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SURGICAL MANAGEMENT OF FRACTURE SHAFT OF FEMUR IN CHILDREN AGED BETWEEN 5 TO 16 YEARS USING ELASTIC STABLE INTRAMEDULLARY NAILING

DISSERTATION SUBMITTED FOR

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MADURAI.

CERTIFICATE

This is to certify that the dissertation entitled ***"SURGICAL MANAGEMENT OF FRACTURE SHAFT OF FEMUR IN CHILDREN AGED BETWEEN 5 TO 16 YEARS USING ELASTIC STABLE INTRAMEDULLARY NAILING"*** is a bonafide record of work done by ***Dr. J. MANIKANDAN*** in the Department of Orthopaedics, Government Rajaji Hospital, Madurai Medical College, Madurai, under the direct guidance of me.

Prof. M. CHIDAMBARAM, M.S.ORTHO., D. ORTHO.,
Professor and Head of the Department,
Department of Orthopaedics & Traumatology
Madurai Medical College and Government Rajaji Hospital,
Madurai.

DECLARATION

I **Dr. J. Manikandan,** solemnly declare that the dissertation entitled "***SURGICAL MANAGEMENT OF FRACTURE SHAFT OF FEMUR IN CHILDREN AGED BETWEEN 5 TO 16 YEARS USING ELASTIC STABLE INTRAMEDULLARY NAILING"*** has been prepared by me under the able guidance and supervision of my guide **Prof. M. Chidambaram, M.S.ORTHO., D. ORTHO., Prof & HOD,** Department of Orthopaedics and Traumatology, Madurai Medical College, Madurai, in partial fulfillment of the regulation for the award of **M.S. (ORTHOPAEDICS)** degree examination of The Tamilnadu Dr. M.G.R. Medical University, Chennai to be held in March 2008.

This work has not formed the basis for the award of any other degree or diploma to me previously from any other university.

Place : Madurai

Date :

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CONTENTS

INTRODUCTION

Femoral shaft fractures account for 1.6% of all PAEDIATRIC INJURIES. In children 5 years or younger, early closed reduction and application of spica cast is an ideal treatment for most diaphyseal fracture. In skeletally mature adolescents, use of antegrade solid intramedullary rod has become standard treatment. But, the best treatment for children between five to sixteen years of age is still debated. Compared with younger children, patients in this intermediate age group have high risk of shortening and malunion when conservative measures used.

Children managed with traction and spica cast as a treatment modality has to undergo various adverse physical, social, psychological and financial consequences, of prolonged immobilization. Various other modalities include external fixation, plates and screws, use of solid antegrade intramedullary nail are available. However, the risk of certain complications, particularly pintract infection and refractures after external fixation or osteonecrosis with solid nails.

In the past seven years fixation with flexible intramedullary nails have become popular technique, for stabilizing femoral fracture in school aged children.

ESIN fixation system is a simple, effective and minimally invasive technique. It gives stable fixation with rapid healing and prompt return of child to normal activity.

This study was intended to assess the results following treatment of fracture shaft of femur by flexible intra medullary nail or elastic stable intramedullary technique.

AIM

The purpose of this study is to analyze the efficacy of ELASTIC STABLE INTRAMEDULLARY NAILING (TENS) in the treatment of fracture shaft of femur in children aged between 5 to 16 years with special emphasis on technical difficulties and complications

REVIEW OF LITERATURE

Although femoral shaft fractures are dramatic and disabling injuries, both to the patient and the family, most unite rapidly without significant complications. Not many year ago traction and casting were standard treatment for all femoral shaft fracture in children.

During 18th century French used the Hippocratic method of traction and co-optation splinting in extension. The English were influenced by SIR POTT, managed the patient on his side with Hip and Knee flexed.

STARR and Others had difficulty in keeping the fragment aligned because of child's restlessness and need to change the dressing.

The use of plaster become popular and was applied to femoral fractures initially in the form of splinting. In the year 1890, at John Hopkins hospital a full spica cast was introduced for the first time.

Fracture surgeons of 19th century applied the basic principles to treat there fractures. They recognized that these fractures did well with conservative method and in children unlike adults, joint stiffness was not a problem, delayed union was rare.

In the early 20th century, fracture surgeons treated these fractures using lane plates, bone suturing with wires and external fixator which failed to show acceptable results.

More recently a variety of therapeutic alternatives such as external fixation, compression plating and flexible or locked intramedullary nailing have become available, to help decrease impairment, increase convenience and decrease the cost.

RUSH LV (1968) studied about 211 cases of fracture shaft of femur in children. The objective of the study had been to find an ideal method of treatment with good healing and minimal surgical trauma, to bone and soft tissue. He found out that any type of rod which is tightly impacted at the isthumus, might not give firm fixation of the lower fragment. Only curved rod driven deeply into the lateral condyles enhances fixation dynamically by 3 point pressure.

GROSS RH et al (1983) conducted a study on 72 patients aged 5-19 years who sustained femoral shaft fractures, were treated with immediate cast bracing at Oklahoma children's hospital. Here they observed that adolescent children shaft fracture were difficult to manage conservatively which ideally requires closed intramedullary nailing.

J.N. LIGIER et al (1988) Studied 123 femoral shaft fracture in children ranged from 5 to 16 years found that ESIN given better result than conservative treatment.

Reever RB et al 1990 performed comparative studies between groups of adolescents with a femur fracture treated by operative and conventional casting, traction techniques. The operative group had better results with a shorter hospitalization and reduced patient cost.

Heinreich et al (1994) observed that results obtained using flexible intramedullary nails for the stabilization of select paediatric diaphyseal femur fractures are comparable to nonoperative treatment, but with less disruption to family life and shorter hospitalisation.

Helphin RD et al (1864) compared the results of reamed intramedullary rods with flexible rods. He found that trochanteric growth arrest was more in reamed rods.

Canale TS et al (1995) observed that open reduction and plate fixation of femoral fractures in the age group of 5 to 10 years old children will result in femoral overgrowth and limb length discrepancy. Also they observed that antegrade intramedullary insertion of a nail may cause growth arrest of trochanteric epiphysis and thinning of the bone of femoral neck, leading to coxavalga deformity.

MILESKI et al (1995) Observed flexible IM nails holds many advantages over the reamed nails because the base of femoral neck and retinacular vessels were avoided during insertion of flexible nails.

Gregory P et al (1995) compared the use of ender with rigid antegrade nailing and found that both techniques produced satisfactory outcomes but flexible nails required much less operative and fluoroscopy time with similar patient satisfaction and outcomes.

CAREY TP AND GALPHIN RD (1996) have reported that flexible nailing seems better suited for peadiatric femoral fracture because most have a stable pattern.

SKAV SU et al (1996) compared the rigid IM nailing and flexible IM nailing in 52 femoral shaft fractures and found that limb length discrepancies and valgus deformity of hip in more is rigid IM nailing.

Bar on et al (1997) compares the use of flexible Im nail with external fixator and reported that full weight bearing, full range of movement and early return to school all were quick in patients who received flexible IM nails.

INFANTE AF et al (2000) reported that spica cast treatment in children is very user dependant and time consuming for the physician and cause economic loss for parents and financial hardship. Crempke et al (2000) and Lee SS et all (2001) in their studies, confirmed that flexible nails gives advantages more than associated with other techniques.

Yameji T et al (2002) compared the callus formation after interlocking and flexible nailing. Callus appeared at a mean of 2-8 weeks in flexible nail and 3-9 weeks in interlocking group. The mean area of callus formation in the ender nailing and inter locking group was 699.4mm^2 and 439.5mm^2 respectively. This is because the elasticity of flexible nails promotes more callus formation.

Greinberg J et al (2002) and John Flynn et al in 2004 compared the patients treated with hip spica cast and flexible nails. They concluded that patients treated with flexible nails had early ambulation, shorter hospital stay and early return to school. AKSOY et al (2003) compared the results of compression plate fixation and flexible IM nailing in 36 femoral shaft fractures in children. They observed that flexible IM nailing gives shorter operation time, shorter healing time, small incision which is cosmetically more acceptable.

ANATOMY OF FEMUR

The femur or thigh bone is the longest and strongest bone in the body. Its shaft is almost cylindrical in most of its length and bowed with forward convexity. Its upper extremity has a rounded articular head, projecting medially on short neck of bone formed by the medial inclination of the upper part of the shaft. The distal or inferior extremity is more massive being in the form of double knuckle or condyle articulating with tibia.

The upper end of the femur comprises a head, neck, a greater and a lesser trochanter. The head of the femur is more than half sphere. It is directed upwards, medially and slightly forwards to articulate with the acetabulum. It has an anteversion of 15.

The neck of femur which is about 5cm long connects the head and shaft which it forms an angle between 125° to 135°. The anterior surface of the neck in flattened and at its junction with the shaft is marked by a prominent rough ridge termed intertrochanteric line. The posterior surface of the neck at its junction with the shaft is termed as intertrochanteric crest.

The greater trochanter in a large quandralangular portion at the upper part of the junction of neck with shaft. It provides insertion for most of the muscles of gluteal region.

The apex of the trochanter overlies trochanteric fossa. This fossa lies along the longitudinal axis of the shaft of femur. Many vascular foramina directed towards the head of femur penetrate the upper and anterior surface of neck of femur.

The lesser trochanter is a conical eminence which projects medially and backwards from the shaft at its junction with the lower and posterior part of neck. It has psoas major attached on its head. The shaft of femur is narrowest in its middle. It expands a little, as it is traced upwards. But it wider appreciably nearer the lower end of bone.

Anterior Bowing:

The most prominent feature of the femur is the anterior bowing. Wide individual variation exist in the magnitude the bow.

In its middle third the shaft possess three surfaces and three borders. The anterior surface in smooth and gently convex in all direction. The lateral surface in directed more backwards than laterally. The posterior border is formed by a broad ridge, termed a lineaaspera which usually forms a crest like projection with a distinct lateral and medial lips.

In this situation the compact bone of the shaft is increased in amount to withstand the compression forces concentrated here by its anterior curvature. The medial surface in directed medially and slightly backwards.

Muscular attachment of the shaft:

The shaft is thickly covered with muscles and cannot be felt through the skin. Its anterior and lateral surfaces provides attachment in their three fourth for the vastus intermedius. The lower portion of the anterior surface in covered by superapatellar bursa. The lower portion of the lateral surface is covered by vastus lateralis, the medial surface in covered by vastus medialis.

In addition to the attachment already described, the lineaaspera receiver adductor longus, the intermuscular septa and the short head of biceps femoris.

The Perforating arteries:

These cross the lineaaspera from medial to lateral side. Under the tendinous arches in the adductor magnus and the short head of biceps femoris. The foramina for nutrient arteries are situated close to the linea aspera.

The medullary cavity of femur:

The shaft of femur is a cylinder of compact bone with a large medullary cavity. The wall of the cylinder is thick in the middle third of the shaft, above and below the wall becomes thinner. Thus the narrowest region of the medullary canal in located immediately proximal to the middle. In the isthumus region the cortex has its greatest thickness, proximally the cavity becomes slightly larger towards the lesser trochanter. After that, it widens rapidly and filled with dense network of trabeculae. Distal from the middle the canal widens gradually towards the distal diaphysis.

OSSIFICATION OF FEMUR:

The lower limb buds appears during fourth week of gestation. During the following week, a condensation of mesenchyme develops as the precussor of the femoral shaft. During the 6^{th} week it undergoes chondrification to form the initial model of femur.

