FUNCTIONAL OUTCOME ANALYSIS OF MANAGEMENT OF COMPOUND FRACTURES OF TIBIA WITH ILIZAROV FIXATOR

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CERTIFICATE

This is to certify that **Dr. S. KUMARESAPATHY**, Postgraduate student (2005-2006) in the department of Orthopaedics, Government Kilpauk Medical College, Chennai has done this dissertation on "**FUNCTIONAL OUTCOME ANALYSIS OF MANAGEMENT OF COMPOUND FRACTURES OF TIBIA WITH ILIZAROV FIXATOR"** under my guidance and supervision in partial fulfillment of the regulation laid down by the Tamilnadu Dr. M.G.R Medical University, Chennai for MS (Orthopaedics) degree examination to be held on March 2008.

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DECLARATION

I, **Dr. S. KUMARESAPATHY,** solemnly declare that dissertation titled **"FUNCTIONAL OUTCOME ANALYSIS OF MANAGEMENT OF COMPOUND FRACTURES OF TIBIA WITH ILIZAROV FIXATOR"** is a bonafide work done by me, at Government Kilpauk Medical College between 2005-2008, under the guidance and supervision of my unit Chief **Prof. Dr. A. SIVA KUMAR M.S. (Ortho.,) D. Ortho.,** Professor of Orthopaedic Surgery.

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INTRODUCTION

Tibia is most frequent site of an open fracture, with incidence ranging from 49.4% to 63.2% (27,28). India has the highest road accident rates in the world one of every forty two vehicle in country had met with an accident in 1986 (37). A large proportion of vehicles involved were two wheelers. The lower Limbs are involved in 49 .6 % of motor cycle accidents (27,28).

By its very location the tibia is prone to frequent injuries. Furthermore, the blood supply of the tibia is more precarious, high-energy tibial fractures are associated with compartment syndrome or neural or vascular injuries(27,28). Open fractures have a higher infection rate than closed fractures(21,29) and the rate increases with the increasing severity of the soft tissue injury(25,26).The risk of delayed union and nonunion in closed, and open treatment is increased with comminution.

Their treatment, prognosis, and outcome are mainly determined by the mechanism of injury, degree of comminution, soft tissue injury and displacement (30).

There are many options available for management of fracture tibia,

1. Closed reduction and cast treatment
2. Pin and plaster technique
3. External fixator
4. Intramedullary nailing
5. Rigid fixation with plate and screws

Each method has its own merits and demerits. The high incidence and variety of these fractures may at times cause difficulties in choosing the type of treatment. The optimal treatment should include anatomical reduction of segments, Stable fixation and early function.

Our study is to highlight the important role of ilizarov ring fixator for compound grossly communited fracture tibia. It is a method of minimally invasive external fixation using small diameter transosseous ‘K’ wires which are tensioned and fixed to circular rings.

It helps achieve stable fixation of the limb at multiple level and permits healing of fracture. Since it is multidirectional, multiplanar, multilevel fixator system it allows cyclic axial micro motion at fracture site and favors fracture union.

AIM OF STUDY

Aim of our study is to highlight the important role of Ilizarov technique in the management of Grossly Comminuted Compound Tibial fracture.

At present there are many methods available for the management of fracture tibia. Even though these methods are valuable for closed stable fracture tibia these methods result in many complication and have high failure rate for complex fractures, like closed comminuted fracture, open comminuted fracture, open fracture with bone loss and intra articular fracture with diaphyseal extension with unhealthy skin.

For those complex fractures, Ilizarov techniques appear to be ideal treatment. It is absolutely indicated in treatment of open comminuted and contaminated diaphyseal fracture as well as for the patient with multiple open fractures with other major trauma.

Aim of our study is to analyze the result of 20 cases of these complex grossly comminuted compound tibial fractures with Ilizarov technique.

HISTORY(18)

Professor Gavril Abramovich Ilizarov was born in the USSR, in the Soviet Union in 1921. He advanced quickly through medical school.

In 1950, in a small village (Dolgovka), he performed his first operation, by using ring fixator for a patient with nonunion tibia fracture for 15 years; after treatment the fracture healed very quickly.

In 1966 Ilizarov was appointed head of the laboratory on scientific investigation. In 1969 Professor Ilizarov published and defended his Ph.D. dissertation in title “Transosseous fixation by avtor’s fixator”.

Until the early 1980s the use of the Ilizarov external fixator remained isolated in Russia, when it was brought into Italy by an orthopedic surgeon. Who had sustained a tibia fracture & developed a nonunion. He underwent multiple attempts at open reduction and bone grafting, but all had failed. He traveled to Russia, had the external fixator placed, and eventually went on to unite his fracture in 3 months.

The technology was brought back to Italy and slowly spread through Europe. In 1986 The Ilizarov external fixator was first used in the United States

SURGICAL ANATOMY (34,40)

A thorough knowledge of both topographic and the structural anatomy of the leg is essential in planning operative approaches to the extremity.

The anteromedial surface of the tibia and anterior crest are easily palpated from the area of the tibial tuberosity and distally into its termination in the medial malleolus . The muscle,tendon,ligament and neuro vascular structure in the leg are divided in to anterior, lateral, posterior compartment for ease in description and location. The tibia in most part is palpable subcutaneously along the anterior border.

The diaphyseal portion is marked by a very dense anterior tibial crest running proximally from tibial tuberosity to just above the ankle. The subcutaneous prominence of tibia lends itself to pin fixation, especially its anteromedial portion.

ANTERIOR COMPARTMENT

Muscles contained are tibialis anterior, Extensor digitorum longus, Extensor hallucis longus and peroneous tertius responsible for dorsiflexion of foot and ankle it is bounded medially by tibia, laterally by fibula posteriorly by interroseus membrane, anterior by the tough crural fascia.

LATERAL COMPARTMENT

It contains peroneous brevis and peroneus longus, the evertors of the foot. The superficial peroneal nerve runs between peroneal muscles and extensor digitorum longus is at risk with fractures of fibula neck, pin insertion and pressure from cast.

SUPERFICIAL POSTERIOR COMPARTMENT

Contains gastrocnemius, soleus, popliteus, plantaris, sural nerve, short and long saphenous veins. This compartment is important in plantar flexion of foot, serves as source of local muscle flaps for coverage of soft tissue defects and can be site of compartment syndrome.

DEEP POSTERIOR COMPARTMENT

Contains tibialis posterior, flexor digitorum longus, flexor hallucis longus muscles, posterior tibial nerve, peroneal and posterior tibial vessels, involved in plantar flexion of foot and toes and in inversion of foot. Posterior tibial artery is the major arterial supply after significant open fracture and is a source for anastomosis with free flaps for soft tissue reconstruction of leg.

BLOOD SUPPLY (34)

The blood supply of tibia is derived from afferent vascular system comprising of

1. Principle Nutrient Artery: arising from posterior tibial artery and enters posterolateral cortex of bone dividing into three ascending branches and one main descending branch which gives off branches to endosteal surface.

2. The periosteal blood supply from branches of anterior tibial artery. Periosteal arterioles enter diaphyseal cortex along fascial attachments.

3. Metaphyseal arteries supply to each metaphyses and anastomose with medullary arteries significant in a fracture.

4. Epiphyseal vessels in cases where capsule is attached to epiphyses.

The anterior tibial artery is vulnerable to injury after its division from popliteal artery when it passes to through a hiatus in interosseous membrane. The lower third is thus prone for infection and nonunion because of its decreased blood supply and inadequate muscle cover.

COMPONENTS AND INSTRUMENTS OF ILIZAROV APPARATUS

The ilizarov device is a ring fixator that can be assembled an almost limitless number of variations depending on the task at hand. This versatility prompted Dr. Paley to label it as human erector (mechano) set.

The apparatus consists of two components

i. primary components

ii. secondary components

i. Primary components

These are the standard parts that join the skeleton to the furnished frame such as transosseus wires, rings and wire fixation bolts.

ii. Secondary components

These are the special elements used to construct the frame of the apparatus - like the threaded rods and telescopic rods.

EQUIPMENTS REQUIRED

Rings

Nuts and washers

Threaded rods without nuts and washers

Washer

Bolts without nuts and washers

K wires and olive wire

Screw

Post

Rancho

Hinges

Telescopic rods, Extension plate

INSTRUMENTS

Wire tensioner

Wrench

Wire cutter

Drill bit

Hand drill

Rings

Are the basic elements in the construction of the ilizarov ring fixator frame.

Types

1. Half rings
2. Full rings
3. Half ring with curved extremities
4. 5/8 half rings

i. **Half rings**

This is the most commonly used which when coupled with another half ring forms a full ring. Various ring sizes 80, 100, 110, 120, 130, 140, 150, 160, 180, 200 and 240 mm are available. They contain holes usually in the intervals of 5° to 10°.

ii. **Full ring**

Full rings are less commonly used than half rings since it lacks its versatility. Its advantage is that it increases the number of the holes for rods and wires, which can be used for the complex extension to the foot or hand.

iii. **Half ring with curved extremities (omega rings)**

They are curved extensions turned outwards. This allows additional holes for support without compromising on space. This is useful for proximal humerus as it allows shoulder motion after fixation.

iv. 5/8th half ring

Extends then 5/8th of a circle that is 225°

Used in-

1. Complex fractures of tibia / femur near knee and ankle
2. Distal humerus – preserves elbow motion.

Wires

Are the important parts of the ilizarov apparatus and wire placement determines the treatment progress and final result.

Dr. Ilizarov used Kirschner wires in fixation.

This has the following advantages.

1. Minimal destruction of compact bone and marrow.
2. Dampens vibration and prevents soft tissue and bony destruction because of its elasticity.
3. Penetration holes are very small.

