The Principles of the Ilizarov Apparatus

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Professor Gavril Abramovich Ilizarov was born in the Caucasus, in the Soviet Union in 1921. He was involved, without much orthopedic training, in looking after injured Russian soldiers in Kurgan, Siberia, in the 1950s. Without any proper equipment, he was faced with crippling conditions of unhealed, infected, and malaligned fractures. With the help of a local cycle shop he devised ring external fixators tensioned like the spokes of a cycle. With the help of this equipment he achieved healing, realignment, and lengthening which considerably surprised him and used its principles for devising the modern apparatus, which is still used today as one of the distraction osteogenesis methods. In 1954 he published his first article on transosseous osteosynthesis. He headed the world's largest orthopedic hospital which is known as the Kurgan All-Union Scientific Centre for Restorative Orthopaedics and Traumatology. Professor Ilizarov continued working in this field of orthopedics for 41 years until his death in 1992 at the age of 71.

Professor Ilizarov's methods were brought to the West in 1981 by an Italian doctor, Prof. A. Bianchi-Maiocchi.

The main principles of Ilizarov can be summarized as follows:

Law of tension-stress which can be elaborated as

1. Distraction osteogenesis
2. Mechanical induction of new bone formation
3. Neovascularization
4. Stimulation of biosynthetic activity
5. Activation and recruitment of osteoprogenitor cells
6. Intramembranous ossification

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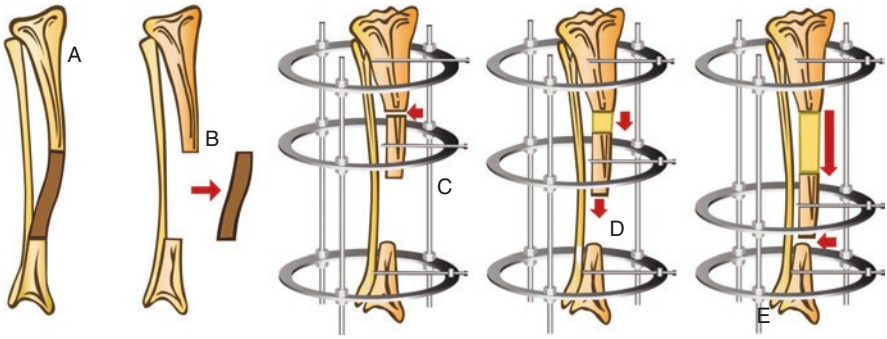

Fig. 28.1 Line diagram showing the stages of neovascularization

Ilizarov developed the law of tension-stress, which describes the gradual process of new bone and soft-tissue regeneration under the effect of tension-stress caused by slow and gradual distraction (Fig. 28.1).

These biological principles can be summarized as follows:

1. Minimal disturbance of bone and soft tissues
2. Delay before distraction
3. Rate and rhythm of distraction
4. Site of lengthening
5. Stable fixation (Fig. 28.2) of the external fixator
6. Functional use of the limb and intense physiotherapy

Distraction osteogenesis, also called callus distraction, callotasis, and osteodistraction, is a surgical process used to reconstruct skeletal deformities and lengthen the long bones of the body. A corticotomy is initially used to fracture the bone into two segments, and the two bone ends of the bone are gradually moved apart during the distraction phase, to allow the new bone to form in the gap or tunnel thus created. When the desired or possible length has been reached, a consolidation phase follows in which the bone is allowed to keep healing. Thus distraction osteogenesis has the benefit of simultaneously increasing bone length and also the volume of surrounding soft tissues around it.

This distraction osteogenesis is also called callus distraction, callotasis, and osteodistraction which is a surgical process used to reconstruct skeletal deformities and at the same time also lengthen the long bones of the body. A corticotomy is used to fracture the bone into two segments, whereby the two bone ends of the bone are gradually moved apart during the distraction phase, thus allowing new bone to form in the gap or tunnel thus developed. When the desired or possible length is achieved, a consolidation phase follows in which the bone is allowed to keep healing.

