PRIMARY INTERLOCKING NAILING AND PRIMARY SOFT TISSUE COVER IN OPEN FRACTURES OF TIBIA-A PROSPECTIVE STUDY

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CERTIFICATE

This is to certify that the dissertation titled **“**primary interlocking nailing and primary soft tissue cover in open fractures of tibia ***– A Prospective Analysis Of Functional Outcome”*** is the original work done by ***Dr.R.Sivashanmugam,*** post graduate in M.S., Orthopaedic Surgery at the Department of Orthopedic Surgery, Madras Medical College, Chennai-600 003 to be submitted to the Tamil Nadu Dr. M.G.R. Medical University, Chennai- 600 032, towards the partial fulfillment of the requirement for the award of M.S., Degree in Orthopaedic Surgery, March 2008.

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CONTENTS

INTRODUCTION

The tibial shaft is one of the most common sites of an open fracture, a fracture that involves a break in the skin with soft tissues communicating with the fracture or its hematoma, or both. Because of the high prevalence of complications associated with these fractures, management often is difficult, and the optimum method of treatment remains a subject of controversy.

About 23% of all tibial fractures are open and most of these are Gustilo grade III. Most of them due to road traffic accidents followed by fall, sports activities, blow / assault, gun shot injuries and other rare injuries like blasts.

Open injuries of tibia are associated with twice the amount of contamination than other open fractures. With better understanding of the importance of serial wound debridement and early soft tissue cover for open fracture [18,20] good results have been achieved. Subcutaneous nature of the tibia makes the secondary reconstructive procedures difficult. But the advent of free flaps and advancement made in the micro-vascular techniques have led to reliable cover of traumatic musculocutaneous defects. Progressive refinement in the fixation of fractures and early bone grafting have resulted in a shorter time to union. The combined treatment of both the soft-tissue and skeletal components of severe open tibial fractures by dedicated teams commonly the orthopaedic-surgeon and plastic-surgeon has further improved outcomes and reduced morbidity.

AIM OF THE STUDY

To evaluate the functional outcome of primary interlocking nailing and soft-tissue cover in open fractures of tibia in government hospital setup.

HISTORICAL REVIEW

Evolution of open fracture management

HIPPOCRATES (460-335 BC) advanced steel and iron in treating the wound that did not progress.

BRUNCHWING AND BOTTELO in 15^{th} – 16^{th} century advocated removal of non-vital tissues.

DESAULT in the 18 century established the making of a deep incision to explore a wound, remove dead tissues and provide drainage, He adopted the word '*DEBRIDEMENT*', LARRY pupil of Desault contended that sooner Debridement is done the better the results.

STADER popularized External fixation in domestic animals external fixation gained considerable popularity in the military during II world war.

ROGER ANDERSON in the 1950 and early 1960 used their External Fixation frames for open fractures.

VIDAL in 1970 modified HOFFMAN fixators which quickly gained wide popularity in 1970.

LOTTES and BAUBIGNE in 1970 showed excellent results using closed tibial nailing in the treatment of open fractures of open fractures of tibia.

GUSTILO and ANDERSON in 1972 showed reduction in infection rate in internal fixation of open fractures. They recommended delayed primary closure for open wounds.

FISHER and AO groups in 1980 modified and popularized External fixation.

CHAPMAN and MAHONEY in 1980 showed good results in internal fixation of open fractures of Tibia.

TORNETTA et al in 1997 reported similar incidence of infection and lower rate of malunion in open fractures of Tibia treated with unreamed interlocking nailing in comparison with external fixation.

O-BRIEN and colleagues in 1997 reported 4% infection rate in reamed tibial nails and 0% infection in non-reamed tibial nails.

J. F. KEATINGS ET AL. in 1997 in their prospective study no increase infection and nonunion with reamed nailing for open tibial fractures.

J. F. KEATINGS ET AL. in 2000 said that reamed intramedullary nailing is a satisfactory treatment for Gustilo grade-III tibial fractures.

GOPAL ET AL. IN 2000 emphasized that interlocking nailing is preferable to external fixator in open tibial fracture and showed good results in primary flap cover for grade III fracture.

The Evolution of Intramedullary Nailing

Incas & Aztees in 16th century used resinous wooden pegs in the medullary canal of long bones for treatment of nonunion BIRCHER used Ivory pegs for intramedullary fixation in 1886.

NICOLAYSEN of Norway, considered as “father of Intramedullary nailing” in 1887 out lined the principles of intramedullary nailing.

In 1907 LAMBOTTE of Belgium employed grooved nails for inter trochanter & sub trochanter fractures.

In 1913 first use of 3 & 4 mm square, silver rods in the radius & ulna by SCHONE of the Kiel clinic in Germany and he showed how they controlled rotations.

In 1937 L. V. RUSH & H. L. RUSH of U. S. A. used Steinman pins for femoral & ulna fractures.

In 1940 KUNTSCHER of Germany carried out successful Intramedullary nailing & published scientific basis for this work.

In 1951 The LIVINGSTONBAR used a short I-bean pattern nail pointed at both ends, had short slots for cross pinning with screws. This was probably the first interlocking nail.

In 1966 KAESSUMAN introduced the concept of “Compression nailing”.

In 1960 – 70 KLEMM, SCHELLMANN AND GROSS-KEMP – Front runners of current generation of interlocking nails.

ANATOMY

TIBIA

Tibia serves as a weight bearing support to the body and also a conduit for neurovascular supply of foot. The location of the tibia and the fact that its antro-medial border is subcutaneous renders the bone susceptible to injury. The length of the tibia varies from 30 cm to 47 cm, its diameter from 8 mm to 15 mm. Diaphysis becomes thinner distally, which means that it is particularly at risk from twisting injuries. The medullary canal is significantly more round in cross section than external appearance. It is hour-glass shaped with variably pronounced Isthmus, such that a tight endosteal fit with intramedullary fixation is achieved only in the middle few centimeters of diaphysis.

Proximal tibia has apex angulation averaging 15 degree which requires a bend in the upper portion of medullary nails. Proximal tonal posterior wall is thin and flat which makes it possible to perforate with intra-medullary nail. The distal cancellous bone is often compact enough to restrict intramedullary nail penetration. So it is prudent to ream specially for distal fourth fractures, for the IM-nail to reach the desired level. Variably pronounced Isthmus may limit the endosteal contact of intramedullary nail even after significant reaming

Compartments

` A thorough knowledge of both topographical and structural anatomy of leg is essential in planning operative approaches to the extremity. The muscle, tendon, ligament and neurovascular structures in leg are divided into anterior, lateral and posterior compartments. An anterolateral septum divides the lateral compartment from the anterior. A posterolateral septum lies between lateral and superficial posterior compartments. Finally a posterior septum intervenes between the deep and superficial posterior compartments.

Anterior Compartment

The anterior compartment of the leg contains the tibialis anterior, extensor digitorum longus, extensor hallucis longus, and peroneus tertius muscles. These muscles are enclosed in a relatively unyielding compartment. The anterior tibial artery and the deep peroneal nerve run deep to the muscles. Near the ankle, the tendons of the tibialis anterior and extensor hallucis longus and extersor digitorum longus are close to the tibia and may be injured by an open fracture of entrapped by callus formed during fracture healing.

Lateral Compartment

The lateral compartment contains only two muscles, the peroneus brevis and peroneus longus. Because of their origin from the proximal and middle fibula, they protect the fibula from direct injury. The superficial peroneal nerve runs the between the peroneal muscles and the extensor digitorum longus.

Superficial Posterior Compartment

The superficial posterior compartment contains the gastrocnemius, the soleus, the popliteus, and the plantaris muscles. A sensory nerve, the sural nerve, and the short and long saphenous veins are also within this compartment, but there are no arterial structures of significance. This compartment also serves as a source of local muscle flaps for coverage of soft-tissue defects in the proximal and middle third of the tibia.

Deep Posterior Compartment

The deep posterior compartment contains the tibialis posterior, flexor digitorum longus, and flexor hallucis longus muscles. The major neurologic structure is the posterior tibial nerve. Two major arteries, are present in this compartment. The posterior tibial artery, because of its protected nature, frequently is the major arterial supply after a significant open fracture and is a potential source for anastomosis with free flaps for soft-tissue reconstruction of the leg.

Blood Supply

The Blood supply of the tibial shaft is derived from the nutrient artery and the periosteal vessels. The nutrient artery of the tibia arises from the posterior tibial artery and enters posterolateral cortex of the bone at the origin of the soleus muscle just below the oblique line of the tibia posteriorly. The artery may traverse a distance of 5.5 cm before entering its oblique nutrient canal. This artery divides into three ascending branches and only one main descending branch, which give off smaller branches to the endosteal surface. While the descending nutrient artery reaches the junction of the middle 3^{rd} and lower 3^{rd}, it is almost exhausted of its supply rendering lower 3^{rd} relatively a vascular.

The periosteum has an abundant blood supply from branches of the anterior tibial artery and posterior tibial artery as it courses down the interosseous membrane. The role of each source in fracture healing is controversial. It nourishes the outer one-fifth to one-third of the cortical bone. Nelson and colleagues believe that the periosteal blood supply plays a relatively minor role in supplying the normal adult tibial cortex.

Rhinelander also stated that the intramedullary vascular supply is the most important in normal bone; however, after an injury that disrupts the intramedullary vascular pattern, the periosteal blood vessels increase their contribution and become prominent in the formation of new bone. Macnab and de Haas found that the periosteal vessels were especially important in distal third tibial fractures but found no difference in intramedullary supply between proximal and distal regions.

The concerns for the effect of reaming in intramedullary nailing of open tibial fractures have led to the use of unreamed nailing for open fractures of tibia. Most researchers have shown a shorter time for revascularization of the endosteum with nonreamed versus reamed techniques, but the clinical advantages of this concept are still a subject for debate since it does not affect fracture healing.

CLASSIFICATION

Classification of an open fracture facilitates the description of the severity of the injury among physicians, and it can provide useful guidance for treatment as well. The classification of an open fracture is based on a number of factors, including the mechanism of injury, the vascular status of the extremity, the size of soft-tissue defects and lacerations of the extremity, the extent of soft-tissue crush or loss, the extent of comminution, the amount of bone loss, the degree of periosteal stripping, and the degree of bacterial contamination. The final classification of an open fracture should be delayed until the time of the initial operative debridement, as many of these factors cannot be assessed fully before that time.

The most common classification system for open fractures used is that of Gustilo et al.[16] {1984} which are the modification of original Gustilo and Andersons {1976}.

