Treatment of Proximal Tibial Fractures with Ilizarov Methodology

Maurizio A. Catagni
Ilizarov Unit, Lecco Hospital, Italy

INTRODUCTION

Without a doubt, the treatment of tibial fractures, with transosseous osteosynthesis, is one of the most important chapters in the methodology proposed by Ilizarov. The high incidence and variety of these fractures may, at times, present difficulties in choosing a treatment method. There are currently many treatment methods available. Optimal treatment should include anatomic reduction, stable fixation, and early function (weight bearing).

Transosseous osteosynthesis may have a "relative" indication in the treatment of a simple, closed diaphyseal fracture, while it is absolutely indicated for the treatment of an open, comminuted, contaminated diaphyseal fracture and for the treatment of open fractures in the multiply injured patient.

Based upon our clinical experiences, we propose the following clinical classification for treating these fractures:

- Open, intra-articular, tibial fractures that require open reduction with minimal internal fixation may also be treated with the Ilizarov apparatus as well as closed fractures with unacceptable displacement of fragments.
- Fractures for which the Ilizarov apparatus is highly recommended include: closed, comminuted fractures; open fractures with or without articular involvement; and open fractures with bone loss.

- The advantages of using the Ilizarov apparatus compared to traditional external fixation, casts, or internal fixation:

1. Stability

The previous biomechanical studies clearly show that the Ilizarov apparatus, using external, circular, transosseous fixation in a standard assembly of four rings with two wires crossing between 45° (and 90°) per ring segment, provides greater stability than a unilateral fixator does. The elasticity of the wires used in the apparatus allows for axial movement. These compressive movements favour the rapid consolidation of the fracture callus.

2. Preservation of Blood Supply

Closed, transosseous fixation respects the vascularity of the fracture segments and soft tissues and so contributes to a more rapid consolidation of the fracture. Furthermore, by avoiding opening the fracture, the risk of infection and subsequent osteomyelitis is minimized.

3. Maintenance of Function

When a patient with a tibial fracture is treated with the Ilizarov apparatus, he is allowed to weight bearing from the first postoperative day on. Progressive weight bearing is encouraged over the next two to three weeks until the patient is full weight bearing on the extremity.

Weight bearing adds the positive effects of compression forces on the fracture site and also increases the venous and lymphatic return preventing swelling and disuse osteopenia.

Other methods of stabilizing fractures that respect the vascularity of the fracture site such as cast treatment often do not provide great stability and so early weight bearing cannot always be permitted.

Internal fixation of fractures, with plates and screws, achieves early stability but at the cost of bone vascularity. Early motion of the joints is allowed but weight bearing in not permitted.

Intramedullary nailing of tibia fractures allows early weight bearing at the cost of the intramedullary blood supply and, in open fractures, increases the risk of infection.

Traditional external fixation respects the vascularity of the fracture segments and allows early motion of the joints but, early Weight bearing is not always permitted. Problems related to the larger half pins are frequently encountered and fixation may provide insufficient mechanical stability.
The Ilizarov method involves a non-invasive procedure without the problems of blood loss and need for transfusion, while providing stability and allowing weight bearing.
Difficulties may be encountered using the Ilizarov method during the closed reduction of fractures. This may require a longer operative time but such difficulties are quickly overcome if the surgeon follows the assembly techniques which will be presented here. Furthermore, as with most other surgical techniques, operative time decreases as the surgeon's experience increases.
The risks of vascular injury caused by wire penetration are no greater than with conventional surgery. If a vascular lesion is produced during the procedure, simply remove the wire which caused the bleeding and apply direct pressure with a compressive bandage for several minutes. (An Ilizarov wire is no larger than a venipuncture needle).
When we first began using the Ilizarov method for treating fractures, we encountered several difficulties including psychological problems with patients and pain with frequent dressing changes to wires sites. Increased surgical experience enables the assembly of a more stable, painfree frame and allows easier dressing changes.
The advantages of the Ilizarov system include stability, preservation of vascularity, immediate joint motion, immediate Weight bearing, minimal operative risk, and minimal blood loss.
The disadvantages include: difficulties for the surgeon in assembling of the frame and performing closed reductions and difficulties for the patient with dressing changes and with wearing the frame.

