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A Prospecive Analysis of Functional Outcome of Closed Tibial Shaft Fractures Treated with Closed Interlocking Intramedullary Nailing

KEYWORDS: closed nailing,closed tibial fractures

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ABSTRACT *INTRODUCTION: Closed Tibial Fractures are commonly encountered in Trauma wards. Because of the high prevalence of complications associated with these fractures, management often is diffcult,and the optimum method of treatment remains a subject of controversy.*

Our aim was to assess the time to bone union and functional outcome in cases of closed fractures of the tibial shaft treated with closed interlocking intramedullary nailing.

METHODS :Fifty patients who had 50 closed fractures of the tibial shaft were treated closed interlocking intramedullary nailing during the period from June 2012 to March 2014 .The patients were followed up for a period of 6 – 14 months.

RESULTS: The Mean time to Bone Union was 19.4 weeks.Functional Outcome was Excellent in 45 (90%),good in 4(8%),fair in 1(2%) patients.

INTERPRETATION AND CONCLUSION: The results in the current study prove that closed interlocking intramedullary nailing is a safe and effective technique for the management of closed tibial shaft fractures.

INTRODUCTION:

" We still have a long way to go before the best method of treating a fracture of the shaft of tibia can be stated with finality".

- Sir John Charnley,1961.

In contrast to the rest of appendicular skeleton, tibia has precarious blood supply due to inadequate muscular envelop. Tibial fractures may be associted with compartment syndrome, vascular or neural injury. The presence of hinge joints at the knee and the ankle, allows no adjustment for rotatory deformity after fracture.

Among the various modalities of treatment such as conservative gentle manipulation and use of short leg or long leg cast, open reduction and internal fixation with plates and screws, intra medullary fixation (including Ender Pins, intramedullary nails, and interlocking intramedullary nails with reaming (or)without reaming), and External fixation techniques, surgeon should be capable of using all these techniques and must weigh advantages and disadvantages of each one and adapt the best possible treatment. The best treatment should be determined by a thoughtful analysis of morphology of the fracture, the amount of energy imparted to the extremity, the mechanical characterstics of the bone, the age and general condition of the patient, and, most importantly the status of the soft tissues(the skin,muscle and associated neurologic and vascular structure of the leg).

Three goals must be met for the successful treatment of open fractures of tibia[1] the prevention of infection, the achievement of bony union, and the restoration of function.

Immobilization in a plaster cast has been used most commonly in the past, but it does not always maintain the length of the tibia and it leaves the wound relatively inaccessible.

Open reduction and internal fixation with plates and screws has yielded unacceptably high rates of infection [2,3]

External fixation, considered the treatment of choice by many traumatologists, has the disadvantages of bulky frames and frequent pin tract infections, non unions and malunions [2,4].

The intra medullary nailing ,locked or unlocked has become an atttractive option since image intensifier has made closed intra medullary nailing possible .Nail is a load sharing device and is stiff to both axial and torsional forces. Closed nailing involves least disturbance of soft tissue , fracture haematoma and natural process of bone healing as compared to other forms of internal fixation .

Intramedullary nails, such as Lottes and Ender nails, used without reaming, have been employed successfully in the treatment of open tibial fractures and have been associated with low rates of post operative infection. They are, however contraindicated for communited fractures, as there tends to be shortening or displacement of such fractures around these small nails[4].

This led us to design a trial, to study the results of closed interlocking intramedullary nailing in the treatment of closed fractures of the tibial shaft.

BIOLOGY OF FRACTURE HEALING WITH INTRAMEDULLARY NAILING

Intramedullary fixation offers many advantages in fracture healing when compared to other methods. Union is usually rapid because unlike rigid plate fixation external callus is seldom completely suppressed. This is due to the fact that a nail can never be completely rigid. Movement at the fracture site along with axial micromotion in dynamically locked nails promote the external bridging callus This may also be due to the fact that as the medullary blood supply is lost the periosteal vascular supply increases.

Intramedullary nailing avoids "Stress Protection Osteopenia" and so the of late refracture after nail removal in uncommon.

BIO MECHANICS OF INTERLOCKING INTRAMEDULLARY NAILS

All the intramedullary nails, regardless of their types, act as flexible internal splints providing stability for the fracture fragments from within.

It is a load sharing device in which stress shielding is minimal due to the fact that is situated close to the neutral axis of the bone where strain is minimal. The strain induced is now considered the most important factor in later stages of fracture callus remodelling.

Intramedullary locked nails, in addition to 3 point fixation and elastic impingement mainly provide stability by anchorage of the bone both proximal and distal to the fracture site by interlocking screws/bolts.

MATERIAL :

Venable and Stuck in 1934 discovered an inert alloy of chromium, Molybdenum and nickel and named it vitallium . Then came 18/12 S M O stainless steel , Titanium and then super alloys. Most of the orthopaedic nails are made of 316 L stainless steel.