During the 8^{th} week, ossification commences, the primary ossification center develops in the femoral shaft. The secondary ossification center develops in the distal femur during the last two month of gestation. The capital femoral epiphysis ossifies, during the first 6 months of postnatal period.

The greater trochanter center appears between second and fifth year and the lesser trochanter center between 9th and thirteenth year, fuses independently to the shaft immediately after puberty. The head fuses with the shaft at 14-16 year and lower end with shaft between 16-18 years.

BLOOD SUPPLY OF FEMUR:

In 1953 P.G.Laning gave a detailed account of the blood supply for the femoral shaft. His study revealed 4 main arterial system supplying femur, that are periosteal, diaphyseal, metaphyseal and epiphyseal. He stated that, nutrient artery of the femur are 2 in number and enter the shaft at lineaaspera. In children the superior artery passes downwards, and the inferior upwards. His conclusions was that the size of arteries related to the size of bones decreases with increasing age.

He also showed the nutrient artery arise as branches of one or the other of the perforating of arteria profundus femoris. First nutrient artery arises from inferior perforating branch. No major artery entered the lower third of femur. A fracture at the upper third and middle third would deprive blood to proximal fragment and the junction of middle third and lower third, will deprive blood to lower third.

In conclusion he stated that since most of the medullary vessels are damaged by passing correctly fitting nail, least damage should be done to the periosteum and lineaaspera. Lineaaspera should be never stripped of muscular attachments.

The blood supply of the immature femur is more abundant than in the adults. This blood supply issues from both periosteal and endosteal vessels. The endosteal vessels, providing rich blood supply that promotes growth and allows rapid healing should the fracture occur.

Haemorrhage in children following femoral shaft fracture is usually limited and less serious than adults. Vascular injuries are uncommon because the vessels are flexible and resistant to perforation. Once damaged, the contractile properties allow prompt control of local haemorrhage thus the percentage of blood loss following fracture in less than adults. Blood replacement in seldom necessary.

So there, are several significant differences between the surgical anatomy of children femur and that of adult. These differences have clinical significance.

Basic principles of femoral growth:

Children bone changes from primarily weak woven to strong lamellar bone through remodeling during childhood.

The lower limb buds appear during the fourth week of gestation, during the following mesenchyme condensation takes place. During sixth week it undergoes chondrification to form the initial model of femur.

During 8^{th} week, primary ossification occurs in shaft, during 8^{th} month secondary ossification centre starts in last two months of gestation.

Initially formed woven bone predominates during the first eighteen months of life. As the child increases in size and weight, woven bone gradually converts to a more rigid bone which has lamellar structure.

The shape of femur changes during growth period. In frontal plane the neck shaft angle gradually decreases from approximately 155^o to 130^o at skeletal maturity. The slight lateral convexity of the femoral shaft straighten with the growth. Transverse place changes occur accompanied by a gradual reduction of femoral anteversion from about 110^0 at birth to approximately 10^0 in males and 15^0 in females at skeletal maturity.

Growth rate is very rapid during early infancy and in the adolescent period. The femur makes up approximately 26% of the total height.

Bone character:

Because of immature bone's inherent flexibility and reduced tensile strength, the child's fracture differs from that seen in adults. Open femoral fractures are seldom seen in infants and younger children the bone tends to bend before it breaks, and since the edge of fracture fragments are not so sharp, penetration of the soft tissue occurs less frequently.

Because of the abundant blood supply, union in rapid and consistent. Thick periosteum aids in protecting the adjacent soft tissues and facilitates union.

Mode of displacement:

In resting unfractured position the femur is relatively neutral due to balanced muscle pull. In proximal shaft fracture, the proximal fragment assumes a position of flexion (illiopsoas), abduction (abductors), and lateral rotation (short external rotators). In midshaft fractures the effect is less extreme as there is compensation by the abductors and extensor attachments on the proximal fragment. Distal shaft fractures produces a little alteration in the proximal fragment position as most muscles attached to same fragment producing balance. Supracondylar fractures often assume a position of hyperextension of the distal fragment due to the pull of gastroenemius.

PAEDIATRIC FEMORAL SHAFT FRACTURES

Femoral shaft fractures including subtrochanteric and supracondylar fractures, represent approximately 1.6% of all bony injuries in children. The male to female ration in 2.6:1 with a bimodal distribution. The first peak in early childhood and second in mid adolescence.

Mechanism of Injury

Most fractures in children are the result of accidents. Most of the injuries in children were due to fall from swings on a play ground equipments also there injuries low energy accident may cause femoral shaft fractures in children with pathologic bone. In his classic text of fractures in children, Blount stated that approximately 70% of paediatric femoral fractures are diaphyseal.

Femoral shaft fractures are commonly isolated injuries or are associated with minor trauma such as abrasion or contusion. High velocity trauma in children produces unstable fracture pattern, with a constellation of other more severe and life threatening injuries.

Child abuse causes a spectrum of injuries, including fractures of femoral shaft. In children younger than walking age, 80% of femoral fractures are caused by child abuse. According to GREEN and

HAGGERTY, an abused child has a 50% chance of father battering and 10% chance of death.

Stress fractures of the femur have been described in skeletally immature patients, and they result from sports activities.

Diagnosis:

Most patients with femoral shaft fractures are unable to walk and are in extreme pain with an obvious fracture. A physical examination is usually sufficient to document the presence of a femoral fracture.

The entire child should be carefully examined. Hypotension rarely results from isolated femoral fracture. WADELL's triad of femoral fracture, intra abdominal, intrathaoracic injury and head injury usually associated with a high velocity automobile injuries.

X-ray findings:

X-ray evaluation of entire femur including the hip and knee, because injury to the adjacent joints is common. The limb should be allowed to settle at its resting length and tube to plate distance should be at least the standard 1 meter. Ruling out the presence of additional injuries is the essential features of the initial examination.

In accurate length measurement may occur for several reasons. If the tube – plate distance is too short, decreased 80cm, there will be excessive magnification. A more serious problem in the malpositioned study in which oblique x rays give wrong picture. This problem can be prevented by proper positioning so that the beam is projected at right angle to the shaft of femur. In many spiral and some oblique and comminuted fractures the exact amount of overriding may be difficult to measure, in such situation it may be necessary to take, an x-ray of the opposite femur taken with the same tube to plate distance for comparison.

Radiographic studies are also necessary to assess alignment in three planes rotational, frontal, and transverse. Rotational malalignment of femur may be assessed in several ways. If the fracture is distal where the bone in is elliptical rather then round, a disparity in the bone diameter indicates malrotation. A second method of assessment is to estimate the position of the lesser trochanter and the most practical method is to determine where the shape of fractured ends match.

Classification of femoral shaft fractures:

Fractures of the shaft of femur may be classified in a variety of ways. Each fractures should be identified and described and each has clinical relevance.

Open versus closed fractures:

Fortunately open fractures are rare in children, but any degree of skin penetration is highly significant. Open fractures should be classified on the basis of Gustillo and Anderson.

Level:

Fractures of the shaft are usually described as occurring in the proximal, middle and distal third of shaft. 70% occur in mid shaft. Subtrochanteric fractures are those occurring upto 7.5cms below the lesser trochanter. Supracondylar fractures are those that occur just above the origin of gastroenemius.

Pattern:

Most children fractures are transverse, oblique or spiral in direction. Their fractures are rarely comminuted.

Displacement:-

Femoral shaft fractures are also classified according to displacement pattern. Shortening is quantified on non traction lateral radiograph. Angular and rotatory deformities reflect the action of unbalanced muscle forces across the fractured shaft. Angulations is described by using the apex of deformity as reference.

Unusual fracture patterns, birth fracture, fractures associated with child abuse, pathological fractures, multiple fractures are also taken into consideration.

Treatment of femoral shaft fractures in children:

The Orthopaedic literature on paediatric femur consist primarily of uncontrolled retrospective clinical series focusing on treatment alternative. Humberger and Eyring stated, “The simplest, safest, and the most effective method should be the treatment of choice”.

Dameron and Thompson outlined seven principles of paediatric femoral shaft fracture care.

1. The simplest form of satisfactory treatment is the best.
2. The initial treatment should be permanent treatment whenever possible.

3. Perfect anatomical reduction is not essential for perfect function.
4. Restoration of alignment is more important than position of fragments with respect to one another.
5. More potential growth equals more probable restoration of normal architecture because of remodelling.
6. Over treatment in usually worse then under treatment.
7. Injured limb should be kept in Thomas splint with skin traction before definitive therapy is begun.

Most Authors recommend treatment based on patients age.

Treatment option for femoral shaft fractures in children and adolescents.

Age	**Treatment**
Birth to 24 months	Pavlik harness (newborn to 6 month) Immediate spica cast Traction → spica cast
24 months to 5 years	Immediate spica cast Traction → spica cast External fixation (rare) Flexible IM Rod (rare)

6-11 years	Traction spica cast Flexible IM rod Compression plate External fixation
12 year to maturity	Flexible IM rod. Compression plate Locked IM rod External fixation.

I: In INFANTS, new born to 6 month of age, femoral fractures usually are reasonably stable because of thick periosteum.

- For stable proximal and mid shaft fractures, simple splinting or a pavlik harness is all that is required.
- For unstable fracture in infancy, a pavlik harness with a wrap around thigh in beneficial.
- For fractures with excessive shortening (more then 1 to 2cm) or angulations increased 30°, spica casting is required.

II: In CHILDREN from 6 months to 6 years of age, immediate and early spica casting is the treatment of choice for femoral fractures with less than 2 cm shortening.

- Femoral fractures with more then 2 cm shortening or marked instability and fractures that cannot be reduced with immediate spice casting requires 3 to 10 days of skin or skeletal traction.
- Skeletal stabilization with external fixators is reserved for children with open or a multiple trauma.
- Large children in whom it in very difficult to maintain reduction in cast may be benefited by flexible IM rod.

III: Treatment of femoral fractures in children 6 to 11 years of age is highly controversial.

- For a stable minimally displaced fracture, immediate spica casting may be done.
- However, in large children with unstable comminuted fractures, traction followed by application of a cast or immediate spica cast may be necessary.
- Enthusiasm for treatment that decreases the hospital stay has led to use of external fixators and flexible nails in children more than 6 years of age.

- Compression plates has been reintroduced as technique with low risks and significant benefit in the management of paediatric femoral fractures.
- In older children and adolescent, antegrade nailing has been recommended as a standard procedure, but the recognized risks of a vascular trauma in and growth disturbance has led to limited use of this as standard techniques.

Advantages and Disadvantages of various treatment options:

Fixation	Advantages	Disadvantages
Spica casting	No scar, no operations	Uncomfortable, skin problems and loss of reduction.
Skeletal traction	No operation, closed treatment.	Loss of reduction, long time immobilization, pin tract infection.
External fixation	Percutaneous fixation early mobilization	Pin tract infection, secondary fractures and re fractures.
Plate osteosynthesis	Immediate stability and mobilization	Large incision and scarring, hardware removal
Flexible IM nails	Small incision,	Possibility of rotational

	immediate, early mobilization.	instability, hardware removal is necessary
Locked intramedullary nailing	Immediate stability and mobilization	Risk of AVN, implant removal necessary.

Acceptable Angulation

Age	**Varus / Valgus (Degree)**	**Anterior / Posterior (Degree)**	**Shortening (mm)**
Birth to 2 years	30	30	15
2-5 years	15	20	20
6-10 years	10	15	15
11 years to maturity	5	10	10

Indications for the surgical management of paediatric diaphyseal femur fractures.

1. children between the ages of 3 year to 9 years with failure to obtain or maintain an acceptable reduction.
2. children with 3 to 9 years with multiple system injuries.