Type-I

A type-I fracture is a low-energy injury with minimum soft-tissue damage and a small (less than one-centimeter) wound; the fracture typically occurs as an inside-to-out puncture from an underlying spike of bone. Typically, there is slight comminution of the bone

Type-II

A type-II fracture represents a transition between the low-energy type-I and the high-energy type-III fracture. Type-II fractures may have associated soft-tissue lacerations one to ten centimeters long, slight or moderate comminution, and no or slight periosteal stripping of the bone fragments.

Type-III

Most severe pattern of open fracture.

Type-IIIA

Type-IIIA open fractures as those having adequate coverage with soft tissue despite extensive soft-tissue lacerations or flaps or injuries reflecting high-energy trauma, such as extensive osseous comminution, a segment fracture pattern, or extensive soft-tissue injury (irrespective of the size of the wound), or a combination of any of these. Open fractures that occur in an environment that predisposes to extensive bacterial contamination, such as a barnyard setting or a public waterway, are also classified as type-IIIA.

Type-IIIB

Type-IIIB fractures were originally defined as fractures with extensive soft-tissue injury, periosteal stripping, and exposed bone. These fractures are those that necessitate local or distant flap coverage of areas of exposed bone. These fractures are commonly associated with extensive periosteal stripping.

Type-IIIC

Type-IIIC fracture is associate with a vascular injury that requires repair for survival of the limb. A tibial fracture with only an isolated injury of the anterior or posterior tibial artery should not be considered Type-IIIC.

Recently the authors of two studies found the Gustilo and Anderson classification system to be associated with low interobserver agreement. Brumback and Jones recently survey a group of orthopedic surgeons and found interobserver agreement only in 60%. In spite of this limitation Gustilo and Anderson classification remains the preferred system for categorizing open fractures since the fracture type co-relates well with the risk of infection and other complications.

Other classification systems for open fractures are available. The AO/ ASIF classification for soft-tissue injuries uses a combination of the alpha-numeric fracture classification system and an IMN system wherein the injury to the integument (I), muscle (M), and nerve (N) is each judged independently. This classification system has several potential benefits for clinical research; however, it is cumbersome in clinical situations. The Hannover open-fracture classification, developed by Sudkamp et al. is based on a point-scale system for bone injury, soft-tissue injury, vascular injury, and contamination. Open fractures are classified as types I through IV.

Recently, Bowen and Bidmaier studied and found not only the Gustilo and Anderson classification but also the number of compromising comorbidities to be significant predictors of infection in the multi variate analysis. Patients are divided into 3 classes under the basis of presence or absence of 14 medical and immunocompromising factors including age of 8 years or more, Nicotine use, diabetis, malignant disease, Pulmonary insufficiency and systemic immunodeficiency infection rate were found to be 4% for class A (no compromising factors), 15% for patients in class B (1 or 2 compromising factors), 31% for class C (3 or more compromising factors).

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MANAGEMENT

Resuscitation

Open fracture [14,23,37,38]is an operative emergency about 20% of the patients may have associated abdominal, chest and head injuries. All trauma patients should be managed according to guide lines given by ATLS. During resuscitation wound should be covered and extremity should be splinted.

Assessment of extremity

Once the patient becomes stable, thorough circumferential inspection and palpation should be done. During the examination brief history should be sought. Wound should be thoroughly examined for size, site, skin loss periosteal stripping and bone loss. Contamination, Neurovascular status of the extremity and compartment syndrome should be specifically looked for.

Foreign bodies or any obvious debris like leaves grass or stones should be removed with sterile forceps. Patients with grossly deformed limbs and obviously dislocated joints should be reduced and aliened. If the patient can be taken up for the surgery within one or two hours, wound can be covered with sterile dressings. If the timing is uncertain irrigate the wound with one or two litres of saline before placing the sterile dressing. Once the sterile dressing is placed no further wound examination should be done until the patient is in the operating room. Patient should have the open fractures irrigated, covered with sterile dressings, and splinter before going for x rays

Tetanus status of the patient should be sought and if necessary tetanus immunoglobulin should be given.

Good quality AP and lateral X rays of the fracture including knee and ankle is necessary. Facture pattern displacement degree of comminution and the joint involvement can be studied. Radio opaque foreign bodies may be seen. Air trapped in the soft tissues may indicate severe degloving injury X rays are essential to decide the method of fixation.

Antibiotic therapy

Antibiotic [17] use has been considered the standard of care since 1974 and the benefit of antibiotics was confirmed by a recent Cochrane systematic review which showed that the administration of antibiotics after an open fracture reduces the risk of infection by 59%. Currently routine use of cultures either before or after debridement is not recommended since most of the time cultured organisms are not the cause of infection. Most of the open fractures caused by gram negative rods and gram positive staphylococci.

There is currently controversy with regard to the specific antibiotic to be given after open fracture. Generally an antibiotic with broad spectrum gram positive coverage usually a first generation cephalosporin like cefazolin is given for grade I and grade II. An aminoglycoside like gentamicin is added for grade III fractures. Pencillin or metronidozole is added when there is organic contamination. But there is no specific antibiotic regimen commonly antibiotics are administered till 24 Hours after the wound closure. Antibiotic should be initiated as soon as possible following injury since it decreases rate of infection as shown by Patzakis and Wilkins.

Local Antibiotic Therapy

Local therapy has been shown to generate high antibiotic concentrations within the wound while maintaining low systemic concentrations, which reduces the risk of systemic side effects. Antibiotic agents that are heat stable , available in powder form, and active against suspected pathogens are appropriate choices for local therapy. Both aminoglycoside and vancomycin met these criteria. Antibiotics are delivered locally by the technique called bead pouch technique in which antibiotic mixed with polymethylmethacrylate are made into beads(< 6mm diameter), string with stainless wire.

Debridement & Classification of the injury.

Emergency operative treatment has long been the standard of care for open fracture. Recent studies have questioned the value of six hour rule instead insisted on thorough operative treatment even for low grade open fractures. In the prevention of infection after open fracture the time [5]from injury to debridement is probably less important than other factors such as the adequacy of debridement [15] and the timeliness of soft tissue coverage

Preparation

Open fractures often present unexpected surprises. Therefore , a full set of soft tissue and bone instruments must be made available. The full assortment of fixation devices that might be necessary to stabilize the fracture must be available. On table, splints and dressings are removed. A thorough Surgical preparation is done with gentle fraction of the limb. Tourniquet should be available. For severely contaminated wounds two phase preparation is advised. With one preparation set, toes to the tourniquet is washed. A liter of saline is poured over the wound. With the second preparation set a formal surgical preparation of the extremity is performed.

Debridement

Debridement[45]of an open tibial fracture involves operative exploration of the wound or wounds to define the zone of injury, removal of devitalized tissue, and use of pulsed lavage to achieve additional mechanical debridement of the wound. The wound should be extended with the use of sharp dissection until healthy tissue is seen at each end. The wound should then be explored systematically to ensure complete debridement of all contaminants and devitalized tissue.

Debridement should begin with the skin. After operative extension , the edges of skin should be inspected carefully about the entire wound. Evidence of skin and subcutaneous tissue that has been avulsed from underlying fascial structures should be noted as this is an indicator of high energy trauma and may be indicative of underlying muscle injury. The debridement should continue in a methodical way with careful inspection of the subcutaneous tissue, muscle, and finally bone to avoid overlooking any devitalized tissue. The skin and subcutaneous tissue are inspected throughout the entire extent of the wound. Any obviously nonviable or crushed skin should be excised. Skin with questionable viability can be retained until a later debridement. This is especially important in the area of the subcutaneous border of the tibia, where injudicious removal of skin may necessitate later use of a local or distant flap to cover the bone.

No mariginally viable fascie to be left. Limited fasciotomoy should be done in all open fracture secondary to high energy fractures and it also helps in assessing the underlying muscle compartment. It should be done always as part of debridement.

Muscle should be inspected carefully for signs of viability, which can be assessed with the so called four c's: color, consistency, contracity and capacity to bleed. Of these four , the later two , particularly contractility , are the more sensitive indicators of viable muscle.Muscle that is weakly contractile and appears contused can be left and reinspected in twenty four to forty eight hours. Attempts should be made to maintain the integrity of musculotendinous units whenever possible without compromising the debridement since that if even 10% of a muscle belly and its attached tendon can be preserved significant function is retained.

Tendons unless obviously severely damage and contaminated should be preserved. Preservation of peritenon is essential for tendon survival. Should not debride the peritenon but rather copiously irrigate it.

Bone that is stripped of all soft tissue attachments is necrotic and can act as a substrate for organism that cause infection. Small to moderate avascular segments of bone should be removed. The decision to debride large portions of devascularized diaphyseal or metaphyseal bone, or both is often a difficult one. Major articular segments of the tibial plateau and the tibial plafond should be retained, even when there is extensive stripping, if the surgeon believes that salvage of the involved joint is possible. Areas of bone that have been stripped of periosteum but that are in continuity with a vascularized portion of the tibia can be retained if there is adequate soft tissue coverage to allow early revascularization.

At this juncture wound should be classified, accordingly appropriate method of skeletal stabilization should be done.

Irrigation

Irrigation is a key component of the effort to prevent infection after open fracture. As it serves to decrease bacterial load and foreign body Copious amount of irrigation preferably 9 liters of normal saline[10]with pulsatile lavage system[3] for grade I to grade III A open fracture. Additional 3 liter is added for more severe fracture. But there is little data on how much volume to be used

Skeletal stabilization

Cast Application

Type I and some type II open fractures with minimum soft tissue injuries and slight to moderate displacement of the bone can be treated with immobilization in a cast[39]. However such treatment precludes access for wound care for fractures with more extensive soft tissue injury. Hooper et al. performed a prospective randomized trial comparing the results of immobilization in a cast with those of intramedullary nailing of closed and type I open fractures of the tibial shaft and demonstrated a significantly higher prevalence of varus or valgus malalignment and shortening with the former treatment.

External Fixation

Earlier this was the method of choice for open fractures of tibia. It is still an excellent preliminary procedure for grossly contaminated grade III compound fracture and also used as temporary skeletal stabilizers until definitely procedure undertaken. External fixation[39] is typically applied as a static form of immobilization to maintain skeletal alignment. Newer forms of external fixation allow compression of the fracture site with weight bearing.

Commonly uniplanar or circular external fixator is used. Ortho fix and circular external fixator can be used as definitive fixationfor some compound fractures

Advantages are easy to apply, easy wound toileting, less deep infection.But has several disadvantages like Pin tract infection and conversion to another form of treatment is necessary since pins get loosened with 3-6 months of life span. Delayed conversion to IM nail has been associated with an increased prevalence of infection. However, good results have been reported with intramedullary nailing following short term (ten to eighteen day) use of external fixation to facilitate initial soft tissue treatment.