CLASSIFICATION

The Ilizarov apparatus can be applied to almost all fractures of the tibia. We will describe the apparatus in detail for its application in the following types of tibial fractures:

Proximal:	**Non-displaced intra-articular**
	Displaced intra-articular
	Complex
Diaphysial:	**Simple**
	With a third (butterfly) fragment
	Segmental
	With bone loss
Distal:	**Metaphysial**
	Epiphysial
	Pylon

PROXIMAL NON-DISPLACED INTRA-ARTICULAR FRACTURES *(Fig. 5.1)*

The preassembled frame consists of two rings; one proximal and one distal. On the proximal ring, two olive wires are inserted.
One from posterolateral to anteromedial and the other from anterolateral to posteromedial, at an angle of 30 degrees to each other. Another olive wire is inserted from medial to lateral. This causes the fragment to be reduced and produces interfragmentary compression. Distally, two wires are inserted , one transversely through the fibula and the other from anterolateral to posteromedial (Fig. 5.1).

Naturally, for this type of fracture, weightbearing is not allowed for at least 45 days. The advantage of percutaneous fixation with wires is that there is less chance of infection, and one can remove the fixator without general anaesthesia.

PROXIMAL DISPLACED INTRA-ARTICULAR FRACTURES *(Fig. 5.2)*

When there is a depressed fragment (Fig. 5.2), with destruction of the joint surface, it is absolutely necessary to restore the alignment of the joint surface. Open reduction is performed to realign the fragments with olive wires or, for smaller fragments, a screw may be used. An apparatus similar to the one previously described is applied for reduction of the fracture. The number of the wires and the position of the olive wires depends upon the type of fracture. Weight-bearing is allowed after 30-45 days, while articular motion begins immediately.

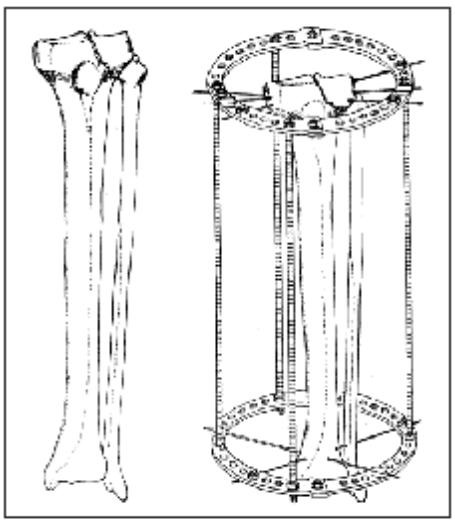

Fig. 5.1

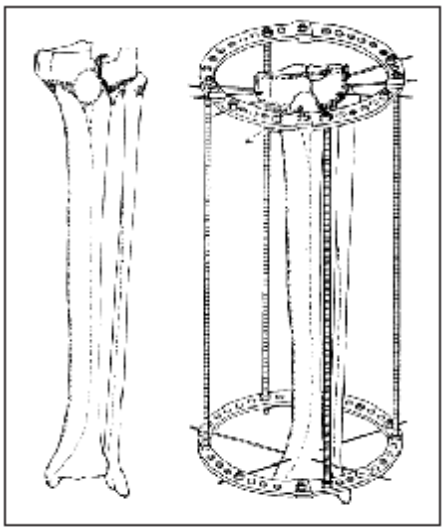

Fig. 5.2

PROXIMAL COMPLEX FRACTURES *(Fig. 5.3)*

In an open fracture, where the fracture involves the joint and the metaphysis, a three-ring-frame will be applied (Fig. 5.3).

Fixation of the proximal fracture is performed as previously described. If the fracture is displaced, it is reduced surgically and fixed with olive wires or smooth wires. The frame is then applied with transverse olive wires proximally and a wire through the tibia and fibula distally. These are placed perpendicular to the tibial axis. After the wires are tensioned, the frame becomes centralized on the leg. Intra-operative radiographs are taken.

Further reduction of the metaphysial fracture may be achieved with a wire attached to the intermediate ring. (This is described in detail in the chapter on fractures of the diaphysis.)