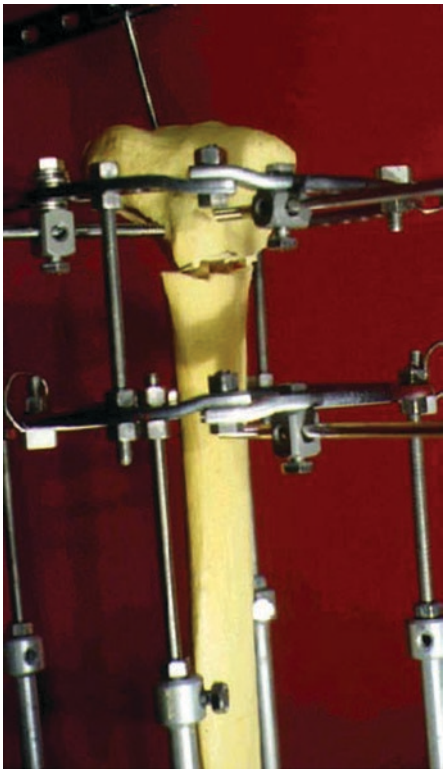

Fig. 28.2 Stable fixation (photograph by the courtesy of Osman A.E. Mohamed, Faculty of Medicine, Al-Azhar University, Damietta)

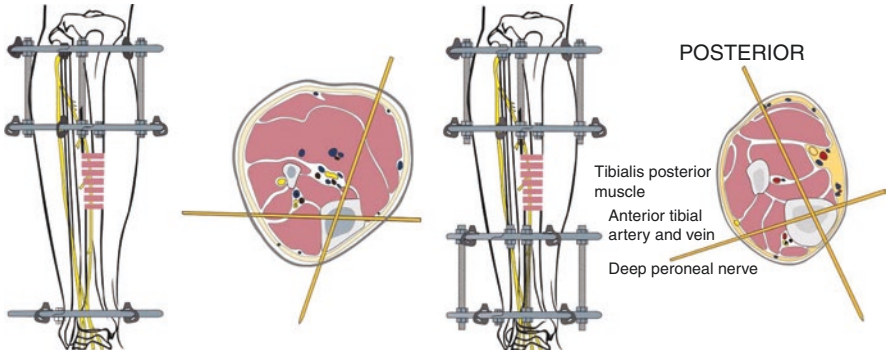

Fig. 28.3 Line diagram showing the passage of wires subcutaneously

The Exact Procedure/Technique

Firstly wires of 1.5 or 1.8 mm diameter are passed percutaneously (through the skin) through bones by means of a drill and the protruding ends of these wires are then fixed to rings with special "wire-fixation" bolts (Fig. 28.3). These rings then in

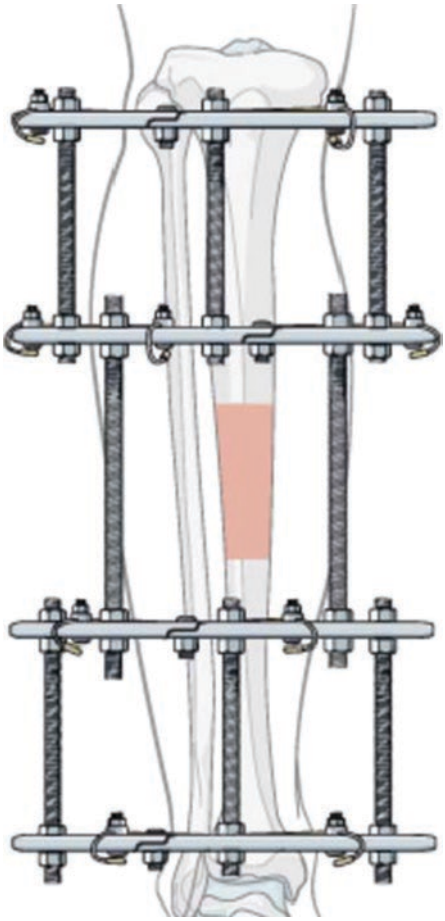

Fig. 28.4 Line diagram showing the assembly of the Ilizarov frame

turn are connected and fixed to one another by threaded rods; when once it is fixed, the Ilizarov frame affords a stable support to the affected limb (Fig. 28.4).