Plate fixation

Fixation with a plate typically is received for the treatment of open fracture of the tibial plateau and selected fractures of the tibial plafond. Rhinelander demonstrated that the normal pattern of bone circulation (from the medullary artery to the periosteum) is reversed following a fracture. The application of a plate requires extensive dissection which devitalizes soft tissue and bone and may lead to more frequent complications. Studies have shown high prevalence of infection and osteomyelites.

Interlocking nailing

Stabilization with IL nailing[6] has become increasingly popular for treatment of open fracture tibia. The use of reaming [26,28,]in the treatment of open fractures continues to be a source of controversy. But recent studies advocate at least 10 mm nail for adequate stability and advises at least minimal reaming to accommodate ten size nail. IL nailing is preferred for grade I , grade II and grade III fractures. For type grade III fractures fixation should be decided between nailing and external fixation in concordance with degree of contamination, soft tissue defects and feasibility of early reconstruction

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Wound management

Historically the closure of open fracture wounds has been delayed to prevent infection with clostridium and other contaminating organisms.But the recent studies have documented significantly better outcome with the early closure [18,19,20,49]than with the late closure, where nosocomial organisms have emerged as main source of infection. Now delayed closure is reserved for wounds with substantial contamination like barnyard and battlefield injuries.

There are number of methods for achieving closure. Including direct suturing, split thickness skin grafting, fasciocutaneous flap, free or rotational Muscle flaps. With fasciocutaneous flapcoverage a segment of the skin, the underlying subcutaneous tissue, and fascia are mobilized to cover the exposed bone or tendon, or both. Fasciocutaneous flaps are based on circulation from the posterior tibial or personeal systems. With careful planning a flap with as high as a 3:1 length to width ratio can be created safely while ratio is necessary for random flaps.

In general , tissue defects in the proximal third of the tibia are covered with a gastrocenmius rotational flap. A soleus rotational flap is recommended for defects in the middle third of the tibial shaft and a free vascularized muscle flap typically is needed for those in the distal third of the tibia.

Recently vacuum assisted closure [21,35](V.A.C) has emerged as a useful method of accelerating wound healing by reducing chronic edema, increasing local blood flow and enhancing granulation tissue formation.

The vaccum assisted closure device is typically applied at the end of each irrigation and debridement until the wound is considered clean. . Vacuum assisted closure is used for an average of ten to twenty days.\

Supplemental procedures

1. **Dynamisation:**

Delayd union can be treated by removal of either proximal or distal interlocking screws (dynamization) to allow axial impaction of the fracture and stimulate healing. The screws (either proximal or distal) considered least crucial for fracture stability are removed. This procedure should be considered at 3 months in fracture s with minimal callus and is most appropriate for axially stable diaphyseal fractures since loss of reduction has been reported to occur in 16% of proximal and distal fractures after dynamization [29,30,52] If this has to work there should be adequate space before tip of the nail hitches against the subchondral bone and there should not be new bone formation in the screw holes that were left out are at the tip of the nail.

2. **Fibular osteotomy**

When Dynamic locked nails are used , fibular osteotomy [12] can be done to facilitate impaction of the fracture upon weight bearing or Dynamization can be combined with fibular osteotomy for collapsing of the fracture ends in the cases of delayed union.

3. **Exchange nailing**

Exchange nailing [7,9] refers to the practice of removing an intrnedullary nail from the tibia, reaming the intramedullary canal,and then inserting a larger nail. If a reamed nail has been used primarily the canal should be reamed so that a nail of 1mm more in diameter can be inserted. If the canal is particularly wide then a larger nail will be required, and the surgeon should ream until endosteal bone is seen on the reamers. If an undreamed nail was primarily, it is wise to ream the canal to allow the insertion of a 10 or 11 mm nail. Commonly done after three – four months where there is minimal callus dynamically locked nails. This can be repeated after 5 -6 months if there is no progression union. Antibiotic coated exchange nailing can be done for infected non unions. It can be combined with wound debridement and bone grafting if there is only minimal infection. Postero lateral grafting can be combined with exchange nailing for treating infected non unions.

4.Bone grafting

Early prophylactic bone grafting is typically performed within twelve weeks after injury (but not before two weeks after wound closure). It is done when more than 50% cortical contact bone loss in open fractures.

Therapeutic bone grafting is done at 3 months when there is no progression of union. Posterolateral bone grafting is done for severe bone loss, scaring or sinus at the anterior aspect. Repeated bone grafting may be necessary to achieve union. Recently evidence has emerged regarding the use of recombinant human bone morphogenetic protein-2 has to promote healing.

Post operative protocol

Quadriceps drill is started in the next day of surgery. Knee and ankle exercise also started on the first posteoperative day. The resistive exercises are started after 6 to 8 weeks.

The weight bearing depends on the fracture configuration.Patient with stable fracture type can be allowed touchdown weight bearing in few days after the fracture fixation when the pain and inflammation has been subsided. But patients with unstable comminuted fracture patterns must be allowed weight bear only after adequate callus formation. Patients with segmental fracture allowed to weight bear only after adequate callus formation.

Vocational rehabilitation must be a part of compound fracture management.

BIOMECHANICS

Intramedullary nail act as load sharing internal splints when placed in a fractured long bone. The stability offered by the IM nail determined by nail site, number of locking screws and distance of the locking screw from the fracture side. In current practice with reaming of the canal and the use of locking screws loads are transmitted to the proximal and distal ends of the nail through the screws. Friction of the nail within the medullary canal determines the resistance to motion. This in turn affected by curvature of the nail, cross section of the nail and diameter as well as corresponding properties of the canal.

Three Types of load act on IM nail: Torsion, compression and tension. On physiological loading when the cortical contact across the fracture site is achieved, most of the compressive loads are borne by the cortex. In the absence of cortical contact compressive loads are transferred to the locking screws.. Implant failure occurs when the healing is delayed. Locked nails fail by screw breakage nail breakage at locking hole side.

Nails usually made of Titanium Alloy (or) 316L Stainless Steel. Although there are measurable differences between these two in modular property, the clinical results with either material appear to be equivalent.

Cross section shape of the nail affects its tensional rigidity and amount of contact within the medullary canal. Nail diameter affects Bending rigidity and Torsional rigidity. Fracture of the long bone fixed with IL nails have 75% of bending rigidity of intact bone.

Interlocking screws placed Proximal and distal to the fracture site restrict translation and rotation at the fracture site. However minor movements occur between the nail and the screws allowing toggling of the bone. Placing the screws in multiple plans may reduce the toggle. Diameter of the locking screws also determines the stability. Especially in immediate weight bearing. Number of locking screws is determined by location and the stability of the fracture.

Nailing may be static or dynamic. A Statically locked nail doesn’t allow gliding and axial shortening. Dynamically locked nails allow gliding and collapse at the fracture site. It is used only in diaphyseal fractures were cortical comminution is < 50%.

Tibial nails are designed with proximal bow to facilitate easy insertion into the straight tibial canal. Usually hollow nails are used for tibia. Solid nails are also available. At present AO or GK nails are extensively used. AO nails have its herzog’s bend distal to Grosse-Kempf nail.

Reaming increases the contact between the nail and the optical bone. When the nail is the same size of the Reamer, 1mm reaming can increase contact area by 38%. Increased Reaming allows insertion of larger nail which provide more rigidity.

Interlocking Nailing in Open Tibial Fractures

Currently intramedullary nailing has been recommended for even severe open fracture [48]of Tibia. Reamed nailing is advised even for grade IIIB fracture.

Reamed Nailing Vs Unreamed Nailing

Intramedullary nailing after reaming [8,9,11,20]is now accepted as method of choice to treat open femoral fractures. But it"s use remains controversial with regard to open tibial fractures. But the recent studies have changed this view.

The vascular damage inflicted by reaming in association with the soft-tissue injury has been thought to be increase the risk of infection and delayed union to an unacceptable level. Earlier reports of use of unreamed nails aiming for open tibial fractures seemed to confirm this view. The criticism that nailing after reaming is associated with high-rates of infection and nonunion is theoretical and is based on limited reports with small number of patients managed mostly with unreamed nails. First Kaltenecker et al. and then Court-Brown et al. (1991) have reported rates of infection, union and malunion compared very favorably with external fixation. He limits his nail size to 11 mm or less and advised to avoid tourniquet during reaming. Keating et al. (1997) said although reaming damages endosteal circulation, it is not associated with increased risk of deep infection and nonunion.

Schemitsch et al. also showed a rapid recovery of blood flow to the site of the fracture despite reaming. The more important factor in fracture-healing and in the body's ability to resist infection is the viability of the surrounding soft tissue. Operative care of the soft-tissue wound is critical in the treatment of open fractures. The pluripotential mesenchymal cells that form fibrous tissue and eventually bone are thought to originate predominantly from surrounding tissue and from the cambial layer of the periosteum. The reaming process is likely to have little detrimental effect on this aspect of fracture-healing. The role of the endosteal circulation in fracture-healing may therefore be less critical than has been supposed. Adequate debridement of the soft tissue and bone followed by sound soft-tissue coverage is the key to minimizing deep infection after these injuries, irrespective of whether the bone is reamed[26]or not. Ziran et al. retrospectively reviewed and said reamed nailing decreases the need for secondary procedures. .

Steven A Olson, in his instructional course lecture (JBJS 96) recommended unreamed nailing for open tibial fractures. He advised results of small unreamed nails with less stability (usually less than 8 or 9 mm) should be overweighed against larger nails with more stability but with increased risk of infection. JF Keating et al. (JBJS 2000) have shown good results with reamed nailing even for grade IIIB open tibial fractures.

Usually solid nails are used for unreamed nailing which decreases the dead space therefore the incidence of sepsis. Unreamed nailing[43] has several disadvantages. It is associated with increased incidence of delayed union and nonunion of open fractures. The fatigue failure of the locking screws is a common complication. The choice of the correct length of the nail is difficult and axial alignment with the unreamed nail is difficult to achieve as the nail is a splint and has very limited contact with the endosteal bone. The nail has also limited applications in proximal and distal fractures.

Till date there is no consensus to recommend reamed or unreamed nailing. Definitive studies are underway. But most of the authors recommend reamed nailing even for grade IIIB fractures.

