“Study of Management of Tibial Diaphyseal Fractures with Interlocking Nail”

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By
DR.RAHUL KATTA
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“Study of Management of Tibial Diaphyseal Fractures with Interlocking Nail”
Tibia is the most commonly fractured long bone in the body with an annual incidence of tibial shaft fractures is 2 per 1000 individuals. Since the tibia is the large bone of the body and one of the principal load bearing bones in lower extremity, fractures can cause prolonged morbidity, extensive disability unless treatment is appropriate. Various techniques are now available for treatment of diaphyseal fractures of tibia where orthopaedic surgeon must be aware of the advantages, disadvantages and limitation of each to select the proper treatment for each patient. The type, location, degree of comminution, age, patients social and economic demands may influence the method of treatment. The use of non-operative treatment of tibial fractures that are widely displaced or that are the result of high-energy forces is associated with a high prevalence of malunion, stiffness of the joint, and poor functional outcome.

Tibia has been posing problems to the orthopaedists the world over.

Sir John Charnley (1961) said, "We still have a long way to go before the best method for treating a fracture of the shaft of the tibia can be stated with finality."

Tibia, because of its very location is frequently exposed to injuries. Its one third surface being subcutaneous, it often suffers from open fractures. Furthermore, the blood supply to the tibia is already precarious and it is guarded by the presence of hinge joints at the knee and the ankle which allow no adjustment for the rotatory deformity.

Sisk (1983) noted "treatment of diaphyseal fractures by techniques that require prolonged immobilization of the extremity has obvious disadvantages."
Hospitalization or convalescence or both are prolonged, limitation of joint movement common, and malunion and nonunion may occur. The unattainably perfect method of fracture treatment would safely fix the fracture so firmly that soft tissues and joints could be mobilized early and continuously during healing and when applicable, ambulation and weight bearing could be permitted. A method closely approaching this is medullary fixation.

The traditional treatment of tibial shaft fractures has been long term immobilization in plaster of paris cast and functional cast brace this is in itself an invitation to the well known "Fracture - disease". The Sarmiento type PTB functional brace, which is so popularly practiced results an average shortening of 6.4mm, an average angulation 8° and an average union time 5.7 months. (Austin RT- Sarmiento Plaster 1981).

How can a method of treatment be acceptable if it gives stiff joints in a shortened, deformed limb? These constraints have to a large extent been overcome by the intramedullary interlocking nail revolution. The sheet anchor for its use remaining, its ability to prevent axial collapse, rotational and angulation deformities and the most important of all being earliest possible ambulation, keeping this treatment modality on the top priority.

Nicoll 67 as early as 1974 pointed out that with conservative treatment the probability of delayed union with comminuted fracture is 15%, displaced fracture 27%. and fracture with severe soft tissue injury 12% and fracture gap more than 1 cm is 65%. Also there is a 25% incident of residual joint stiffness and muscle weakness.
The difficulties that may arise in the treatment of fractures of shaft of tibia include: (1) a high incidence of open and infected fractures as tibia lies superficially just beneath the skin; (2) a tendency of redisplacement of the fragments when swelling subsides, particularly in oblique and spiral fractures; (3) cosmetics and sometimes functional disability if the alignment or rotational position of the fragment is imperfect because the knee and ankle joint normally move in the same parallel axis; (4) Conspicuous disfigurement if apposition of the fragments is imperfect because the tibia lies subsequently; (5) slow union as a result of severity of the fracture, poor blood supply to one fragment and sometime distraction of the bone fragments; (6) the occasional limitations of joint movement in the knee, ankle and foot, usually caused by associated joint, soft tissue or vascular injury (Watson Jones, 1982).

It is these difficulties that have given rise to so much controversy between surgeons as to the best method of managing tibial fractures.

Later, as a result of ability to lock the nail proximally and distally, closed intramedullary nailing became an accepted treatment for closed shaft fractures during the ninth decade (Kuntscher, 1962; Hoentzsch et al, 1989). However side effects of conventional reaming technique had been noted probably due to mechanical, thermal and biological factors impairing the endosteal blood supply (Pfister et al, 1979; Klein et al, 1990). Good results had been shown by using locking nails for both closed and Gustllo grade I open fractures (Gustllo and Anderson, 1976; Kfemn and Broner, 1986; Court –Brown et al, 1990; Hooper et al, 1991).
The conventional method used in our hospitals in India is towards closed reduction of displaced tibial fractures and then application of groin-to-toe cast for the full period of clinical and radiological healing. This results in patients lying on bed without weight bearing for many months leading to complications like joint stiffness, muscle atrophy, osteoporosis and prolonged recumbence and its side effects (Cast syndrome).

The method of closed nailing without reaming followed by early ambulation and weight-bearing has positive advantages over all existing methods, significantly lower complication rate and has comparable results. Compared with A.O. technique it has the advantages of (1) not requiring specialized technique as complications following treatment with A.O. methods have been explained as due to insufficient expertise (Thunold et al, 1975); (2) not requiring special equipment and (3) being more suitable for high energy fractures (Bauer et al, 1962; Edwards, 1965).

Interlocking nailing has proven to be the method of choice for fixation of these fractures.

The intramedullary nailing under image intensifier fulfills the objective of stable fixation with minimal tissue damage resulting in better and quicker fracture unions.

The present study has been taken to review the results of diaphyseal fractures of tibia treated with Intramedullary Interlocking nailing.
AIMS & OBJECTIVES

- To study and evaluate the results of Interlocking intramedullary nailing in diaphyseal fractures of tibia.
- To study the period of union and union rate on radiological evidence.
- To Study the range of movements at knee and ankle joint.
- To Study the complications of interlocking intramedullary nailing in diaphyseal fractures of tibia.
- To compare end results with the other methods of treatment & other studies.
The Edwin Smith papyrus (an ancient Egyptian treatise on trauma surgery from the 17th century BC) contained references to the management of long-bone fractures with splints and bandages. Hippocrates recommended the use of bandages and splints in his treatise on fractures; he stressed the need to change these bandages frequently to accommodate changes in limb swelling.

The advent of plaster and the design of functional casts revolutionized the management of tibial fractures. Anthonius Mathijsen, Fedor Victor Krause, Pierre Delbet, and, more recently, Augusto Sarmiento have considerably refined the indications and methods of conservative management of tibial fractures. Austin RT (1981) - Sarmiento Tibial plaster (145 case prospective study) described early mobilization by this type of FC3. He used PTB cast which was applied when once the fracture become sticky. Early mobilization prevented the fracture disease and enhanced union. The sarmiento type PTB functional barce, which is so popularly practised results an average shortening of 6.4 mm, an average angulations 8.0 and has an average union time 5.7 months.

Understanding wound debridement and knowing Sir Joseph Lister's work on antisepsis enabled surgeons to treat open diaphyseal tibial fractures with some prospect of avoiding amputation.
The history of intramedullary nailing for the treatment of long bone fractures and nonunions is long and storied. From the earliest recorded examples in 16th century Mexico to the current procedures of today, there has been an evolution of design, materials, and basic science principles, which has resulted in a well accepted and successful technique for the past several decades. Interestingly, throughout the early history of intramedullary nailing, these advances in method, principle, and design appear to parallel advances in anesthetic and aseptic techniques, allowing for routine operative care of fractures to emerge.

Although intramedullary nailing is now the standard of care for the treatment of most diaphyseal lower extremity fractures, introduction of the technique was met with a great deal of skepticism in both Europe and North America during the first half of the 20th century. In the latter half of the 20th century, intramedullary nailing of long bone fractures revolutionized the care of the multiply injured patient.

**The Beginnings**

Bernardino de Sahagun, a 16th century anthropologist who traveled to Mexico with Hernando Cortes, recorded the first account of the use of an intramedullary device. De Sahagun witnessed Aztec physicians placing wooden sticks into the medullary canals of patients with long bone nonunions. Other pre-Twentieth century intramedullary techniques also seemed to be conducted in patients with nonunions and not in patients with acute long bone fractures.

During the mid 1800s through the first decade of the 1900s, most of the work in intramedullary nailing of nonunions appear to revolve around the use of ivory pegs. It had been observed that ivory pegs would reabsorb in the human body compared to metallic implants, which became encapsulated with fibrous material. The majority of
this work was reported at the time in the German literature. During the 1890s, Gluck recorded the first description of an interlocked intramedullary device. The device consisted of an ivory intramedullary nail that contained holes at the end, through which ivory interlocking pins could be passed. Around the same time period, Nicolaysen of Norway described the biomechanical principles of intramedullary devices in the treatment of proximal femur fractures. Nicolaysen proposed that the length of intramedullary implants be maximized to provide for the best biomechanical advantage. While ivory seemed to be the material of choice reported in the German literature, Hoglund of the United States reported the use of autogenous bone as an intramedullary implant in 1917. He described a technique in which a span of the cortex was cut out and then passed up the medullary cavity across the fracture site. During World War I, Hey Groves of England reported the use of metallic rods for the treatment of gunshot wounds. These rods were passed into the medullary cavity through an incision made over the fracture site. This technique appeared to have a high infection rate and was not universally accepted. It was not until Smith-Petersen’s 1931 report of the successful use of stainless steel nails for the treatment of femoral neck fractures, that the application of metallic intramedullary implants began to expand rapidly. In the United States, Rush and Rush described the use of metallic Steinman pins placed in the medullary canal to treat fractures of the proximal ulna and proximal femur. While these techniques provided a foundation of principles for the treatment of fractures with intramedullary fixation, there would be an explosion of principles and methods in the decades to come.
**Origins and Evolution of Kuntscher Nailing**

Gerhard Kuntscher was born in Germany in 1900. His early interest in intramedullary devices resulted from his work with the Smith-Petersen nail in the treatment of femoral neck fractures. Kuntscher believed the same basic science principles would be applicable in the treatment of diaphyseal fractures. During development of his "marrow nail," he conducted cadaveric and animal studies. His original intramedullary nail was a V-shaped stainless steel nail that was inserted antegrade. Kuntscher first reported use of the V-shaped nail in 1940 and proposed the nail would act as an internal splint that created an elastic union with the inner medullary cavity. It appears that early in the development of his technique, he recommended inserting the nail into the bone distant to the fracture site, thus, avoiding any disturbance of the zone of injury. Intraoperative reductions were achieved with the use of multiple slings; while head worn fluoroscopy was used for bony visualization. Kuntscher believed that proper insertion of his nail would allow for immediate functional mobilization of the patient.