After fracture reduction has been achieved, the frame is further stabilized with a wire in the distal ring placed from anterolateral to posteromedial and a half-pin on the intermediate ring, perpendicular to the inserted wire (Fig. 5.5).

It is important to realize that in all described fractures, weightbearing is not allowed for the obvious reason of loosing the reduction. In special cases, when the fracture is extremely complex and unstable, the frame can be extended onto the distal femur with two levels of fixation (Fig. 5.4).

The femoral and tibial frame are connected with hinges which are placed in line with the center of rotation of the knee.
With this type of frame, it is also possible to distract the knee joint in order to avoid compression and subsequent displacement of the fracture (Fig. 5.6 - 5.7 - 5.8).

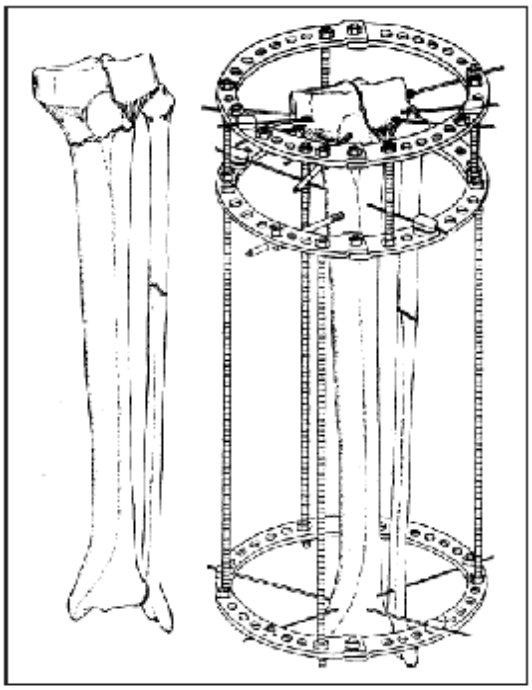

Fig. 5.3

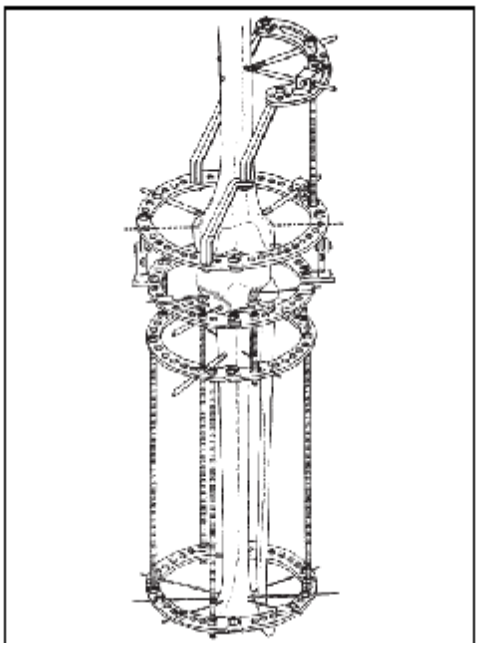

Fig. 5.4 Configuration of a standard assembly for a tibial plateau fracture with extension to the femur. (From Advances in Ilizarov Apparatus Assembly)

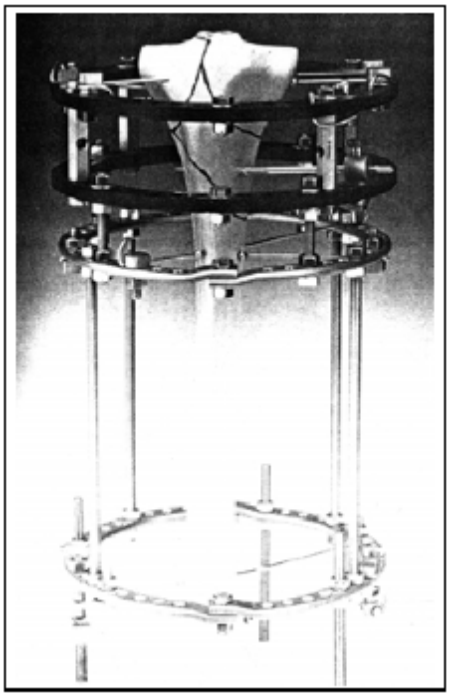

Fig. 5.5 Standard apparatus assembled for treatment of a complete articular, comminuted fracture of the tibial plateau. (From Advances in Ilizarov Apparatus Assembly).