PROCEDURE

Position of the patient

In standard technique for interlocking nailing fracture table is used. Patients positioned supine with hip flexed to 45 degrees and knee flexed to 90 degrees under calcaneal pin traction.Patient may be positioned supine on the ordinary table with the knees hanging down the end of the table or the knee kept in flexion with pillow under the knee.

Fracture reduction

Fracture reduced by the traction through the calcaneal pin under C-arm control. Calcaneal pin should be parallel to the ankle axis to avoid varusrvalgus malalignment. When fracture table is not used fracture reduction done after insertion of guide wire and manipulation under C-arm or distractor may be used to reduce the fracture.

Entry Point

Patellar tendon splitting approach

A vertical insertion from tuberosity to the lower end of the Patella is made. Patellar tendon is exposed and split in the middle. Entry point is made with awl, proximal to tibial tubercle approximately 1.5 cm distal to joint line and in line with the center of the medullary canal on the anteroposterior view. First awl is directed perpendicular to the shaft when it first penetrates the cortex, then gradually brought to more parallel to the shaft as it is inserted more deeply.

Medial Parapatellar approach

Here incision is made from middle of the medial border of patella to tibial tuberosity. Patellar tendon is exposed and retracted laterally. Entry point is made similar to the previous approach.

Fracture Reduction, Reaming and Nail Insertion

After entry point is made ball tipped guide wire is passed under C-arm. Guide wire should be in center of the distal fragment on both views and advanced to within .5 cm to 1 cm of ankle joint. Then serial reaming done in 0.5 mm increments. Then flexible Teflon sleeve is passed over the ball tipped guide wire. Then ball tipped guide wire is exchanged for a smooth tip wire for nail insertion.

Length of the nail determined by (Fluoroscopic measurement):

1. With the help of graduated guide wire.
2. Subtraction of the exposed guide wire from the total length of the guide wire.
3. Using radiopaque ruler and measuring distance between anterior edge of the entry portal to a point 0.5 to 1 cm proximal to ankle join.

Nail diameter is selected 1 mm less than the last reamer used. Now the appropriate nail mounted in the Jig and it is inserted over the guide wire under C-arm control. The distal tip of the nail should lie approximately 0.5 to 2 cm from the subchondral bone of the ankle joint. Now the traction is released to allow impaction of the fracture. Proximally counter sinking of nail is done up to 0.5 to 1 cm. Now the distal locking is done under C-arm control as free hand technique. Proximal locking is done with Jig. Before insertion of proximal locking fracture site is checked and if it is distracted reverse jamming is done.

Outcome assessment

There is no specific scoring system to analyze the outcome of open tibial fracture after fixing with interlocking nailing. Scoring derived from Karlstorm and olerud's functional outcome assessment of tibial fracture of interlocking nailing and modified Kalstorm and olerud. Outcome assessment of tibial open fracture using ilizarov ring external fixation

Functional Evaluation System by Karlstrom-Olerud

Measures	3 points	2 points	1 point
Knee pain	No	Little	severe
Ankle pain	No	Little	severe
Difficulty in walking	No	Moderate	severe
Difficulty in stairs	No	Supported	unable
Difficulty in previous sportive activity	No	Some sports	unable
Limitation at work	No	Moderate	unable
Status of skin	Normal	Various colours	Ulcer/sinus
Deformity	No	Little	remarkable
Muscle atrophy	<1	1-2	>2
Shortening	<1	1-2	>2
Loss of motion at knee	$<10^o$	$10\text{-}20^o$	$>20^o$
Loss of motion at ankle	$<10^o$	$10\text{-}20^o$	$>20^o$

*36 points, excellent; 35-33 points, good; 32-30 points, satisfactory; 29-27 points, moderate; 26-24 points, poor

MATERIALS AND METHODS

This study was done from February 2006 – November 2007, for a period of 22 months, in Department of Orthopedic Surgery, Madras Medical College & Government General Hospital, Chennai. We did primary interlocking nailing and immediate skin cover in 31 patients for 31 fractures. Out of these 31 patients, we have lost follow-up of 4 patients and we have analysed the results with the average follow-up of 12 months and miimum follow up of 5 months.

Inclusion critiria

Any Gustilo and Anderson Grade II, III A and III B compound tibial fractures presenting to our institute within 48 hours of injury.

Exclusion critiria

Patient presenting with more than 48 hours of injury. Grade I and Grade III C compound tibial fractures.

AGE INCIDENCE

Patients' age ranged from 18 to 70 years. Average: 37

Age in yrs	No. of Patients
11 – 20	1
21 – 30	14
31 – 40	4
41 – 50	8
51 – 60	1
61 – 70	3
TOTAL	31

SEX INCIDENCE

In our series, Male predominated with the ratio of 9:1.

Sex	No. of Patients
Male	28
Female	3

MODE OF INJURY

In our series, RTA was the predominant cause of injury. In RTA, 2 wheeler Vs 4 wheeler was the most common (10 cases).

MODE	No. of Patients
RTA	25
Fall of heavy weight	2
Industrial	1
Assault	1
Buffalo stampede	1
Wood cutter injury	1

PLACE

In our series, nearly half (45%) of the patients were referred from other hospitals.

PLACE	No. of Patients
Around Chennai	17
Referred from outside	14

SIDE

In our series, Right side was more common.

SIDE	No. of Patients
Right	18
Left	13

ASSOCIATED INJURIES / FRACTURES

In our series, 23% of the patients had Associated Injuries / Fractures

Injuries / Fractures	No. of Patients
Head Injury	2
Posterior dislocation hip	1
Tibial Plateau fracture / Galeazzi fracture	1
Metatarsal fracture	1
Distal radius fractures	1

TIME DELAY TO SURGERY

In our series, average time to admission after injury was 9 hours (minimum of 1½ hours to 45 hours). In cases referred from outside chennai average time to admission after injury was 15½ hours.

In our series, average time from admission to surgery was 6½ hours (minimum of 1 hour to 14 hours).

In our series, total time delay from injury to surgery was 15½ hours. For the patients referred from outside it was 23 hours

CLASSIFICATION OF SOFT TISSUE INJURY

We classified the open fractures of tibia according to Gustilo and Anderson et al classification. Among 31 patients:

Grade II – 15

Grade III A - 12

Grade III B - 4

ANATOMY OF FRACTURE

Type of Fractures	No. of Fractures
Transverse	8
Oblique	9
Comminuted	12
Segmental	1

In our series, nearly 40% of fractures were comminuted.

LOCATION OF FRACTURE

Tibia was divided into 4 quarters from A to D.

Location	No. of Patients
A	1
B	14
C	11
D	4

In our series, most of the fractures were in middle half of the tibia.

TREATMENT PROTOCOL

On receiving the patients, we resuscitated them according to advanced Trauma life support guide lines in our Trauma ward. Patients were specifically examined for other associated injuries. Patients were Haemodynamically stabilized. Injection Tetanus Toxoid was given to all of the patients. All the patients were given 2g of Cefataxime at admission. Injection Diclofenac and Injection Pentazocine were used for pain relief.

After stabilisation wound was inspected and preliminary typing according to Gustilo and Anderson was made. Plastic Surgeon's opinion was obtained in all patients, in the initial wound examination itself.

If the wound is clean sterile dressing was applied and above knee slab was given. If the wound is contaminated with external dirt, wound wash was given. Sterile dressing and above knee slab was applied. Injection Tetglobulin was given in patients with gross contamination.

All patients were shifted for investigations after resuscitation and preliminary examinations. Good quality antero-posterior and lateral X-Rays including knee and ankle were taken for the involved limb and other necessary X-Rays were taken to rule out associated fractures. CT-Brain and Ultra-sound was taken in necessary patients.

Fracture pattern was carefully studied. Length of the nail was decided with Tibial tubercle – medial malleolar distance (TMD). The TMD is determined by measuring the length between the highest points on the medial malleolus and Tibial tubercle4. Diameter of the nail was determined with lateral X-Ray.

Patients were taken to operation theatre after preliminary Anesthesiological assessment. At the time of induction 2g of Cefataxime was given to all of the patients. Dressing was opened in the theatre. Limb was prepared for surgery.Thorough wound debridement was done layer by layer after adequate extension of the wound. Fracture ends were debrided and loose fragments were removed. Adequate irrigation was done with normal saline.

After thorough debridement the wound grading was done as per Gustilo and Anderson method. Plastic Surgeon’s help was sought whenever necessary.

After ensuring thorough debridement, fracture was fixed with interlocking nail [8,9,19,27.] We used either split Patellar or medial para patellar approach for entry point identification. We used government purchased indigenous nails and instrumentation set. We reamed[8,9, 26-28] the medullary canal up to the measured nail size. Proximal locking was done with the help of Jig. Distal locking was done with either Distal locking Jig or freehand technique under C-arm. Most of the cases distal locking done with the Jig and confirmed by the guide wire. If distal locking could not be done with the Jig, locking was done under C-arm either on the day of surgery if available or locking was done on the next elective theatre. Till then patients were immobilized with above knee slab.

All Grade II wounds were closed primarily. All Grade III A wounds were closed primarily or split skin grafting was done. For Grade III B wounds flap cover [46] was done. 2 muscle flaps and 2 fasciocutaneous flaps were done with the help of plastic surgeons.

POST OPERATIVE PROTOCOL

All patients were started on injection Cefataxime and Amikacin. For Grade II patients, same antibiotics were continued for 3 days. And then changed to oral Gatifloxacin till suture removal.

For Grade III A patients same antibiotics were continued for 1 week. And then changed to oral Gatifloxacin for another 1 week.

For Grade III B fractures, same antibiotics with Metrogyl was continued for 2 weeks. Then changed to oral Gatifloxacin till complete healing.

Post operative anteropostirior and later X-Rays were taken and analysed for Nail length, locking and stability of the fixation.

First look dressings were done on 3rd post operative day. Dressings were changed frequently whenever there was soakage. After that dressings were changed for every 3rd day. During dressing wound was inspected for signs of infection. Culture and sensitivity was done when there was any sign of infection. Culture and sensitivity was repeated every week when there was infection. Antibiotics were changed accordingly and were given for extended period.

We started static quadriceps exercise and toe movements on the second post operative day. Knee mobilization started as soon as the pain subsides.

Weight bearing was delayed for comminuted fractures and type III compound wounds for stable statically locked fractures weight bearing was started as soon as the patient tolerates. Partial weight bearing was started for Grade III and comminuted fractures once the callus formation was seen.

All uncomplicated Grade II and Grade III A, fractures were discharged after second look dressing of the wound.

All complicated and Grade III B fractures were retained till adequate healing occurs.