Kuntscher's early work was not well received in Germany, and early in World War II he was sent to the northern Finnish front. There he collaborated with Finnish surgeons, which resulted in a report, in 1947, of 105 cases using the V-shaped nail. (By the late 1940s, Kuntscher had begun to abandon use of the V-shaped nail design in favor of another Kuntscher design, the cloverleaf nail.

While there was some interest in the use of Kuntscher's technique in Europe during World War II, his method was essentially unknown in the US. The use of the Kuntscher nail was first described in the US in a March 12, 1945, Time Magazine article, entitled "Amazing Thighbone." This article discusses the skepticism displayed
by American surgeons on discovering the metallic rods implanted in US servicemen by German doctors. It would be several more years until the first report of the Kuntscher nail would appear in the English medical literature. During the 1940s, various other intramedullary designs were introduced. Westerborn reported his experience with a V-shaped nail in the Scandinavian literature in 1944. In 1946, Soeur reported on his use of a U-shaped nail in the femur, tibia and humerus.

In the US, the Hansen-Street nail was introduced in 1947. This was a solid diamond-shaped nail, designed to resist fracture rotation via its compressive fit within the cancellous bone. These nails were originally inserted using a closed method in order to avoid the high infection rate reported earlier by Hey Groves. However, with the utilization of penicillin, Street transitioned to open retrograde nailing to avoid side effects of the radiographic techniques of the day.

1950s

During the 1950s, two important techniques were developed and introduced. In 1942, Fischer had reported, in the German literature, the use of intramedullary reamers to increase the contact area between the nail and host bone, with the hope of improving stability of the fracture. However, it took another decade with Kuntscher's introduction of flexible reamers for the concept to take hold. Fischer also believed that reaming in combination with a larger diameter nail would enhance the stability of fractures by increasing the contact area.

He felt that, although the intramedullary vascular supply was obliterated through this technique, the periosteum and surrounding tissues would promote adequate bone formation for healing. Another currently used technique introduced in the 1950s was the application of interlocking screws to enhance stability of the construct. Modny
and Bambara introduced the transfixion intramedullary nail in 1953. This nail was cruciate-shaped, with multiple holes the length of the nail to allow for placement of screws at 90[degrees] angles from each other. Modny and Lewert later reported excellent results in a series of 261 femur fractures treated with this nail.

1960s

Enthusiasm for compression plating of long bone fractures exploded during the 1960s, and general advancement in the use of intramedullary nails "went on hiatus." Despite the emergence of compression plating, there were several advancements that changed the future practice of intramedullary nailing.

Cephalomedullary nails were first introduced in the 1960s, highlighted by the development of the Zickel nail in 1967. The Zickel nail contained a hole in the proximal portion in order that a separate nail could be placed through the lateral cortex of the proximal femur into the neck and head. A set screw, which continues to be found on some current cephalomedullary designs, could be inserted through the proximal portion of the shaft nail to prevent backout of the head and neck nail.

During the 1940s and 1950s, many surgeons abandoned early radiological techniques, such as head worn fluoroscopy, because of the potential side effects to both surgeon and patient. This forced these surgeons to adopt an open nailing technique. The development of radiological image intensification, in the 1960s, allowed surgeons to readopt closed nailing techniques with a much lower risk to patient and surgeon alike.
1970s and 1980s

The exuberance that accompanied the advent of compression plating for tibias and femurs in the 1960s quickly diminished in the 1970s and, thus, a renewed interest in refining closed nailing techniques appeared. This reemergence of closed nailing has led to many of today’s current techniques. As the use of reamed nailing gained more traction, unreamed nailing became reserved for open fractures. Also during this time, a rapid gain in experience occurred using reamed nails for treating tibial shaft fractures. The dominant design during this time period was the slotted cloverleaf-shaped interlocked nail, e.g., the AO and Grosse-Kempf nails.

As surgical techniques continued to expand during this time, there was a surge in clinical data regarding the use of reamed interlocking nails of both the femur and tibia. This was culminated by a three-part study of reamed interlocked femoral nails by Brumback and colleagues. This work reported a 98% (85/87) initial healing rate with statically locked, reamed intramedullary nails in 87 femur fractures. Union was reported in the remaining two fractures after dynamization.

1990s and the 21st Century

While there was certain progress as far as nail design and materials is concerned during the 1990s, the major advancements came with the expansion of indications for unreamed and reamed intramedullary nailing. Open tibial shaft fractures were now being treated with intramedullary fixation with good results. Likewise, open femur fractures that previously were managed with unreamed nails, were now being treated with reamed nails. In addition, very proximal and distal tibia and femur fractures, once thought to be unsuitable for nailing, were benefiting from intramedullary fixation. Design achievements of the 1990s included the introduction
of new titanium nails, cephalomedullary devices such as the Gamma nail, and retrograde supracondylar intramedullary nails such as the GSH (Green-Seligson-Henry) nail.

In addition, slotted cloverleaf cross-sectional designs were being replaced by nonslotted designs that provided greater torsional rigidity.

In 1999, Brumback and associates reported a two-part study looking at immediate weightbearing in patients with comminuted femoral shaft fractures that were treated with intramedullary nailing. These investigators concluded that immediate weightbearing is advisable in patients who had their femur fractures fixed with larger diameter nails with high fatigue strength, as this allows for more rapid mobilization for the trauma patient with multiple injuries of the extremities.

**Future Advancements**

While today's experience with intramedullary fixation for tibial and femur fractures has been quite good, there will most certainly be continued research to improve the technique. The most likely two areas of future research will revolve around different biomaterials and biologically active agents to promote bone healing. Two types of biomaterials that may hold promise include biodegradable polymers and shape memory alloys. Biologically active agents, such as bone morphogenic protein-2 and -7, have been used with good success in the promotion of bone healing in both animal models and humans. How to combine these bioactive agents with implants in a cost effective manner is yet to be determined.
Lawrence B. Bone \textsuperscript{57} (1986) treated 112 cases of closed tibial fractures by reaming and intramedullary nailing. They opined that it is also indicated in the treatment of non-union and malunion in the absence of sepsis. In segmental fracture, excellent results were noted with average time in union at 19 week.

Average time to full weight bearing was 4 week, 50\% of primary nailing and 40\% of secondary nailing healed within 3 months. They concluded that interlocking nailing is an excellent management for unstable fractures and for secondary procedures in fractures not associated with infection.

Hooper et al \textsuperscript{45, 46, 47} (1991) reviewed fractures of tibia treated with conservative treatment and closed intramedullary nailing. The results showed that the intramedullary nailing gives more rapid union with less malunion and shortening. Nailed patients had less time off work, with a more predictable and rapid return to full function.

Paul Gregory and Roy Sanders \textsuperscript{71} (1995) proposed that interlocked intramedullary nailing inserted in an unreamed manner has become the treatment of choice for the closed, unstable tibial shaft fractures in polytraumatized patients in the authors institution. A high union rate, coupled with lack of compartment syndromes or peroneal palsy, makes this procedure an attractive and alternative to reamed nailing.

Hernigou P \textsuperscript{43} (2000) in a report on proximal entry for intramedullary nailing of the tibia, concluded that it is important to enter the medullary canal at the right point, so that the nail is introduced in line with the axis of the tibia in both the coronal and sagittal planes. If the entry point is low, posterior tibia is endangered, if high then, unrecognized articular penetration can occur injuring the menisci and ligamentum transversum.
Jarmo AK, Toivannen\textsuperscript{48} (2002) in a prospective randomized study of intramedullary nailing of closed fractures of the tibial shaft, compared the results of anterior knee pain in two different nail insertion techniques. The incidence of chronic anterior knee pain was seen in up to 56\% of patients. They noted that irrespective of incision used, whether transtendinous, or paratendinous incision, the prevalence of anterior knee pain is the same. They concluded by saying that intramedullary nailing is the treatment of choice for displaced tibial shaft fractures and any change in approach in nail insertion does not change the incidence of anterior knee pain.

Vineet Jain\textsuperscript{49} (2005) concluded that primary unreamed intramedullary nailing offers advantage of rigid fixation, low incidence of infection, non union, good functional result and early return to work. An adequate soft tissue management is mandatory in treatment of these fractures.