4. Minimal external contamination.

Ilizarov used three types of wires in fixation

1. ilizarov wire with bayonet point (for cortical bone)

2. ilizarov wire with trocar point (for metaphyseal bone)

3. **Olive wire**

   Wire with a stopper. This has a support bead and is used in many special situations like interfragmentary compression, increasing stability of the construct, gradual distraction or translation of bone fragments.

Wire tensioner

The tensioner allows tightening of the wires to an exact predetermined tension, improving stability of the construct and enabling interfragmentary compression and distraction or translation of fragments.

MECHANISM OF INJURY

Direct violence accounts for increasing number of tibial fractures. The exposed subcutaneous border of tibia offers little production from a direct blow and in a mechanized society, high energy trauma as a result of motor vehicles, motor cycle or motor vehicle vs. pedestrian accidents involve the tibia in over 15% of accidents. **(32,40)**

Damage of extremity, associated with a significantly soft tissue injury is a result of high energy impact between an object and the limb. The amount of energy dissipated during this collision is determined by the following equation: $EK = mv^2/2$, EK is kinetic energy, m the mass and v the speed.

CLASSIFICATION

Classification of tibial fractures have been based on:

1. Clinical appearance

    a. Deformity

    b. Extent of soft-tissue damage

    c. Presence of an open wound

2. Radiographic appearance

a. Fracture level

b. Fracture pattern (morphology)

c. Comminution

d. Displacement

3. Mechanism of injury

4. Combination of the above

Tibial fracture classifications have been broadly described as:

1. Descriptive (Describes about the fracture alone)
2. Dynamic (Includes Mechanism of injury into the classification)

DESCRIPTIVE CLASSIFICATIONS

I. Ellis Classification (1958)

II. Alms' Classification (1962)

III. Nicoll Classification (1964)

Other classifications in descriptive types are:

IV. Edwards Classification (1965)

V. Weissman Classification (1966)

VI. Ekeland Classification (1988)

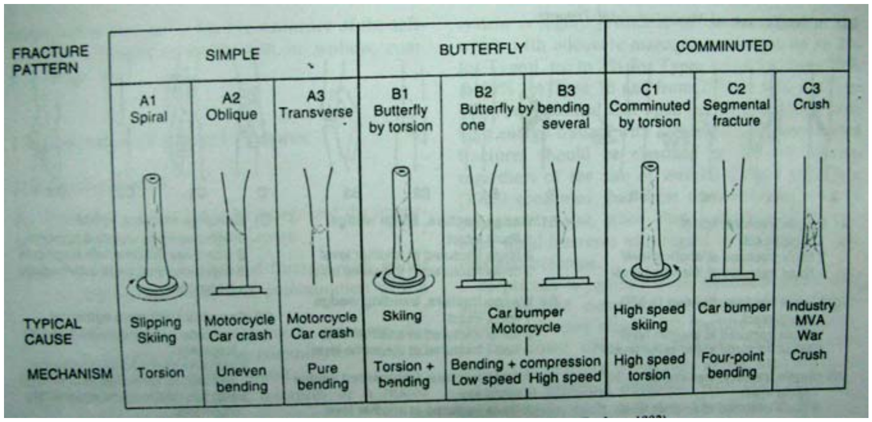
DYNAMIC SYSTEMS

1. JOHNER AND WRUHS' CLASSIFICATION

This classification recognized the important relationship between the fracture pattern and injury mechanism. In addition to mechanism, comminution was considered an indicator of severity of injury. There are three major categories:

1. Type A. Simple non-comminuted patterns
2. Type B. Butterfly or wedge patterns
3. Type C. Comminuted and segmental fractures.

The three main types are further divided into three sub-types to make nine separate categories:



2. AO CLASSIFICATION

MULLER AO CLASSIFICATION (35)

The concept

The Muller concept goes beyond the mere production of an alpha-numeric coding, valuable through that is in the acquisition, storage, and retrieval of data; what distinguishes Muller's system is that one is required to recognize, identify, and describe the injury to the bone (14).

There are nine morphological groups in this classification. There are three types: 42A (simple fracture) 42B (wedge) and 42C (complex). Forty two is the code for the tibia shaft (4=tibia and 2=diaphysis). The code and classification have been designed so that they can be entered into a computer for analysis. This is distinct advantage of this system in research and documentation.

The letters A,B,C (types) are used to represent an increasing degree of comminution and the numbers 1, 2, 3 represent criteria of the accident mechanism, i.e direct and indirect impact and the amount of absorbed energy. These are divided into three groups:

Group 1 fractures include all spiral fractures produced mainly by indirect impact (torsion), i.e. A1, B1 and C1.

Groups 2 and 3 include fractures produced by direct impact (bending), causing oblique, transverse and segmental fractures namely B1, B2, B3, and C1, C2, C3.

CLASSIFICATION OF OPEN FRACTURES

GUSTILO & ANDERSON 1976

TYPE	DEFINITION
I	Open fracture with clean wound <1cm
II	Open fracture with laceration >1cm without extensive soft tissue damage, avulsion or flaps
III	Open fracture with extensive soft tissue laceration damage, or loss or open segmental fractures or traumatic amputation. High velocity gunshot injuries, open fractures by farm injuries or requiring vascular repair or older than 8 hours.

Type III subtype classification

Subtypes	Definition
IIIA	Adequate periosteal cover despite extensive soft tissue or flaps, high energy trauma despite size of wound
IIIB	Extensive soft tissue loss with periosteal stripping and exposure of bone, massive contamination is usual
IIIC	Associated with arterial injury requiring repair

TSCHERNE & OESTERNE CLASSIFICATION (1984)

This classification emphasizes grading of the severity of soft tissue damage in closed and open injuries.

For Open fractures:

Grade 1:

First degree open: small puncture wound without skin contusion, negligible bacterial contamination and a low energy fracture pattern.

Grade 2:

Small skin and soft tissue contusion, moderate contamination and variable fracture patterns.

Grade 3:

Heavy contamination, extensive soft-tissue damage, often associated arterial and nerve injuries.

Grade 4:

Incomplete or complete amputations.

PRINCIPLES OF MANAGEMENT OF COMPOUND TIBIAL FRACTURES(10,16)

1. Rapid debridement, irrigation, antibiotic therapy and tetanus prophylaxis.
2. Fracture reduction followed by application of splint with window for grade1 and grade 2 Gustilo.
3. Fracture reduction and application of external fixation for grade 3 Gustilo.
4. Vascular perfusion doubtful referred to vascular surgery.
5. Open wound treatment with loose gauze packing.

6. Staged debridement of necrotic soft tissue and bone in operating room every 24-72 hours until good granulation tissue develops.

7. Delayed closure; application of STSG or delayed myocutaneous flap as needed.

8. Conversion to definitive fixation after initial wound management and general condition improvement.

ANTIBIOTICS

The incidence of infection of the wound in patients who have an open fracture correlates directly with the extent of soft tissue damage (17). The value of 'preventive' antibiotics in open fractures is well documented in literature(38). All open fractures are documented and are likely to get infected unless debrided.

A cephalosporin is recommended for type 1 open fractures in a single dose of 2gms on admission and 1gm 6 – 8th hourly for 48-72 hours. For type II or type III fractures, combined therapy in the form of 2gm cephalosporin on admission and 3-5 mg/kg body weight each day in divided doses is recommended(17,38). Prolonged antibiotic therapy more than 3 days has been reported not to prevent infection (17,38).

BIOMECHANICS (7,3)

The elements of 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 wire, rings and wire fixation bolts.

The secondary components are the special element used to construct the frame of the apparatus, such as threaded and telescopic rods, connecting plates, hinges and posts, nuts and bolts. The various wrenches are also considered secondary components of the apparatus.

BIOMECHANICS OF THE ILIZAROV EXTERNAL FIXATOR (4)

Lanyon and Rubin showed that cyclic axial loading of bone is important for maintaining bone mass and remodeling. Sheer forces are deleterious to fracture healing and bone formation. Fleming, Paley, Kristriansen and Pope compared the stiffness profile of several conventional cantilever fixators with five configurations of the ilizarov fixator. In addition to AP and lateral bending, torsion and axial stiffness, they measured the axial gap closure and translational sheer motion at the fracture site in an invitro model.

The Ilizarov circular, multiplanar fixator was tested in five configurations

1. Ilizarov $90^o/90^o$ centered

2. Ilizarov $45^o/135^o$ centered

3. Ilizarov $90^o/90^o$ off centered 90 kg tension

4. Ilizarov $90^o/90^o$ off centered 130 kg tension

5. Ilizarov $90^o/90^o$ off centered 130 kg tension Olive wires.

STIFFNESS

The Ilizarov fixator was significantly less stiff than some of the unilateral fixators in lateral bending, defines as the plane of bending of the pins for the uniplanar fixators.

SHEAR STIFFNESS (5)

The ability of the fixator to resist translational shear at the fracture site is represented by the shear stiffness value for each loading mode (20). The higher the shear stiffness the fixator, the greater the resistance to fracture gap shear. The $90^o/90^o$ configuration had lower lateral shear stiffness than the $45^o/135^o$ configuration. Increasing the wire tension from 900 to 1300 N led, paradoxically, to lower torsional stiffness. The olive wires significantly increased the bending shear stiffness of the Ilizarov but not torsional stiffness (5).

AXIAL STIFFNESS

The ability of the fixators to resist axial motion at the fracture site, i.e., motion along the central axis of the Pylyn, was defined by axial stiffness(6). The $90^o/90^o$ configuration demonstrated less axial stiffness than $45^o/135^o$ configuration (6).