The bending rigidity depends on the moment of inertia of the design which is proportional to the fourth power of the radius and the quantity of the material, that is to say that the bending stiffness increases as the diameter and thickness of the nails increase . A 25% increase in diameter of the nail will double its bending strength.

The rotational stiffness depends on the configuration of the cross section abolishing the open slot in the cross section increases the rotational stiffness approximately 50 times, when compared to nails with open slot.

Clinically, bending strength and stiffness can be increased by using slotted thick nail with large diameter.

When an implant is loaded to failure, the resulting load deflection curve would show the structural properties of the implant

LOAD DEFLECTION CURVE :

The elastic phase is the working area of the medullary implant. Part the *elastic* portion is the stiffness of the object. The higher the stiffness, the rigid the object.

As stiffness decreases the object becomes more flexible. An object will return to its original shape following load removal ,once the load exceeds the proportional limit, a plastic deformation takes place and the shape of the object changes . Hence the implant should not be loaded beyond its proportional limits.

Material properties are defined geometrically in the stress-strain curve. The stress is defined as load per unit area and strain is the change in length divided by the original length.

STRESS STRIAN CURVE :

The slope of this curve is called modulus of Elasticity (Youngs modulus). It is the constant proportionality between the stress and strain. It is a material property

Ex : A material with a high modulus is stiff i.e. for high stress, little strain

Titanium has more strength because of low modulus.

Strength : Is the stress at which the implant fails. The yield strength is at which the implant undergoes plastic deformation.

The structural characteristics and mechanical factors important in the design and evaluation of intramedullary implants are: Strength; Stiffness; Rigidity .

Fatigue failure occurs when an implant is cyclically loaded to a certain stress level.

Intra medullary nails are designed to share the load with the bone for a limited period, as the fracture heals. They are designed to bear significant load for few million cycles, until fracture unites.

Henley[5] showed that an unreamed solid nail (9mm), locked with good cortical contact at fracture site was 117% as stiff as intact tibia on axial loading and 6.5% stiff in torsion. Without cortical contact, tibial nail construct was only 55% stiff in axial loading and 3.1 % stiff in torsion.

Results of the fatigue and single cycle tests show that locking mehanisms and stress concentrators at critical locations on the nail . These critical stress concentrators reduced the strength of all devices far below the working length strengths.

Working length[6] is defined as the length of a nail spanning the fracture site from its distal point of fixation in the proximal fragment to its proximal point of fixation in the distal fragment. A less technical definition states that it is the distance between the two points on either side of the fracture where the bone firmly grips the metal. Thus, working length is the unsupported portion of the nail between the two major bone-fragments and reflects the length of mill carrying the majority of the load across the fracture site.

The bending stiffness of a nail is inversely proportional to the square of its working length, while the torsional stiffness is inversely proportional to its working length. Shorter working length means stronger fixation.

Working length is affected by various factors. A nail has shorter working length in bending in fixation of a transverse fracture than *in* stabilizing medullary reaming and interlocking. Medullary reaming prepares a uniform canal and improves nail-bone fixation towards the fracture, thus reducing the working length. Interlocking screws also modify the working length in torsion by fixing the nail to the bone at specific points. The torsional stability is substantially improved by this technique and is directly related to the distance between the two fixation points. Weight bearing with an interlocked nail further improves the nail bone contact as the nail bends under axial load reducing the working length and adding to the overall stiffness of the fixation.

Interlocking nail can be locked in two modes - Dynamic

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and Static.

Dynamic locking refers to transfixation only in the shorter fragment which is susceptible to rotational instability and allows intermittent compression of the fracture site during early weight bearing. It is indicated in fractures of the lower third and upper third of the shaft with no comminution and the contact area between the two major fragments is at least 50% of the cortical circumference.

Static locking refers to the placement of transfixing screws above and below the fracture. it controls the rotation, bending and *axial loading. It* is indicated when the fracture is comminuted, unstable to compression or subject to rotational forces.

Dynamization means removal of either the proximal or distal locking screws to allow increased axial loading of the tibia. There is no certian time interval when dynamization should occur. However a general guide line would be 6-8 weeks postoperatively if no signs of fractures healing on x-ray. Ultrasound can help for the early diagnosis of fracture healing.

Dynamization is not indicated if it will compromise the tibial construct.

MATERIALS AND METHODS :
The present prospective study of Closed interlocking intramedullary nailing of closed fractures of shaft of tibia was between June 2012 –March2014.

All the cases were fresh fractures.
The criteria for selection of cases:

Inclusion criteria:
1. Age more than 18 years.
2. Closed fractures of shaft of tibia.

Exclusion criteria:

1. Children and Adolescents.
2. Open Fractures.
3. Associated chest injuries.

This prospective study was approved by the hospital ethics committee.