Kyung-Cheon Kim\textsuperscript{56} (2008) in their article “Percutaneous reduction during intramedullary nailing in tibial shaft fracture” stated that the use of unreamed intramedullary nailing in tibial shafts has gained favour because they better preserve the endosteal blood supply and minimally disturb the soft tissue envelop. Percutaneous reduction with conventional reduction forceps and unreamed intramedullary nailing is tough to facilitate fracture reduction and decrease complications, such as non-union malalignment, instability and fixation failure.

Vaisto O\textsuperscript{84} (2008) in their article “Anterior knee pain after intramedullary nailing of fracture of tibial shaft: an eight year follow-up of a prospective randomized study comparing the different nail-insertion techniques” stated that anterior knee pain is the most common complication after intramedullary nailing of the tibia. Dissection of patellar tendon and its sheath during transtendinous nailing is thought to be a contributing cause of anterior knee pain compared with a transpatellar tendon
approach, a paratendious approach for nail insertions does not reduce the prevalence of chronic anterior knee pain or functional outcome after intramedullary nailing of tibial shaft fracture. In long term anterior knee pain seems to disappear from many patients.

**Hooper et al** 45,46,47 undertook the first prospective comparison of intramedullary nailing and cast management in closed and type 1 open fractures, finding that intramedullary nailing gave a statistically faster time to union as well as significantly less time off work and hospitalization time.

**Klemm and Borner** 53 reported 94% excellent or good results in 267 tibial fractures treated with interlocking intramedullary nails. The deep infection rate was 2.2% but all fractures responded to therapy and no chronic osteomyelites developed.
Surgical Anatomy

(Williams & Warwick - Gray's anatomy 36th Ed. Osteology of tibia 397-404).

The tibia is the medial and much stronger of the two bones of the leg. It is the second largest bone of the body. It is prismoid in section in the shaft and is expanded more from side and forms two large condyles which overhang the posterior surface of the shaft. The upper end of tibia includes the medical and lateral condyles, non-articular intercondylar area and the tuberosity of tibia.

The lower end is smaller than the upper end and on its medial side is a stout process the medial malleolus which projects down to take part in formation of the ankle joint.

The fibula is the lateral bone of the leg. it is attached to the tibia at the fibular facet on the lateral condyle and below to the fibular notch. The interosseous membrane attaches to the interosseous border of tibia and fibula except at the upper and lower end. Although the fibula does not significantly contribute to transmission of weight, its continuity helps in stabilizing unstable fractures and maintaining length in severely comminute fractures. The lower end of fibula forms the lateral malleolus and forms the lateral mortise of ankle joint and is extremely important for the structural stability of the ankle.

The shaft of tibia is triangular in section and is thinnest at its middle third and lower third junction, it has three borders anterior, posterior and
interosseous which forms three surfaces medial, lateral and posterior. The three borders of tibia, the attachment of the deep fascia and the interosseous membrane divides the leg into three compartments:

i. The Anterior Compartment of the leg contains the Tibialis Anterior, Extensor Digitorum Iogus and Peroneus Tertius muscles. The Anterior Tibial artery and deep Peroneal nerve runs deep to the muscles. The compartment is bounded by the tibia medially, fibula laterally, interosseous membrane posteriorly and the tough crural fascia anteriorly.

ii. The Lateral Compartment contains peroneus brevis and peroneus longus muscles. The superficial peroneal nerve runs in the intermuscular septum between the peroneal muscles and the Extensor Digitorum longus. It is bound by the lateral septa and deep fascia covering lateral crural muscles.

iii. The Posterior Compartment is formed by posterior intermuscular septum, posterior surface of tibia and fibula, interosseous membrane and fascia covering the posterior crural muscles. The deep transverse fascia divides it into superficial and deep compartments. Sural nerve and short and long saphenous veins are also within this compartment, but there are no arterial structures of significance. The Deep Posterior compartment contains the Tibialis posterior, Flexor Hallucis longus and Flexor Digitorum longus. One major nerve, the posterior tibial nerve and two major peroneal and posterior tibial arteries are present in this compartment.
Blood Supply of Tibia

(Joseph Trueta, 1974; F W Rhinelander, 1974; Ian Mac nab, 1974).

The blood supply of tibia is derived from three main systems:

(I) Nutrient Artery:

The nutrient artery of tibia arises from the posterior tibial artery and enters through the posterolateral cortex of the bone at the origin of soleus muscle, just below the oblique line of tibia posteriorly. The artery divides into three ascending and only one main descending branch. The nutrient artery provides afferent supply to all areas of endosteal surface and inner two third of diaphyseal cortex.

(ii) Epiphyseal - Metaphyseal vessels:

The periosteal vessels are derived from the main vessels of the limb and run transversely to the long axis of the bone. With fracture, the nutrient vessels are obviously disrupted and as periosteal vessels runs transversely to the long axis of bone, blood supply to periosteum is maintained on both sides of fracture line, thus sustaining adequate vascularity for periosteal callus. In resting bone the periosteal vessels contribute to a very little part in nutrition of the cortex. Following fractures, however, the vessels penetrate the cortex and thereby help to reestablish the endosteal circulation right up to the fracture site.
**Transitory Extraosseous Blood supply to the healing bone:**

The healing bone receives a new external blood supply which is distinct from the normal as it is derived completely from the extraosseous arterial systems which are only facultative in regards to bone vascularisation.

This consists of:

a) The torn blood vessels in the vicinity of the fracture where they help in External haematoma formation and later periosteal "callus formation over the organized haematoma.

b) Where fascia has been detached from bone, ruptured periosteal arterioles combine locally with unruptured capillaries and arterioles of torn muscle in supplying the external callus.

The extraosseous supply persist until the regenerating and enlarging medullary arterioles can restore the normal centrifugal blood flow through full thickness of the cortex and external callus, after which it subsides completely (usually 3 weeks).
CLINICAL CORRELATION OF ANATOMY WITH INTRAMEDULLARY NAILING AND TIBIAL FRACTURES:

(a) **Significance of Bony architecture:**

Reparative osteogenesis is intimately related to vascular proliferation. Thus those segment of bone which are more abundantly provided by vessels, have better chance to heal. The cancellous and less dense bone of upper metaphyseal epiphyseal region has greater local supply and produce union, whereas the narrow and dense diaphyseal region is poorly supplied by vessels and thus more likely to be affected by delay or lack of union.

(b) **Significance of Blood supply:**

i. The anterior tibial artery is often injured in upper third fractures as well as lower third fracture.

ii. Nutrient artery is disrupted in fractures of the shaft.

iii. Displacement of periosteum and soft tissues along with comminuted compound fractures associated with delayed union or non-union.

iv. Segmental fractures in which the proximal fracture line is distal
to the entrance to the nutrient artery are highly prone to nonunion, if not establish properly, underlining the importance of periosteal blood supply in union of tibial fractures.

(c) **Soft tissue envelope and its significance:** Fractures of the lower third of tibia are more prone to delayed union because:

i. The bone is surrounded by tendons and there are no muscles to give soft tissue coverage and extraosseous blood supply, more would help in union.

ii. Bone being more subcutaneous is more prone to periosteal damage and compounding.
MATERIAL AND METHOD

This is a prospective study conducted during the period of May 2008 to Oct. 2011. This will include patients of both sex and age group between 15-70 year, admitted in the orthopaedic wards with diaphyseal fracture of tibia. All cases will be followed for a period of 5 months to 4 years.

Source Material

The source material comprised of all patients who were 17 years and older with fracture of the tibia mainly of the middle third and distal third. Cases of Gustilo's grade I and II compound tibial fractures & closed fractures were only included in the study.

The management of the injury was based on the following protocol.

Initial Management and Resuscitation

1. The patient was received in the emergency and his vital parameters were recorded & monitored.
2. Associated limb, chest, abdomen and head injury were ruled out.
3. An intravenous line was established, tetanus prophylaxis and I/V cephalosporin antibiotics was given, fluid replacement started and hemorrhage from the wound was controlled by pressure bandage.

4. The wound over the fracture site was cleaned and dressed and a groin to toes slab was applied by simply aligning the bone. Other wounds, if any, were taken care of appropriately.

5. The patient once settled from the acute injury, was shifted to the orthopaedic ward.

**Preoperative Assessment and Planning**

On admission in the ward, detailed history was taken, noting mode and seventy of the injury, extent and type of the trauma to the tissues and detailed examination of the affected extremity. Skiagrams were studied in detail so as to classify the fracture.

Numerous fracture classifications have been proposed over the past decades. Most of these tend to be descriptive in nature and are based on the following criteria: (1) open versus closed injury; (2) involvement of the proximal, middle, or distal thirds; (3) the number and position of fragments, such as comminution or butterfly fragments; (4) transverse, spiral, or oblique fractures; (5) varus, valgus, anterior, or posterior
angulation; (6) displacement or the percentage of cortical contact; (7) rotation; and (8) associated injuries.

Classification of the fractures of tibia: The fractures were classified according to Edwards (1965):

1. **According to the fracture pattern :**
   
   i. **Longitudinal Fracture:**

      Defined as such fractures in which the fracture line formed an angle of less than 45° with the long axis of diaphysis.

   
   ii. **Transverse Fracture :**

      All other fractures were classified as transverse fractures -

      a) **Simple-Transverse Fracture:** Those fractures where the fracture line formed an angle close to 90° with long axis of diaphysis. We took this angle to be between 90° and 75° with long axis of diaphysis.

      b) **Short oblique Fractures:** Those fractures where the fracture line formed an angle of less than 90° but more than 45° with long axis of diaphysis. We took this angle to be between 75° and 45° with long axis of diaphysis.

      c) **Comminuted Fracture :** Comminuted Fractures with an intramedullary fragment larger than half the diameter of the diaphysis were classified as comminuted fractures with additional intramedullary fragments were classified as grossly comminuted. When the diaphysis had
fracture at two separate levels, the fracture was classified as a double fracture.