According to the literature summarized. It is reasonable to suggest the following two hypothesis (7).:

1. Cyclic axial micro motion is beneficial to fracture healing

2. Translational shear at the fracture site is deleterious to fracture healing.

For the wires used for Ilizarov fixation, Bagnoli showed the yield point to be 120kg/mm^2 that is 210kg for 1.5mm wires and 305kg for 1.8mm wires. What therefore, is optimum tension to apply to the wires? Bagnoli argues that one should not exceed 50% of the yield strength of the wire to be on the safe side and minimize breakage and stretching (ductility) of the wire. This would be 105kg for 1.5mm wire and 150kg per 1.8mm wires.

$$\text{Load by pass (N)} = \frac{\text{IL (cm)}}{\text{E (N/cm) A (cm}^2)}$$

This is analogous, to Ohm's second law

$$\text{Resistance} = \frac{QL}{A}$$

Q – Specific resistance constant of conductor

L – Length of conductor

A – Cross sectional area of conductor

M_E – Modulus of elasticity of conductor tissue (constant).

DISTRACTION OSTEOGENESIS AND CORTICOTOMY(36)

Distraction osteogenesis is the mechanical induction of new bone between bony surfaces that gradually pulled apart .The biological bridge between these bony surfaces arises from local neovascularization and spans the entire cross-section of the cut surfaces when the biological and mechanical conditions during distraction are ideal, bone is formed by pure intramembraneous ossification (36).

CORTICOTOMY(36)

The term corticotomy was first used by ilizarov after he conducted many controlled animal experiments in which he tried out this technique. After his experiments, he concluded that preservation of endosteal tissues and vasculature results in more rapid and reliable bone formation and consolidation.

Corticotomy is transaction of only the bone cortex with preservation of the Periosteum,endosteum and the bone marrow with its blood supply. This indicates a small portal entry and minimal disruption of surrounding soft tissue and manual osteclysis of the remainder of the cortical circumference.

TECHNIQUES OF CORTICOTOMY

1. Classical method

Is a percutaneous sub periosteal corticotomy . This is performed with an osteotome by 2 different methods.

1 Triangular bone method

Eg.Tibial, ulnar or radius corticotomy

2 Round bone method

Eg. Femoral or humeral corticotomy

BASIC PRINCIPLES OF OPERATIVE TECHNIQUE(36,20)

INSERTION OF WIRES

The wire provided the key element to successfully controlling the biology, of healing. Proper wire insertion techniques are critical to avoid pain, to maintain function and to expedite healing. Bayonet wire tips on 1.5 to 1.8mm diameter wires are specially designed for hard cortical bone, whereas the trocar tips are reserved for metaphyseal cancellous bone.

Of course, nerves and vessels must be avoided during wire passage by awareness of the anatomy. Push the wire manually to bone before drilling. Drill through both cortices, then hammer the wire out through the opposite soft tissues.

Muscles must be properly positioned for wire placement to maximize excursion of adjacent joints. Prior to impalement, each muscle should be stretched maximally at the adjacent joint. In the example, the ankle plantar flexors are stretched by maximum dorsiflexion of the foot during posterior wire passage and then the foot maximally plantar flexed as wire passes out dorsally.

The same method is used to insert wires with stoppers but it is necessary to make a small incision when the stopper reaches the skin to allow it to pass through the soft tissue to the bone.

Transosseous wires constitute a foreign body passing through the muscular and tendinous planes and may thus limit joint movement. It is a good general to insert the minimum number of wires compatible with stability of the assembly.

FIXATION OF THE WIRES TO THE RINGS

The size of the rings (made up of two half-rings) is chosen based on the maximum diameter of the limb. It is suggested that a two-to-three centimeter distance be left between the internal part of the ring and the soft tissue circumferentially.

The ring assembly is carried out so that the limb segment (not necessarily the bone) is placed in the centre of a ring.

To obtain suitable balance between the stability and the flexibility of the apparatus the suggested tension for wire is as follows:

1. wire on half-ring or drop wire 50kg

2. single wire on a ring 70kg

3. two wire on a ring (in young patients) 110kg

4. two wire on a ring (in adult patients) 120kg

5. two wire on a ring (in heavy patients) 130kg

ASSEMBLY OF THREADED RODS TO CONNECT THE RINGS

The rods (threaded) which are used to connect the rings are placed parallel to one another and must at the same time be parallel to the mechanical axis of the bone. The rods must be approximately at on equal distance from each other on the circumference of the ring. Three or four rods are used to connect rings.

In fractures, when the apparatus is assembled correctly and longitudinal distraction of the segments has been completed, securing the nuts and bolts on the rods will automatically produce a reduction.

Cut 0

In first transverse cut of the lower extremely is made just Proximal to the ankle joint. The model demonstrates one wire from 310° to 110° and another from 260° to 70°. Tibio fibular articulation, is immobilized.

Cut 4

This section is located "2t" proximal to the ankle joint. If the fibula is to be fixed, a construct (260° – 50°) and (320° – 110°) is preferred. "t" – {"thumb"}, {"tsun"} – Measure of a thumb across (or) measured in interphalangeal of the patient to be trected.

Cut 24

This cut is taken "6t" distal to the knee. Tibial fixation can be carried out from (20° – 240°) and (280° – 60°).

Cut 28

This cut is taken "4t" distal to the knee. Tibial fixation can be carried out from (200° – 60°).

Cut 36

This cut traverses the medial and Lateral tibial plateus just inferior to the knee joint, the fibular head is included in the osteosynthesis. Optimal divergence is achieved with (100° – 310°) and (60° – 260°) positioning.

BONE GRAFTING

Early posterolateral autogenous cancellous bone grafting by posterolateral approach (Harmon) is used (6-12 weeks), if soft tissues are stable, for severe fractures or with more than 50% bone loss circumferentially. Edwards suggested grafting at 2-3 weeks and a second or third cancellous graft if initial graft proves insufficient during next 8-12 weeks. Injection of bone marrow aspiration is a useful technique for accelerating bone healing (50).

Fischer et al. reported delayed bone grafting after a well vascularized soft tissue envelope, resulted in decreased infection(38). Olson concludes bone grafting for IIIB fractures without callus at three months.

Procedures for treatment of Acute fractures of Tibia

TYPE A1 ASSEMBLY

Transverse Proximal Fractures

In proximal fractures, two pairs of wires are initially placed, the first pair in the proximal epiphysis, the second pair in the distal epiphysis. The planes formed perpendicular to the axis of the fractures segments.

TYPE A2 ASSEMBLY

Oblique Proximal Fracture

In oblique fractures, it is better to use olive wires in opposite position

TYPE B1 ASSEMBLY

Transverse Diaphyseal Fractures

It is necessary to use two intermediate rings one placed approximately two centimeters proximal to the fracture site and the other distal.

TYPE B2 ASSEMBLY

Oblique Diaphyseal Fractures

It is best to use wires with stoppers.

1. Interfragmentary compression may be exerted by means of the opposing forces applied between two rings fixed to the bone with wires.

2. By using two wires with stoppers, the stoppers are placed on opposite sides of the bone, on either side of the fracture.

3. By using two wires placed through the fractures sire and a reduction is obtained by applying traction.

4. Interfragmentary compression may be exerted with a single wire with stopper placed in an oblique position.

TYPE B3 ASSEMBLY

Only Variation from B2 Assembly consisting of fixation of the third Fragment with stopper wire. Two wires with stoppers are placed approximately two centimeters above and below the fracture site and opposing directions. A wire with a stopper is inserted, through the third fragment from posts attached to third ring.

TYPE C1 ASSEMBLY

Transverse Distal Fracture

Fixation of the distal tibia entails the use of three wires places on a ring. One of the wires is transtibiofibular. A fourth wire with a stopper may also be used. It is placed approximately two centimeters proximal to the distal ring and fixed to with two support posts or half ring with threaded rods.

TYPE C2 ASSEMBLY

Oblique Meta-epiphyseal Distal Fracture.

When the distal fragment is small and difficult to Stabilize, the assembly must be extended across the Ankle joint to the calcaneus.

Correction of Lateral Displacement in Acute Fractures

Two crossed wires are inserted into the proximal segment (A) and a wires with a support stopper is used for the distal segment(B).

The limb is placed in traction in order to distract the two segments apart.

For rotational displacement,

A series of buckles and posts with threaded rods all facing the same direction on the distal ring may be used. Derotation of the fragments can be carried out in controlled mechanical fashion in this way.

POST OPERATIVE MANAGEMENT

Post operative management following the method of ilizarov is divided into immediate primary, secondary and late treatment. Immediate primary treatment is defined as that which is carried out on the first or second post operative day, with secondary that which is carried out in the next week or so following surgery until there is initial recovery of the injury produced by surgery. Late treatment is that which is carried out until removal of apparatus.

IMMEDIATE PRIMARY

The patient leaves the operating room with his/her limb elevated. The wire skin interface is protected by a piece of gauze.

IMMEDIATE SECONDARY:

The individual changing the dressing must

1. clean the skin around the wire with betadine
2. place dry, sterile gauze around each wire
3. cleaning of the wires with white spirit

ACTIVE AND PASSIVE MOBILISATION:

The stable fixation afforded by the apparatus facilitates early joint mobilization. Partial weight bearing with crutches is begun on the third to fifth postoperative day, as tolerated by the patient. In the tibia similar active movement is advised with particular emphasis on the knee and ankle.

LATE TREATMENT

During treatment, the wires must be checked to ensure that they remain tight. If not they should be retensioned. If there is evidence of wire site inflammation or early infection, antibiotics may be used locally and systemically, if necessary. The apparatus is left in place until radiological consolidation.

HOW AND WHEN TO REMOVE THE APPARATUS?

Another complication is constituted by intermittent or persistent pain which generally, however, it is true that healing time is often less than with other methods. This is due to the fact the ilizarov method is essentially non-surgical and utilizes biology to effect healing.

When the patient is able to walk without pain and x-ray reveal good new bone formation, we advise unscrewing the nuts of the threaded rods slightly and allowing the patient to walk in the clinic.