Follow-Up

We advised

Suture removal on 12th day.

Monthly follow-up for first 3 months.

Every 3 months up to union and every six months afterwards.

Out of 31 patients, we have lost 3 patients follow-up. 1 patient has returned after 1 year after getting treatment outside. Remaining patients' follow-ups were poor (Average: 3 for total follow-ups). We tried our level best to achieve 2 follow-ups in 6 months. Each follow-up patient were examined for

Knee / Ankle pain

Tenderness at the fracture side

Signs of infection

Joint motion

Radiological assessment of union

Union was defined as presence of 3 cortical callus on two radiographic views with complete absence of pain on walking.

Delayed Union[5] A failure to see evidence of union on radiographs at various time-points ranging from twenty to twenty-six weeks.

Nonunion[20] A fracture that occurred a minimum of nine months previously and has not shown radiographic signs of progression toward healing for three consecutive months.

Infection[5] was defined as a purelent discharge from which organisms were grown'

. Malunion[5] was defined as more than 1 cm of lengthening or shortening or more than 5o of rotational or angular deformity.

RESULTS

Type II Fractures

Union was observed in 11 of the 13 patients. The mean time to union was 27 weeks (range 20 weeks to 40 weeks). Dynamisation was done in 1 patient and Dynamisation followed by bone grafting was done in 1 patient. For infective non union seen in 1 patient posterolateral bone grafting was done and for non union in 1 patient bone grafting was done. Results of these patients were awaited.

Type III A Fractures

Union was observed in 7 of the 10 patients. The mean time to union was 31 weeks (23-37 weeks). Prophylactic bone grafting was done in 1 patient.

Aseptic nonunion was seen in 1 patient for which bone grafting[13] was done. Infective non union was seen in 2 patients, for which antibiotic exchange nailing has been planned.

Type III B Fractures

Two of the four type III B fractures united in average time of 47 weeks. Out of the 4 patients muscle flaps was done in 2 patients and fasciocutaneous flaps in 2 patients. 3 patients developed infection, for which appropriated anti biotics were given

Grade	No. of Cases	Union	Dynamisation	Bone Graft	Time (Wks)	Deep Infection	Non Union	Aseptic Non Union
II	13	11	2	2	27	1	1	1
III A	10	7	-	1	31	2	2	1
III B	4	2	1	1	47	3	2	-
Total	27	20	3	3	35	6	5	2

1 patient required wound debridement. Dynamisation was done in 1 patient. Union achieved in 1 infected patient following posterolateral bone grafting. Wound debridement and bone grafting was done in 1 patient and wound debridement, anti biotic coated exchange nailing with bone grafting in 1 patient.Results awaited for the 2 patients.

We assessed the outcome with Karistorm-Olerud criteria.

Functional Evolution System by Karistorm-Olerud

Grade II : Excellent – 7, Good – 4, Satisfactory – 2.

Grade III A : Excellent – 4, Good – 3, Satisfactory – 2, Poor – 1.

Grade III B : Good – 1, Satisfactory – 2, Poor – 1.

COMPLICATIONS

Early:

Alcoholic delirium developed in three patients.they were treated with I.V.Fluids amd diazepam.

Fasciocutaneous flap necrosis occured in two patients which was allowed to granulate and got infected. Superficial infection was seen in five patients.

Split skin graft necrosis occurred in one Grade IIIA patient and one Grade IIIB patient which were allowed to granulate because of superficial infection.

Late:

Deep infection developed in six patients (Grade II-1, Grade IIIA – 2, Grade IIIB – 3) and all developed Non-union.

Aseptic Non-union in two patients

Ankle stiffness in 1 patient and movement restriction was noted in 3 patients.

Anterior knee pain was observed in 4 patients.

Hyper pigmentation of flap was noted in 2 patients.

DISCUSSION

External skeletal fixation has become the established treatment for severe open tibial fractures despite the problems of malunion and pin-track sepsis associated with its use. In early years intramedullary nailing using undreamed unlocked nails had produced good results in type III open tibial fractures but the method did not adequately stabilize comminuted or segment fractures. Then reamed interlocking nailing (J.F.Keatings Et al) have become the answer for this without increasing the rate of infection. Recently treatment for open tibial fractures have evolved into a stage where primary nailing and immediate/early soft tissue cover[49] became the prime method of treatment.

In our hospital immediate wound debridement and cast immobilization followed by elective interlocking nailing is the routine for grade I and grade II open tibial fracture. But it is associated with multiple surgical procedures and long hospital stay.

Wound debridement and External fixation followed by repeat wound debridement and elective delayed primary cover followed by internal fixation is the method of treatment for grade III fractures. But because of heavy inflow of patients repeated wound debridement/primary soft tissue cover could not be given as and when required. Frequently leading to delay and increased amount of infection mostly cross infection of mixed organism. To overcome these practical difficulties and to improve the patient's outcome, we have conducted this prospective study in our hospital.

We have done 31 cases out of which we have lost the follow up of 4 patients. We have analyzed union, infection and functional outcome in the remaining 27 patients. In our study average time to union was 35 weeks (gradeII – 27 wks, gradeIIIA – 31 wks, gradeIIIB - 47 wks)

Grade II fractures results were comparable with the previous studies (Averaging 23.5 wks in Court-Brown et al).one required dynamisation and another required dynamisation and bone grafting. Grade III fractures union time is comparable with the previous studies. one Gr IIIA and one GrIIIB patient had bone grafting. Dynamisation was done in one GrIIIB patient.

Author	Treatment	UnionTime(wks)	
		III A	III B
Blick et al (1989)	External fixation	38.6	47
Court-Brown et al (1990)	External fixation	26.5	47.4
Court-Brown(1991)	Intramedullary nailing	27.2	50.1
Our study	Intramedullary nailing	31	47

Comparing with other studies our union rate was on par with other studies.

Deep infection was noted in 6 patients, 5 were early infections (GrII-1, GrIIIA-2 and GrIIIB-3) and one (GrIIIA) being late. Comparing with other studies infection rate was high. Three of them were (GrII-1,GrIIIA-1,GrIIIB-1) taken up for surgery after twenty four hours and all of them were referred from places out side Chennai. Probably this could have been the reason for infection. Two of the three GrIII compound fractures developed infection following flap necrosis. This can be prevented with improved expertise in plastic surgery.

Study	Treatment	Union Time(weeks)	Infection (%)
Our study	Interlocking nailing	39	35
Blick et al (1989)	External fixation	45.2	9.5
Court-Brown (1990)	External fixation	36.7	17.6
Court-Brown (1991)	Intramedullary nailing	38.2	11.1

GrII fracture (case No.17) was discharged with superficial infection and was lost for follow up. He presented late with fracture site infection and anterior sinus for which posterolateral grafting [22,41,44,48] was done. GrIIIA fractures, one (case No.16) was lost for follow up for 9 months then she presented with medullary canal infection with osteomyelitis. Case No. 24 presented with anterior sinus after 8 months. Both cases have been planned for wound debridement and exchange nailing. The above complications could have been avoided with better patient education regarding importance of timely intervention.

GrIIIB fractures two patients developed infection following fasciocutaneous flap necrosis (case No.8 & 15).one patient (case No.10) for whom medial gastrocnemius flap cover was done, developed infection because of delayed presentation.

For case No.8 union achieved with posterolateral grafting.[22,41,44,48] Antibiotic exchange nailing and bone grafting was done for case No.15.case No.10 wound debridement and anterior bone grafting[2,31.48] was done.

Of the six infected cases most common organisms cultured were proteus and pseudomonas but the pattern kept changing from initial staph aureus to mixed organisms.(gram negative and staph epididimis)

the nailing procedure was carried out in an operating room where all other procedures including general surgery were carried out.

Infection rate following sequential nailing

Study	Infection	Non union
Megraw et al 1988	44%	54%
Maurer et al 1989	25%	35%
Our study	35%	26%

Comparing the other studies the infection rate following sequential nailing was comparable or better.

Non union developed in 7 patients out of which 2 being aseptic nonunion. These two aseptic nonunion were diagnosed to have delayed union for which bone grafting was adviced but the patients were not willing to undergo any procedure at that time. Bone grafting was done in these two patients later after a trial of dynamisation.

Study	Treatment	Nonunion (%)
Our study	Interlocking nailing	26%
Clifford etal. 1997	External fixation and delayed cover	23.8%
J.F.keatings etal.1997	Primaryinterlocking nailing and delayed cover	12%
Sanders etal. 1994	Primaryinterlocking nailing & delayed cover	17%

In our study nonunion rate was similar to the external fixation group but morbidity associated with external fixator was not there ‘

On comparing with other studies,high rate of nonunion due to delay in secondary intervention.5 out of the 7 cases secondary intervention has been done and results are awaited .But results were better than secondary nailing with single surgical procedure .

Though there is high rate of nonunion functional outcome assessment by Karlstrom & Olerud score was excellent to satisfactory in 25 patients and poor in only two patients.

Anterior knee pain[25] was noticed in four patients but all of them were done through medial Para-patellar approach.

CONCLUSION

Primary interlocking and primary closure produces excellent results in GrI and GrII fractures as compared to any other modality of treatment.

For GrIII fractures infection rate was 35%, which is as good as external fixation but better than secondary nailing.

Primary interlocking nailing and primary closure as a single staged procedure required less number of secondary procedures as compared to external fixation and secondary nailing.

Functional outcome was far better in primary interlocking and primary closure than other procedures.

Although the infection rates in GrIIIB fractures treated with primary interlocking was high this can be improved by better theatre sterility, early surgical intervention, timely secondary procedures and accurate assessment of soft tissue injury.

CASE ILLUSTRATIONS

Case 1

25 yr,old Logesh, following RTA, had Gr II compound left tibia fracture

Wound debridement, interlocking nailing and primary closure was done

7½hrs after injury.

Fracture united at six months.

Functional outcome was excellent.

Case 2

23 yr, old Laksmanan ,following RTA(two wheeler Vs two wheeler) had GrII left tibia fracture.

wound debridement interlocking nailing and primary closure was done 9hrs after injury.

Fracture united at seven months.

Functional outcome was excellent.

Case 3

23 yr old, Raja, following RTA(bike hit against road side post) had GrIIIA compound tibia fracture.

Wound debridement, interlocking nailing and primary closure was done 10hrs after injury.

Fracture united at eight months.

Functional outcome was excellent.

Case 4

30 yr old, srinivasan, following RTA(two wheeler Vs two wheeler) had GrIII B left tibia fracture. He had associated posterior dislocation of the left hip.