2. **Displaced / Undisplaced**

   i. **Undisplaced**: Fractures with minimal displacement were classified as Undisplaced.

   ii. **Moderate displacement**: Fractures with some contact between the fractured fragments were classified as moderately displaced.

   iii. **Severe displacement**: Fractures with no contact between the fractured fragments were classified as severely displaced.

**Close V/s Open fractures**

i. **Close**: Fractures not communicating with external atmosphere through a wound were classified as closed fractures.

ii. **Open**: Fractures communicating with external atmosphere through a wound were classified as open fractures. The type of wounds were further classified according to **Gustilo**\(^{40}\) (1976) classification (Paul W. Gorman, 1989) as follows:

   - **Grade I**: Wound less than 1 cm long, clean
   - **Grade II**: Wound more than 1 cm long without extensive soft tissue damage, flaps or avulsion
   - **Grade IIIA**: Adequate soft tissue coverage of fracture bone despite
extensive soft tissue laceration or flail. high energy regardless of wound size.

**Grade IIIB** : Extensive soft tissue injury loss with periosteal stripping and bone exposure usually associated with massive contamination.

**Grade IIIC** : Associated with arterial injury requiring repair.

In this study only Gustilo Grade I and II open fractures were included.

**Level of Fracture** :

i. Proximal third

ii. Middle third

iii. Distal third
### AO/ASIF classification of tibia shaft fractures

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<th>Type</th>
<th>Fracture</th>
<th>Subclassification</th>
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<tbody>
<tr>
<td>A</td>
<td>Simple</td>
<td>A1 – spiral</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A2 – oblique</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A3 – transverse</td>
</tr>
<tr>
<td>B</td>
<td>Wedge</td>
<td>B1 – spiral wedge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B2 – bending wedge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B3 – fragmented wedge</td>
</tr>
<tr>
<td>C</td>
<td>Complex</td>
<td>C1 – spiral</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C2 – segmental</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C3 – irregular</td>
</tr>
</tbody>
</table>

AO/ASIF, Arbeitsgemeinschaft Osteosynthesefragen/Association for the study of Internal Fixation.
Case Selection:
All patients above 17 years of age, of either sex having Gustilo's Grade I or II open fracture and close fracture of the diaphysis of the tibia were chosen for the dynamic interlocking nailing. Patients selected were fit for general anaesthesia i.e. had no major head, chest or abdomen injury.

Method of collection of Data
All cases of both sexes belonging to adult age group with diaphyseal fractures of tibia

Inclusion criteria
- Adults both males and females
- Close & Compound fractures Type 1 and Type 2, according to Gustilo Anderson classification
- Isolated diaphyseal fractures of tibia
- Segmental and comminuted diaphyseal fractures of tibia

Exclusion criteria
- Compound fractures of Tibia, type 3A, Type 3B, Type 3C, according to Gustilo Anderson classification
- Patient medically unfit for surgery
- Patients with open physis
Implants and Instrument

- A complete set of IL-nails from 28-38cm length available in 7, 8, 9 mm diameter.
- An Osteotome, Hammer and Periosteum elevator
- An diamond - tip bone awl
- A V-nail
- An aluminium tissue protector
- A nail-extractor
- Hand/Power drill and drill bits of 3.2mm
- Depth gauge, bone tap and 4.5 mm cortical screw set
- Hexagonal tipped screw drive, tourniquets
- Image intensifier television (IITV)
- Flexible Reamer
- Guide wire
**Description of IL-Nail:**

A specially constructed IL-nail was used for the purpose in all cases. IL-nail is a hallow, metallic modified clover-leaf nail having a D-shaped platform at its proximal" end (head) and a proximal locking hole. It has proximal bent of 20° in anteropostenor direction to compensate for the proximal Herzog's curve within the medullary canal. The nail has a slot along its whole length on the posterior direction which facilitates unreamed nail insertion (A.O.-UTN-Melcher et al, 1993). About 2.5cm above the tip of the nail is a distal locking hole in the anteroposterior direction.

A suitable length of the nail is chosen by measuring from the tibial tuberosity to the base of the medial malleolus on the unaffected side. The diameter of the nail is decided according to the size of medullary canal on the X-ray or by reaming.

(c) **Operative Procedure**

All cases were operated within 7 days of the injury. All cases were done in the orthopaedic operation theatre. Close intramedullary nailing was done without opening the fracture site and with or without reaming.
Operative Technique (Lottes, J.O\textsuperscript{58}, 1954, 1974; Muller,\textsuperscript{64} 1990)

i. In the operation theatre, under anaesthesia, under all aseptic precaution, painting and draping done. Then a tourniquet is applied and a pad is placed under the proximal part of the thigh. A 3" long incision is marked on the anteromedial aspect of the tibial tuberosity. The periosteum is incised along the skin incision.

![Split patellar tendon approach](image1)

![Medial para-patellar tendon approach](image2)

ii. The knee is flexed to more than 90°. A quadrangular flap of bone with its proximal base intact is made just medial to the tibial tuberosity in the anterior tibial cortex with the help of an osteotome. The lid of the bone so formed is inturned so as to form a sort of a hood for the head of the IL-nail to about the
Keeping the knee flexed, with the help of a curved awl, the window is tunneled to
the medullary canal. A V-nail is used to further smoothen the passage, if need be.
Reaming is done after inserting guide wire by flexible reamer.
**FIGURE 55-20**

A. The use of a bone awl to penetrate the cortex. B. A guide wire is passed across the fracture site followed by a reamer if a reamed nail is to be used. C. The nail is passed into the tibia.
iv. The IL nail is introduced over guide wire with its eye anteriorly and the slot kept posteriorly. The fracture is close reduced under IITV and the nail is negotiated into the distal fragment with the gentle taps of the hammer over the nail head, keeping the nail dead parallel to the axis of the limb. Impaction may be done, if needed, by padded gentle strokes over the heel.

v. The distal locking of the nail is done as under IITV using the free hand technique. An appropriate length of 4,5mm cortical screw is used for locking.

vi. After suturing the periosteum with Vicryl, skin closure is done. Compression bandage is applied and the tourniquet is removed and GT slab applied. The average operating time for close nailing was 45 minutes and 15 minutes for locking under IITV.

vii. Cephalosporin antibiotics are continued till suture removal.
(d) **Post Operative Regimen**

The limb is kept elevated at all times and active toe movements are encouraged. The patient is watched for excessive swelling, pain and distal circulation. The first dressing is done after 5 days of the operation. If suture line is clean, suture removal done after 10 to 12 days under full asepsis. The compression bandage and GT slab is removed a crepe bandage is applied from knee to the ankle. Active knee and ankle mobilization is started immediately after the dressing. Partial weight bearing with 2 axillary crutches started. Gait training on the parallel bars if possible, can also be done review after 1 month. Advice regarding full weight-bearing is given on the basis of pain and the stability of the fracture fixation.

(c) **Follow-up and Evaluation**

The patient is usually followed up at 4 weeks, 8 weeks, 16 weeks, 20 weeks, 6 months. Check X-rays are taken at every visit and patient is assessed clinically for fracture union.
The results are assessed on the basis of Alho\textsuperscript{4} and Ekeland\textsuperscript{36} criterias (Clinical Orthopaedic 231; 205; 1988).

This, criteria considers six aspects:

1. Tibial mal-alignment and shortening
2. Range of knee motion and extensor lag
3. Range of ankle motion
4. Foot Motion
5. Pain in limb
6. Swelling

The functional assessment of the results is one on the basis of (Per Edwards,\textsuperscript{35} 1965).
.a. Resumption of the activities of daily living

b. Resumption of the occupation

c. Pain free movements and walking

d. Squatting and sitting cross legged
<table>
<thead>
<tr>
<th>Criteria</th>
<th>Grade 1</th>
<th>Grade II</th>
<th>Grade III</th>
<th>Grade IV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Excellent</td>
<td>Good</td>
<td>Fair</td>
<td>Poor</td>
</tr>
<tr>
<td>A. Tibial malalignment and Varus/Valgus (degrees)</td>
<td>2.5°</td>
<td>5°</td>
<td>10°</td>
<td>&gt;10°</td>
</tr>
<tr>
<td>Shortening (cm.)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>&gt;3</td>
</tr>
<tr>
<td>B. Range of knee motion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexion</td>
<td>&gt;120°</td>
<td>120°</td>
<td>90°</td>
<td>&lt;90°</td>
</tr>
<tr>
<td>Extension deficits</td>
<td>5°</td>
<td>10°</td>
<td>15°</td>
<td>&gt;15°</td>
</tr>
<tr>
<td>c. Range of ankle motion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dorsiflexion</td>
<td>&gt;20°</td>
<td>20°</td>
<td>10°</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Plantar flexion</td>
<td>&gt;30°</td>
<td>30°</td>
<td>20°</td>
<td>&lt;20°</td>
</tr>
<tr>
<td>D. Foot motion (as compared to normal)</td>
<td>5/5</td>
<td>2/3</td>
<td>1/3</td>
<td>&lt;1/3&quot;</td>
</tr>
<tr>
<td>E. Pain in the Limb</td>
<td>None</td>
<td>Sporadic</td>
<td>Significant</td>
<td>Severe</td>
</tr>
<tr>
<td>F. Swelling</td>
<td>None</td>
<td>Minor</td>
<td>Significant</td>
<td>Severe</td>
</tr>
</tbody>
</table>
OBSERVATIONS

120 patients of fractures leg bones were studied until the final follow up.