The patient may then be sent home and asked to return in two weeks. If, after this period, the patient has experienced no discomfort with weight bearing, the apparatus may be safely removed. The wires are cut several millimeters outside the skin, the apparatus is slipped off the limb and the skin is disinfected. The wires may then be easily removed.

COMPLICATIONS(9)

The complications may be divided into the following:

a. Intra-operative complications

b. Immediate postoperative complications

c. Late postoperative complications

INTRA-OPERATIVE COMPLICATIONS:

These included skin, nerve, vascular or musculotendinous lesions. In general, these are usually due to errors related to wire placement (drill speed too fast) and position (incorrect anatomical site). Malreduction of the fracture due to incorrect construction of the apparatus may be observed.

IMMEDIATE POST OPERATIVE COMPLICATIONS (9):

These included loss of reduction of fractures, particularly those of an unstable nature, usually due to the use of an incorrect frames and/or the incorrect assembly of the frames itself, prevent active mobility of the limb or weight bearing. The pain is almost always due to instability of the apparatus and consequent mobility of the fracture site.

LATE POST-OPERATIVE COMPLICATION (9):

These may involve loss of reduction of the fracture due to incorrect management of the apparatus in relation to the dynamic instability of the fracture itself. Minor complications included rare cases of dermatitis and more frequently, intolerance to the wires.

Another type of late complication in fracture of the leg may involve disorder in circulation represented by edema which may, at times, be quite marked, particularly in overweight.

A rare but severe and important complication is poor fracture consolidation. It is important to adjust frame stability according to the bone callus in order to avoid complications such as refracture after removal of the apparatus.

Joint stiffness is an important late complication. This may be encountered during the treatment of comminuted segmental fracture of the tibia where the type of apparatus is, by necessity, complex. This may also occur in cases where the patient has difficulty with active mobilization and weight bearing due to pain or other injuries incurred at the time of the accident.

MATERIALS AND METHODS

Material consists of 20 cases of compound comminuted tibia using Ilizarov technique at Govt. Royapettah Hospital, Chennai between June 2005 to September 2007.

The following types of cases were included

1. Compound diaphyseal fracture comminuted
2. Compound periarticular fracture.
3. Compound tibial plateau fracture
4. Compound metaphyseal fracture with shaft extension.
5. Compound segmental fracture.
6. Compound diaphyseal fracture with bone loss.

Over the past 28 months we analyzed the treatment of 20 cases of compound tibial comminuted fracture using Ilizarov technique.

Table 1

AGE DISTRIBUTION

20 – 60 years

Age group	No of Cases	Percentage
10-20	1	5%
20-30	8	40%
30-40	8	40%
40-50	2	10%
50-60	1	5%

Table 2

SEX DISTRIBUTION

Out of 20 cases all cases were males

Sex	No of cases	Percentage
Male	20	100%

Table 3

MODE OF INJURY

Mode of Injury	No. of Cases	Percentage
RTA	18	90%
H/O fall from height	2	10%

Table 4

We treated open fracture with Gustilo Classification

Grade	No. of Cases	Percentage
Grade –I	3	15%
Grade –II	3	15%
Grade –IIIA	4	20%
Grade –III B	10	50%

Table 5

SIDE OF AFFECTED LIMB

S. No.	Side involved	No. of patients
1.	Right lower limb	11
2.	Left lower limb	9

Table 6

Associated injuries

S.No	Associated Injuries	No. of patients
1.	Distal radius fractures	2
2.	Fracture clavicle	1
3.	Metatarsal fracture	2

TYPE OF FRACTURE:

We used AO classification.

PROXIMAL(1/3)TIBIA{41}	MIDDLE(1/3) TIBIA{42}	DISTAL(1/3) TIBIA{43}
41.A. 3 . 3	42.B. 3 . 3	43.B. 3 . 3
41.C. 2	42.B. 3 . 1	43.B. 3 . 3
	42.C. 2 . 1	
	42.C. 2 . 1	
	42.B. 3 . 3	
	42.B. 3 . 1	
	42.C. 2 . 1	
	42.C. 2 . 1	
	42.C. 2 . 1	
	42.B. 3 . 1	
	42.C. 3 . 1	
	42.C. 2. 1	
	42.C. 2. 1	
	42.C. 2. 1	
	42.B. 3. 1	
	42.C. 3. 1	

NUMBER OF CASES

PROXIMAL (1/3) TIBIA--2

MIDDLE (1/3) TIBIA--16

DISTAL (1/3) TIBIA-- 2

PRE-OPERATIVE EVALUATIONS

Examination

Evaluation of extent of injury (Ex. Ligament damage, open fracture, etc.)

Range of motion, mobility

X-Rays

X-ray leg AP / Lateral view including knee to ankle joint taken for all 20 cases and following features were assessed.

Length of space between tibial plateau and fracture

Length of fracture

Length of space between fracture and tibial plafond

Associated fibular fractures

Templating

Use opposite normal extremity to help template ring sizes

Space between inner rings must be more than the length of fracture comminution

Assess potential for transfibular wires

OUR BASIC OPERATIVE TECHNIQUE:

Anaesthesia-

All cases were done under spinal anaesthesia.

Position -

Patients were placed supine in the operating table with sand bag under the thigh and another under the heel leaving the entire operating area free for the surgeon.

METHODS

Frame Construction

Two half rings are selected that are 2-3 cm larger than the major diameter of the injured limb.

The rings are positioned in the same plane and a bolt and nut anchor together at both ends of the half rings. Typically, a 4 ring assembly is required with 2 rings proximal and distal to fracture site. Two rings are used on large fragments. Ring & drop post used for smaller fragments. Two proximal & distal rings are connected via two rods of appropriate length .

Surgical Strategy

Preliminary reduction of fracture. Insertion of transverse proximal and distal wire, Application of frame. Frame brought to the wires.

Only hand drill was used for wire placement. First wire passed through the head of fibula. It was attached to proper sized ring with wire fixation bolt. Tibial fractures required 140, 160, 180 rings.

The second ‘K” wire was passed through tibia from anterolateral to posteromedial direction.

The distal ring was applied with two ‘K’ wires one through fibula, another through tibia. The intermediate loose rings were connected with proximal, distal rings by connecting rods. The proximal, distal rings were tensioned. Fracture was reduced by distraction of rods and reduction checked with X-ray or image intensifier. Then intermediate rings were fixed with 2 ‘K’ wires/olive wires according to topographical anatomical atlas. wires manipulated according to displacement of fragments.

Bayonett tipped 1.8mm ‘K’ wire used for all age group and 1.5mm olive wire for translation, displacement correction and for interfragmentary compression. Application of distraction across the fracture site if shortening is present. Tensioning of proximal and distal wires. Tensioner was used for tensioning for all cases. This achieves partial reduction in the coronal plane and helps to suspend the leg in the middle of the frames. We used Betadine dressing for each pin tract. After checking the position with X-ray compression was given at fracture site.

FOLLOW UP

All corticotomy patients were treated as in patients during distraction period.

X rays were taken every week, callus amount and quality, any angulations of transport segment was reviewed. Once distraction period is completed and if transport segment is satisfactory, patient is discharged and reviewed once in two weeks.

Patients were discharged once pain subsided and patient was ambulated in a walker, with partial weight bearing. Patients were followed up once in every fortnight with x rays and following parameters were reviewed and treated accordingly.

1. Wire breakage
2. Pin site infection
3. Joint stiffness
4. Neuro vascular deficit
5. Pain on walking
6. Deformity

OBSERVATION

- Majority of injured patients were males (100%)
- Highest number of patients were in their 2nd to 4th decade (80%)
- RTA was the most common mode of injury (80%)
- There was not a single case with bilateral fractures
- 2 patients had associated Ipsilateral Distal Radius Fracture, 1 patient had Ispilateral Clavicle fracture, two patients had associated Ipsilateral metatarsal fracture.
- Most of the patients, reported with in 36 hours of injury
- Majority of the injured patients were injured patients were in Gustillo type IIIB (50%).
- Type of 42.C. 2.1 of A.O. Classification was the most common type out of 20 patients
- The shortest follow up period was 8 months and the longest follow up period was 22 months.

- Early complication were encountered in 4 patients these were pin tract infection

- Late complication were observed like malunion with valgus deformity in 1 patient, recurvatum deformity in 1 patients, shortening in 4 patients

- The average stay in hospital was about 20 days

- Autogenous iliac crest graft were used in 8 out of 20 patients

RESULTS

In our study, 20 cases were followed up until union and for further period till date. Patients were assessed for pain and functional limitations, and examined for angular and rotational mal-alignment and range of motion. Leg lengths were measured clinically.

Pin tract infection occurred in 4 (20%) of cases. 2 resolved by systemic antibiotics for 5 days, in another one, soft tissue release around the offending wire was done and in one the wires had to be completely removed and reapplied. 2 (10%) patients had an angulation of 10° at the fracture site, and 4 (20%) had shortening between 1-2 cms of the fractured leg. Knee and ankle range of motion was satisfactory in almost all cases. There were no cases of osteomyelitis or neurologic or vascular complications among these patients.

When there was early evidence of callus formation in the follow up X-rays, union was clinically verified by the absence of pain and motion while fully weight bearing on the tibia with the frame still attached and destabilized. If pain or angulations occurred, the frame was restabilised and immobilisation continued until the above criteria were met. A patella-tendon bearing cast was used for an additional 3 to 4 weeks. Union was determined to be the time when fracture healing occurred and all forms of immobilization or support were discontinued. Union occurred at an average of 5.3 months (3.5 to 8.5 months). Based on Johner and Wruhs criteria (24), the final results were rated as excellent (15), good (2) and fair (3). No poor results were seen.