A corticotomy is then performed; it is an osteotomy (cutting the bone only) where the periosteum of the bone is preserved like a tunnel. Adjustments in the rods produce compression or distraction as desired between the bone ends, and simultaneously deformities are also corrected. The ring fixator is then removed at the end of the treatment.

Aftercare of the Apparatus

The postoperative management of a patient requires the frequent contact and close monitoring by the surgeon:

1. Deformities and contractures cannot be allowed to persist or progress.
2. The patient must be encouraged to bear weight on the lengthening limb.

3. Pin- or wire-site sepsis must be treated aggressively; osteolysis around an implant suggests that additional transosseous fixation is needed.
4. Adequate physiotherapy is essential as follows:
   (a) The patient has to participate in a proper program of exercises, mobilization, and ambulation.
   (b) In fact following the Ilizarov's original technique requires the patients to stay in hospital and participate in at least 2 h of therapy in various forms every day.
   (c) When the services of a physiotherapist are not always available, it is ideal and preferable for the surgeon himself/herself to supervise the therapy for the patient.
   (d) Achieving length or correcting a deformity at the cost of decreased motion, mobility, or function is not a worthwhile goal.

Removal of the Apparatus

1. Broadly a month too late is far better than a day too early.
2. The follow-up X-rays must show at least three cortices; that is, out of four cortices (anterior, posterior, medial, and lateral) in AP and lateral projections, at least three should be fully ossified, with a sharp outline of the cortical bone.
3. Finally before actually removing the frame the patient must be administered a "stress test" and asked to use the limb in a functional manner (weight bearing for the lower limb and functional activities for the upper limb).
4. If the patient is able to do this the frame can then be removed with confidence along with actual removal of the fixator to be usually done under anesthesia.

Advantages

No skin incision is made as in a conventional operation.
Incidents of hemorrhage, tissue trauma, and infection are much fewer.

1. This is a minimally invasive procedure as only wires are used to fix the bones to the rings and hence there is very little soft-tissue damage.
2. The Ilizarov fixator is very versatile; the cylindrical shape of the fixator permits deformities to be corrected simultaneously in three dimensions.
3. The patient remains mobile throughout the course of the treatment. Intensive physiotherapy is started early; and hence, problems of joint stiffness and contractures are rare. Above all, the patient's stay in the hospital is considerably reduced.

Disadvantages

1. Mechanical:
   (a) Distraction of fracture site

   (b) Inadequate immobilization
   (c) Pin-bone interface failure
   (d) Weight/bulk
   (e) Refracture (may be seen in a pediatric femur)
2. Biologic
3. Infection (pin track)
4. Neurovascular injury
5. Tethering of muscle
6. Soft-tissue contracture

Indications

1. Limb lengthening
2. Deformity correction (Figs. 28.5a, 28.5b, 28.5c, and 28.5d)
3. Infected nonunions
4. Congenital pseudarthrosis
5. Treatment of joint contractures, e.g., resistant congenital talipes equino varus, post-burn contractures, and posttraumatic stiffness (Fig. 28.6).