• **Age and Sex**

The study included patients 17 years and above in age.

Table 1 shows the age distribution of both the groups of the patients. 88 patients were male & 32 were female.

**Table 1 ; Age Distribution**

<table>
<thead>
<tr>
<th>SNo</th>
<th>Age Group</th>
<th>No. of patients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17-24</td>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>25-34</td>
<td>39</td>
<td>32</td>
</tr>
<tr>
<td>3</td>
<td>35-44</td>
<td>27</td>
<td>23</td>
</tr>
<tr>
<td>4</td>
<td>45-54</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>5</td>
<td>55 and above</td>
<td>16</td>
<td>13</td>
</tr>
</tbody>
</table>

**Age group**

- 17-24: 20 (17%)
- 25-34: 39 (32%)
- 35-44: 27 (23%)
- 45-54: 18 (15%)
- 55 and above: 16 (13%)
Fractures of tibia were found to be much more common in males as against female and more than half of the cases were below 45 years of age. There seemed to be a decreasing incidence of injury with age.

- Mode of Injury

Table 2. Mode of Injury

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Mode of Injury</th>
<th>No. of patients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>R.T.A.</td>
<td>88</td>
<td>73</td>
</tr>
<tr>
<td>2.</td>
<td>Fall from height</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>3.</td>
<td>Fall on floor/stairs</td>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td>4.</td>
<td>Assault</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
Road traffic accidents were found to amount for most of the injuries (73%) as compared to other modes.
Severity of Injury

Table 3 Type of Fracture (Commination)

<table>
<thead>
<tr>
<th>S</th>
<th>Fracture comminution</th>
<th>No. of patients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Non comminuted</td>
<td>61</td>
<td>51</td>
</tr>
<tr>
<td>2</td>
<td>Mild comminution</td>
<td>37</td>
<td>31</td>
</tr>
<tr>
<td>3.</td>
<td>Moderate comminution</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>4.</td>
<td>Severe comminution with loose fragments</td>
<td>8</td>
<td>7</td>
</tr>
</tbody>
</table>

'Most of the fractures in the study were non comminuted. & with mild comminations.'
### Grade of Fracture

**Table 4 Grade of Fracture**

<table>
<thead>
<tr>
<th>S. No</th>
<th>Grade of Fracture</th>
<th>No. of patients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Close Fracture</td>
<td>95</td>
<td>79</td>
</tr>
<tr>
<td>2</td>
<td>Compound Fracture</td>
<td>25</td>
<td>21</td>
</tr>
<tr>
<td>a</td>
<td>Grade I</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>b</td>
<td>Grade II</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>c</td>
<td>Grade III A</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

**GRADE OF FRACTURE**

- **No. of patients**
- **Percentage**

![Graph of Grade of Fracture](image)
Cases included in the study 79% were close fractures. Among compound fractures Grade I - Gustilo's (17%) were more while Grade - II Gustilo's (3%). 2 patients had associated head injury which led to delay in the surgery while four patients had associated fracture shaft femur (2) / supracondylar (2) and one associated with fracture of medial malleous.

- **Level of Fracture**

**Table 5  Level of Fracture**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Level of Fracture</th>
<th>No. of patients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Proximal third</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>2.</td>
<td>Middle third</td>
<td>62</td>
<td>52</td>
</tr>
<tr>
<td>3.</td>
<td>Distal third</td>
<td>41</td>
<td>34</td>
</tr>
</tbody>
</table>

**LEVEL OF FRACTURE**

- Proximal third 14%
- Middle third 52%
- Distal third 34%
Most of the fractures requiring fixation were either in the middle third of the shaft (52%) or distal third (34%).

- **Injury Surgery interval**

In most of the patients (83%) nailing was done within 1-7 days of injury. Delay of upto 7 days was either due to associated head injury (2), associated fracture of the shaft of the femur (2), Cervical Injury (1), Fat Embolism (1) & other medical causes. Three patients reported after almost a month of injury.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Fixation time after trauma</th>
<th>No. of patients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Within 48 hours</td>
<td>54</td>
<td>45</td>
</tr>
<tr>
<td>2.</td>
<td>2-7 days</td>
<td>46</td>
<td>38</td>
</tr>
<tr>
<td>3.</td>
<td>8-15 days</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>4.</td>
<td>16-23 days</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>5.</td>
<td>24-31 days</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>6.</td>
<td>&gt;1 month</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
• Associated Injuries

Table 7. Associated Injuries

<table>
<thead>
<tr>
<th>S.NO</th>
<th>Injuries</th>
<th>No. of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Contralateral fracture both bones leg</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Fracture superior rami of pubis</td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>Ipsilateral femur fracture</td>
<td>2</td>
</tr>
<tr>
<td>4.</td>
<td>Fracture of upper limb Long bones</td>
<td>3</td>
</tr>
<tr>
<td>5.</td>
<td>Fracture of skull bones</td>
<td>2</td>
</tr>
<tr>
<td>6.</td>
<td>Fracture of cervical spine</td>
<td>1</td>
</tr>
<tr>
<td>7.</td>
<td>Fracture of Metacarpal or Phalanx</td>
<td>4</td>
</tr>
</tbody>
</table>

Supplementary Internal Fixation

No supplementary internal fixation was done in the present series. Fibular fracture was also not fixed. Two patients had associated ipsilateral fracture of the shaft of femur (2) and. Both fractures were dealt simultaneously by IF in the same seating.

Secondary Procedure

In one patients removal of the IL-nail with Phemister bone grafting was done for delayed union. The nail had to be removed because of constant complain of anterior knee pain at the site of nail head, in one patient initial fibula osteotomy followed by weight bearing was tried for delayed union failing which Phemister bone grafting has to be done.

Hospital Stay

The average hospital stay of the patients was Five days. The patient was discharged with advice to active toe movement, quadriceps exercise and to come for suture removal after 10 to 14 post-operative day.
Partial Weight Bearing:

Partial weight bearing was started with the help of two axillary crutches. The average duration of partial weight bearing was two weeks (range 2 to 4 weeks).

Full Weight Bearing

The average duration of full weight bearing was six weeks (range 6 to 12 weeks).

- Time of Weight Bearing

Table 8 Time of Weight Bearing

<table>
<thead>
<tr>
<th>No. of Patients</th>
<th>Partial weight bearing</th>
<th>No. of patients</th>
<th>Full weight bearing</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>2 - 4 weeks</td>
<td>89</td>
<td>6-12 weeks</td>
</tr>
<tr>
<td>74</td>
<td>4-6 weeks</td>
<td>28</td>
<td>13-16 week</td>
</tr>
<tr>
<td>19</td>
<td>&gt; 6 weeks</td>
<td>3</td>
<td>&gt; 16 weeks</td>
</tr>
</tbody>
</table>
Time of the Fracture Union:

The union of the fracture was assessed by standard radiological and clinical criteria (Edwards, 1965; Court Brown et al., 1990). Due to presence of nail we couldn't stress the fracture site; hence loss of pain on walking was deemed a better clinical indicator of union (Bradford Henley, 1989). In four cases Phemister bone grafting had to be done when they were still in the phase of delayed union.

Table 9. Union Time with Grade of Fracture

<table>
<thead>
<tr>
<th>S. No</th>
<th>Fracture Type</th>
<th>14-16 weeks</th>
<th>16-18 weeks</th>
<th>18-20 weeks</th>
<th>&gt;20 weeks</th>
<th>Mean (weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of patients</td>
<td>No. of patients</td>
<td>No. of patients</td>
<td>No. of patients</td>
<td>No. of patients</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Close Fracture</td>
<td>95</td>
<td>34</td>
<td>43</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>2 Compound Fracture</td>
<td>25</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>a</td>
<td>Grade I</td>
<td>20</td>
<td>14</td>
<td>5</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>b</td>
<td>Grade II</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>c</td>
<td>Grade III A</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
Depending upon the level of fracture in the tibial shaft, the union time varies. About 100% of the fractures of upper third united by >16 weeks while about 80% of the fractures of middle third united by 16 weeks and about 90% by 20 weeks (average 17 weeks). While about 60% of the distal third fractures united within 16 weeks and 100% by 18 weeks (average 16.5 weeks). The average union time was shortest in fractures of lower third of tibial shaft because of the dynamic interlocking technique with distal locking.
### Post-Operative Complications