Johner and Wruh's Criteria for evaluation of Final Results After Tibial Fracture

Criteria	**Excellent**	**Good**	**Fair**	**Poor**
Nonunion/infection	None	None	None	Yes
Neurovascular injury	None	Minimal	Moderate	Severe
Deformity				
Varus/valgus	None	2-5°	6-10°	>10°
Pro/recurvatum	0-5°	6-10°	11-20°	>20°
Rotation	0-5°	6-10°	11-20°	>20°
Shortening	0-5 mm	6-10 mm	11-20 mm	>20 mm
Mobility				
Knee	Full	>80%	>75%	<75%
Ankle	Full	>75%	>50%	<50%
Subtalar	>75%	>50%	<50%	
Pain	None	Occasional	Moderate	Severe
Gait	Normal	Normal	Mild limp	Significant
Activities				
Strenuous	Possible	Limited	Severely limited	Impossible
Study results	34	6	2	0

In our study of 20 cases with Ilizarov technique, we obtained fracture union rate 100%.

In our series no case gone for non-union. One case went for Delayed union which was grafted. In our series antibiotic cover was only for 7 to 10 days. All the 20 cases were allowed to weight bear as pain permitted.

Acceptance: 4 patients of our study initially hesitated for bulky appearance.

Mal union	2	10%
Delayed union	1	5%
Shortening	4	20%
Pin tract infection	4	20%

CASE ILLUSTRATONS

1) Case No.10

Mr. Raja agriculturist, 38 yrs. Male had sustained grade III B compound segmental fracture both bone right leg due to RTA. He had minor soft tissue injuries with no bony involvement on the other leg, which was treated with cleaning and dressing. He was treated with wound debridement and AO external fixation for right side on day one. 11^{th} day after injury AO external fixator was removed and ilizarov fixator was applied. Compression was done for 5 days from 3 rd P.O.day. Patient had good union by 30 weeks. Patient had no pin tract infection. He was put on PTB cast and mobilized to bear weight as able at 26 weeks after removal of ilizarov fixator. Follow up was available up to 8 months.

ROM (Range of Movements)

Knee: Flexion 0- 130^0

Ankle: Dorsi flexion 0-15°

Plantar flexion 0- 40°

Patient was able to walk after 32 weeks. Results were regarded as excellent.

2) Case No.11

Mr. Murugan, 22 yrs, Male, student had sustained grade I compound communited fracture both bone left leg due to R.T.A. He also sustained ipsilateral extra articular distal radius fracture. On day one distal radius fracture was treated with CMR and AE slab. Tibial fracture was debrided. Ilizarov fixator was applied after 7 days. Compression was done for 5 days from 10thP.O.day. Patient had good union by 26 weeks. Patient had no pin tract infection. He was put on PTB cast and mobilized to bear weight as able at 22 weeks after removal of ilizarov fixator. Follow up was available up to 12 months.

ROM (Range of Movements)

Knee : flexion 0- 125^0

Ankle: Dorsi flexion 0-15°

Plantar flexion 0- 40°

Patient was able to walk after 28 weeks. Results were regarded as excellent.

3) Case No.13

Mr. Nazeer Ahmed, 35 yrs male, clerk, had grade III B compound communitted fracture both bone right leg middle third due to RTA. He had minor soft tissue injuries with no bony involvement on the other leg, which was treated with cleaning and dressing. He was treated with wound debridement, prophylactic antibiotics and AO external fixation for right side on day one. Flap cover was done on 5^{th} day. 11 days after injury AO external fixator was removed and ilizarov fixator was applied. Compression was done for 5 days from 10^{th} P.O. day. Patient had good union by 34 weeks. Patient had no pin tract infection, had recurvatum deformity up to 10^0 of proximal tibia and shortening of 0.5cms in right leg. He was put on PTB cast and mobilized to bear weight as able at 30 weeks after removal of ilizarov fixator. Follow up was available up to 14 months.

ROM (Range of Movements)

Knee: flexion 0-125°

Ankle: Dorsi flexion 0-15°

Plantar flexion 0- 40°

Patient was able to walk after 36 weeks. Results were regarded as good.

4) Case No.15

Mr. Sasikumar, 26 yrs, male, student, had grade II compound communited fracture both bone right leg middle third due to RTA. He had abrasions over the ipsilateral thigh, contra lateral knee and elbow with no bony involvement on the other leg, which was treated with cleaning and dressing. He was treated with wound debridement, prophylactic antibiotics. 9 days after injury ilizarov fixator was applied. 14th week after application of ilizarov fixator bone grafting was done. Patient had good union by 30 weeks. Patient had no pin tract infection and no deformity. He was put on PTB cast and mobilized to bear weight as able at 26 weeks after removal of ilizarov fixator. Follow up was available up to 12 months.

ROM (Range of Movements)

Knee : flexion 0-130°

Ankle: Dorsi flexion 0-15°

Plantar flexion 0- 40°

Patient was able to walk after 32 weeks. Results were regarded as excellent.

5) Case No. 6

Mr. Karthik, 19 yrs male, student, had grade III B compound communitted fracture both bone right leg middle third due to RTA. He had minor soft tissue injuries with no bony involvement on the other leg, which was treated with cleaning and dressing. He was treated with wound debridement, prophylactic antibiotics and AO external fixation for right side on day one. SSG with flap cover was done on 5^{th} day. 11 days after injury AO external fixator was removed and ilizarov fixator was applied. Bone grafting was done at 14^{th} week. Patient had good union by 32 weeks. Patient had no pin tract infection, had valgus deformity up to 10^0 of proximal tibia. He was put on PTB cast and mobilized to bear weight as able at 28 weeks after removal of ilizarov fixator. Follow up was available up to 14 months.

ROM (Range of Movements)

Knee: flexion 0-125°

Ankle: Dorsi flexion 0-15°

Plantar flexion 0- 40°

Patient was able to walk after 34 weeks. Results were regarded as fair.

DISCUSSION

Transosseous osteosynthesis of fracture, according to Ilizarov is essentially a non surgical method except for the insertion of wires, which is carried out in a sterile operative room. The structure is stable and enables the patient to bear weight on the affected limb straight away even in very comminuted fractures.

The advantages of fixation with Ilizarov apparatus compared with a traditional external fixation, cast, internal fixation are

1. Stability
2. Preservation of blood supply
3. Maintenance of function
4. Negligible blood loss
5. Early weight bearing

The best mode of treatment is elusive in high-energy tibial fractures. Because of the tenuous soft-tissue coverage of the tibia, plate fixation has typically been associated with an unacceptably high prevalence of wound complications, especially when it has been performed for more severe fractures (2). Tibial nailing though in popular use also has its own share of complications. Malunion occurs after up to 37% of tibial nailing procedures (46) and it is particularly common following fractures of the proximal third of the tibia (33). Severe comminution further adds to the complication. Twenty one (51%) proximal tibial comminuted fractures were treated with Ilizarov fixator with only one case of malunion. Intramedullary nail insertion is also shown to interfere with circulation in the diaphyseal cortex (19,31). Current debate concerns the use of reamed and unreamed intramedullary nailing because both techniques, to varying degrees negatively affect the circulation of cortical bone (39,41). In patients with an open fracture, this has significant implications. When the intramedullary blood supply is destroyed, it leads to necrosis of diaphyseal bone. The vascular system will reconstitute in 2 to 3 weeks, during which time the presence of dead bone and an open fracture wound may increase the risk for infection. External fixator only provided a temporary measure with the additional morbidity associated with pin tract infections. Moreover early weight bearing could not be encouraged.

Ilizarov fixator was chosen to fix those fractures that produced high rate of complications with most conventional methods of fixation. For over half a century the Ilizarov device has been used for treatment of acute fractures and non-unions (8). The structure is stable and enables the patient to bear weight on the affected limb straight away even in very comminuted fractures (15), not easily achievable by other methods of fixation. The Ilizarov device is minimally invasive with little interference in the biology of fracture while at the same time providing optimal skeletal stability. It also provides opportunity for wound care and management of open fractures. The timing of soft tissue coverage is a subject of controversy. The standard teaching has been that open fractures remain open until the patients is returned to the operating room for a secondary debridement to ensure that adequate debridement of necrotic tissue from the wound has done prior to wound closure (11).

Our protocol encouraged patient to partially weight bear within 48 hours progressing to full weight bearing within the limits of pain (usually within the first week). General condition of the patient and the presence of other associated injuries also influenced the decision to weight bear. An Ilizarov fixator enables the surgeon to correct malalignments and in case of bone loss, to perform adequate limb lengthening (45). All the fractures in this series united. Tucker et al. (44) reported 100% union of 26 tibial fractures in 23 patients treated with the Ilizarov fixator. The average union time was 25.6 weeks. Schtaker (43) reported 32 open tibial fractures treated with Ilizarov fixator. Healing time was 21.9 weeks in patients with a single injury and 25.7 weeks with multiple trauma similar to the results reported by Schwartsman et al (42).

This series is unique with respect to the complexity of the fractures considered. The specific category of fractures subjected to Ilizarov fixation was with the view to clearly define the role of the fixator in management of tibial fractures. Even though the circumstances were adverse with respect to the fracture pattern, the union time was not unduly prolonged. However cases that required corticotomy and distraction, necessitated prolongation of the time on the fixator. This is an additional option with the Ilizarov fixator that makes it so versatile.

VARIOUS TYPES OF TREATMENT:

1. Conservative – Closed reduction, Cast application.

Only indicated in undisplaced, isolated stable fracture tibia. Delayed union rate - 19%, Non union rate - open fracture- 21%,closed fracture-6%(1)

2. External fixator - External fixator only provided a temporary measure with the additional morbidity associated with pin tract infections - 16.2%(22). Nonunion rate-22% (30), Ankle joint stiffness-20% (30),

Malunion -20% (22), Delayed union -24% (22), 68.5% requires at least one further operation before union(22), Orthofix- nonunion- 9%.