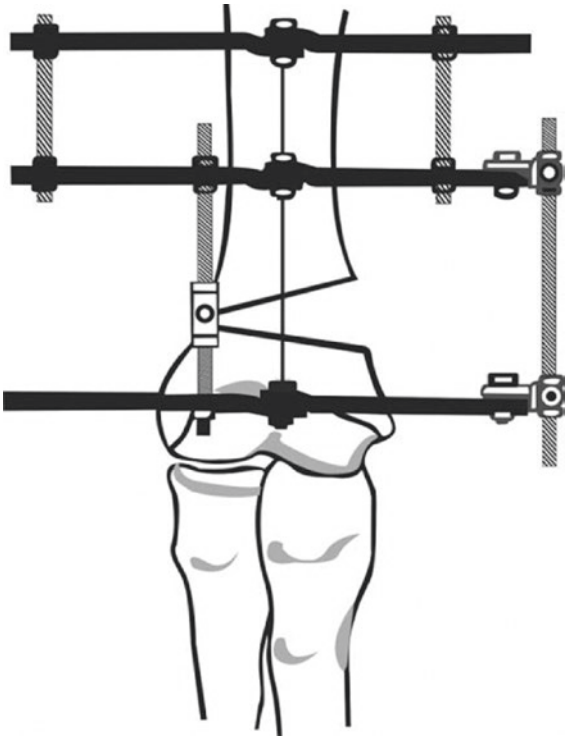

Fig. 28.5a Line diagram showing the first step in deformity correction

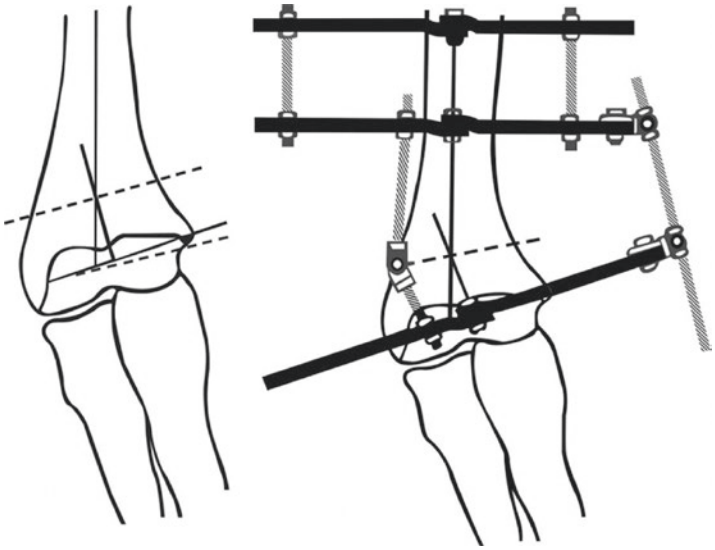

Fig. 28.5b Line diagram showing the deformity finally corrected

Fig. 28.5c Photograph of Ilizarov frame for correction of reconstruction osteotomy for neglected dislocation of the hip in young adults (figure by the courtesy of Osman A.E. Mohamed, Faculty of Medicine, Al-Azhar University, Damietta)

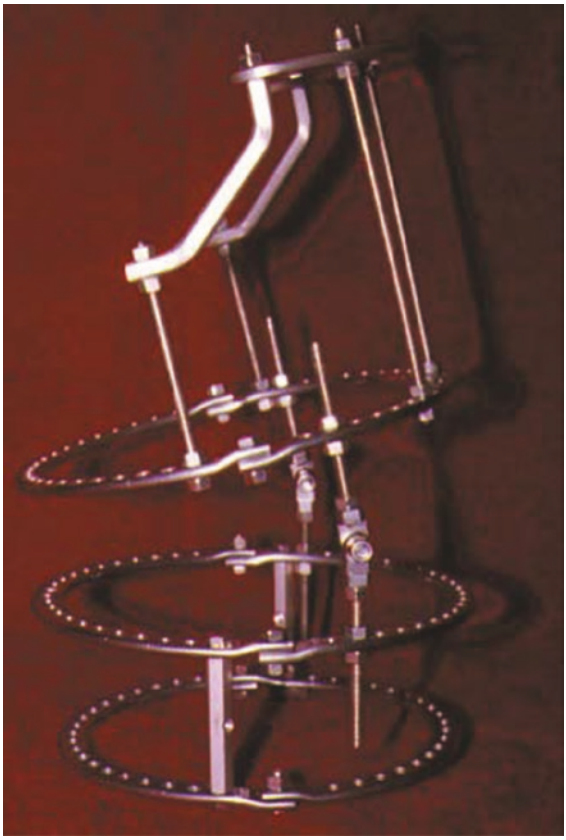

Fig. 28.5d Photograph of Ilizarov frame for correction of reconstruction osteotomy for neglected dislocation of the hip in young adults (figure by the courtesy of Osman A.E. Mohamed, Faculty of Medicine, Al-Azhar University, Damietta)