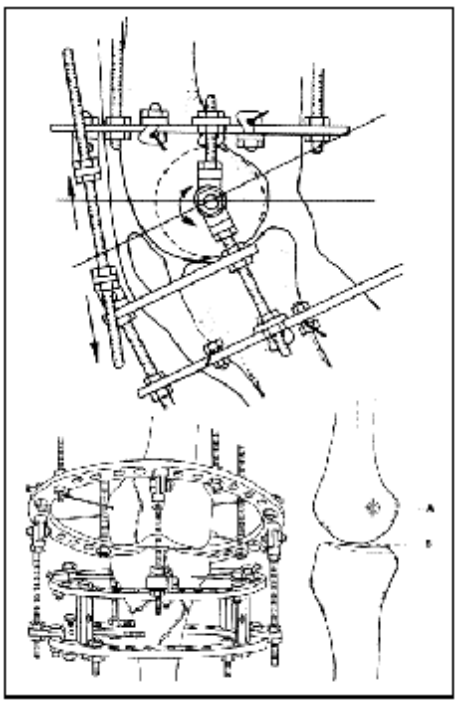

Fig. 5.6 Detail of the knee assembly. The center of rotation must be at about 2 cm from the articular surface at the posterior third of the femoral condyle.

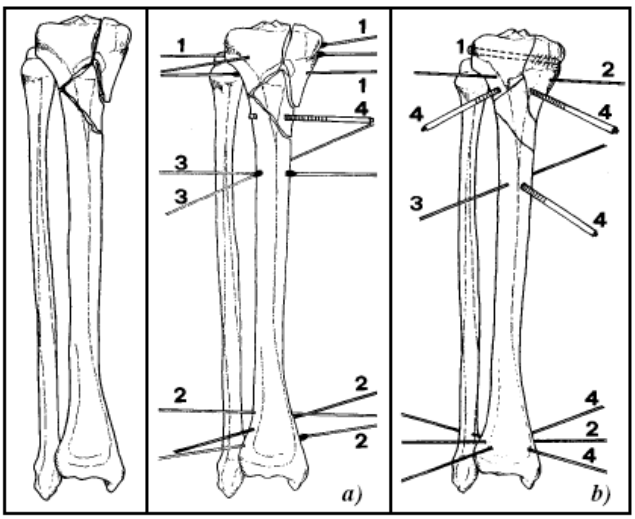

Fig. 5.7 Diagram for the serial insertion of wires and half pins:
a) Hybrid Traditional System
b) Hybrid Advanced System associated with internal osteosynthesis
(1 = open reduction, 2 = centralization, 3 = reduction, 4 = fixation)

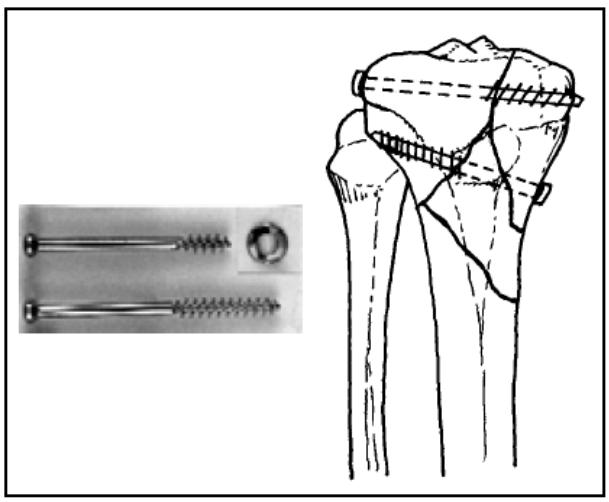

Fig.5.8 Internal osteosynthesis with cancellous screws following the AO technique (From Advances in Ilizarov Apparatus Assembly)

CASE REPORT: **Proximal complex fracture**

Fig. 5.9 (C. Lombari - Naples Hospital)
I.M., 40 year-old male
a) Proximal complex, tibial fracture with depression of the lateral tibial plateau.
b) The tibial plateau has been elevated by an open surgical approach, the fracture is reduced and fixed with opposite olive wires. Early motion and weightbearing was encouraged from the first postoperative day.
c) Radiographic and functional follow-up. Length of treatment was 90 days. Note the reconstruction of the articular surface.