3. Internal fixation with plate and screws-

Because of the tenuous soft tissue coverage of tibia, plate fixation has typically been associated with an unacceptably high prevalence of wound complications, especially when it has been performed for more severe fractures. Most authors now recommend plating for tibial shaft fractures associated with displaced intra articular fracture of knee, ankle. Plate fixation failed 2%. Deep infection 19%(13). Significant joint stiffness occurred in 11.4% and angular malunion more than 5 degree in any plane was seen in 3.1% (23).Skin necrosis seen, re-fracture after plate removal, delayed weight bearing.

4. IM nailing -

Full weight bearing at 3 months. Compartment syndrome seen in closed nailing. Posterior cortex penetration also seen. Anterior knee pain during kneeling also seen. Current debate concerns the use of reamed and unreamed intra medullary because both techniques, to varying degree negatively affect the circulation of cortical bone .Malunion occurs after up to 10% of nailing procedures, unreamed / reamed 6% .Delayed union, unreamed 22%(22).

In comprising the various modalities of treatments. It is noted that cast treatment respects the vascularity of the fracture fragments but does not achieve great stability and early weight bearing, wound dressing.

Internal fixation with plates and screws achieves stability and allows early mobilization of joint, there is always risk of infection in compound fracture. It neither respect vascularity nor does it allow early weight bearing.

Intramedullary fixation allows early weight bearing, there is always risk of infection in compound fracture. Intra medullary nail insertion is also shown to interfere with circulation in diaphyseal cortex.

Traditional external fixation respects the vascularity of the fracture segments and allows early joint mobilization but external fixation respects the vascularity of the fracture segments and allows early joint mobilization but early weight bearing is not always possible. Problems related to the larger pins are frequently encountered. moreover early weight bearing could not be encouraged.

Non modular has disadvantage that it cannot provide compression or distraction at fracture site. Modular (orthofix) has disadvantage of insufficient mechanical stability.

Ilizarov method involves a non invasive operation without problem of blood loss and transfusion, while providing stability and allowing weight bearing.

Difficulties may be encountered with the closed reduction of fracture necessitating longer operating time. Such difficulties are quickly overcome; however if the surgeon keeps to the assembly technique, pre assembled rings, proper pre operative planning the operating time is reduced with experience.

The advantage of the Ilizarov system includes stability preservation of vascularity, immediate joint mobilization and weight bearing, minimal operative risks and minimal blood loss.

Disadvantages include difficulties with frame assembly and closed reduction for the surgeon and difficulties with dressing and inconvenience for the patient.

CONCLUSION

From our study of 20 cases of management of compound comminuted fracture tibia with Ilizarov technique, we conclude that Ilizarov technique has a definite role in the management of fracture tibia like

1. Open comminuted fracture.

   Open segmental fracture

   Open fracture with bone loss

   Open complex fracture.

2. It reduces hospital stay

3. Full functional recovery

4. Early weight bearing

5. Gives definite union

To date we have not had any significant complication with Ilizarov method. Pain during treatment and acceptance of apparatus were two important subjective problems encountered in our experiences.

The usage of Ilizarov apparatus provides definitive fixation for high-energy tibial fractures. Early weight bearing even in severely comminuted fractures is the key factor that separates it from other methods of fixation. It promotes early functional recovery, eliminating fracture disease. Dynamisation and correction of deformities in any plane is easily accomplished. Frame constructs could be modified to facilitate wound cover and access. Therefore it lends the much-needed flexibility in complex fractures.

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PROFORMA

AGE/SEX

NAME :

OCCUPTION :

ADDRESS :

IP NO :

UNIT/WARD :

D.A.O :

D.O.S :

TEL. NO :

D.O.D :

DIGNOSIS :

TIME OF INJURY :

TIME OF ARRIVAL :

MODE OF INJURY / ASSOCIATED INJURIES :

CONDITION ON ARRIVAL

1. GENERAL EXAMINATION :

PULSE : BP :

RESPIRATION : G.C.S :

ISS :

SOFT TISSUE INJURY :

PAST MEDICAL H/O./ ALLERGIES

DIAGNOSIS :

INITIAL IMPRESSION

AFTER DEBRIDEMENT :

2.ORTHOPAEDIC & RADIOLOGICAL EXAMINATION :

3. MEASURES ON ADMISSION

A. INITIAL TREATMENT

(i). Time of Wound debridement.

(ii). Antibiotics

B. SURGICAL

(i). Management of the wound :

(ii). Management of the fracture :

4. MANAGEMENT OF THE FRACTURE :

i. Date of Application of external fixator

ii. Date of removal of external fixator

i. Date of Application of ilizarov fixator
ii. Date of Corticotomy
iii. Period of bone transport

iv. Period on compression and or distraction
v. Date of bone grafting
vi. Date of partial weight bearing
vii. Date of ilizarov removal and PTB application
viii. Date of PTB removal.