3. social: Children 6 to 9 year of age in whom there are overriding psychological, educational or economic factors that makes non operative treatment unacceptable.
4. All children older then 10 year of age
5. Children with pathological fractures.

Complications of femoral shaft fractures

1. Limb length discrepancy:

- The most common sequale after femoral shaft fracture in children
- The fractured femur may be initially short from overriding of fragments at union. Growth acceleration occurs to make up the difference but often the acceleration continues and over growth occurs.
- Age seems to be most constant factor, but fractures in the proximal third and oblique comminuted fractures also have been associated with growth acceleration.
- According to STAHELI et al, in patients over 10 years of age, shortening is more likely, over growth in more likely in patients with age 2-10 years. Average overgrowth is .9 cm.

- The surgeon should ensure equal leg length at injury and not accept more than 2cm of shortening.

2. Angular deformity:

Some degree of angular deformity in frequent after femoral shaft fracture in children, but this usually remodell with growth. WALLACT and HOFFMAN concluded that a angular malunion of up to 25^0 in any plane will remodel.

In children older then 9 years, remodelling should not be relied on to correct angular deformity.

3. Rotational deformity:

Rotational deformity in usually expressed in terms of Femoral Anteversion Angle [FAA] on the fractured side compared with the normal side. A difference of more than 10 degrees has been the criterion of significant deformity.

The goal should be to reduce a rotational deformity to 10°, based on alignment of proximal and distal femur radiographically and correct positioning with cast.

4. Delayed and non union:

Are uncommon in children

Typical causes are either infection or stress shielding often caused by fracture management itself.

Treatment is as same for adults.

5. Infection:

Pin tract infection occurs with use of skeletal traction and external fixation, but most are superficial infection that resolve with local wound care and antibiotic therapy.

6. Neurovascular Injury:

Nerve and vascular injuries are uncommon with femoral fractures in children. An estimated 1.3% of femoral fractures in children are accompanied by vascular injury.

7. Compartment syndrome:

Rare, but it has been reported after femoral fracture and treatment. Thigh fasciotomy is indicated when the pressure in >30mm/Hg.

8. AVASCULAR NECROSIS of the femoral head: some times occur with hip spica cast, when hip in placed in wide abduction, also in antegrade nail insertion through piriform fossa.

ELASTIC STABLE INTRAMEDULLARY NAIL

A. Implant Design and Characteristic Features:

The technique of elastic stable intramedullary nailing, adopted from existing flexible rod systems, was first described by surgeons from Nancy clinic in France. Ligier et al reported the results of the Nancy experience in 123 fractures of femoral shaft in the year 1988. This ESIN is based on the theoretical concept by FIRICIA.

Biomechanics:

Working from the concept of three point fixation, they were able to improve the stability significantly by using two pre-tensioned nails inserted from the opposite sides of the bone. LIGIER, METAZIEU and their colleagues were able to show that titanium nails allowed greater elasticity than steel. They also proved that titanium nails which can be accurately contoured and properly inserted could impart excellent axial and lateral stability to diaphyseal fractures in long bones. Rotational stability was also better then had been previously experienced although this remain the weakest point of this technique.

The flexible rod is initially bent or curved. An elastic nail which is present retains its memory. During intramedullary insertion, which is typically retrograde in femur, the relatively straight medullary canal forces the curved rod to straighten within in bone. This elastic deformation causes a bending moment within the long bone which will tend to angulate the fracture in the direction and the plane of the concavity of the rod, as the rods also want to return to its initial status.

This moment is counteracted by a second rod of matched diameter and curve, which balances the first rod with an equal but opposite moment.

The two intramedullary rods acts complimentarily to stabilize the fracture. The biologic fixation is not stable but sufficiently stable against angular, translation and deforming forces and is associated with early and exuberant callus formation. Typically no external immobilization is needed. Titanium nails have been distinguished from other nails such as Ender made of stainless steel which are not sufficiently elastic.

There are prerequisite for optimum fracture stability by elastic nails.

1. Nails should be prebend in such a way that apex is located at the fracture site.
2. Diameter of the nail should be atleast 40% of the internal diameter of the medullary canel.
3. Both nails should be of same diameter.
4. Both the nails should bent to same extent.
5. When inserted the nails should have maximum cortical contact at the fracture site at opposite directions.

Indication:

1. All fracture shaft in children older than 5 years.
2. Children younger then 5 years who is not suitable for closed reduction and early hip spica.
3. Children with fracture shaft of femur with multiple system injury, multiple fractures and some pathologic fractures.
4. Social indication: this is explained as conservative treatment alternatives. Unacceptable to patients parents.

The ideal fracture for this technique is a transverse or short oblique diaphyseal fracture with minimal comminution in a long bone.

Contraindication:

1. Intra articular fractures.
2. complex femoral fractures, particularly in connection with over weight (50-60kg) end or age (15-16 years).
3. Supracondylar fracture femur.

B. SURGICAL TECHNIQUE

NAIL SELECTION:

Titanium elastic nails are available in five diameters 2, 2.5, 3, 3.5 and 4 mm and are 440mm in length. The nails are colour coded for easy identification.

Nail diameter is equal to .4 x internal minimum diameter of bone.

The following sizes are typically used for children of average stature.

6-8 years : 3.0mm nails.

9-11 years : 3.5 mm nails.

12-14 years : 4.0 mm nails.

Always select two nails of the same diameter so the opposing bending forces are equal.

Procedure:

Step I : Positioning and draping:

The patient may be placed supine on a fracture table with a traction boot. If fracture reduction can be accomplished with manual reduction we can use a standard radiolucent table. Position the image intensifier on the lateral side of the affected femur for AP and lateral view of the thigh from hip to knee. The set up must allow the surgeon to access both medial and lateral aspects of the distal femur. Reduce the fracture and confirm alignment with ‘c’ arm both AP and lateral views. Prepare and drape the leg from hip to knee.

Step II contouring The Nail:

Contour both nails into a bow shape with nail tip pointing towards the concave side of the bowed nail. The apex of the bend should be at fracture site and at a distance, 3 times the diameter of bone., usually it requires about 30^0 bend.

Step III : Nail Entry Point:

The selection of entry point for the nails in medial and lateral at the top of the flare of the femoral condyles, so that after insertion, they will tend to bind against the flare of the condoyle. If the nail insertion is too low it will tend to back out.

An incision in made on the lateral side of leg 2.5c.m above the physis and extending distally for 2.5cm. The fascialata is incised and vastuslateralis is retracted. Select the next largest drill bit relative to diameter of nail. Use drill sleeves to protect the soft tissues. Start the drill bit perpendicular to the bone surface, penetrate the cortex. Use a curved boneawl, enlarge the hole in 45° angulations. Similarly make a medial entry point in same manner.

Step IV Nail insertion and fracture reduction:

Both the nails are inserted through entry points one after the other and are driven upto the fracture site. Using ‘C’ arm align the nail tip so the convex side will glance off from far cortex. It is very important that sufficient reduction of the fragment in achieved so that about half of medullary canal overlap. Use ‘F’ tool for reduction which is a radiolucent device.

Viewing with image intensifier note which nail will be the easiest to drive across the fracture site. This nail is advanced 2cm into proximal fragment and then rotated. Motion of the proximal fragment demonstrates that the nail is in the proximal fragment. At this point it is advanced further. By rotating this nail further reduction of fracture can be accomplished, and then second nail in inserted. Don’t advance the first rod so far until the second rod crossed the fracture site. If the first rod in advanced too far, it will shift the fragments and make passing of the second rod difficult.

Step V : Nail advancement and cutting:

The traction in released and both the nails are advanced to their full length. Any deformity can be corrected by altering the position of nail. Varus or valgus angulation can be corrected by rotation of the nail whose concavity faces same direction of deformation through 180°. The two curves which were originally diametrically opposite are now facing the same direction. Opposing the deforming force and correcting axial deformation with saggital angulations, the two nails are directed so that their convexity opposes deformation. If there is any significant mal rotation, the child must be repositioned and nailing redone. The cut off point for the nail should be 1 to 2 cm out side the cortex : bending the nail tip sometimes irritates the soft tissues.

Step VI the closure

The wound in closed in layer and a water proof dressing applied. Before waking up the patient bend the knee to 90^0 to avoid stiffness of knee.

Post -Op Protocol:

With usual transverse fracture, no external immobilization is necessary. The patient is started on range of motion of knee and hip .Weight bearing will depend on the fracture pattern and stability. Progression of weight bearing should be at the discretion of surgeon. When early callus formation is observed weight bearing can be increased, external support can be discontinued when radiographic healing in complete.

Nail Removal:

Usually nails for fracture shaft of femur is removed from 6 to 9 months.

C. COMPLICATIONS AND FAILURES OF ESIN TECHNIQUE :

Principle failure:

1. Biomechanical Properties:

In contrast to solid nails, which are locked by means of screws for axial as well as rotary instability, the same principle in achieved in ESIN though so called “3” – point support. This principle must be strictly adhered to.

2. Nail Diameter:

In general nail diameter should be selected to correspond 40% narrowest medullary space diameter. Differing nail thickness may lead to axial deformity.

3. Insertion point:

i) Insertion points that do not lie opposite to one another greatly influence the biomechanics and thus stability of fracture fixation.

ii) Too diaphyseal insertion can lead to severe muscle irritation.

iii) Insertion too close to epiphysis may damage the growth plate.

4. Corkscrew Phenomenon:

Difficulties with fracture reduction as well as advancing the 2nd nail which makes the surgeon to rotate the nail more than 180° will lead to one nail being wound around the other. This process in called the ‘corkscrew phenomenon’. Then the nails will acts as single central nail and that will not axially or rotationally stable.

5. Perforation of medial nail through calcar.
6. Failure to catch the proximal fragment.

MATERIALS AND METHODS

In this study 20 patients aged 5-16 years, with fracture shaft of femur were treated with flexible intramedullary nail with TITANIUM

ELASTIC NAILS (TENS) at Government Rajaji Hospital attached to Madurai Medical College, Madurai from May 2006 to November 2007.

Inclusion Criteria:

- Children and adolescent patients from 5 to 16 year with diaphyseal femur fracture.

Exclusion Criteria:

- Patients less than 5 years of age and more than 16 years of age.
- Patients unfit for surgery
- Comminuted and segmental fractures.
- Fracture involving the distal 1/3rd of femoral shaft.

As soon as the patient was brought to casuality, patients airway, breathing and circulation assessed. Then a complete survey was carried out to rule out other injuries. Plain X-ray of femur, both AP and lateral view taken including both hip and knee joints were taken.Limb was rested in a Thomas splint

AFTER SURGERY:

Each child was followed upto 1 year to 1 year 6 months after the surgery. Postoperatively the patient was immobilized in a resting Thomas splint. Patients were started on quadriceps exercise as soon as the pain subsides. After 3 wks, the range of motion exercise were started, partial weight bearing after visible callus seen. With radiological evidence of union, full weight bearing was started after 6-8 wks. Follow up were carried out 12 wks, 24 wks and 1 year.

Follow up anteroposterior and lateral radiographs were reviewed for each postoperative visit. These radiography were analysed for coronal and saggital plane malalignment and shortening across fracture site. Patients range of motion of knee, hip and limb length discrepancy, degree of pain or swelling documented. Rotational deformity of femur were measured using foot progression angle. All operative and post operative complications and secondary and unplanned procedures were noted.

OBSERVATION AND RESULTS

All patients were followed until fracture union occurred. The followup period ranged from 6 months to 18 months. Results were analysed both clinically and radiologically.