CASE REPORT: **Proximal complex fracture**

Fig. 5.10 (From the Ilizarov Unit- Lecco Hospital)
F.R., 55 year-old female
a) Proximal, non displaced, intrarticular fracture of the right tibia. Open reduction and fixation with cancellous screws is accomplished along with the repair of the lateral meniscus. The Ilizarov apparatus acts to distract the joint space and is accomplished with the frame extended onto the femur. (Fig. 5.4 - 5.6 - 5.8)
b) Configuration of a standard assembly extended to the femur for treatment of a complete intrarticular fracture of the tibial plateau.
c) x-ray examination of the reduced fracture. After 1 month.
d) x-ray after 2 months
e) After 3 months the apparatus is removed. Final follow-up.

CASE REPORT: **Proximal complex fracture**

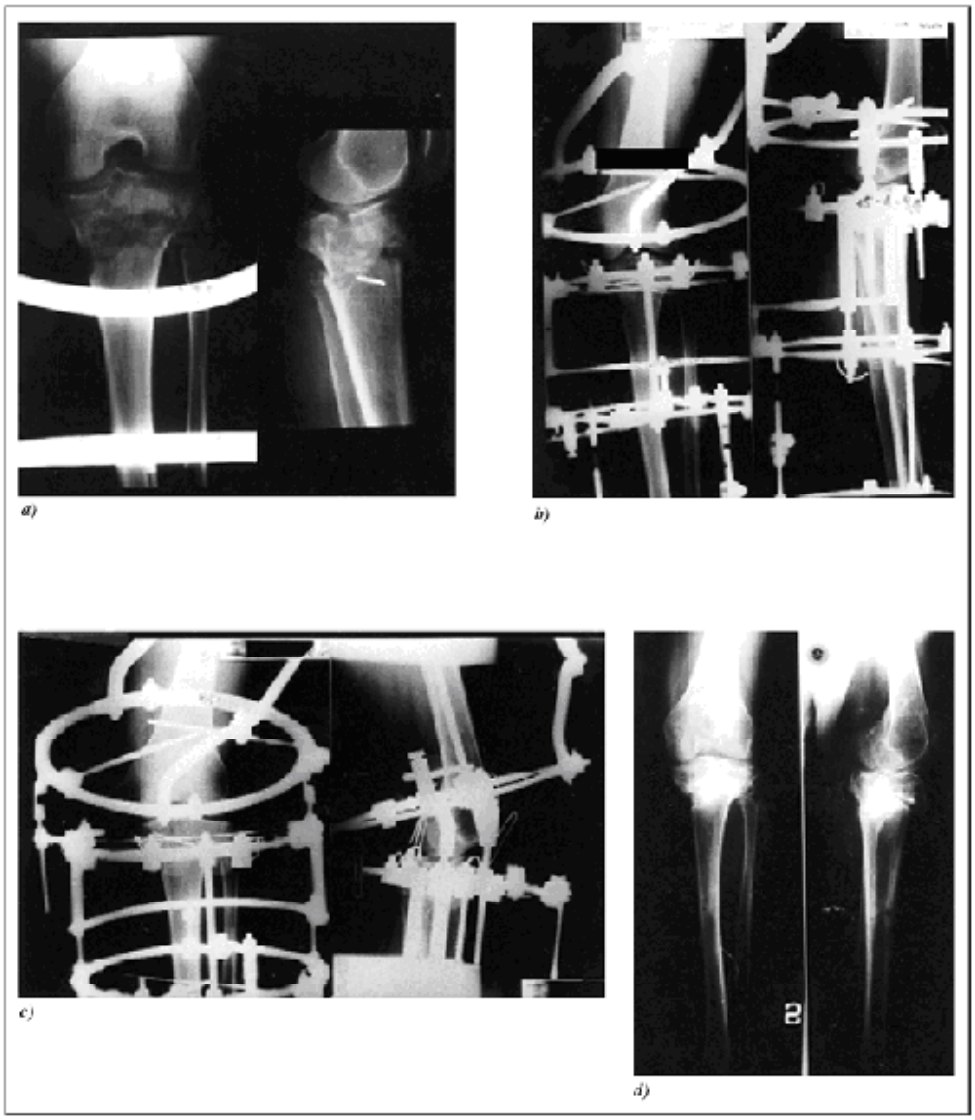

Fig. 5.11 (From the Ilizarov Unit - Lecco Hospital)
B.A., 65 year-old female
a) Proximal, displaced, intra-articular fracture of the left tibia.
b) Open reduction after 15 days; the Ilizarov apparatus is extended onto the femur and acts as a knee joint distractor (see Fig. 5.4)
c) x-ray examination of the reduced fracture.
d) The apparatus is removed after 5 months. Final follow-up.
Note: see reconstruction of the tibial articular surface.

CASE REPORT: **Proximal complex tibial fracture. Composite Hybrid Fixation**

Fig. 5.11 bis (M.Raschke - Virchow-Klinikum - Berlin)
35 year-old male
a) Closed tibial plateau fracture with a proximal, comminuted, tibial fracture with severe soft tissue injury (Tscherne G3-Compartment Syndrome). Admission x-rays.
b) Immediate fasciotomy was performed. The tibial plateau was reduced using an impactor under arthroscopic control and radiographic assistance.
