to the distal osteotomy fix the distal fragment. Hinges between the rings allow fine tuning of varus correction at the lower level (Fig. 3).

Advantages of using an Ilizarov fixator for the double tibial osteotomy.

1. It is possible to fix both osteotomies simultaneously and fine tune correction in one of them.
2. The intra-articular osteotomy is fixed securely after being distracted apart by a spreader by the right amount.
3. Accurate correction of the mechanical axis to ensure added benefit to intra-articular correction.
4. Sagittal plane deformities and Rotations can be corrected as can lengthening through the lower osteotomy.



Fig. 2. a,b,c,d. 60-year-old lady had a large varus and FFD on the Right lower limb. e. The TSF fixator was used instead of the Ilizarov. Incisions of the fibulectomy and anterior incision for retinacular release with dome osteotomy are seen. Once the varus and procurvatum (FFD) are corrected. A plate is inserted on the medial side. f,g,h. Full-length x-rays show good correction of the axis, also seen clinically. Close-up AP shows dome osteotomy with the minimal lateral translation of distal fragment. Lateral x-ray shows a reduction of the tibial slope to correct the FFD of the knee.

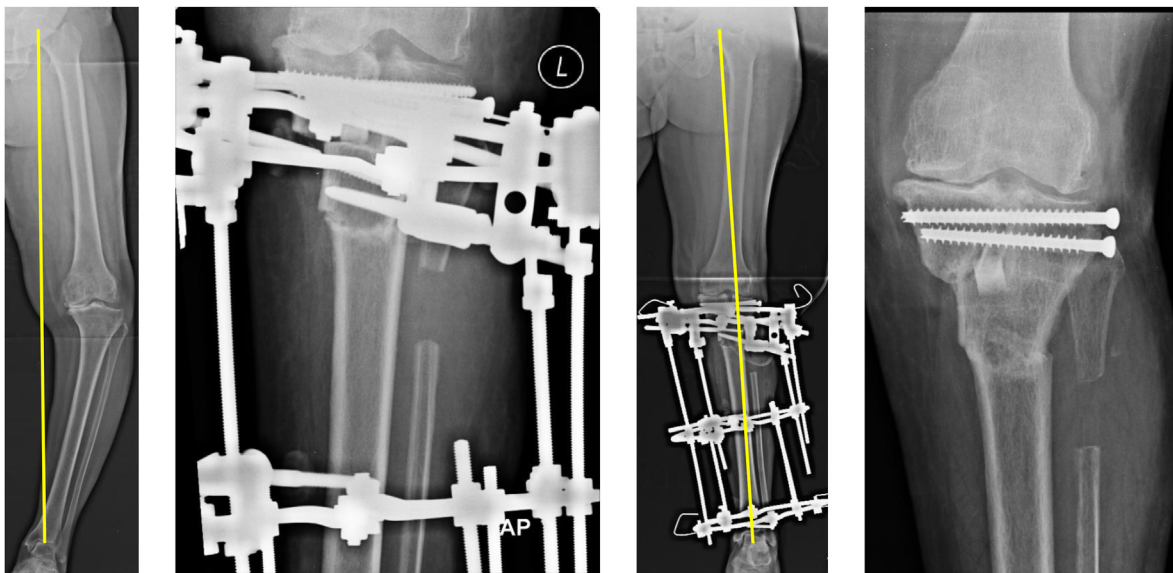


Fig. 3. a,b,c,d. Large varus deformity with an obvious upper tibial extra-articular deformity and also a “pagoda tibia” showing an intra-articular deformity. Ilizarov fixator was used to fix the double osteotomy. The Upper osteotomy is an L-shaped osteotomy with elevation of medial tibial condyle. This is fixed with two Cancellous screws. This improves the congruity of the articular contact. The gap is filled with an excised piece of the fibula. The upper osteotomy zone is also fixed with two half-pins. 4 cm intervening zone had a fixation with two half pins. All these four pins are fixed to the upper ring. A Distal dome osteotomy is performed with the lateral translation of distal fragment which allows adequate correction of mechanical axis (seen on intra-operative x-rays).

Ideal Indications: younger or middle-aged patients with a large varus MAD with presence of an intra-articular as well as an extra-articular varus deformity. When we are unable to correct the MAD to 50% or beyond with only the intra-articular osteotomy. We add a second extra-articular osteotomy using a fixator to gradually correct it.

Our Experience: We have used this method in 28 double osteotomies. A Mean of 53% postoperative MAD has been achieved (range 39%–76%). Delta MAD (change in MAD after surgery) in these patients has ranged from 52% to 151%. Pin track osteomyelitis was seen in two patients needing debridement. One patient suffered a fall and developed a tibial tuberosity # with knee stiffness. There were no Neuro vascular complications. One developed a fracture at the lower osteotomy due to fall and was treated in a cast which lead to knee stiffness.

Hence the Ilizarov fixator has three uses in high tibial osteotomies: 1. Fixation of a focal dome osteotomy for correction of moderate to severe varus deformity. 2. As an intra operative tool in fixator assisted plating of large varus deformities. 3. as a fixation device that helps correct the intra-articular component acutely and extra articular osteotomy gradually in large varus deformities.

Complications of the use of Ilizarov fixator:

A Fibular osteotomy may heal prematurely and not allow the tibial osteotomy to compress and heal soon. A repeat fibular osteotomy will help. Pin track infection may fester if not treated early and aggressively. Pin loosening can manifest as pin-track infection and additional connections will help stabilize if they are loose in the frame.

Replace any loose pins as pin loosening may lead to delayed healing. Comminution of the posterior cortex at the osteotomy site will lead to poor contact and a procurvatum deformity. A procurvatum deformity mimics a flexion deformity and makes walking rather difficult.

Pin infection and loosening can lead to undetected axial deviation at the osteotomy site unless carefully looked for. Acute correction of a dome osteotomy with fixator assistance may be inaccurate due to lack of a fixed end point. Accurate alignment is hard to achieve because of confounders like thickness of the tourniquet, a mild flexion in the knee, slack in holding the cautery cord, operator hand movement, and a large sandbag under the pelvis.

Pin-track infections may lead to osteomyelitis or a ring sequestrum if not treated promptly. Adequate time needs to be spent in the post-operative period to detect problems. Prolonged fixator duration may make treatment unpleasant for some, especially the elderly.

4. Conclusion

The Ilizarov fixator is a universal fixator and can correct

deformities in all planes. It is effective in correcting varus and other deformities present in medial compartment osteoarthritis of the knee. The Ilizarov fixator is best for correcting large varus deformities with a focal dome osteotomy. It is the most effective intra-operative tool to tool to accurately correct a large varus deformity which is then fixed with a locking plate. Finally it serves to fix double osteotomies performed when large intra-articular and extra-articular deformities are present in medial compartment osteoarthritis.

Declaration of competing interest

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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