<table>
<thead>
<tr>
<th>S.no</th>
<th>Complications</th>
<th>No. of patient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Early</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Infection</td>
<td>09</td>
</tr>
<tr>
<td></td>
<td>Superficial</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Deep</td>
<td>01</td>
</tr>
<tr>
<td>2</td>
<td>Compartment syndrome</td>
<td>01</td>
</tr>
<tr>
<td>3</td>
<td>Neuro vascular injury/ Neuropraxia</td>
<td>01</td>
</tr>
<tr>
<td>4</td>
<td>Thromboembolism/ Fat Embolism</td>
<td>01</td>
</tr>
<tr>
<td>5</td>
<td>Stiff knee joint</td>
<td>02</td>
</tr>
<tr>
<td>6</td>
<td>Implant failure</td>
<td>02</td>
</tr>
<tr>
<td></td>
<td><strong>Delayed</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Delayed union</td>
<td>08</td>
</tr>
<tr>
<td>2</td>
<td>Mal union</td>
<td>02</td>
</tr>
<tr>
<td>3</td>
<td>Non-union</td>
<td>02</td>
</tr>
<tr>
<td>4</td>
<td>Shorting Limb &gt;1cm</td>
<td>02</td>
</tr>
<tr>
<td>5</td>
<td>Instability</td>
<td>00</td>
</tr>
<tr>
<td>6</td>
<td>Poor function</td>
<td>01</td>
</tr>
<tr>
<td>7</td>
<td>Hardware failure</td>
<td>02</td>
</tr>
<tr>
<td></td>
<td>Nail breakage/Bent nail</td>
<td></td>
</tr>
</tbody>
</table>
A. Implant Failure

i. Bent Nail: Two patient had bend nail after he started full weight bearing (4 weeks). They reported back with complain of pain at the fracture site. X-ray showed minimal bent in the nail at the level of distal locking hold. The same nail was continued but with guarded weight bearing until the fracture united (14 weeks).

ii. Broken Nail: We had no cases of broken nail. We had 2 cases of breakage of locking bolt, probably because of early full weight bearing. Both fractures united in 18 – 20 weeks.
B. Infection

Superficial wound infection of the proximal incision site was encountered in nine patients. This cleared by regular dressings and the usual oral antibiotics. Out of nine six were compound fractures.

One patient had deep infection and presented with discharging sinus at the proximal incision site. Partial weight bearing with dressings and antibiotics were continued till the fracture until (18 weeks). Then the nail was removed and Patellar tendon bearing cast was applied.

C. Delayed Union

In four cases after waiting four about a period of 16 weeks when abundant callus was not visible in the skiagram and the patient had persistent tenderness at the fracture site, Phemister bone grafting was done. Post operatively Groin to toe cast applied for four weeks. Gradual mobilization was then started. Both the fractures united within eight weeks of bone grafting.

D. Others:

We had compartment syndrome in 1 patient, lateral popliteal nerve palsy in 1 patient, fat embolism in 1 patient. All patients recovered with conservative treatment. Few patients experienced anterior knee pain, pain at fracture site & locking bolt in treatment phase, most of them recovered after sound union, physiotherapy & analgesics.
<table>
<thead>
<tr>
<th>S. NO</th>
<th>Criteria</th>
<th>Grade I</th>
<th>Grade II</th>
<th>Grade III</th>
<th>Grade IV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No. of patients</td>
<td>No. of patients</td>
<td>No. of patients</td>
<td>No. of patients</td>
</tr>
<tr>
<td>A</td>
<td>Tibial malalignment and shortening</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Varus Valgus (degree)</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Shortening (cm)</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>B</td>
<td>Range of Knee motion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flexion</td>
<td>117</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Extension deficit</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>Range of ankle motion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dorsiflexon</td>
<td>115</td>
<td>4</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Plantar flexion</td>
<td>116</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>D</td>
<td>Foot motion (as compared to normal)</td>
<td>119</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>E</td>
<td>Pain in the limb</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ant. Knee Pain</td>
<td>104</td>
<td>11</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Pain at # site</td>
<td>116</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>F</td>
<td>Swelling</td>
<td>108</td>
<td>9</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

Grade I - Excellent, Grade II - Good, Grade III - Fair, Grade IV - Poor.
<table>
<thead>
<tr>
<th>Result</th>
<th>Percentage of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>85%</td>
</tr>
<tr>
<td>Good</td>
<td>12%</td>
</tr>
<tr>
<td>Fair</td>
<td>2%</td>
</tr>
<tr>
<td>Poor</td>
<td>1%</td>
</tr>
</tbody>
</table>

RESULT

```
Excellent 85%
Good 12%
Fair 2%
Poor 1%
```
The parameters examined were as follows:

A. **Tibial Malalignment and Shortening**

One of the patients treated with interlocking nail had valgus angulation \[\text{less than 10 degree}\]. None of the patient had gross rotational deformity (>10 degree) one patient had mild external rotation.

Two patients had shortening of 1 cm. because of associated ipsilateral fracture of the shaft of femur in one patient & One patient had shortening because of severely comminuted fracture.

B. **Range of Knee Motion**

98% of the patients had knee flexion more than 120 degree. None of the patients had any extension leg. Only two patients had mild restriction.

C. **Range of Ankle Motion**

96% of the patients had ankle dorsiflexion >20 degree while 96% had planter flexion >30 degree i.e. full range.

D. **Range of Foot Motion**

There was however, no difference in the foot motion as compared to normal.
E. Pain

About 10% of the patients complained of pain in the leg around ankle and anterior knee which too was tolerable or occasionally needed oral analgesic.

F. Swelling

About 30% of the patients had minor swelling around ankle and foot which gradually subsided with mobilization and was never significant to become worry some to the patient.

Functional Assessment

A. Resumption of activities of daily-living:
Quick resumption of the activities of daily-living remained the main focus of this form of treatment. Since the average partial weight bearing time was 2-4 weeks full weight bearing 6-12 weeks, patients resumed his daily activities quickly and became self dependent. This also shortened the hospital stay.

B. Walking Capacity / Limp:

All patients had limp and pain while walking until fracture union, which gradually alleviated and patients could walk normally. Walking distance also improved as the union progressed.

C. Squatting and Sitting Cross - legged:

None of the patients had any problem with sitting cross legged once the fracture united. Due to full range of ankle dorsiflexion and knee flexion, there was no
problem with squatting. Due to early mobilization, joint movements were well maintained.

D. Pain at the Fracture Site:
None of the patients had pain at the fracture site while walking/working. Some patients did complain of anterior knee pain at the level of nail head which responded to analgesics.

E. Resumption of the work:
All patients returned to their original work. Change of occupation was not reported by any of the patients.
DISCUSSION

The aim of the study was to evaluate the results of closed dynamic interlocking nailing in close and compound tibial diaphyseal fractures.

The treatment programme should ensure a low incidence of complications; it should require minimum possible interventions, short hospitalization and convalescence, and the end result should be comparable with the more complicated methods (Roïf Onnerflat, 1973).

The worst part of the study is that these injuries are encountered in young males below 45 year (70%), who are the central pillar of the family.

Fractures of the tibia are the commonest among the major long bones fractures. Very often, they are open owing to the subcutaneous location of the tibia. The commonest cause of the fracture being high velocity road traffic accidents. In our series, 73% of the fractures groups were due to high velocity road traffic accidents. In these accidents, a tremendous amount of energy is dissipated to the surrounding soft tissue thus causing severe damage. Also, all grades of comminution are encountered. About 49% of the tibial fractures in our series were comminuted ranging from mild to severe grade.

Due to the availability of the new broad spectrum antibiotics, the "golden-period" of 6 hours can now safely be extended for compound fractures. This
gives the treating surgeon adequate time to plan and tailor a suitable treatment regimen for a patient. With the use of new third generation Cephalosporin (Ceftriaxone), we were able to operate our cases presenting even as late seven days. This however, did not increase the infection rate as it appears.

There are several methods of treatment of fracture of shaft of tibia. Some people apply a groin-to-toe cast after closed reduction till clinical union occurs. These causes avoidable joint stiffness, muscle atrophy, osteoporosis, prolonged recumbency, and loss of working days. The popularly applied patellar tendon bearing cast (Sarmiento Tibial Plaster) and early weight bearing may not control alignment in all cases. Besides, there is a danger of slipping of the fracture after weight-bearing. Further, not all cases can be reduced to an acceptable position by closed methods.

Sarmiento type patellar tendon bearing functional brace result an average shortening of 6.4mm, an average angulation of 8.0 and an average unión lime of 5.7 months (Austin RT- Sarmiento Plaster; 1981).

These days there is a trend towards more use of AO compression osteosynthesis. This has the advantage of perfect anatomic reduction and early movement of the affected limb, but need expertise. Complications following treatment with the AO-compression methods have been explained as due to insufficient experience (Thunold et al 1975). Also open reduction and internal fixation is not tolerated by high energy fractures which are common in the tibia.
(Bauer et al. 1962). Besides, howsoever attractive the possibilities of open reduction and internal fixation, it converts a closed fracture into open, the stay in hospital is longer, delayed union is more frequent as weight bearing with a plate fixed on the bone leads to complications like fracture of plate and refracture of bone after removal of plate (Van-der-Linden and Larsson, 1979).

Another method of treatment is a compromise between closed and open methods (semi open) where closed nailing of tibia is done without exposing the fracture site, thus avoiding complications of opening the fracture. Perfect anatomic reduction and rigid fixation may be achieved by reaming the medullary cavity and inserting a nail with wide caliber, but it may not be applicable to fractures in proximal and distal third of tibia where the nail has no hold over fracture in the wide medullary cavity.