Wound debriment, interlocking nailing and soleal muscle flap was done 8 ½ hrs after injury.

At 3 months, there was no progression in healing at the fracture site for which Dynamisation was done.

Fracture united at 10months.

Functional outcome was good.

Case 5

42yr, old Vasu had injury to his right leg following fall of heavy iron rod over his leg.He had Grade IIIB compound fracture right tibia.

Wound debriment, interlocking nailing and superiorly based fasciocutaneous flap cover was done 4 ½ hrs after injury.

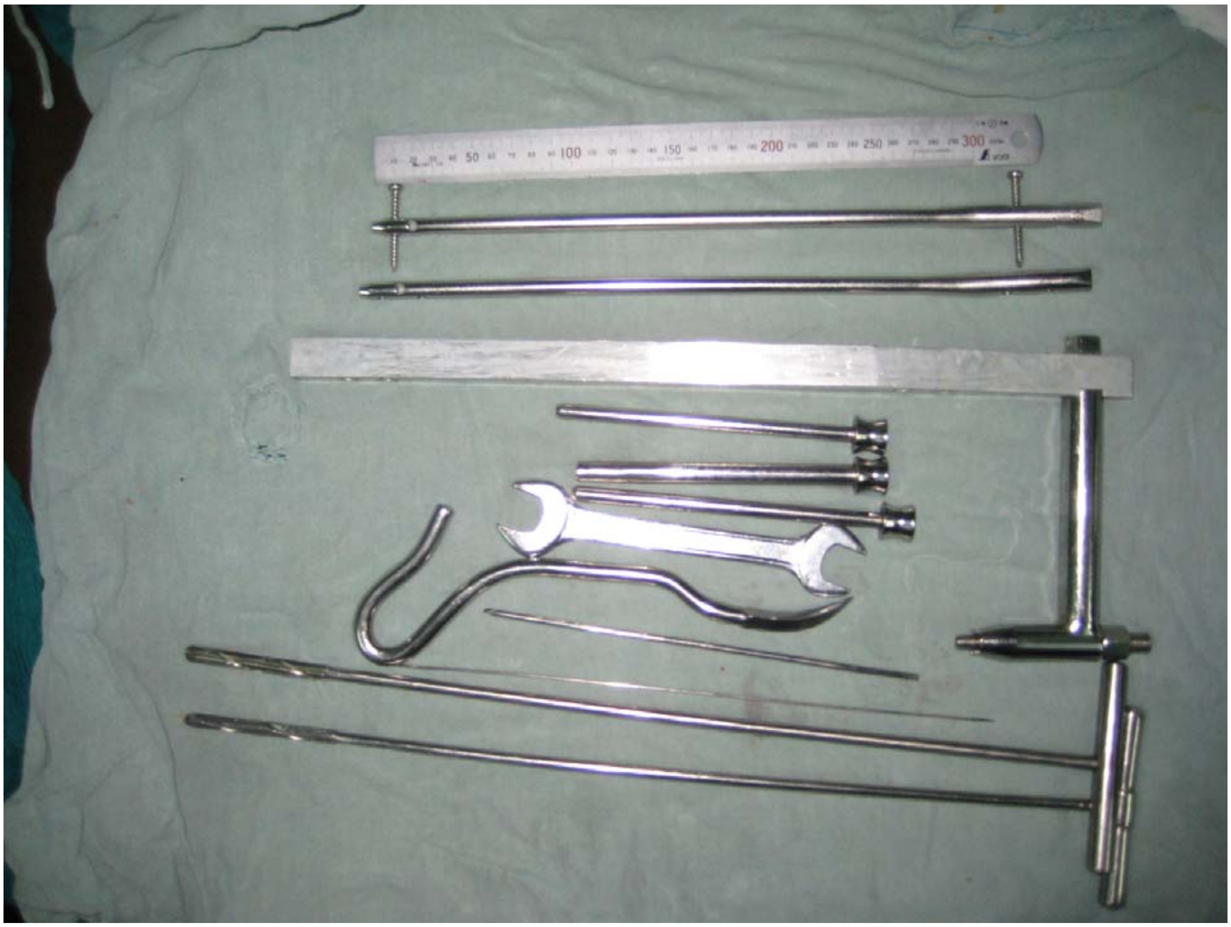
Postoperatively patient developed flap necrosis and infection. Repeated wound debridement was done and infection contolled with appropriate antibiotics.

Wound healed with the sinus in the anteromedial aspect of distal leg. But patient developed Non- union for which posterolateral bone grafting was done.

Fracture united at 1year.

Functional outcome was satisfactory.

INSTRUMENT SET



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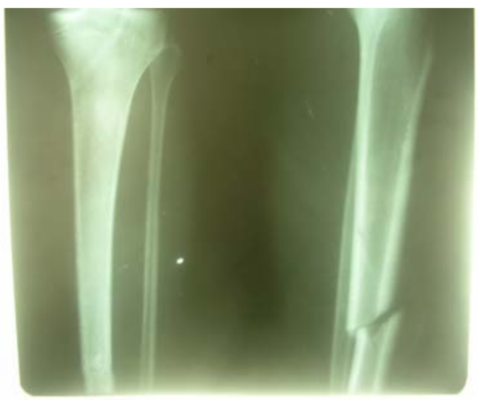
Case no. 1: Logesh, 25 yr Male, RTA, Grade II fracture

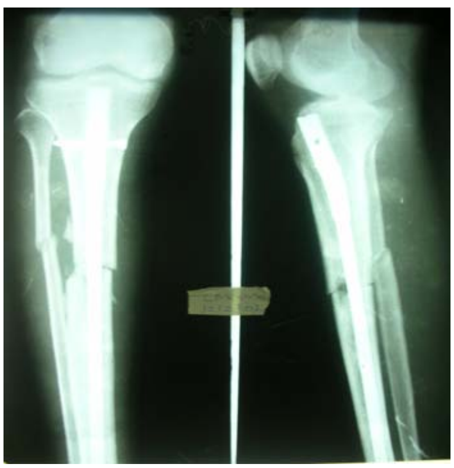
At Admission **After Wound Debridement**



After six Months **Functional Outcome: Excellent**

Case no .2:   Laxmnan 23 yr Male,RTA,Grade II fracture

At Admission   After Wound Debridement



Post OP x-ray   7-months follow up

Functional outcome: Excellent

Thangaraj 22 yr Male, RTA, Grade II fracture

Pre Op X-ray

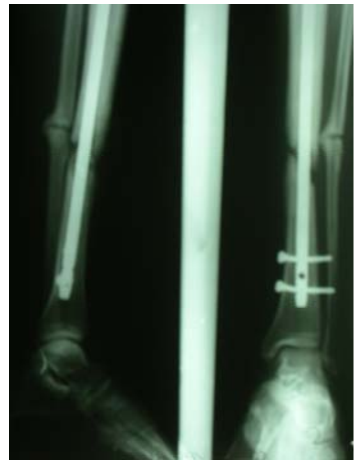
7-months follow up

Functional Outcome: Excellent

complications

Flap Necrosis

Non union



Intramedullary infection

Osteomyelitis

Stiff ankle with hyperpigmentation

Case no .3: Raja 23 yr male, RTA, Grade III Fracture

At Admission **After Wound Debridement**

Pre op x-ray **8 months follow up**

Functional Outcome: Excellent

Case no.4: Srinivasan 30 yr male, RTA, Grade IIIB Fracture with Left Hip Posterior Dislocation

At Admission

After Wound Debridement

Soleal flap cover

Pre-op X-ray

s

Post-op X-ray

10months follow up

Functional outcome good

Case no :5 Vasu 42yr male, fall of heavy weight, Grade III B fracture
Wound debridement, Interlocking nailing and Fasciocutaneous flap