The results were evaluated according to the TENS SCORING SYSTEM used by FLYNN et al as shown in Table I

Table : 1

The Scoring Criteria for Tens

	Excellent	**Successful**	**Poor**
Limb length discrepancy	< 1.0cm	< 2cm	> 2cm
Sequence disorder	5°	10°	>10°
Pain	Absent	Absent	Present
Complication	Absent	Mild	Major Complication or increased morbidity

Table 2 : Age Incidence

Age in Years	No of Cases	Percentage
5-8 years	8	40
9-12 years	5	25
13-16 years	7	35

Majority of the patients i.e. 8 (40%) were in the age group of 5-8 years. The younger patient was 5 years and the oldest was 15 years and the mean age of study was 10.15 years.

Table 3 : Sex Incidence

Sex	No of Cases	Percentage
Male	18	90
Female	2	10

Majority of patients were males and 2 were females.

Table 4: Mode of Injury

Nature of Trauma	No of Cases	Percentage
RTA	11	55
Fall while playing	7	35
Fall from height	2	10

Major Cause of fractures in our series is RTA.

Table 5 : Side Affected

Side Affected	No of Cases	Percentage
Left	9	45
Right	11	55

Right femur involved in 55% of cases.

Table 6 : Pattern of fractures

Pattern of fracture	No of Cases	Percentage
Transverse	14	70%
Oblique	4	20%
Spiral	2	10%

Table 7 : Level of Fracture

Level of Fracture	No of Cases	Percentage
Proximal	8	40%
Middle	12	60%

Middle 1/3rd of the shaft was involved in 12 (60%).

Table 8 : Type of Fracture

Type of Fracture	No of Cases	Percentage
Closed	18	90
Open	2	10

Table 9: Associated Injuries:

Head Injury	2
Abdominal Injury	1
Ipsilateral Tibia	1
Pelvic fracture	1

Table 10: Time Interval Between Trauma and Surgery

Duration in Days	No of Cases	Percentage
< 24 hrs	7	35
2-4 days	10	50
5 – 7 days	1	5
> 7 days	2	10

Average Time interval between trauma and surgery was 3.95 days.

Table 11: Type of Reduction

Reduction Method	No of Cases	Percentage
Closed	18	90
Open	2	10

One patient who had a head injury problem, we operated after 2 wks needed an open reduction. Another patient who had compound required open reduction.

Table 12: Post Operative Immobilization

We done postoperative immobilization in two cases in form of skin traction in a Thomas Splint, both were comminuted fractures.

Mode of Immobilization	No of cases

No Immobilization	18
Skin Traction	2

Table 13: Stay in Hospital

Hospital Stay in Days	No of Cases	Percentage
6 – 9	8	40
6-12	10	50
> 12	2	10

2 patient who had superficial infection stayed more than 12 days in hospital. Average duration of hospital stay in our series in 10.1 days.

Table 14: Time for Union

Time of Union	No of Cases	Percentage
8 wks	12	60
10 wks	4	20
12 wks	4	20

Time of union was defined as the period between operation and full weight bearing without external support and a radiographically healed fracture. Average time of union in about 8.2 weeks.

Complication in out Series

Complications	**No of cases**	**Percentage**
Limb lengthening < 5 mm > 5 mm	 4 2	 20 10
Infection	2	10
Delayed union / Non Union	-	-
Nail Protrusion	3	15
Mal alignment Varus angulation	 2	 10

Range of motion of Hip and Knee

All patient had full range of motion of hip joint, 3 patient who had a nail protrusion and bursa had little bit knee stiffness and it also soon recovered with physiotherapy.

Limb Length discrepancy

6 patients had limb length discrepancy. Out of them 4 had less than 5 mm limb length discrepancy 2 had nearly 1cm limb length discrepancy. No patient in our series had significant limb length discrepancy (i.e. > - 2 to + 2cm).

Infection

Superficial infection was seen in 2 patients in our study and it was controlled by antibiotics.

Delayed union and Non union

No cases of delayed union and non union were seen in our series.

Mal alignment:

Two cases of varus malalignment of 10 and 12° respectively were observed in our series.

No cases of valgus, Anteroposterior or rotational malalignment was observed.

We analysed our final results with TENS EVALUATION SCORE GIVEN BY FLYNN et al.

We had

Results	No of cases
Excellent	9
Successful	8
Poor	3

We compared our results with other international studies.

Table No 15: Comparison Table

	Our series	**Ligier et al**	**Flynn et al**	**Levent celeb et al**
No of cases	20	128	48	35
Time of union	8.2 wks	8	-	8 wks
LLD	6	7	Nil	3
Angulation ↑ 10°	2	14	2	2
Knee stiffness	3	13	-	-
Hospital Stay	10.1	8.5 days	6 days	5.5 days
Return to school	62 days	51 days	48 days	42 days

DISCUSSION

In has been commonly accepted that surgical intervention is indicated in paediatric femoral shaft fracture in age group of 5-16 are generally open fracture, poly trauma, concominant head injuries and neurovascular wounding. However there are number of publications, suggesting that surgery can also be considered for isolated femoral fractures.

Due to achievements such as earlier return to function, less joint stiffness, lesser wound complication, Malunion, Non union, reduction in duration of hospitalization and cost makes intramedullary nailing one of the best methods of choice in children too.

In children, intervention using elastic nails are technically easier than the use of rigid nails. Using ender nails is little bit difficult becauses it is very hard and canal diameter is a restrictor factor in ender nail.

The studies have shown that the intremedullary fixation with TENS can be performed successfully in age group of 5-16 years. The mean age in our series was 10.15 years.

Some authors reported that they were using elastic nails in compound fracture upto to Grade 3. We have used for 2 cases of compound G II injuries in our series.

It appears that most of the femoral fractures we treated were transverse. However LIGIER ET AL have demonstrated that it can be successfully used in oblique and spiral fractures.

FLYNN et al & LIGIER et al reported mean hospitalization was about 5-10 days in this method. In our series mean hospitalization was 10.1 days.

The most common complication in treating femoral shaft fractures in children is limb length discrepancy. Significant discrepancy is LLD > 2cm. We had 4 cases of < .5mm LLD and two cases of LLD between 5mm and 1 cm. It didn't give any problem for the patients.

Another complication in a pediatric femoral shaft fracture in angulatory malunion. Herdon et al reported 7 of his 24 patients treated with spica casting developed malunion but none of him 21 patients who were treated by elastic nail developed malunion. Gaplin et al had 2 patients out of 35 developed malunion by this technique and they had excellent improvement in angulation deformity in the final follow up. We had 2 cases of malunion especially varus malunion 10° and 12° and which didnot give any functional difficulty for patients.

We analysed rotational deformities by clinically measuring the foot progression angle and looking for intoeing or outtoeing when the child stands. We never had rotatory malunion as seen by clinical methods.

Other complications in our series in the protrusion of nail in 3 cases causing skin irritation and knee stiffness. Luhmann et al. indicated that the technical problem can be minimized if the part of the nail which in left outside the femur in smaller than 2.5cm.

Flynn et al found very few complication in a multicenter study with 58 cases on whom they performed TENS. First callus tissue emerged in four weeks on the average. In this study the nail was routinely removed in the 6^{th} month. While early removal was required in five cases due to soft tissue irritation. But it has reported that it did not affect stability. We have removed nail between 6 to 9 month in our series. Following surgery in Flynn series 2 children had 15° of rotational asymmetry and 6 patients had limb length discrepancy of 1-2 cm. 2 patients had deep tissue infection.

Studies with ender nails for pediatric femoral shaft fracture by Kareglu et al and Ozturkmen et al found increased incidence of varus - valgus angulation when compared with elastic nails.

Bar et al compared ESIN with external fixation for paediatric femoral shaft fractures and concluded that increase in number of complications is associated with external fixation technique.

Many studies recommended allowing walking using crutches after the pain subsided. But Flynn et al suggested that it is ideal to allow partial weight bearing, when there is development of callus and full weight bearing only after clinical and radiographically complete union has occurred.

Kiely biomechanically compared the application by two nails in ‘C’ shape and two nails one in S shape and another in ‘C’ shape and concluded that there was basically no difference between there 2 groups.

Several case reports of avascular necrosis of femoral head were observed while using antegrade rigid interlocked nails for children and these complication were not reported in elastic nailing technique.

CONCLUSION

Twenty patients with 20 diaphyseal fractures were treated with Elastic Stable Intramedullary nailing between May 2006 to November 2007 at Government Rajaji Hospital, Madurai.

Children and adolescents aged between 5 to 16 years were included in this study with the average age being 10.15 years and 90% of them were boys.

RTA is the major course for the fractures and 2 fractures were open fractures.

12 cases were in middle 1/3 fractures and 8 of them were upper third and middle third junction fractures.

All patients were operated on a fracture table. 18 fractures were closely reduced and fixed, 2 cases open reduction done.

Except one case we allowed active hip and knee range of motion exercise on 2nd post operative day we allowed partial weight bearing around 3-4 wks and full weight bearing only after clinical and radiological complete union was evident .

The follow up duration was 6 to 18 months. All the fractures united between 8-12 weeks, with average time of union being 8.2 wks.

All patient had good range of movements except 3 patients who had nail protrusion. They regained full range of motion after nail removal and physiotherapy.

6 patients had limb length discrepancy, 4 of them had < 5mm lengthening and 2 had >5mm lengthening and that were not clinically significant.

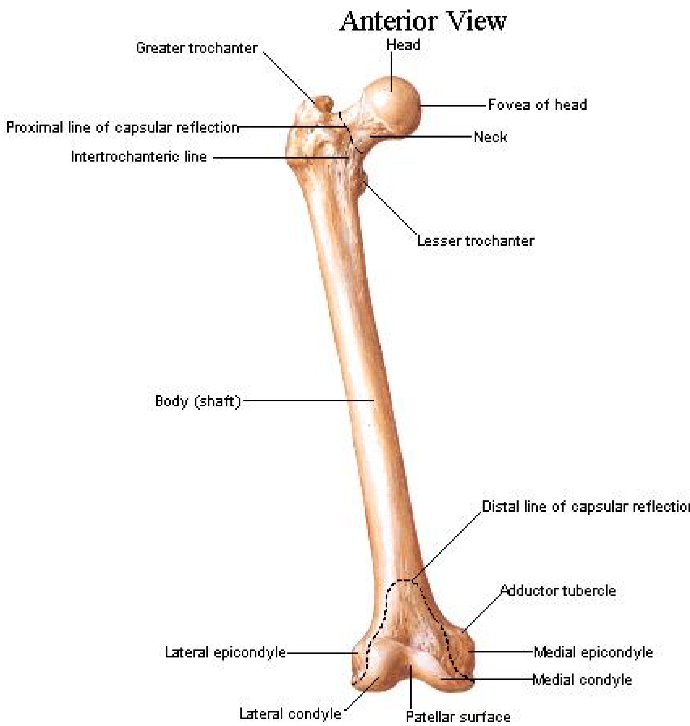
Superficial infection occurred in 2 cases, subsided with antibiotics.