5. MANAGEMENT OF OTHER INJURES :

6. MEASURES IN THE WARD :

I. MEDICAL

II. PLASTIC SURGICAL PROCEDURE FOR WOUND :

a. Date of Surgery
b. Type of Surgery
c. Outcome

7. COMPLICATION : Immediate

Delayed

Late

8. CONDITION ON DISCHARGE :

9. FOLLOW UP :

CLINICAL UNION

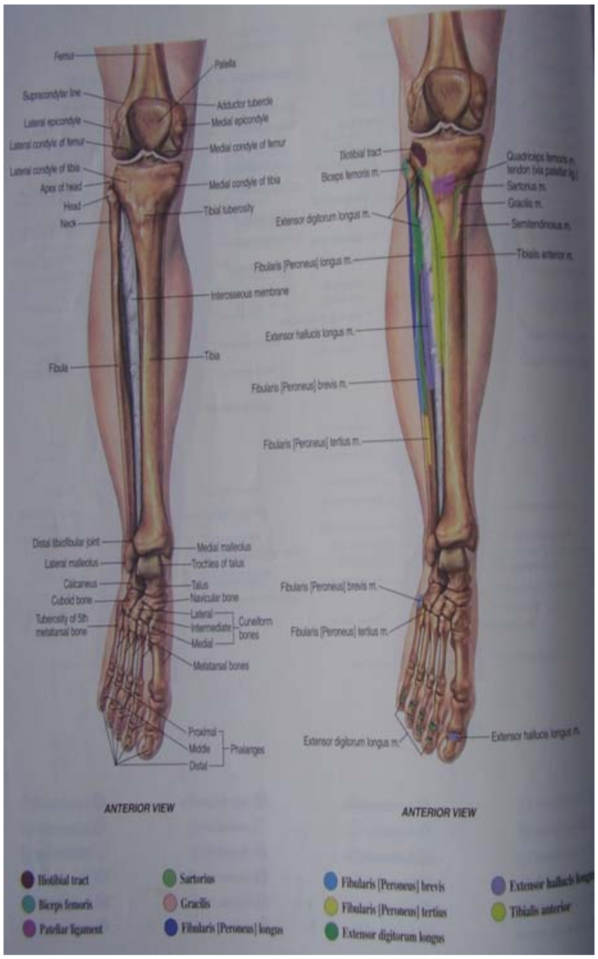
RADIOLOGICAL UNION

TIME OF RETURN TO PREINJURY STATUS

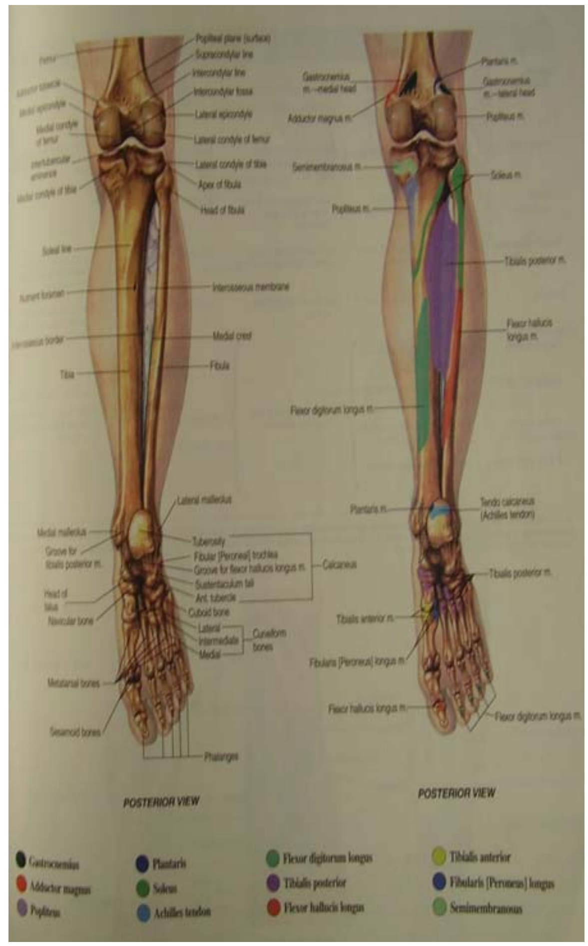
EVALUATION OF RESULTS

SURGICAL ANATOMY

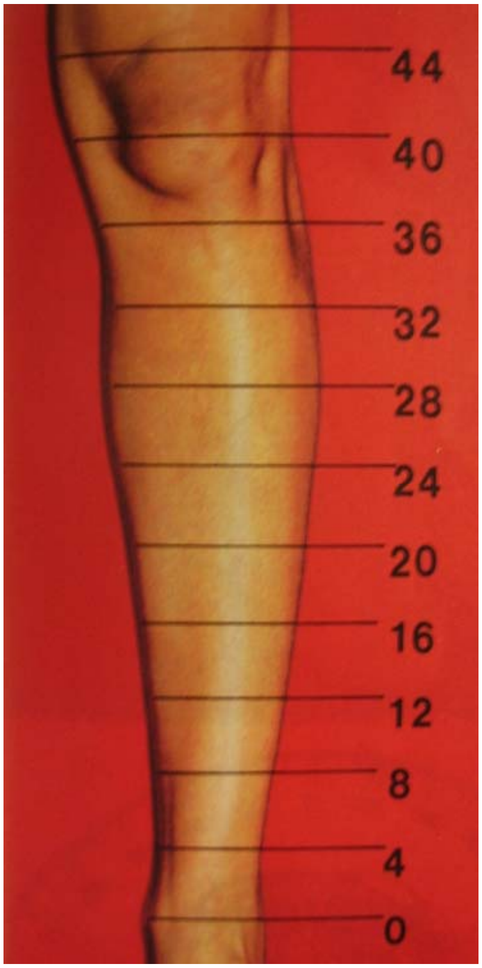
ANTERIOR VIEW



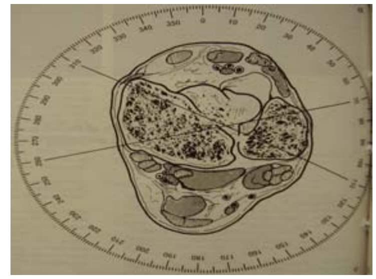
POSTERIOR VIEW



Levels of the anatomical cuts of the left lower extremity expressed in centimeters



Cut 0



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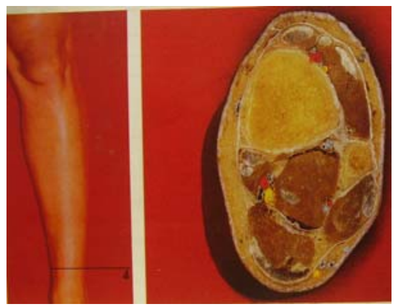
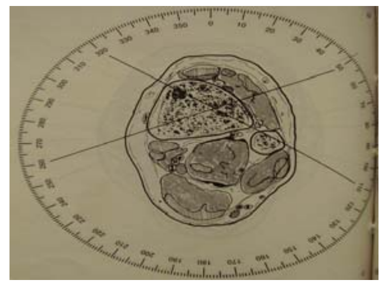
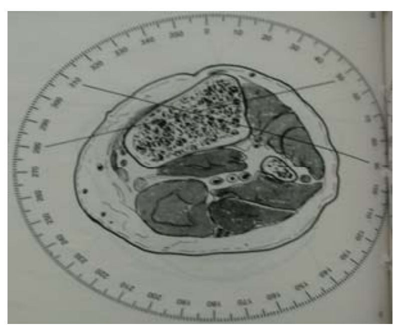




Cut 24



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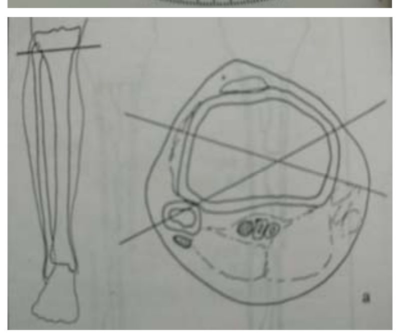
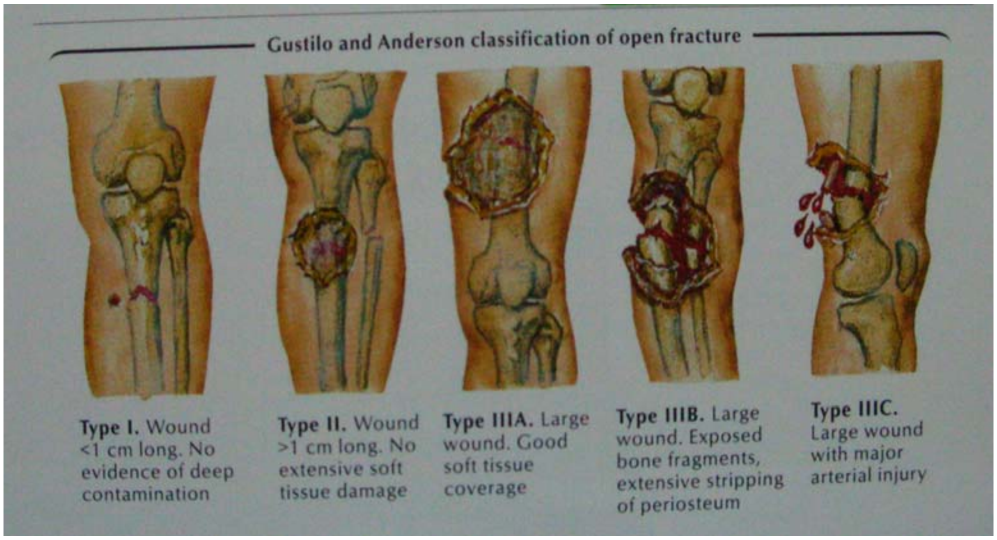


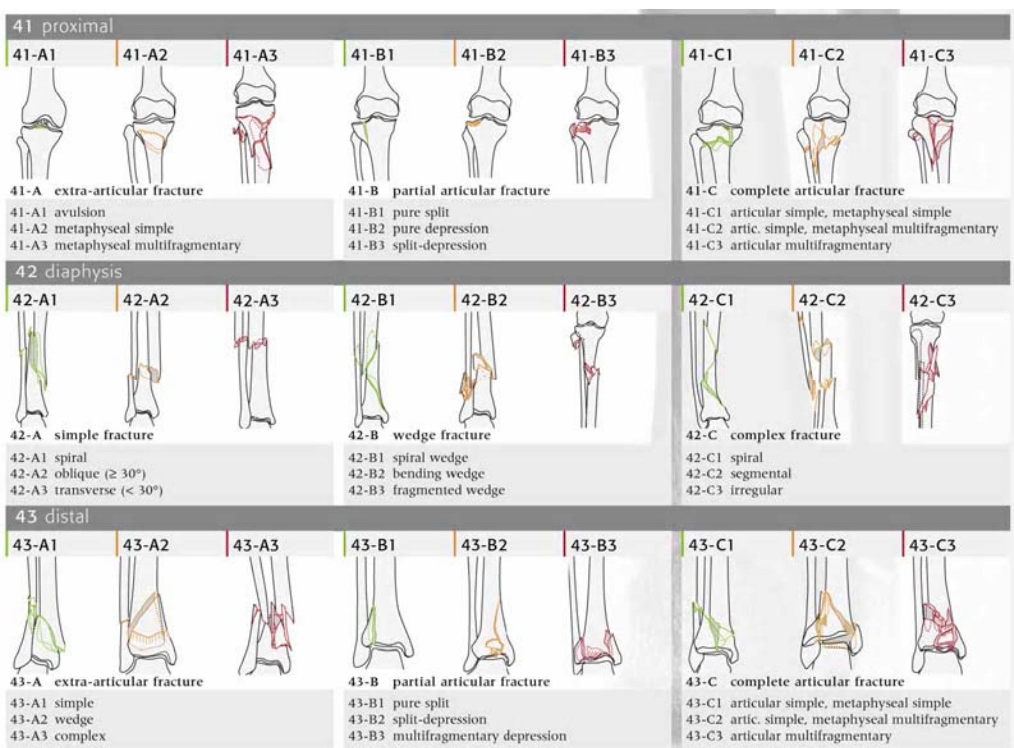
Cut 36

CLASSIFICATION OF OPEN FRACTURES

GUSTILO AND ANDERSON



MULLER AO CLASSIFICATION

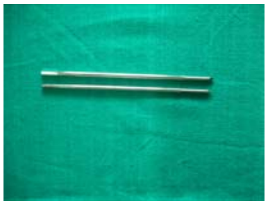


EQUIPMENTS REQUIRED


Connecting Rods


Bolt


Nuts


Schanz Screw


Rancho Cube


Post Male & Female


K-Wire & Olive Wire

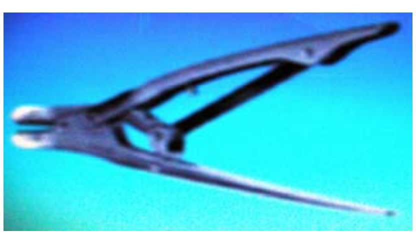

Rings


Extension Plate

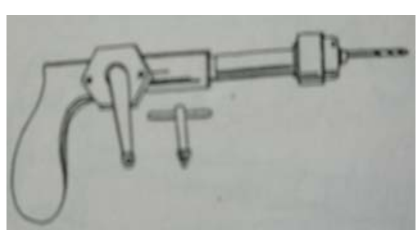
INSTRUMENTS


Wire tensioner

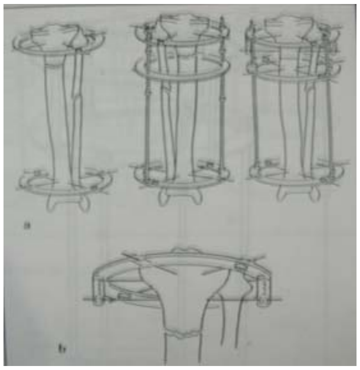

Wrench


Wire cutter


Drill bit


Hand drill

Procedures for treatment of Acute fractures of Tibia



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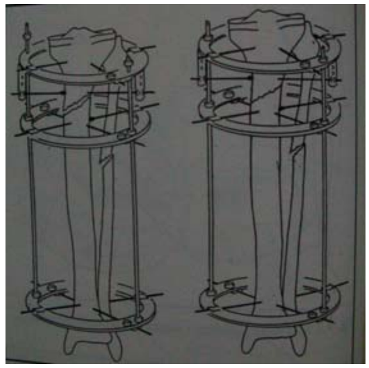
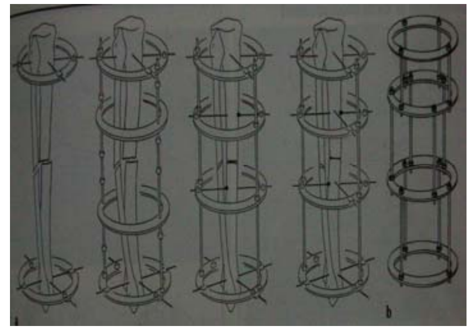
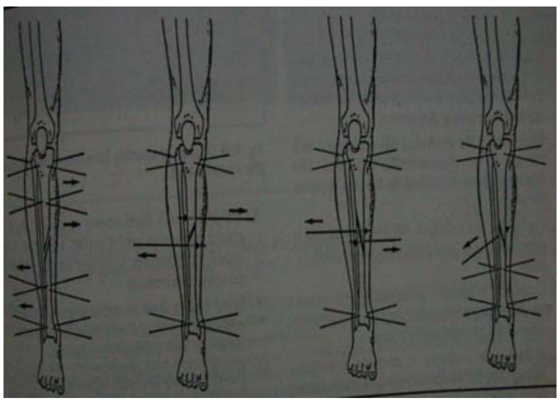