Fifty patients who had fifty fractures were taken up for the study. The duration of follow-up ranged from 6 months to 14 months. On admission general condition of the patient was evaluated, all patients were administered with tetanus toxoid and intravenous antibiotics (inj.cefotaxime, inj.amikacin) and limb was immobilized with an above knee pop slab. Surgery was performed at the earliest

Pre-operative evaluation included evaluation of haemoglobin and blood sugars, bleeding time and clotting time, HIV, HBs, Ag, chest xray and ECG in case of patients more than 45 years.

Written and Informed consent was taken.

IV antibiotics half an hour before surgery was given.

All the patients were operated under spinal anaesthesia. Patients were placed supine with knee flexed to 90^0 on the operating table.

Image intensifier was used for all the patients. Indian nails were used for all the patients. All the nails were stainless steel nails. Closed reduction was achieved in all the patients.

Post operatively, IV antibiotics were given for ,ranging from 1 day to 3 days. Active range of movements were started on the first post-operative day, if associated injuries permit. Check x-rays were taken on the first postoperative day.

The functional results were graded according to **Johner & Wruh's criteria**[7]-

Table 1

	Excellent (Lt=Rt)	Good	Fair	Poor
Non union, Osteitis, amputation	None	None	None	Yes
Neuro- vascular disturbances	None	Minimal	Moderate	Severe
Deformity				
Varus / valgus	None	2^0- 5^0	6^0- 10^0	>10^0
Anteversion / recurvation	0^0- 5^0	6^0- 10^0	11^0- 20^0	>20^0
Rotation	0^0- 5^0	6^0- 10^0	11^0- 20^0	>20^0
Shortening	0-5 mm	6-10 mm	11-20mm	>20mm
Mobility				
Knee	Normal	> 80%	>75%	<75%
Ankle	Normal	>75%	>50%	<50%
Subtalar joint	>75%	>50%	<50%	
Pain	None	Occasional	Moderate	Severe
Gait	Normal	Normal	Insignificant limp	Significant limp
Sternous activites	Possible	Limited	Severely Limited	Impossible

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RESULTS:

The present study includes 50 CLOSED fractures of tibial shaft treated with closed interlocking intramedullary nailing

In our study 22(44%) patients were in age group of 21-30 years and 18(36%) were in between 31-40 years and 10 (20%) patients were in 40-55 years. In our study most of the fractures occurred in males 41(82%) compared to female 9(18%). Road traffic accident as a mode of injury were responsible for most of the fractures 40(80%) followed by fall in 8(16%) cases and direct blow in 2(4%) case. Most of the fractures were oblique 18(36%) cases, followed by transverse 16(32%) cases , comminuted 12(24%) cases, spiral 3(6%) cases and segmental 1 (2%) case. In our series, tibial shaft fractures occurred middle third in 28(56%) cases , lower third in 20(40%) cases and upper third in 2 (4%) case. Right side leg fractures 26(52%) were more common than left side 24 (48%).

Table 2: Post operative complications

POST-OPERATIVE COMPLICATIONS	NO. OF PATIENTS	PERCENTAGE
SUPERFICIAL INFECTION	2	4
DELAYED UNION	2	4
ANTERIOR KNEE PAIN	3	6
PAIN AT SCREW SITE	2	4
REDUCED RANGE OF MOVT. AT ANKLE	1	2

Post operative complication in our cases were 1 (4%) superficial infections, 3(6%) patients had anterior knee pain and 2(4%) delayed union, decreased ankle movements for 1(2%) patientand pain at screw site for 2(4%) patients.

MEAN TIME TO UNION:

The Mean Time to union was 19.4 weeks.

Functional Outcome:

Functional Outcome was Excellent in 45 (90%),good in 4(8%),fair in 1(2%) patients.

Table 3

FUNCTIONAL OUTCOME	NO. OF PATIENTS	PERCENTAGE
EXCELLENT	45	90
GOOD	4	8
FAIR	1	2

DISCUSSION:

Introduction of interlocking nails in the treatment of fracture tibia has widened the scope of closed nailing. It can be used in most type of fracture shaft of tibia like segmental, comminuted with or without bone loss and open fracture. Short morbidity, early weight bearing, early range of motion excises and correction of axial, angular and rotational deformity are advantage. Comparing our results with other reported series is difficult due to lack of standardization of fracture and number of different grading system. During the study it was found that the road traffic accident were the common cause of fracture shaft of tibia (80%) and 4 (16%) were due to fall while as in Wiss (1986)[8] series of patients 84% of the fracture was due to automobile accidents. In our study results of type and morphology of fractures were comparable to results of Hooper et al (1991)[9]. In our study the results of level of fracture, side involved, associated injuries and postoperative complications were comparable to the other studies like Puno et al (1986)[10], Hooper et al and Bone et al.

CONCLUSION

We here conclude from our study that closed interlocking nailing appears to be promising method of treatment of unstable shaft of tibia fractures in adults without any external splintage after adequate stabilization and early weight bearing leading to excellent functional results in most of cases. This implant leads to an extremely low rate of infection and alignment with early mobilization and decreased limitation of motion of knee and ankle joint.

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