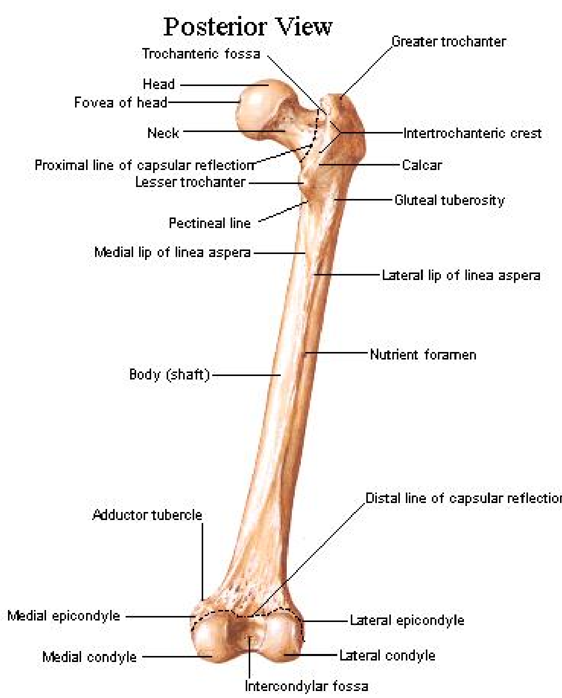
One patient had varus angulation of ↓ 10° degree and one had 12° degrees. Rotational malalignment was never observed clinically in our study.

Early return to school is possible in this technique when compared with conservative methods.

Based on our experience and results, we conclude that ELASTIC STABLE INTRAMEDULLARY NAILING technique is an ideal method for treatment of pediatric femoral shaft fractures. It gives elastic mobility promoting rapid union at fractures site and stability which is ideal for early mobilization. It gives lower complication rate, good outcome when compared with other methods of treatment.

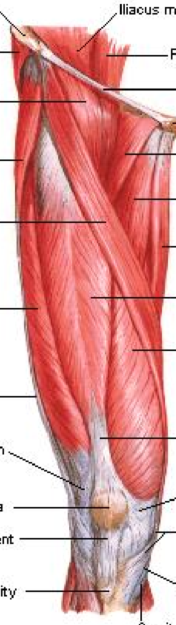
FEMUR


Anterior View
Greater trochanter
Head
Fovea of head
Proximal line of capsular reflection
Neck
Intertrochanteric line
Lesser trochanter
Body (shaft)
Distal line of capsular reflection
Adductor tubercle
Lateral epicondyle
Medial epicondyle
Medial condyle
Lateral condyle
Patellar surface


Posterior View
Greater trochanter
Trochanteric fossa
Head
Fovea of head
Neck
Intertrochanteric crest
Proximal line of capsular reflection
Calcar
Lesser trochanter
Gluteal tuberosity
Pectineal line
Medial lip of linea aspera
Lateral lip of linea aspera
Nutrient foramen
Body (shaft)
Distal line of capsular reflection
Adductor tubercle
Medial epicondyle
Lateral epicondyle
Medial condyle
Lateral condyle
Intercondylar fossa

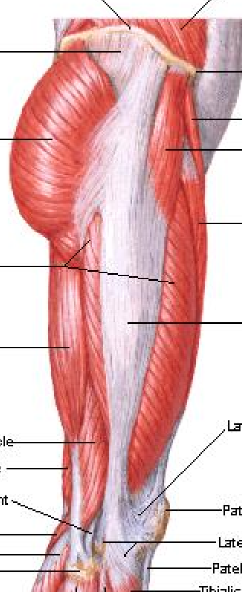
Muscles of Thigh

Anterior View - Superficial Dissection



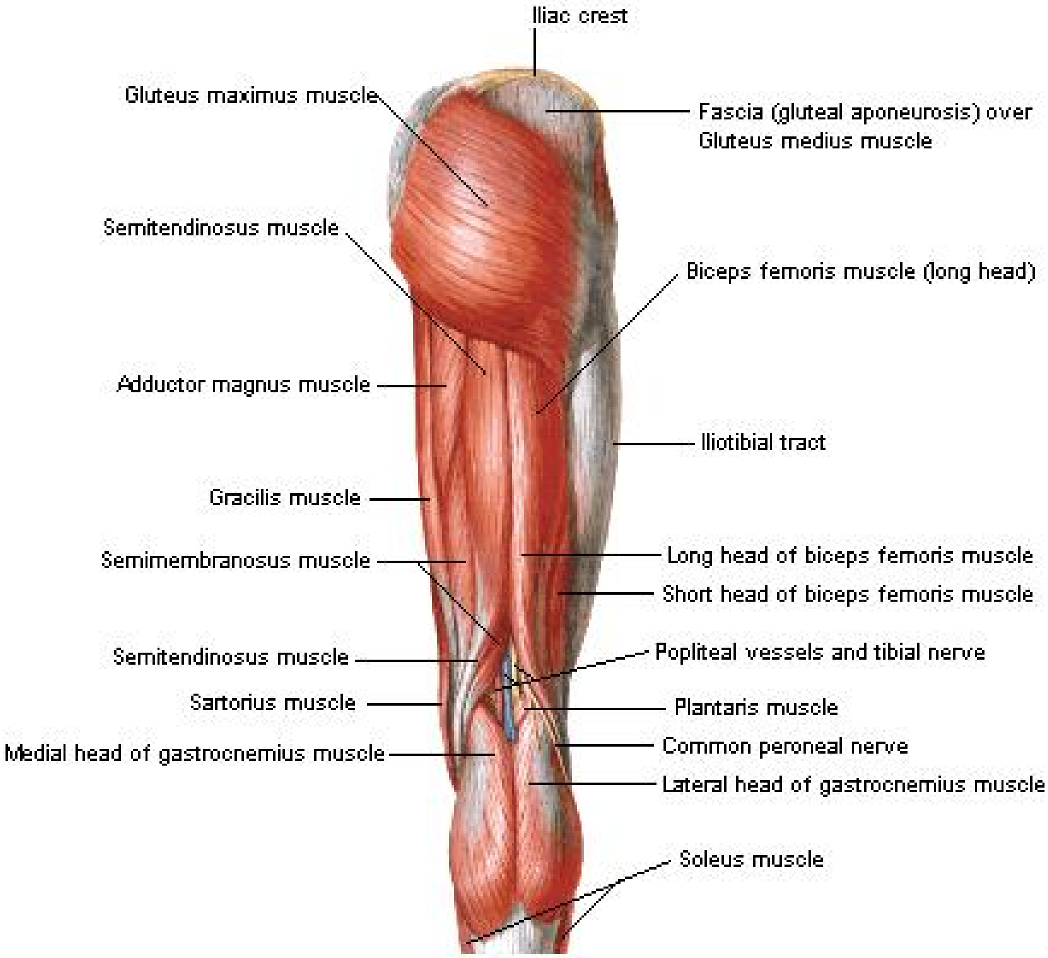
Muscles of Hip and Thigh

Lateral View



Muscles of Hip and Thigh

Posterior View - Superficial Dissection

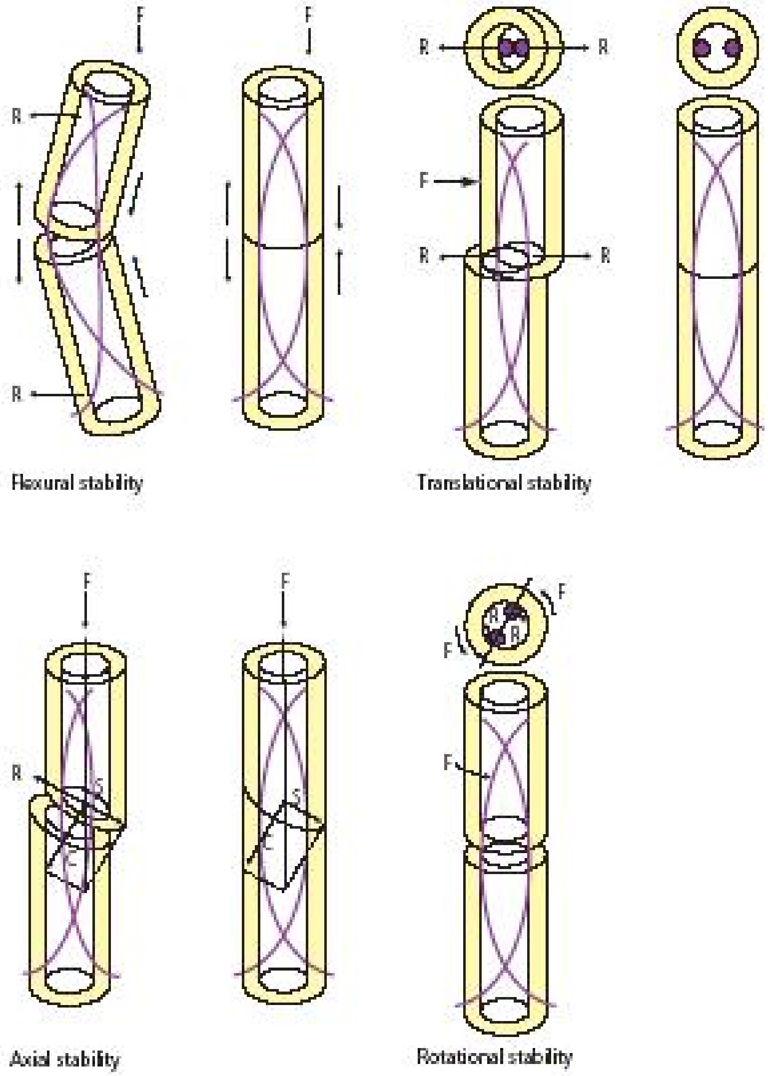


BIOMECHANICAL PRINCIPLE OF ESIN

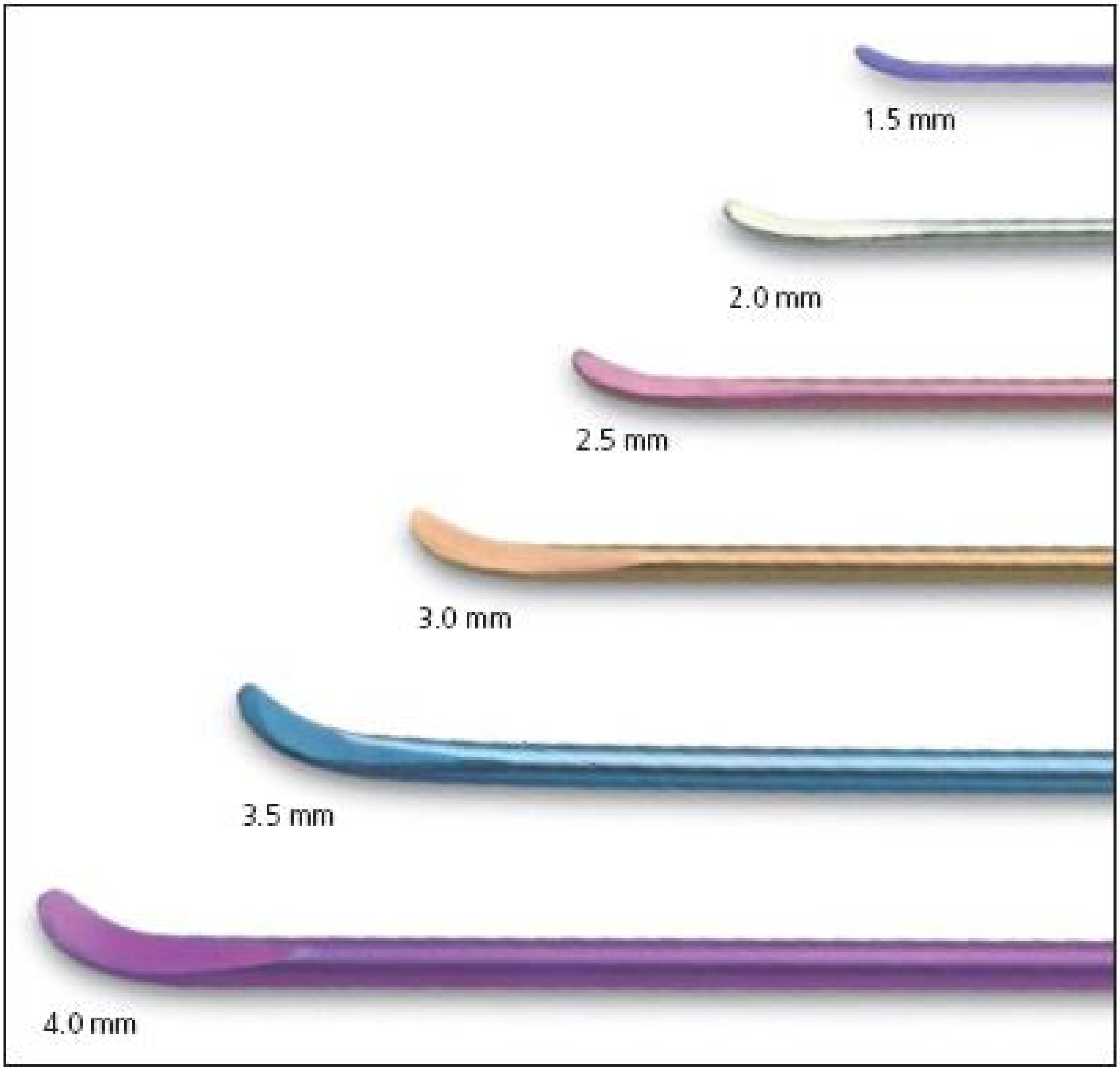
The aim of this biological, minimally invasive fracture treatment is to achieve a level of reduction and stabilization that is appropriate to the age of the child.