Percutaneous screw fixation with perpendicular olive wire positioning provides interfragmentary compression. The ring construction is restricted to the area of comminution. In the diaphysial portion of the tibia, monolateral fixation is performed with an AO-Fixator (Composite Hybrid Fixator). Post-operative x-ray of the articular surface.
c) Post- operative x-ray of the articular surface.
d) Full weightbearing after soft tissue consolidation (6 weeks post injury).
e) X-ray after removal of the Composite Hybrid Fixator 16 weeks post injury.
Fixator removal with full recovery of function. The canulated screws were left in place (b).

PROXIMAL METAPHYSIAL FRACTURES *(Fig. 5.12)*
The preassembled frame consists of 3 rings: one ring is placed proximally at the level of the fibular head, the second ring is placed 2 cm distal to the fracture, and the third ring is placed 2- 3 cm proximal to the ankle joint. To centralize the frame, a proximal wire is inserted transversely and perpendicular to

the long axis of the tibia. A second wire is inserted distally through the tibia, also perpendicular to the tibial axis. After the frame is centralized, the fracture is reduced with a wire attached to the intermediate ring.

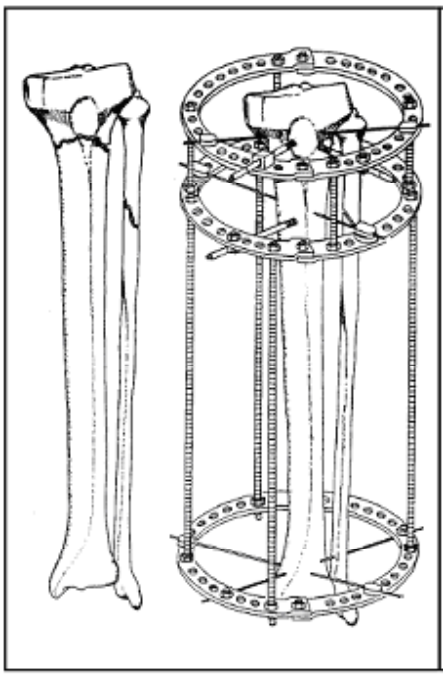

Fig. 5.12

The frame is strengthened with another wire on the distal ring (from anterolateral to posteromedial) and two half-pins on the proximal ring (one from anteromedial to posterolateral, and the second from anterolateral to posteromedial). A half-pin is also inserted on the intermediate ring from anteromedial to posterolateral (Fig. 5.12).
This configuration provides enough stability to allow partial weightbearing a few days after surgery. Full weightbearing may be allowed after approximately 20 days. After consolidation (according to radiologic criteria), the apparatus can be removed without anaesthesia.