CHAPTER **11**

The Application Of The Ilizarov Frame In Foot And Ankle Surgery

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The Ilizarov method of external fixation applies the scientific principles of tissue neogenesis in dealing with a wide variety of orthopaedic problems. These include a variety of osseous deformities, such as bone infections, limb length discrepancies, fracture healing, non-unions, and congenital pseudarthroses and malformations. Skin and soft tissue defects and the vascular insufficient limb are also responsive to this form of therapy. The Ilizarov principle, in short, respects osteogenic tissue and its vascular supply, while preserving the weight-bearing function of the limb.

Conventional surgical treatment of foot and ankle deformities is often limited by the severity of the deformity, or inhibitive due to the risk of failure. In these instances, alternatives to traditional modes of treatment can be particularly helpful. These situations include severe deformities in which the mobility of the overlying skin is insufficient to permit osseous correction. Various techniques are currently being used to deal with this problem, including staged manipulations after release of the foot, along with staged fusion or additional releasing procedures. Traditional methods of correcting foot deformities in the older child and adult often require extensive bone resection, resulting in significant shortening of the foot. With severe multi-directional deformities, correction through resection of large section of bone is often an inappropriate form of treatment.

The mechanical characteristics of the Ilizarov external fixator can be compared to that of the standard uni-planar external fixator. The most common type of uni-planar external fixators is the Hoffmann device. The Hoffmann external fixator utilizes large diameter threaded pins (4-6 mm) to stabilize osseous segments. The major advantages of this type of fixation is that the uni-planar system minimizes the transfixion of soft tissues, and is a less bulky device. In most instances, the use of this type of external fixation does not allow for full weight-bearing.

The Ilizarov frame in contrast, utilizes non-threaded, small diameter (1.5 - 1.8 mm) Kirschner wires to stabilize bone. The wires, when placed under tension and connected to a circular frame, provide a high degree of osseous stability. The use of smaller wires reduces soft tissue and bony reaction, when compared to the larger pins. Whether the frame is used for distraction or for stability of a joint or bone, full weight-bearing can be allowed postoperatively. During the entire treatment period, both the weight-bearing function of the limb and the range of motion in the adjacent joints are preserved. This is actually one of the requirements for success with this method.

Elements of the Ilizarov compression-distraction apparatus can be divided into primary and secondary components. The primary components are standard parts that join the skeleton to the finished frame, such as transosseous wires, rings, and wire fixation bolts. The secondary components are the special elements used to construct the frame of the apparatus, such as threaded and telescopic rods, connecting plates, hinges and posts, and nuts and bolts. Various wrenches are also considered secondary components of the apparatus. To use the Ilizarov apparatus, one should also have available the equipment needed for standard osteosynthesis techniques, including osteotomes, power drills, mallets, and pliers.

The dynamometric wire tensioner is a very important instrument which allows one to tension the wires to an exact force, improving stability of the entire bone-frame construct. The wires should be tensioned from 50 to 130 kilograms. The exact amount of tensioning depends upon the weight of the patient, local bone quality, treatment plan, and the local frame construct. The wires can be retensioned or further tensioned during the treatment of the patient. In most instances, the entire apparatus is made of stainless steel, which allows for maximum strength and stability. However, graphite rings are now available which provide greater strength to the frame with less weight. In addition, the graphite rings are radiolucent allowing for ease of radiographic interpretation.

The unique design of the Ilizarov fixator compares favorably with other external fixators. The ideal fixator should demonstrate high shear stiffness and low axial stiffness. It is accepted that shear forces at the fracture site are deleterious to osteogenesis, whereas cyclic axial micromotion promotes bone repair and regeneration. The Ilizarov apparatus, constructed of parallel rings connected with threaded rods, assumes an axial configuration. It has high shear stiffness, particularly when the "olive" wires are used. The "olive" wire, or wire with a stopper, is used so that force is directly applied to the bone fragment through tension on the wire. Common applications of the olive wire include correction of angular deformity, prevention of undesirable displacement, transport of an osseous fragment (longitudinally or transversely), increase stability and rigidity of the system, and to aid in the reduction of a fracture.

The apparatus consists of a system of rings and semi-rings, connected with threaded rods (1 mm pitch) or special telescoping rods. The original Ilizarov apparatus consisted of 32 basic mechanical parts. The varied combinations of these parts allows construction of a customized apparatus, individualized to the specific needs of each patient. The versatility of the system allows for more than 700 different types of application. Frames can be built to produce lengthening, shortening, angulation, rotation, and translation in any direction. Correction can be achieved immediately, or gradually by applying force over an extended period or time.

The Ilizarov frame can be used for gradual correction of foot deformities without the limitations of prolonged treatment, cast sores, incomplete correction, or damage to growth plates or joints. Application of compression or distraction forces can be used to correct a deformity in any given part of the foot, ankle, or leg.

The Ilizarov method offers many advantages over casting techniques in that gradual adaptation occurs through a constantly applied force. Three dimensional control is possible (axial, angulation and translation). In addition, the skin is always visualized directly, and correction is usually faster than with casting.

The Ilizarov technique provides an ideal and minimally invasive method for fusion of the ankle and subtalar joints. If the limb is shortened with fusion, distraction osteogenesis is possible following 20 to 30 days of compression. This allows for limb lengthening within the arthrodesis site.

One of the main indications for the use of the Ilizarov technique is fusion of the ankle joint. Joint resection can be carried out in the conventional fashion, and a four ring apparatus is applied involving the tibia, talus, calcaneus and forefoot. The fusion is stabilized and placed in compression with four threaded rods connecting the distal ring and the calcaneal ring. Subtalar joint fusion can also be achieved with a very similar construct. The main advantage of fusion with the Ilizarov technique is that full weight-bearing can be achieved immediately. One also has the option to intermittently tighten the frame in the postoperative period resulting in greater compression of the fusion site.

The Ilizarov method permits stable fixation of limb segments adjacent to an abnormal joint. By distraction, translation and angulation, subluxed or dislocated joints can be realigned. Through correct hinge placement in the axis of joint rotation, controlled joint motion can be used to avoid subluxation. Gradual distraction of periarticular soft tissues can be achieved at a rate of 1 mm per day, which can permit one to three degrees of correction per day.

Arthrodiastasis, or distraction of a joint, must transfer forces from the bone to the soft tissues. Ligaments, tendons and capsular structures are primarily composed of collagen, which should respond to controlled distraction in a predictable manner based upon the biology of distraction osteogenesis. Contracture of muscle involves myofibril structures with active and passive elasticity. Distraction of muscle is often painful and less predictable. Nerves are known to regenerate at a rate of one millimeter per day following axonotmesis. Nerve distraction, gradual or slow, may still result in paresthesias, which are usually transient. Skin is highly elastic and can easily adapt to any lengthening process, with the exception of skin grafts, free flaps, and rotational flaps. With these exceptions, slower distraction may be necessary. Blood vessels retain proliferative activity and can usually respond to gradual distraction by growth. However, the cornerstone of the Ilizarov method is the biologic law of "tension stress" in bone and soft portional to time. The transosseous wires minimize this problem by their small diameter and stability under tension. When the wires must cut through the skin, the trailing scar is well-formed and clean.

7. Frequent Out-Patient Monitoring

The patient who wears an apparatus must be frequently monitored on an out-patient basis. Each visit may be quite time consuming.

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