Besides, rigid nailing with reaming leads to a higher incidence of infection as dead bone produced due to reaming (debris/endosteal necrosis) acts as a good culture medium for bacteria (Bintcliffe, et al. 1984). Merle D, Aubigne et al (1974) first used the method of closed nailing without reaming in fracture of tibial shaft. This was followed by groin-to-toe cast 4 week, after which patellar tendon bearing cast was given and patient was allowed weight bearing. They concluded that though it was not a mechanically sound way of bone stabilization, but when associated with a plaster cast, simplicitly of technique, nearly complete elimination of infection, the security it provides in reduction and immobilization and the superiority of results determines its use in preference to all other methods of treatment of fracture of tibial shaft.
Sir John Charnley (1961) had said "I feel sure that a closed method will eventually prevail, but we need mechanical aids to improve our control of the bone fragments. It is possible time will show that an intramedullary rod introduced through the tibial tubercle without exposing the fracture site, will be enough to enhance alignments as an adjuvant to closed metallic rods. Used in this simple way the intramedullary rod will not be responsible for immobilization; it will merely control alignment and prevent slipping of the reduced fracture". These words seem to emerge true in supporting the method of closed nailing.

The present method of closed tibial nailing omits the disadvantages of other methods while including their advantages. It is advantageous over the method of AO technique vis a vis, operating time and complications; over, Sarmiento's patellar tendon bearing cast in terms of malalignment and being suitable for unstable fractures; and over conventional conservative treatment by groin-to-toe cast in terms of avoiding joint stiffness, muscle atrophy, osteoporosis and ill effects of prolonged recumbency, and malalignment.

The regimen tested in this study is applicable to majority of cases of fractures of tibia in adults. Primary medullary nailing by closed method without exposing the fractures site was done in close & open fracture and early weight bearing without cast was done after 2-4 weeks. The results of this investigation were compared here with. The other method of treatment of fracture of shaft of
tibia i.e. Boné and Johnson \(^{12}(1986)\); Court Brown et al\(^{22}(1991)\) series were
Grosse-Kempt nail was used in Gustilo's grade one and two fractures.

Closed interlocking nailing was done in all except 2 case which required
open reduction and nailing ásthey were more than a month old and maluniting.
Most of the authors used reamed iníerlocking nails viz. Olerud and Karlstrom\(^{68}(1972)\), Puno ét ál\(^{74}(1986)\), Klemn and Borner\(^{53}(1986)\), Ekeland ét ál\(^{36}(1993)\}
and Renner et ál\(^{75}(1993)\) used unreamed tibial nail while Court-Brown ét al\(^{24}(1996)\) did a comparativé stüdy of reamed and unreamed nails. "Reaming resulted
in the destruction of áll vessels of the medullary canal while medullary nail without
reaming caused minor damage to the blood supply. They found necrosis of the
inner 50-70% of the cortex after reaming.

Interlocking was done by putting locking screws proximally & distally in áll of the
cases.

**Complications**

1. **Infection:**

The incidences are discussed below:

<table>
<thead>
<tr>
<th>Author</th>
<th>Nail</th>
<th>Fracture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Closed Gustilo's Type</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I  II  III</td>
</tr>
<tr>
<td>Klemn &amp; Borner</td>
<td>Klemn -- Schellmann</td>
<td>0.9% 6.4% - -</td>
</tr>
<tr>
<td>Bone &amp; Johnson</td>
<td>AO Grosse-Kempf</td>
<td>4.4% 4.7% 10.5% 25.0%</td>
</tr>
<tr>
<td>Court Brown ét al</td>
<td>Grosse- Kempf</td>
<td>1.8% 3.8% 9.5% -</td>
</tr>
<tr>
<td>Our Series</td>
<td>Various</td>
<td>4% 12% 8% -</td>
</tr>
</tbody>
</table>
In our series 9 patients (7.5%) had superficial wound infection of the proximal incision site. This responded to the usual oral antibiotics and daily dressings. One patient (1.8%) had deep infection. Regular dressing, oral antibiotics and guarded weight bearing was continued till the fracture united (18 weeks). Then the nail was removed and patellar tendon bearing cast applied. Infection rate in our series, therefore, was comparable with the above three studies. Nine cases had superficial infection. Of these 3 cases was Gustilo’s grade I and 2 was grade II. The injury surgery interval in two of these cases was 7 days and the other 3 was 15-30 days (because of associated head injury). This delay in the surgery was the probable cause of superficial infection in two cases. One case which had deep infection was operated after 7 days. The cause of infection in this case remained obscure. This indicates that early surgery with a proper antibiotics cover is a must when considering a case of compound tibial fracture for nailing.

Sir Watson Jones\(^{86}\) (1982) said "what may be an ideal safe treatment in a first class and fully staffed trauma unit in Europe could be disastrous if employed in an underdeveloped country with very limited surgical services.'

2. **Delayed Union and Non-Union**

We encountered 8 cases of delayed union in which, after waiting for about 16 weeks when abundant callus was not visible in the skiagram and the patient had persistent tenderness over the fracture site. Phemister bone grafting was done
in Four. Two of the cases had hypertrophy type of non-union. The reason in the cases was probably was a small diameter nail (8 mm) which was used. This nail because of its small diameter could not prevent rocking of the fragments. Phemister bone grafting and groin-to-toe cast used in these cases severed both the purposes. This indicates that a proper diameter, well-fitting nail should be used in all cases.

Puno at al^{74} (1986) analysed the incidence of delayed union/non union in tibial fractures treated by intra medullary nailing and cast treatment. The results were:

<table>
<thead>
<tr>
<th></th>
<th>No. of patients</th>
<th>Avg. Union Time (Weeks)</th>
<th>NonUnion &amp; Delayed Union (%)</th>
<th>Mal Union (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intra medullary nailing</td>
<td>17</td>
<td>15.19</td>
<td>1.7</td>
<td>0</td>
</tr>
<tr>
<td>Cast treatment</td>
<td>124</td>
<td>23.46</td>
<td>9.9</td>
<td>4.3</td>
</tr>
<tr>
<td>Our series</td>
<td>120</td>
<td>17.0</td>
<td>0.9</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Oleurd and Karlstrom^{68} (1972) used compression plating for their study and reported non union/delayed union rate of 3.73% Melher^{60} (1993) used AO unreamed tibial nail and reported a case of non unión (5%).

Court Brown et al^{24} (1996) did a comparative study of reamed and unreamed tibial nails and reported 20% incidence of non union with unreamed AO-
UTN nail while none with reamed Grosse-Kempf nail. Most of the authors had used reamed tibial nail and showed earlier union than the present series.

3. Other Complications

Two patient had bend nail after he started full weight bearing (4 weeks). They reported back with complain of pain at the fracture site. X-ray showed minimal bent in the nail at the level of distal locking hold. The same nail was continued but with guarded weight bearing until the fracture united (14 weeks).

We had no cases of broken nail. We had 2 cases of breakage of locking bolt, probably because of early full weight bearing. Both fractures united in 18 – 20 weeks.

We had compartment syndrome in 1 patient, lateral popliteal nerve palsy in 1 patient, fat embolism in 1 patient. All patients recovered with conservative treatment. Few patients experienced anterior knee pain, pain at fracture site & locking bolt in treatment phase, most of them recovered after sound union, physiotherapy & analgesics.
Various authors presented different complications in their series like:

**Puno et al,\textsuperscript{74} 1986 (Closed interlocking nailing V/s casting)**

<table>
<thead>
<tr>
<th>Complication</th>
<th>Nail Group</th>
<th>Cast Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extension or comminution of fracture</td>
<td>3 cases (5%)</td>
<td></td>
</tr>
<tr>
<td>Penetration of guide wire in ankle</td>
<td>1 case (1.7%)</td>
<td></td>
</tr>
<tr>
<td>Pain at Patellar tendon</td>
<td>4 cases (6.7%)</td>
<td></td>
</tr>
<tr>
<td>Malunion</td>
<td>No case (0%)</td>
<td></td>
</tr>
<tr>
<td>Conservative (cast) group</td>
<td>6 cases (4.3%)</td>
<td></td>
</tr>
<tr>
<td>Reduction failure in cast group</td>
<td>19 cases (13.5%)</td>
<td></td>
</tr>
</tbody>
</table>

**Klemn & Borner,\textsuperscript{53} 1986 (Closed interlocking nailing)**

<table>
<thead>
<tr>
<th>Complication</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Open nailing</td>
<td>7 cases (1.3%)</td>
</tr>
<tr>
<td>Plaster cast</td>
<td>2 cases (0.5%)</td>
</tr>
<tr>
<td>Compartment syndrome</td>
<td>1 (0.25) Fasciotomy done</td>
</tr>
<tr>
<td>Nail Break</td>
<td>3 cases (0.8%)</td>
</tr>
<tr>
<td>Peroneal Palsy</td>
<td>2 cases</td>
</tr>
</tbody>
</table>
### Ekeland et al, 1988 (Closed interlocking nailing)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>External rotation malposition</td>
<td>2 case (4.4%)</td>
</tr>
<tr>
<td>Material fatigue</td>
<td>1 case (2.2%)</td>
</tr>
<tr>
<td>Extension / Comminution of fracture</td>
<td>2 case (4.4%)</td>
</tr>
<tr>
<td>Shortening of 1 cm</td>
<td>3 case (6.6%)</td>
</tr>
<tr>
<td>Shortening of 2 cm</td>
<td>1 case (2.2%)</td>
</tr>
</tbody>
</table>

### Bradford Henley, 1989 (Closed interlocking nailing)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restricted knee motion</td>
<td>1 case (4.2%)</td>
</tr>
</tbody>
</table>

(Associated fracture of femur and knee ligament injury).