At Admission

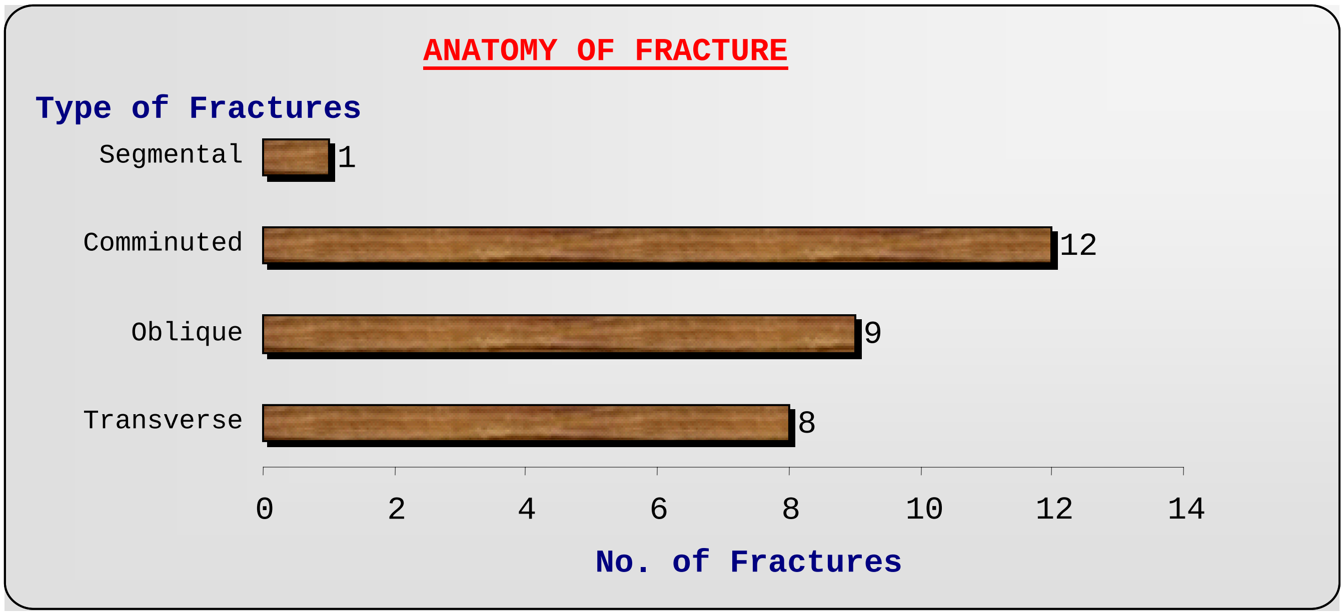
After wound debridement

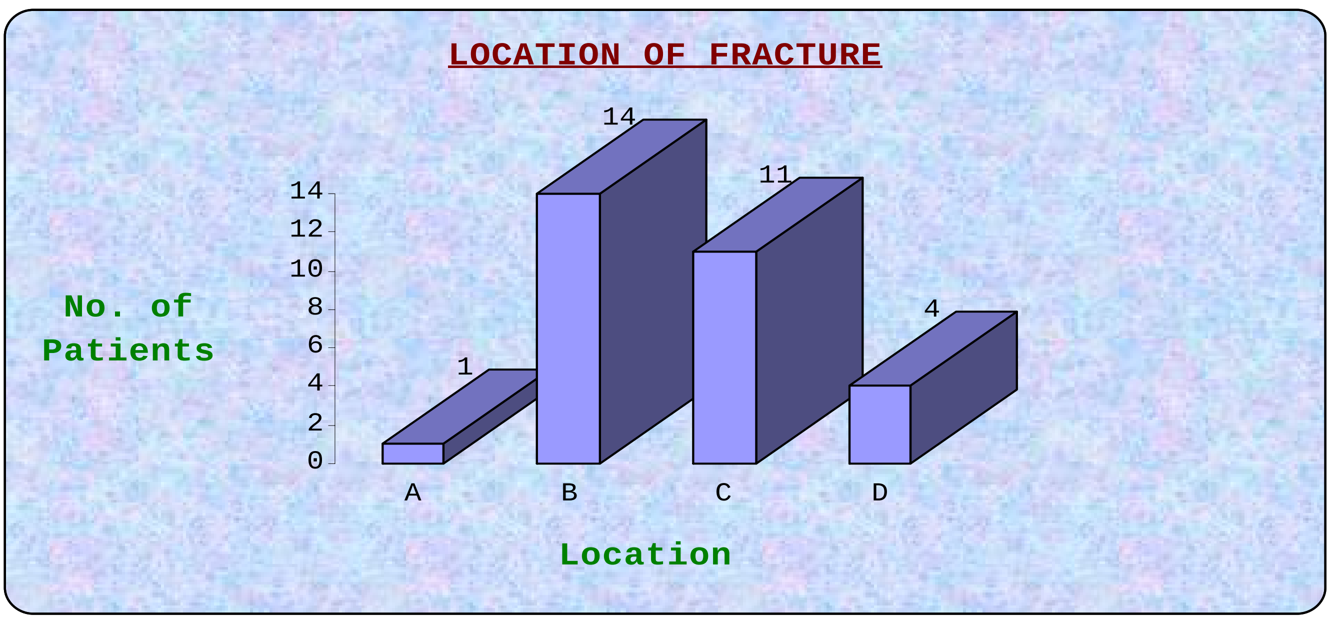
Fasciocutaneous flap

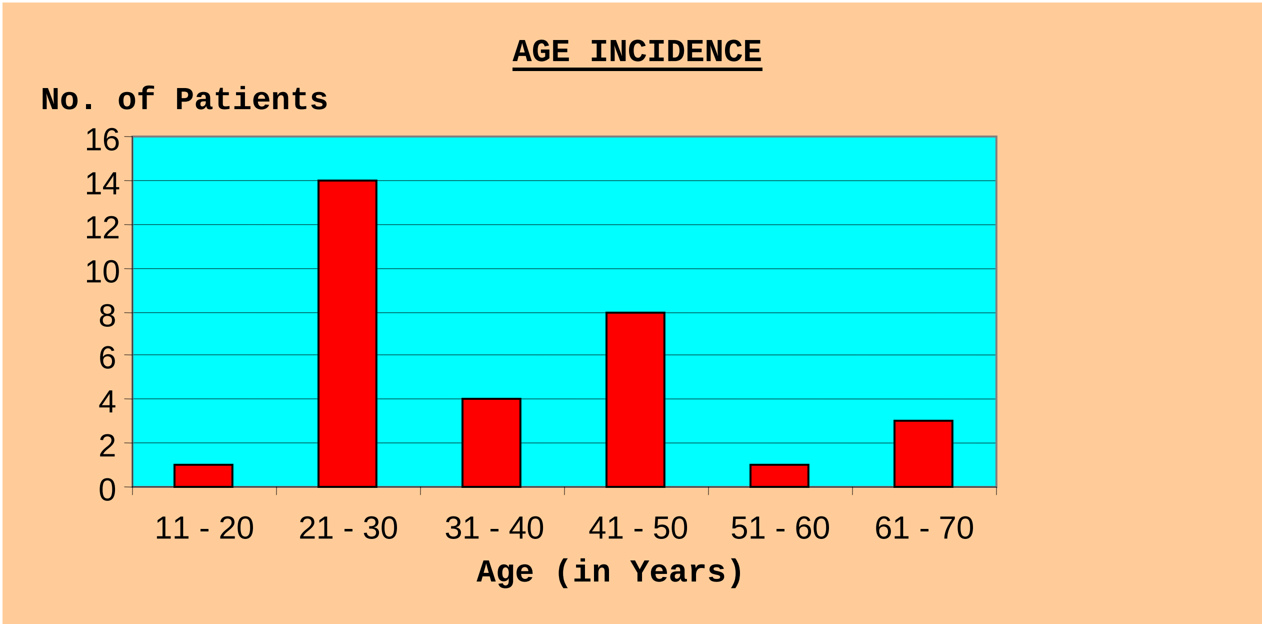
Pre op- xray

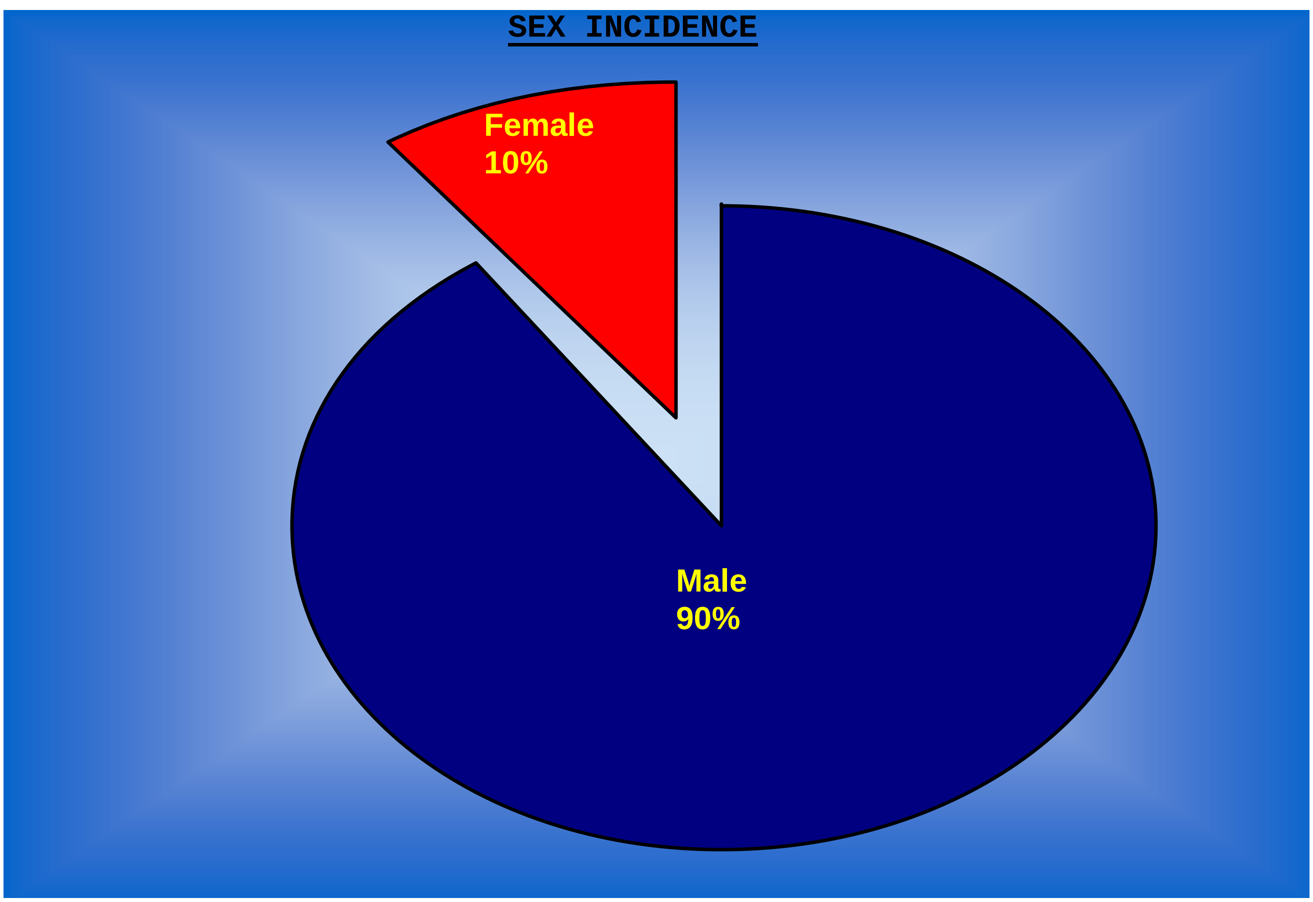
1year follow up- union after posterolateral bone grafting