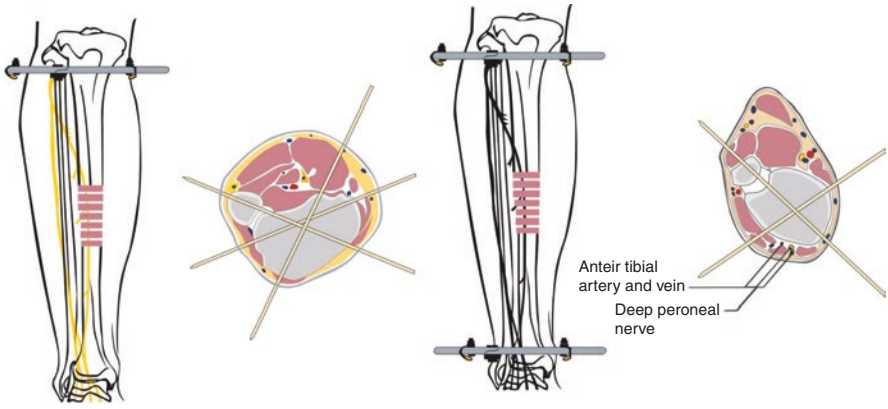

Fig. 28.6 Line diagram showing the steps in the correction of joint contractures

6. Fixation of complex fractures (Fig. 28.7)
7. Bone transport and osteomyelitis (treatment of missing bone in the limb, due to various causes).
8. Arthrodesis (fusion or joining of two bones across a joint) (Fig. 28.8).
9. Peripheral vascular disease like thromboangiitis obliterans.

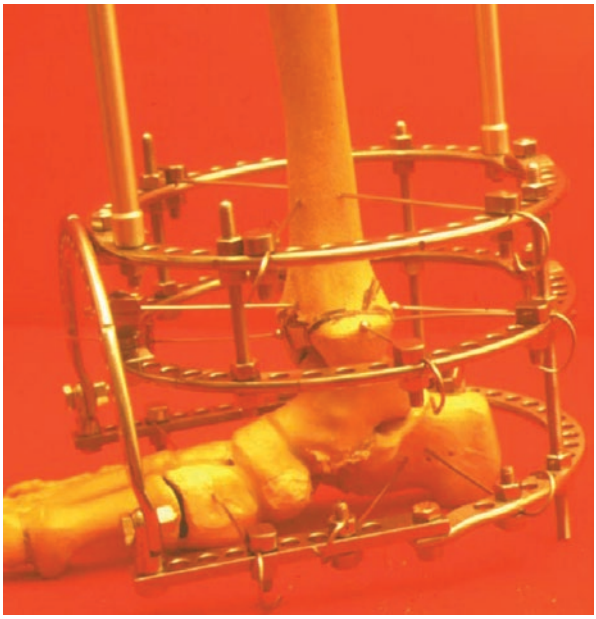

Fig. 28.7 Fixation of complex fracture. Photograph of Ilizarov frame (figure by the courtesy of Osman A.E. Mohamed, Faculty of Medicine, Al-Azhar University, Damietta)