TYPE A2 ASSEMBLY



TYPE B1 ASSEMBLY



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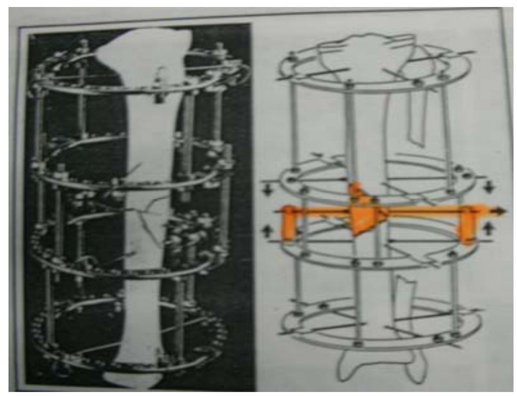

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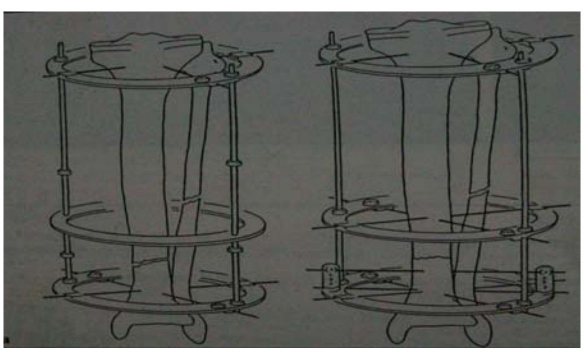
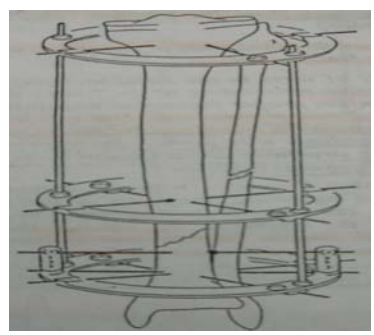
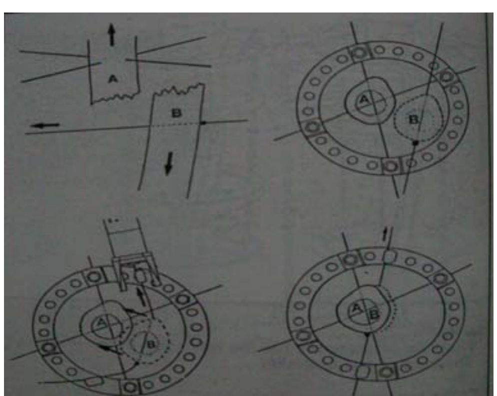


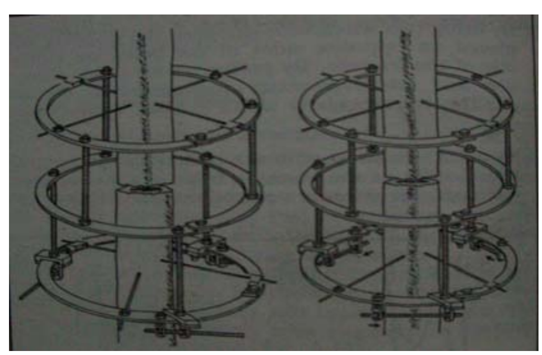
TYPE C1 ASSEMBLY



TYPE C2 ASSEMBLY



Lateral Displacement



Rotational Displacement

MASTER CHART

Case	Name	Age	Sex	Mode of injury	Side	Fracture pattern	Soft tissue damage	Duration On AO fixator (days) {applied on day of injury}	Duration on ilizarov Fixator (months)	Duration on PTB (weeks)	Fracture union time	PIN Tract Infection	Deformity	Shortening	Mobility Knee	Mobility Ankle	ADD SURGERY	Functional Outcome
1	VIJAYAKUMAR	28	M	RTA	LT	42.B. 3 . 3	GrIIIB	11	5.5	4	6.5	+	NIL	2cms	FR	FR	NIL	fair
2	PALANIAPPAN	41	M	FFH	RT	42.B. 3 . 1	Gr II	NIL	4.5 (applied 7 days after injury)	4	5.5	NIL	NIL	NIL	FR	FR	NIL	excellent
3	MANJUNATHAN	38	M	RTA	LT	42.C. 2 . 1	GrIIIA	9	6.5	4	7.5	NIL	NIL	NIL	FR	FR	Bone Grafting AT 14wks	excellent
4	SEKAR	31	M	RTA	LT	43.B. 3 . 3	GrIIIB	11	7.5	4	8.5	NIL	NIL	1.5	FR	FR	Proximal tibial Corticotomy AT 8wks & flap cover at 4wks PO	fair
5	SUBBIYAH	41	M	RTA	RT	42.C. 2 . 1	GrIIIA	11	5	4	6	+	NIL	NIL	FR	FR	Bone Grafting AT 14wks	excellent
6	KARTHIK	19	M	RTA	RT	42.B. 3 . 3	GrIIIB	11	7.5	4	8	+	10° VALGUS	NIL	FR	FR	SSG with flap cover on 5th day after injury Bone Grafting AT 14wks	fair
7	RAMASWAMY	21	M	RTA	RT	42.B. 3 . 1	Gr I		4.5 (applied 11 days after injury)	4	5	NIL	NIL	NIL	FR	FR	Nil	excellent
8	SRINIVASAN	33	M	RTA	LT	42.C. 2 . 1	GrIIIB	13	7.5	4	8.5	NIL	NIL	NIL	FR	FR	Flap cover AT 2wks & BONE grafting AT 12wks	excellent
9	SUBRAMANI	34	M	RTA	LT	42.C. 2 . 1	GrIIIB	11	6.5	4	7.5	NIL	NIL	NIL	FR	FR	Flap cover	excellent
10	RAJA	38	M	RTA	RT	42.C. 2 . 1	GrIIIB	11	6.5	4	7.5	NIL	NIL	NIL	FR	FR	Compression FOR 5days from 3rd PO	excellent
11	MURUGAN	22	M	RTA	LT	41.C. 2	Gr I	NIL	5.5 (applied 7days after injury)	4	6.5	NIL	NIL	NIL	FR	FR	Compression for 5days after 10th PO	excellent

12	FRANCIS	30	M	RTA	RT	43.B. 3 . 3	GrII	NIL	6.5 applied 9 days after injury)	4	7.5	NIL	NIL	NIL	FR	FR	Proximl Tibial Corticotomy at 8wks	excellent
13	NAZEER AHMED	35	M	RTA	RT	42.B. 3 . 1	GrIIIB	11	7.5	4	8.5	NIL	10°Recurvatum	0.5cms	FR	FR	Flap cover was done on 5th day after injury Compression for 5days after 10th PO	good
14	SARAVANAN	33	M	FFH	LT	41.A. 3 . 3	Gr I	NIL	5.5(applied 7days after injury)	4	6.5	NIL	NIL	NIL	FR	FR	compression FOR 3days after 14th PO	excellent
15	SASIKUMAR	26	M	RTA	RT	42.C. 3 . 1	Gr II	NIL	6.5 applied 9days after injury)	4	7.5	NIL	NIL	NIL	FR	FR	Bone grfting at 14wks	excellent
16	VINOTH KUMAR	28	M	RTA	LT	42.C.2.1	GrIII A	9	6.5	4	7.5	NIL	NIL	NIL	FR	FR	Bone grafting at 14 weeks	excellent
17	MANICKAM	52	M	RTA	RT	42. C. 2.1	GrIII A	11	5	4	6	+	NIL	NIL	FR	FR	Bone grafting at 14 weeks	excellent
18	BHASKAR	24	M	RTA	LT	42 .C .2 .1	GrIIIB	11	6.5	4	7.5	NIL	NIL	NIL	FR	FR	Flap cover at 1 week	excellent
19	PAULRAJ	25	M	RTA	RT	42. B. 3.1	GrIII B	11	7.5	4	8.5	NIL	NIL	1 CM	FR	FR	Compression for 5 days after 10TH POD	good
20	RENGARAJAN	28	M	RTA	RT	42. C. 3. 1	GrII	NIL	6.5(Applied 9 days after injury)	4	7.5	NIL	NIL	NIL	FR	FR	Bone grafting at 14 weeks	excellent

M - Male **RTA** - Road traffic accident **FFH** - Fall from height

FR - Full range **LT** - Left lower limb **RT** - Right lower limb