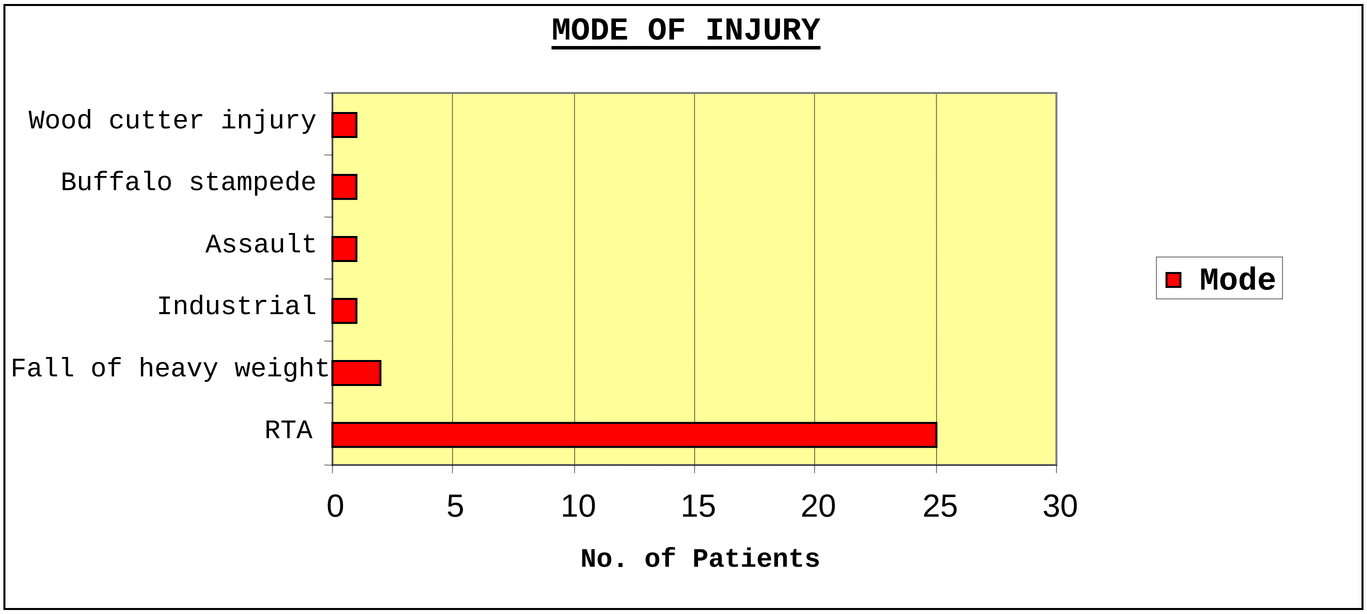
Functional outcome satisfactory

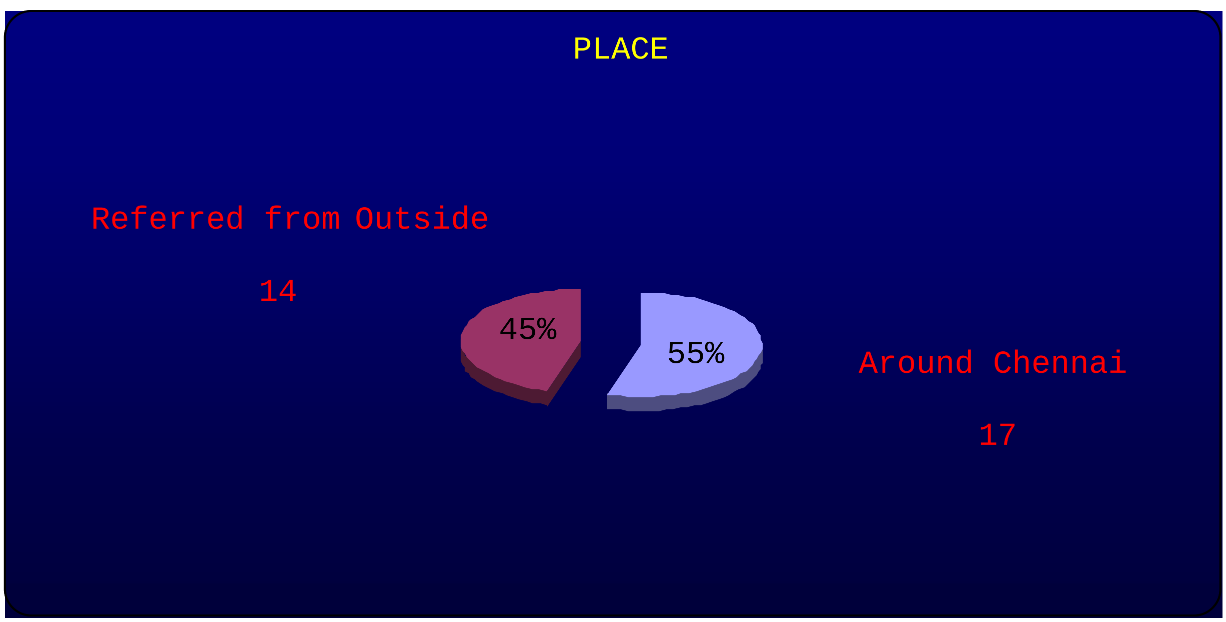

ANATOMY OF FRACTURE
Type of Fractures
Segmental
Comminuted
Oblique
Transverse
1
12
9
8
0
2
4
6
8
10
12
14
No. of Fractures


LOCATION OF FRACTURE
No. of Patients
14
12
10
8
6
4
2
0
1
14
11
4
A
B
C
D
Location


AGE INCIDENCE
No. of Patients
16
14
12
10
8
6
4
2
0
11 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 70
Age (in Years)


SEX INCIDENCE
Female
10%
Male
90%


MODE OF INJURY
Wood cutter injury
Buffalo stampede
Assault
Industrial
Fall of heavy weight
RTA
0
5
10
15
20
25
30
No. of Patients
Mode


PLACE
Referred from Outside
14
45%
55%
Around Chennai
17

S.NC	NAME	IP NO.	AGE/ SEX	MODE	PLACE	INJ TO ADM.(Hrs)	AD.TO SURG (Hrs)	TIME DELAY(Hrs)	GRADE	NAIL SIZE cm*mm	ST COVER
1	RADHA	785220	25/F	RTA	OUTSIDE	20	12	32	GIIIA	32*8	CLOSURE
2	RAJENDRAN	785572	27/M	INDUSTRIAL	CHENNAI	2	3.25	5.25	GIIIA	36*9	CLOSURE
3	RAJENDRAN	785629	43/M	RTA	OUTSIDE	3.75	7.25	11	GIIIA	34*9	CLOSURE
4	ANUMAN	787519	30/M	RTA	CHENNAI	3	8	11	GII	38*10	CLOSURE
5	RAJA	838439	23/M	RTA	OUTSIDE	3.75	9.75	13.5	GIIIA	34*9	CLOSURE
6	ELLAIYAN	840387	22/M	RTA	CHENNAI	2.5	3.5	6	GIIIA	32*8	CLOSURE
7	ARUN	841389	18/M	RTA	OUTSIDE	15	7	22	GII	31.5*8	CLOSURE
8	VASU	842076	42/M	HEAVY WEIGHT	CHENNAI	1.25	3.25	4.5	GIIIB	32*9	FC FLAP
9	JOTHIRAMALINGAM	844155	49/M	RTA	CHENNAI	3	7	10	GIIIA	32*9	SSG
10	MANI	845066	49/M	WOOD CUTTER	OUTSIDE	43	8	51	GIIIB	34*8	GM FLAP
11	GOVINDASAMI	845189	43/M	RTA	CHENNAI	3.25	1	4.25	GII	36*9	CLOSURE
12	RAGAVAN	857712	70/M	RTA	OUTSIDE	2.75	9	11.75	GIIIA	34*9	CLOSURE
13	RAMU	850058	38/M	RTA	OUTSIDE	12.25	12.5	24.75	GII	32*9	CLOSURE
14	MANOHARAN	852685	42/M	RTA	CHENNAI	4	12	16	GII	34*9	CLOSURE
15	ARUMUGAM	856658	34/M	RTA	OUTSIDE	6	4	10	GIIIB	36*9	FC FLAP
16	VISHALAXI	856796	60/F	RTA	CHENNAI	4.5	4.25	8.75	GIIIA	30*9	CLOSURE
17	MOORTHY	858329	32/M	RTA	OUTSIDE	45	6	51	GII	34*9	CLOSURE
18	SRINIVASAN	859083	30/M	RTA	CHENNAI	4	8.25	12.25	GIIIB	36*9	SM FLAP
19	THANGARAJ	859653	22/M	RTA	CHENNAI	7	1.5	8.5	GII	32*9	CLOSURE
20	BASKAR	861205	25/M	RTA	OUTSIDE	17.75	5.25	23	GII	34*8	CLOSURE
21	FERRIA	862474	70/F	RTA	CHENNAI	2.75	5	7.75	GII	30*9	CLOSURE
22	LAKSHMANAN	983	23/M	RTA	OUTSIDE	4.75	4	8.75	GII	34*8	CLOSURE
23	LOGESH	2555	25/M	RTA	CHENNAI	3.5	4	7.5	GII	36*9	CLOSURE
24	KARTHIKEYAN	4775	30/M	BUFFALO	OUTSIDE	12.75	13.75	26.5	GIIIA	38*9	CLOSURE
25	KAMAL	5525	28/M	HEAVY WEIGHT	CHENNAI	1.75	3.5	5.25	GIIIA	32*8	SSG
26	LOGANATHAN	17219	40/M	RTA	CHENNAI	2	4	6	GIIIA	36*9	CLOSURE
27	MUNUSAMY	22167	23/M	RTA	CHENNAI	4	6	10	GII	32*8	CLOSURE
28	VASUDEVAN	28690	43/M	RTA	CHENNAI	12	14	26	GIIIA	32*8	CLOSURE
29	ANANDHAN	28902	23/M	RTA	CHENNAI	4	6	10	GII	34*9	CLOSURE
30	NALLASEVI	33030	65/M	ASSUALT /LOG	OUTSIDE	16	8	24	GII	32*8	CLOSURE
31	PENCILLIAH	41568	45/M	RTA	OUTSIDE	12	3	15	GII	32*10	CLOSURE

ST COMPLICATION	SUPER. INFECTION	DEEP INFECTION	NON UNION	SEC PROC	FOLL UP(MON.)/ VISIT	UNION	SCORE
			LOST FOR FOLLOW UP				
					22/4	33	EXCELLENT
					20/2	37	GOOD
			LOST FOR FOLLOW UP				
					13/2	34	EXCELLENT
			ASEPTIC	DY/BG	15/3		GOOD
					15/5	30	EXCELLENT
FLAP NECROSIS	PRESENT	PRESENT		PL BG	14/2	53	GOOD
					14/6	23	GOOD
		PRESENT	PRESENT	BG	1-Nov		SATISFACTORY
				DY	14/5	22	EXCELLENT
			LOST FOR FOLLOW UP				
			LOST FOR FOLLOW UP				
				DY BG	13/5	40	EXCELLENT
FLAP NECROSIS	PRESENT	PRESENT	PRESENT	ANT.EX/BG			POOR
		PRESENT	PRESENT		12/5		POOR
SKIN NECROSIS	PRESENT	PRESENT	PRESENT	PL BG	11/3		SATISFACTORY
				DY	11/6	41	GOOD
					12/3	28	EXCELLENT
					10/3	27	EXCELLENT
					12/6	33	GOOD
					11/4	30	EXCELLENT
					11/3	24	EXCELLENT
		PRESENT	PRESENT		10/3		SATISFACTORY
SSG NECROSIS	PRESENT				10/2	24	EXCELLENT
					8/2	35	SATISFACTORY
					7/2	27	GOOD
				BG	7/2	29	GOOD
			PRESENT		6/2		GOOD
					5/2	24	GOOD
					5/3	22	GOOD