The biomechanical principle of the Titanium Elastic Nail is based on the symmetrical bracing action of two elastic nails inserted into the metaphysis, each of which bears against the inner bone at three points. This produces the following four properties: flexural stability, axial stability, translational stability and rotational stability. All four are essential for achieving optimal results.[1]

F = force acting on the bone
R = restoring force of the nail
S = shear force
C = compressive force

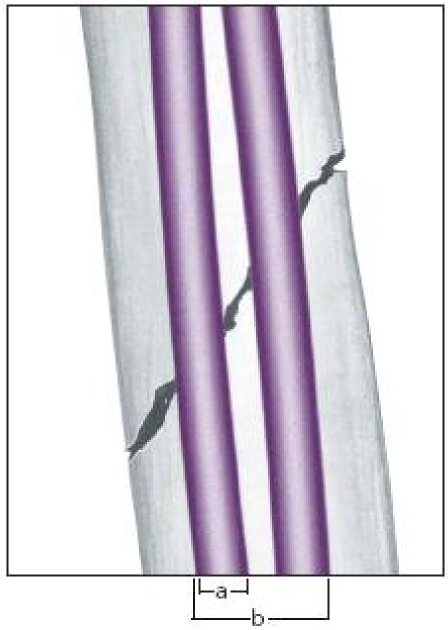


ELASTIC NAILS



INSTRUMENTATION FOR ESIN

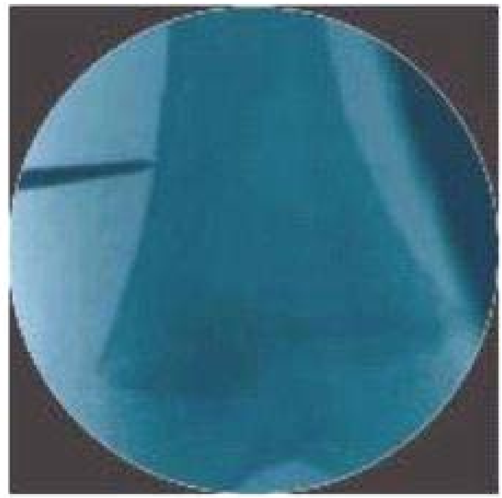
PRE OP PLANNING

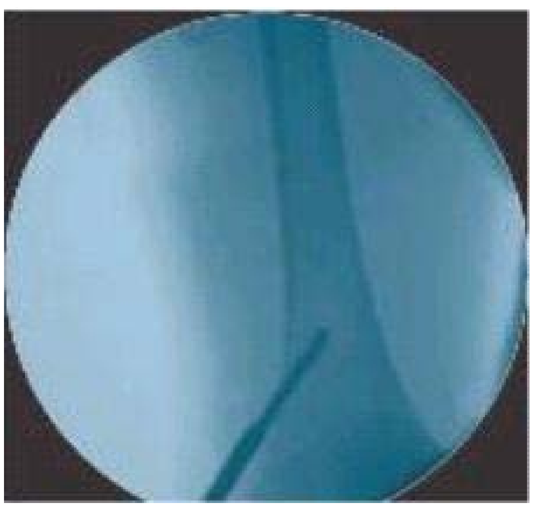


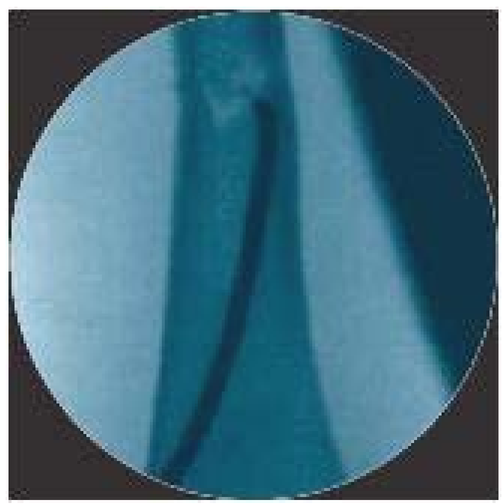
diameter of the nail = 0.4 x diameter of isthmus of femur

PRE BENDING OF THE NAIL

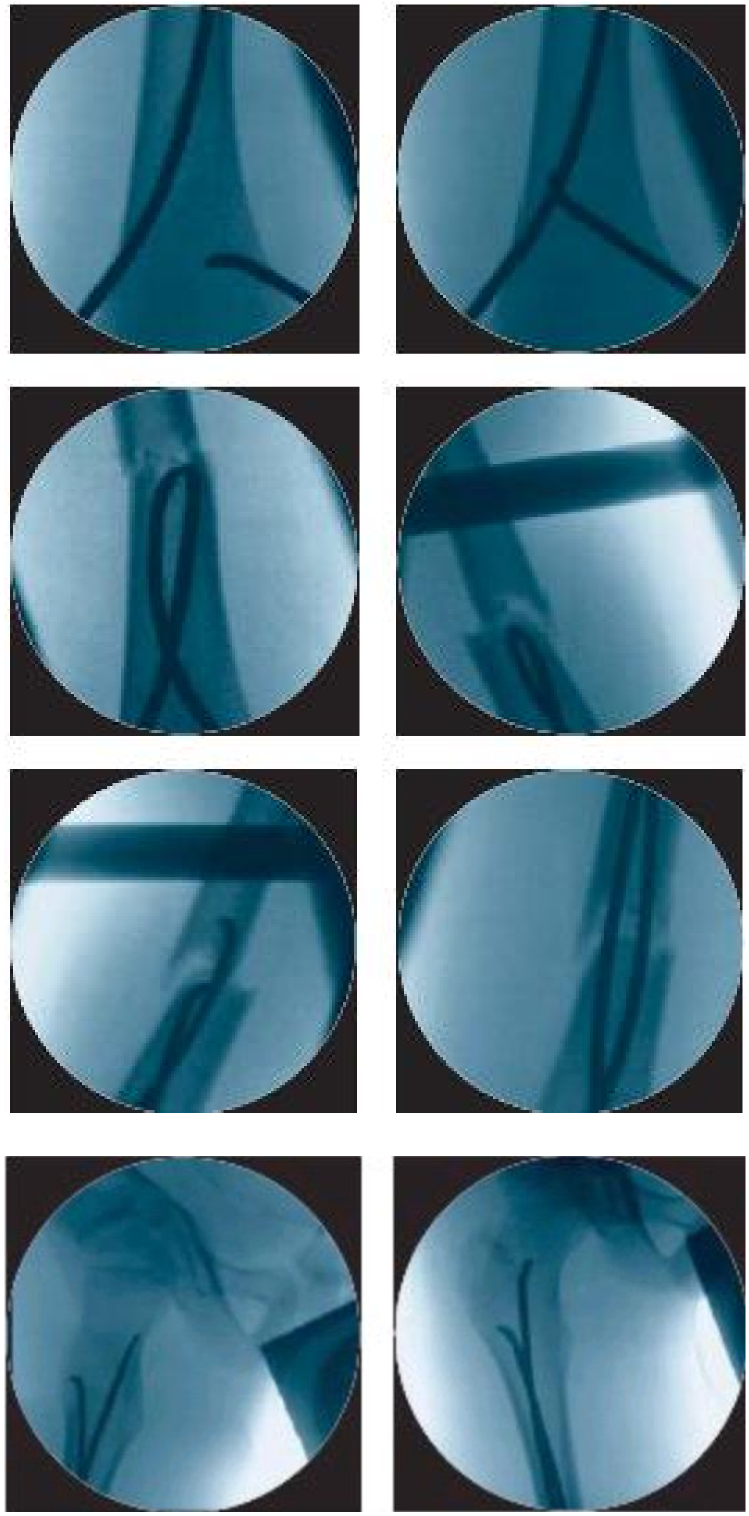
SURGICAL TECHNIQUE OF ESIN







PASSAGE OF THE NAIL (ESIN)



SURGICAL TECHNIQUE OF ESIN

CLOSE REDUCTION BY BOOT TRACTION IN FRACTURE TABLE UNDER 'C' ARM CONTROL

CASE: 1
MUTHUSAMY 14/M

PRE OP

POST OP

FOLLOW UP

CASE : 2

NANTHAKUMAR 8 /M

PRE OP **FOLLOW UP**

CASE – 3
VIGNESH 10/M

PRE OP

POST OP

CASE – 4

RANJITH 10/M

PRE OP

POST OP

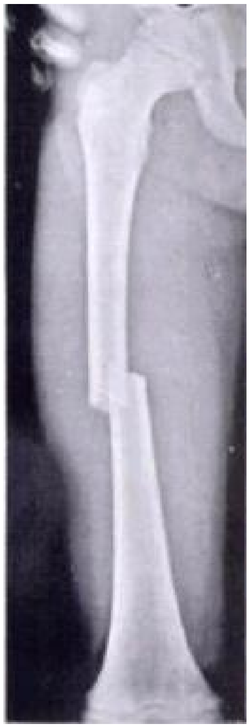
FOLLOW UP

CASE – 5
SARAVANAN – 9/M

POST OP

FOLLOW UP

CASE – 6
PRABHU – 10 /M



PRE OP FOLLOW UP

CASE – 7
BOOPATHY – 8/M

PREOP

POST OP

FOLLOW UP

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PROFORMA

Serial No. I.P. No:

Name : DOA:

Age : DOS:

Sex: DOD :

Address :

Hospital :

Occupation Unit:

Informant :

HISTORY

Presenting Complaints :

Pain in the thigh

- Onset
- Duration
- Type and Severity
- Aggravating / Relieving factors

Swelling

Restriction of movements

Deformity

History of Presenting Illness

- Mode of injury
- Place of injury Domestic / road traffic accident / farm

  Yard / assault/ others

Associated injuries if any:

Past History

H/O DM/ HTN / TB / IHD / Bronchial Asthma

Family History

H/O DM / HTN / TB in the family

Personal History

- Socio-economic status
- Diet
- Appetite
- Sleep
- Micturition / Bowel

EXAMINATION

General Examination

- Build
- Vitals

  Pulse BP:

  RR: Temperature :

- Pallor / Iecerus / Cyanosis / clubbing / Edema / Lymphadenopathy

Systemic Examination

CVS

RS

P/A

CNS

Local Examination of Thigh:

- Gait
- Attitude

Inspection

- Swelling Deformity
- Deformity
- Wounds if any

Palpation:

- Local rise of temperature
- Local tenderness
- Swelling
- Crepitus
- Abnormal mobility
- Bony irregularity

- Distal pulsation

Range of Movement :

- Hip joint movements
- Knee Joint movements

Measurements	**Right**	**Left**
- Length of the thigh segment		

Neurological Examination

INVESTIGATIONS

Routine:

- Blood

  Hb%: TC: DC: ESR:

- Urine

  Albumin Sugar Microscopy

- RBS
- Blood Urea
- Serum Creatinine
- HIV
- HBsAg

X-ray

- Plain X-ray of full length of femur including hip and knee joint
    - AP
    - Lateral View
- Report
- Side affected — Right / Left
- Side of fracture : — Proximal 1/3rd
  Middle 1/3rd
  Distal 1/3rd
- Type of fracture : — Transverse / Oblique / Spiral / Segmental / comminuted

Special Investigations

Diagnosis :

Management

- Immobilization

Surgical Management

- DOS – date of Surgery
- Duration between trauma and surgery
- Pre operative antibiotics
- Anaesthesia – general or spinal

- Procedure
- Duration of surgery

OPERATIVE FINDINGS

Size of Nail :

- Medial
- Lateral

Difficulties during operation

- Difficulty to active reduction
- Difficulty in passing nail
- Others

Management of other fractures and injuries

Post operative management

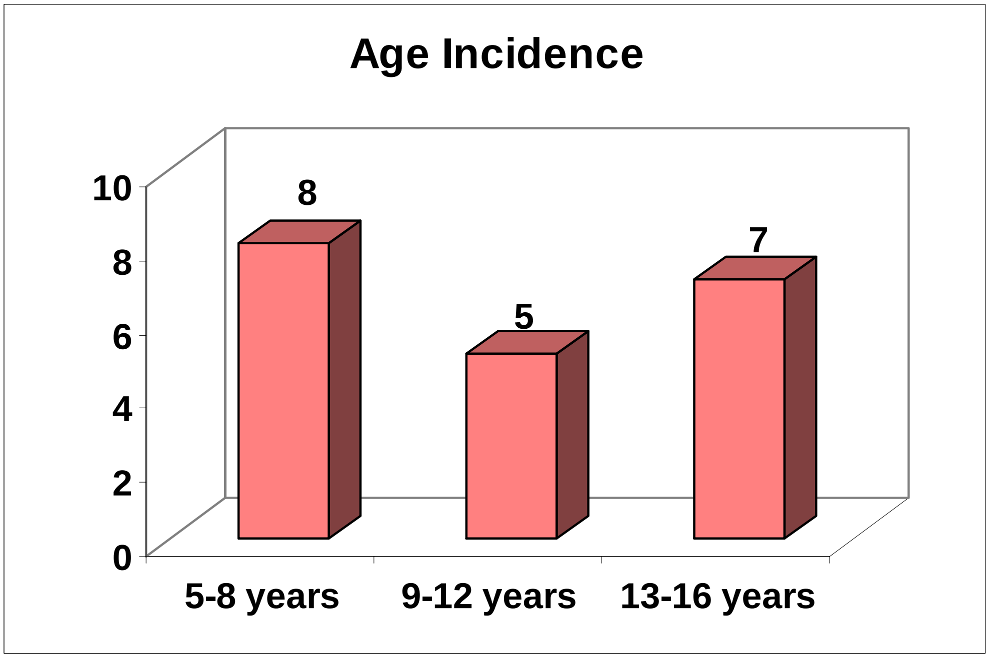
- Antibiotics
- Post operative X-ray
- Post operative immobilization
- Wound care
- Quadriceps set exercise
- Knee bending exercise
- Non weight bearing crutch walking / walker
- Date of suture removal

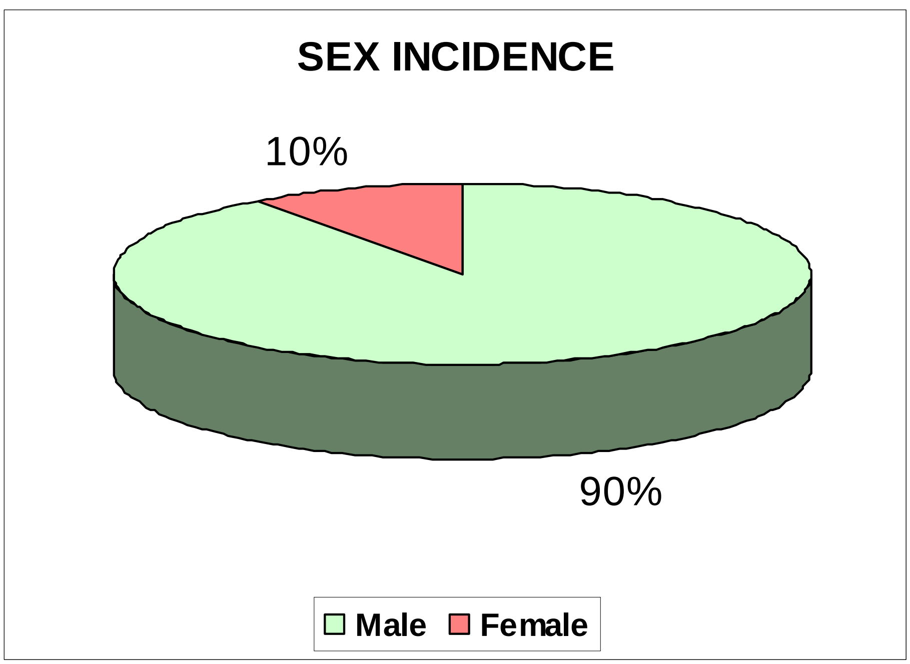
Advice at the time of discharge

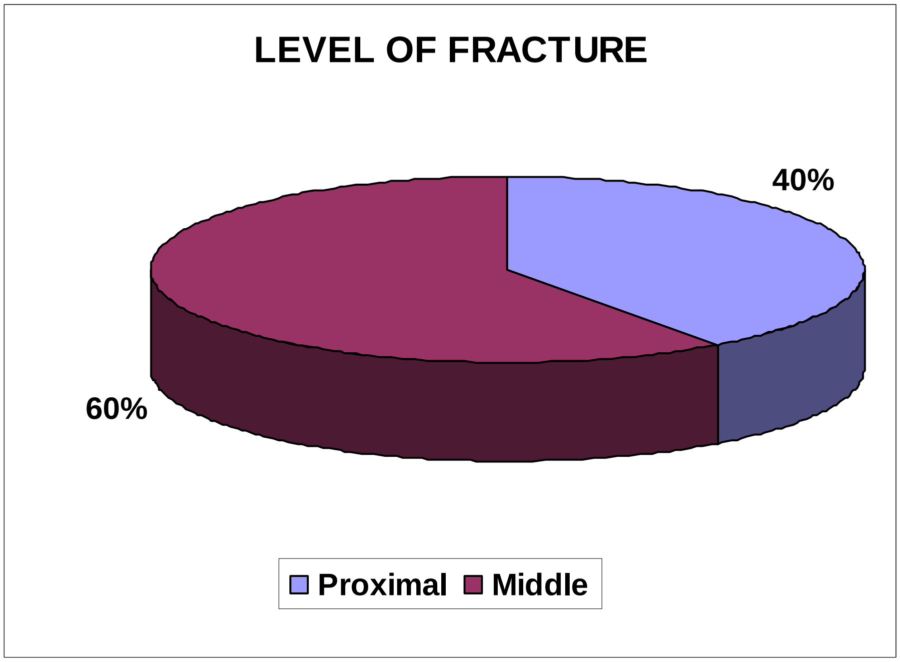
- Quadriceps exercise
- Active movements of the hip and knee

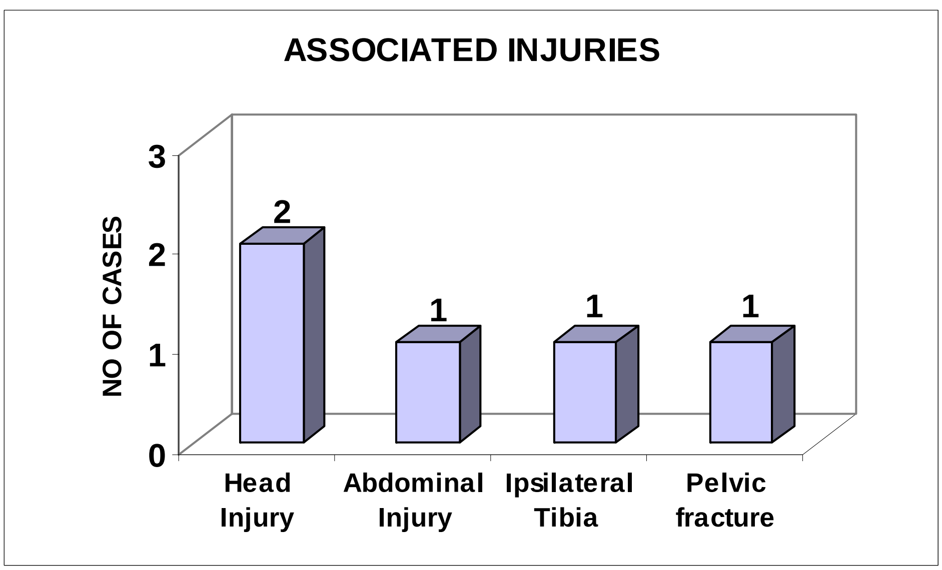
Follow up

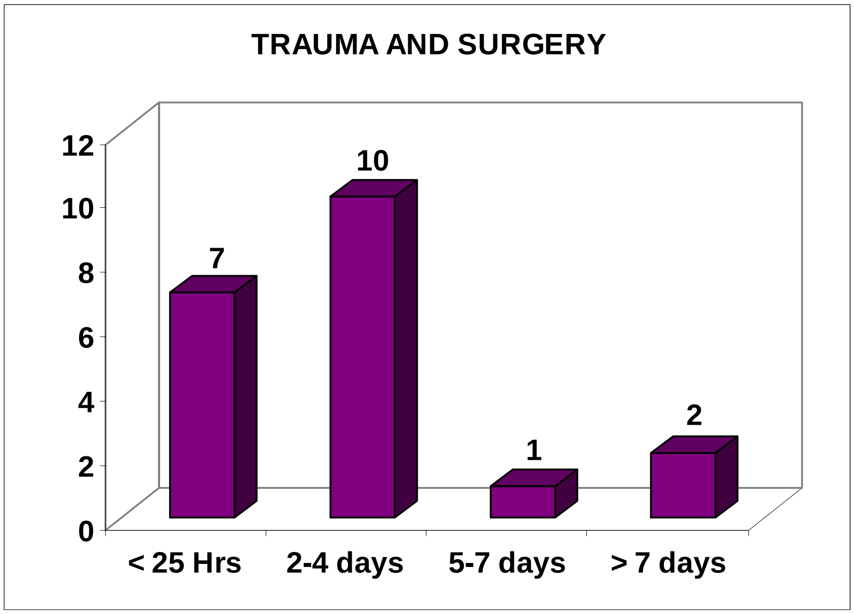
Complications	6 weeks	12 weeks	24 weeks	1 year
Pain / deformity/swelling/ difficulty in walking / discharging wound others				
On Examination **Tenderness** **Shortening / Lengthening** **Knee Movement** **Muscular atrophy** **Rotational alignment of the lower limb**				
X-ray **Callus formation / union** **Varus / Valgus alignment** **AP angulation**				
Distal migration of the nail **Restriction of knee flexion** **Infection** **Delayed union / non union**				
Advice **Quadriceps exercise** **Weight bearing**				
Others				