### Melcheret et al, 1993 (Closed interlocking nailing)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varus/Vaigus deformity (Max 5°)</td>
<td>2 cases (10%)</td>
</tr>
<tr>
<td>Breaking of locking bolts</td>
<td>4 cases (20%)</td>
</tr>
<tr>
<td>Shortening 0.5 cm - 1cm</td>
<td>5 case (25%)</td>
</tr>
<tr>
<td>Functional results impaired</td>
<td>3 cases (15%)</td>
</tr>
<tr>
<td>Author</td>
<td>Technique</td>
</tr>
<tr>
<td>----------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>Present Series</td>
<td>Closed interlocking nailing</td>
</tr>
<tr>
<td>Edward\textsuperscript{34,35} series</td>
<td>Closed IM nailing</td>
</tr>
<tr>
<td>Puno et al\textsuperscript{74} (1986)</td>
<td>Closed interlocking Vs Casting</td>
</tr>
<tr>
<td>Ekeland et al\textsuperscript{36} (1988)</td>
<td>Closed interlocking nail</td>
</tr>
<tr>
<td>Bra'dford Henley\textsuperscript{41} (1989)</td>
<td>Closed interlocking nail</td>
</tr>
<tr>
<td>Melcher et al\textsuperscript{60} (1993)</td>
<td>Closed interlocking nail</td>
</tr>
<tr>
<td>'Court Brown et al\textsuperscript{24} (1996)</td>
<td>Closed interlocking nail Reamed V/s Unresrned</td>
</tr>
</tbody>
</table>
Healing was judged to have occurred when the fractures was clinically stable and did not elicit pain on palpation or manual stress (Sradeford Henley, 1989), Sarmiento (1974), compared the results of nail; plaster, traction and fixation by plates and screws and concluded that healing time was shorter (13.6 weeks) in cases of nailing.

Puno et al compared closed nailing with conservative treatment and observed average union of 10.8 weeks and 16.68 weeks respectively. Court Brown et al (1996) showed shorter union time with reamed nails (15.4 weeks) than unreamed (22.8 weeks). The union time of present series 17 wks is comparable with the above series.

Fifteen of our cases had associated fractures. Anderson et al (1974) observed that in their series of 208 fractures of 29.4% had major associated fractures that involved contralateral tibia, upper extremity bones, the pelvis or spine, one or both femurs or a combination of all these injuries. These injuries had a major bearing on the treatment of these patients and on their final results.

All the fractures in our series united with an average time interval of 17 weeks. We believe that reaming helps to shorten union time. This has been supported by other studies also. Bone LB and Johnson KD in one of the earliest large series of interlock nailing reported an average healing time of 17.8 weeks and concluded that the reamed nails were best used for closed, unstable fractures. Court Brown CM et al (1996) made a prospective study in 50 cases and concluded that reamed is
better than unreamed nailing in tibial closed fractures. Blachut et al\textsuperscript{11} concluded that there is a higher prevalence of delayed union and breakage of screws after nailing without reaming. Larsen et al (2004) studied 45 patients and concluded that the average time to fracture healing was 16.7 weeks in reamed group and 25.7 weeks in the unreamed group. The difference was significant (P=0.004). Mohit Bhandari et al\textsuperscript{63} (2008) conducted a multicenter, blinded randomized trial of 1319 adults in whom a tibial shaft fracture was treated with either reamed or undreamed intramedullary nailing and demonstrated a possible benefit for reamed intramedullary nailing in patients with closed fractures.

**Anterior knee pain** is the commonest complication in intramedullary tibial nailing. In our series, it was seen in Eight cases. We used the midline longitudinal incision made over the patellar tendon for nail insertion and used a paratendinous approach for insertion. The aetiology of anterior knee pain after intramedullary tibial nailing is uncertain, although there may be a combination of factors responsible. Toivannen et al\textsuperscript{82} showed that, a paratendinous approach for nail insertion does not reduce the prevalence of chronic anterior knee pain or functional impairment by a clinically relevant amount after intramedullary nailing of tibial shaft fracture. Oarfley et al\textsuperscript{70} showed that paratendinous approach is related with less knee pain and nail position in relation to the anterior cortex and tibial plateau had no influence on knee pain. Only 45% had improvement in symptoms following nail removal in their series. Devitt et al\textsuperscript{27} found arthroscopic evidence of chondromalacia patellae in a small number of patients with anterior knee pain after tibial nailing. They described an increase in force and contact pressure on the lateral facet when the medial Paratendinous approach was used and on the medial facet with a
Transtendinous approach. Pressure increases were more notable with the latter and patellar chondral injury was more likely. Flexion of the knee to greater than 100° resulted in minimum contact between the introducer and the patella making pressure changes at the patellofemoral joint less likely.

All our cases were under image intensifier. The duration of radiation varied from 1.30 min to 5 min. Kwang et al. measured the radiation exposure during femoral nailing and the total duration of the fluoroscopy averaged five minutes (range, thirty seconds to fourteen minutes). They advocated gonadal shielding for all types of fractures and locations regardless of the conditions.

Results at Follow Up

Final evaluation must take into account both functional and anatomic parameters. In present series early weight bearing was promoted without plaster as in other series of interlocking nails.

1. Joint stiffness

We did not see any significant joint stiffness and according to the present series parameters all were near to normal as compared with other series of interlocking nails. Some residual joint stiffness seen in few of the series could probably be due to ischemic muscle damage i.e. compartment syndrome (Ellis, 1958; Karisírom and Oierum 1974) or other associated injury at the ankle.

2. Muscle atrophy
There was no difference between Oleruc and Karisírom series and present series in regard to muscle atrophy.

3. Shortening

Sarmiento (1974) had demonstrated that early weight bearing did not increase initial shortening.

In present series, 2 patients had shortening of 1cm, both were having severe comminution.

Sarmiento\textsuperscript{78} (1967) - Average shortening - 1.5cm.

Ekeland et al\textsuperscript{36} (interlocking nailing) shortening of 1cm - 3 cases while 2 cm - 1 case.

Melcher et al\textsuperscript{60} (interlocking AO UTN nail) shortening of 0.5-1cm - 5 cases (25%).

Shortening in different series of interlocking nail were mostly due to screw breakage incidence.

4. Angulation

None of our cases treated by nailing had varus/valgus angulation of 5° or more.
Final Result

The following table shows comparative final results of various series of different modalities of treatment of tibial fractures:

<table>
<thead>
<tr>
<th>Author</th>
<th>Technique</th>
<th>Excellent (%)</th>
<th>Fair-Poor (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present Series</td>
<td>Closed Interlocking nailing</td>
<td>97%</td>
<td>3%</td>
</tr>
<tr>
<td>Edward serie (1965)</td>
<td>Closed intramedullary nailing</td>
<td>85%</td>
<td>15%</td>
</tr>
<tr>
<td>Olerud &amp; Karlstrom</td>
<td>Compression plating</td>
<td>91%</td>
<td>9%</td>
</tr>
<tr>
<td>Puno et al. (1986)</td>
<td>Closed Interlocking nailing Vs</td>
<td>98.3%</td>
<td>1.7%</td>
</tr>
<tr>
<td>Klemn and Bronner serie</td>
<td>Closed Interlocking nail</td>
<td>94.3%</td>
<td>6.7%</td>
</tr>
<tr>
<td>Ekolond et al. (1988)</td>
<td>Closed interlocking nail</td>
<td>94%</td>
<td>6%</td>
</tr>
<tr>
<td>Melcher et al. (1993)</td>
<td>Closed interlocking nail</td>
<td>85%</td>
<td>15%</td>
</tr>
</tbody>
</table>

Court Brown et al. (1996) reported excellent result of reamed interlocking nail (percentages were not mentioned)

Olerud and Karistrom's series (1972) represented AO-compression plate method which required technical expertise and complications were due to technical failiures (Thunold et al, 1975). Hence the statements seemed reasonable that the compression plate method is not a suitable and routine method in tibial shaft fractures (Olerud and Karistrm, 1972 and 1976).
On the other hand, closedreamed interlocking tibial nailing gives favourable end result functionally and anatomically.

**CONCLUSION**

The present study was undertaken to investigate the outcome of closed interlocking nailing of diaphyseal fractures of tibia, done with the help of image intensifier. 120 cases of closed tibial diaphyseal fractures were fixed with intramedullary interlocking nail. The cases were followed up minimum for a period of six months. The fractures in our study united in an average of about 17 weeks. Interlocked intramedullary nailing done under image intensifier has proved to be a one-time procedure leading to union in almost all the cases. This procedure allows earlier weight-bearing leading to earlier fracture union with less morbidity. Because of the high union rate and low infection rate, we consider closed interlocking nailing as the best mode of treatment for diaphyseal tibial fractures.
BIBLIOGRAPHY

1. A. Paige Whittle, “Fractures of lower extremity”: Chapter 51 in Campbell’s 
H. Beaty; Mosby Elsevier; 2008:3121.


bracing and locked medullary nailing treatment of displaced tibial 

5. Alms Michael: Medullary nailing of fracture shaft tibia. J.B.J.S. 44B; 328: 
1962.

6. Anderson JT, Gustilo RB: Prevention of infection in the treatment
   of 1025 open fractures of long bones. J Bone Joint Surg 1974; 58-
   A: 453-58


Etiology of poor results in a consecutive series of 173 fractures. Acta 


44. Hey Grooves: On modern methods of treating fractures Wright, Bristol & Sons, 916.


82. Toivanen JAK, Väistö O, Kannus P, Latvala K, Honkonen SE, Järvinen MJ : Anterior Knee Pain After Intramedullary Nailing of