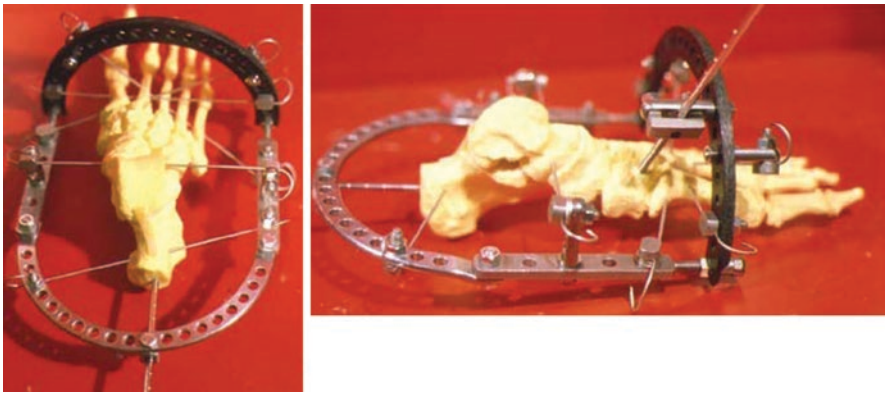

Fig. 28.8 Arthrodesis (photograph by the courtesy of Osman A.E. Mohamed, Faculty of Medicine, Al-Azhar University, Damietta)

Treatment of Nonunions

1. Ilizarov revolutionized the treatment of recalcitrant nonunions demonstrating that the affected area of the bone could be removed, the freshened ends "docked," and the remaining bone lengthened using an external fixator device.
2. The time taken for healing after such treatment is much longer than normal bone healing.
3. Usually there are signs of union within 3 months, but the complete treatment may continue for many months beyond that.

Treatment of Infected Nonunion

Ilizarov is the gold standard for the management of nonunion of osteomyelitis for both achieving union and eradication of infection, however generous, though careful sequential debridement and hardware/dead tissue removal and bone grafting are also options for some selected cases.

Osteomyelitis burns in the fire of regeneration, thus activating a biosynthetic process, while increasing local resistant to infection.

Hence there are three ways to correct INU:

1. Controlled osteogenesis, filling of cavities by newly formed tissue
2. Resection of infected bone and subsequent intercalary bone lengthening
3. Gradual bone transport of one wall of the cavity

Limb Lengthening

Limb-lengthening and reconstruction techniques can be used to replace missing bone and lengthen and/or straighten deformed bone segments as these procedures can be performed on both children and adults who have limb length discrepancies due to birth defects, diseases, or injuries.

Here the regenerated bone is normal and does not wear out. The muscles, nerves, and blood vessels grow in response to the slow stretch like they do during a growth spurt or in pregnancy. The actual procedure is minimally invasive and requires only one or two nights in the hospital and literature says that successful limb lengthening is possible up to 18 cm (Fig. 28.9).

Buerger's Disease

Here in this condition, arterial reconstructive surgery is not feasible and sympathectomy has temporary limited role and progression of the disease invariably leads to amputation. Ilizarov's method increases the vascularity of the ischemic limb and hence Ilizarov's method is an excellent and affordable procedure in the treatment of Buerger's disease.

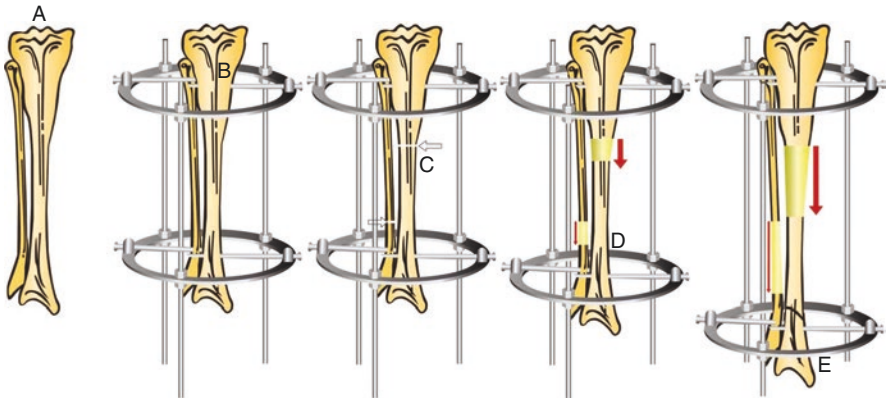

Fig. 28.9 Line diagram showing the stages of limb lengthening

Summary

Ilizarov is a compression-distraction device that can do osteogenesis:

1. Infection nonunion and congenital deformity corrections are one of the golden indications.
2. You can be taller even after 18 years with this.
3. Wearing Ilizarov is not a fancy style. It returns painful discomfort.
4. Physiotherapy is essential.