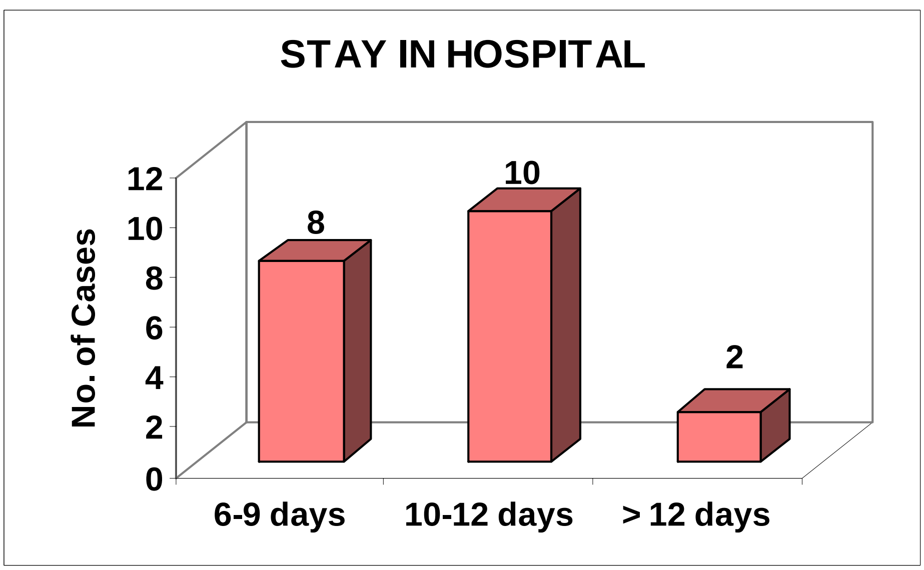

Age Incidence
10
8
6
4
2
0
8
5
7
5-8 years
9-12 years
13-16 years

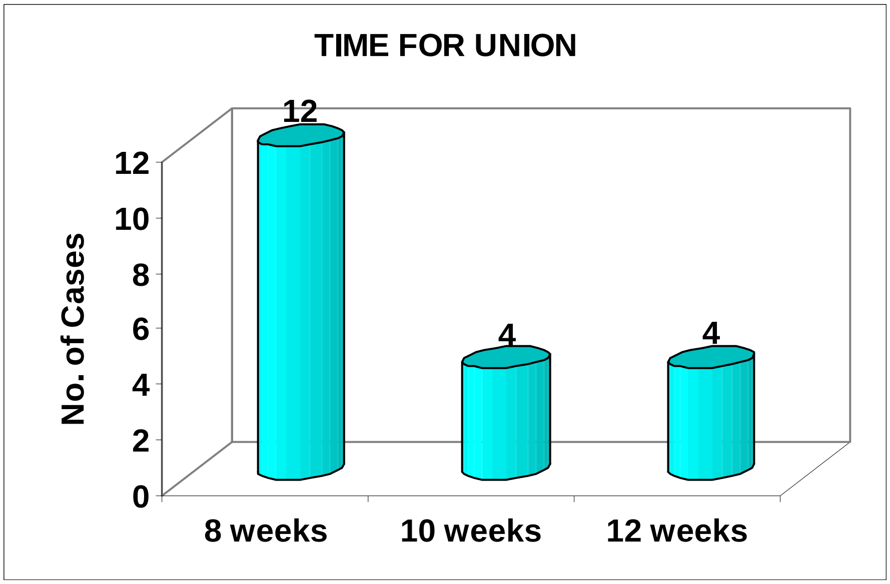

SEX INCIDENCE
10%
90%
Male
Female

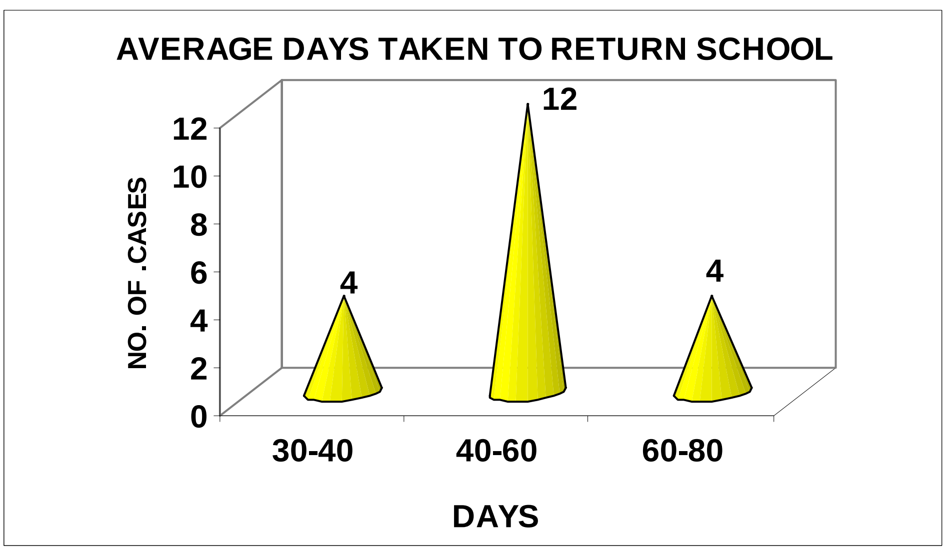

LEVEL OF FRACTURE
40%
60%
Proximal
Middle

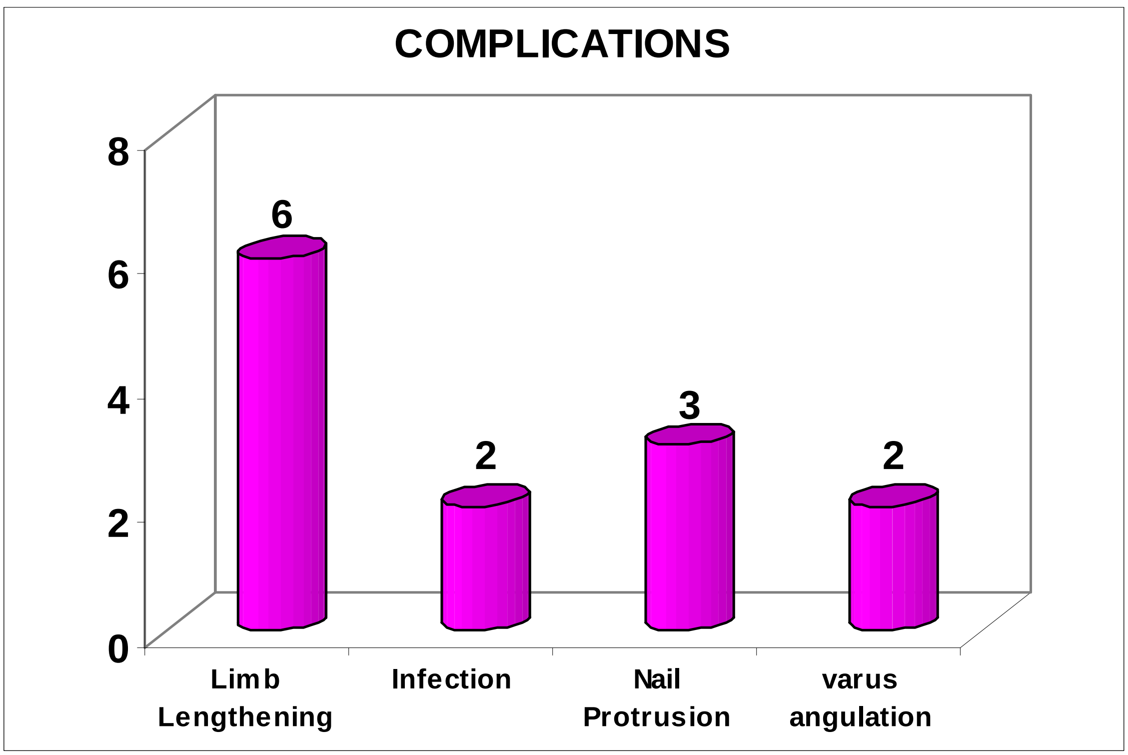

ASSOCIATED INJURIES
NO OF CASES
0
1
2
3
2
1
1
1
Head Injury
Abdominal Injury
Ipsilateral Tibia
Pelvic fracture


TRAUMA AND SURGERY
12
10
8
6
4
2
0
7
10
1
2
< 25 Hrs
2-4 days
5-7 days
> 7 days


STAY IN HOSPITAL
No. of Cases
12
10
8
6
4
2
0
8
10
2
6-9 days
10-12 days
> 12 days


TIME FOR UNION
No. of Cases
0
2
4
6
8
10
12
12
4
4
8 weeks
10 weeks
12 weeks


AVERAGE DAYS TAKEN TO RETURN SCHOOL
NO. OF .CASES
0
2
4
6
8
10
12
4
12
4
30-40
40-60
60-80
DAYS


COMPLICATIONS
8
6
4
2
0
6
2
3
2
Limb Lengthening
Infection
Nail Protrusion
varus angulation

MASTER CHART

S. NO	SEX	AGE	TYPE OF FRACTURE	LLD UPTO 2 C.M	ANGULATION >10°	CLINICAL ABNORMALITY	RESULTS
1	MALE	12	Transverse	NIL	NIL	-	EXCELLENT
2	MALE	8	Oblique	NIL	NIL	-	EXCELLENT
3	FEMALE	11	Oblique	PRESENT	NIL	-	SUCCESSFUL
4	MALE	9	Transverse	NIL	NIL	-	EXCELLENT
5	MALE	9	Transverse	NIL	VARUS 10°	-	SUCCESSFUL
6	MALE	13	Oblique	PRESENT	VARUS ANGULATION 12°	-	POOR
7	FEMALE	8	Transverse	NIL	NIL	-	EXCELLENT
8	MALE	12	Transverse	NIL	NIL	SKIN IRRITATION	SUCCESSFUL
9	MALE	11	Transverse	NIL	NIL	NIL	EXCELLENT
10	MALE	8	Oblique	PRESENT	NIL	NIL	SUCCESSFUL
11	MALE	9	Transverse	PRESENT	NIL	KNEE STIFFNESS	POOR
12	MALE	15	Transverse	NIL	NIL	SKIN IRRITATION	SUCCESSFUL
13	MALE	13	SPIRAL	NIL	NIL	-	EXCELLENT
14	MALE	12	Transverse	PRESENT	NIL	-	SUCCESSFUL
15	MALE	7	Oblique	PRESENT	NIL	KNEE STIFFNESS SKIN IRRITATION	SUCCESSFUL
16	MALE	12	Transverse	NIL	NIL	-	EXCELLENT
17	MALE	9	Transverse	NIL	NIL	KNEE STIFFNESS	POOR
18	MALE	7	Transverse	NIL	NIL	NIL	EXCELLENT
19	MALE	9	Transverse	NIL	NIL	NIL	EXCELLENT
20	MALE	10	Oblique	NIL	NIL	NAIL PROTRUSION + IRRITATION	SUCCESSFUL