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Study of management of tibial diaphyseal fractures with interlocking nail

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Abstract
Introduction: Tibia is the most commonly fractured long bone in the body with an annual incidence of tibial shaft fractures is 2 per 1000 individuals. 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 communition, age, patients social and economic demands may influence the method of treatment. 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
Aim: To study and evaluate the results of Interlocking intramedullary nailing in diaphyseal fractures of tibia.
Materials and Methods: This was a prospective study included patients of both sex and age group between 15-70 year, admitted in the orthopaedic wards with diaphyseal fracture of tibia. All cases were followed for a period of 5 months to 4 years. X-rays were taken at every visit and patient was assessed clinically for fracture union. The results were assessed on the basis of Alho and Ekeland criterias. The functional assessment of the results was done on the basis of Per Edwards, 1965.
Results and Discussion: Following results were observed in our study; excellent (85%), Very good (12%), Good (2%) and Fair (1%). These resuts along with the observed complications are comparable with other studies.
Conclusion: 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.

Keywords: tibial diaphyseal, fractured, economic demands, functional assessment

Introduction
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 communition, 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.
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 [1] 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) [2]. 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) [3]. 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 Gustlio grade I open fractures (Gustiio and Anderson, 1976; Kfemn and Broner, 1986; Court –Brown *et al*, 1990; Hooper *et al*, 1991) [4, 19, 5, 6].

The conventional method used in our hospitals in India is towards closed reduction of displaced tibial fractures and then application of groin-to-to*e* 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) [7, 8].

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.

Aim

To study and evaluate the results of Interlocking intramedullary nailing in diaphyseal fractures of tibia.

Materials and Methods

This was a prospective study conducted during the period of May 2012 to Oct. 2014. This study included patients of both sex and age group between 15-70 year, admitted in the orthopaedic wards with diaphyseal fracture of tibia. All cases were followed for a period of 5 months to 4 years.

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

Initial Management and Resuscitation

The patient was received in the emergency and his vital parameters were recorded & monitored. Associated limb, chest, abdomen and head injury were ruled out. 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. 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. 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 severity 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.

Inclusion Criteria

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

Exclusion criteria

Compound fractures of Tibia, type 3A, Type 3B, Type 3C, according to Gustilo Anderson classification. Patient medically unfit for surgery and 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

Operative Technique (Lottes, J.O., 1954, 1974; Muller, 1990) [9, 10]

In the operation theatre, under anaesthesia, under all aseptic precaution, painting and draping were done. Then a tourniquet

was applied and a pad was placed under the proximal part of the thigh. A 3" long incision was marked on the anteromedial aspect of the tibial tuberosity. The periosteum was incised along the skin incision. The knee was flexed to more than 90°. A quadrangular flap of bone with its proximal base intact was 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 was in turned so as to form a sort of a hood for the head of the IL-naiL to about the underneath it. Keeping the knee flexed, with the help of a curved awl, the window was tunneled to the medullary canal A V-nail was used to further smoothen the passage, if need be. Reaming was done after inserting guide wire by flexible reamer. The IL nail was introduced over guide wire with its eye anteriorly and the slot kept posteriorly. The fracture was close reduced under IITV and the nail was 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. The distal locking of the nail was done as under IITV using the free hand technique. An appropriate length of 4,5mm cortical screw was used for locking. After suturing the periosteum with Vicryl, skin closure was done. Compression bandage was applied and the tourniquet was removed and GT slab applied. The average operating time for close nailing was 45 minutes and 15 minutes for locking under IITV. Cephalosporin antibiotics were continued till suture removal.

Post-Operative Regimen

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

Follow-up and Evaluation

The patient were followed up at 4 weeks, 8 weeks, 16 weeks, 20 weeks, 6 months. X-rays were taken at every visit and patient was assessed clinically for fracture union. The results were assessed on the basis of Alho [11] and Ekeland [12] criterias (Clinical Orthopaedic 231; 205; 1988). The functional assessment of the results was done on the basis of Per Edwards 1965 [13].

Observations and results

In this study**,** 120 patients of fractures leg bones were studied until the final follow up. The following observations were made.

Age and Sex

The study included patients 17 years and above in age. Both males and females were included in the study. 88 patients were male & 32 were female. 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.

Table 1: Age Distribution

S. No	Age Group	No. of patients	Percentage
1,	17-24	18	15
2.	25-34	39	32
3.	35-44	27	23
4.	45-54	20	17
5.	55 and above	16	13

Mode of Injury: Road traffic accidents were found to amount for most of the injuries (73%) as compared to other modes.

Table 2: Mode of Injury

S. No.	Mode of Injury	No. of patients	Percentage
1.	R.T.A.	88	73
2	Fall from height	11	9
3.	Fall on floor/stairs	18	15
4.	Assault	3	3

Type of Fracture (Comminution)

Table 3: Type of Fracture (Comminution)

S. No	Fracture comminution	No. of patients	Percentage
1.	Non comminuted	61	51
2	Mild comminution	37	31
3.	Moderate comminution	14	11
4.	Severe comminution with loose fragments	8	7

Grade of Fracture

Table 4: Grade of Fracture

S. No	Grade of Fracture	No. of patients	Percentage
1	Close Fracture	95	79
2	Compound Fracture	25	21
a	Grade l	20	17
b	Grade ll	4	3
c	Grade lll A	1	1

Of all the 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: Most of the fractures requiring fixation were either in the middle third of the shaft (52%) or distal third (34%).

Table 5: Level of Fracture

S. No.	Level of Fracture	No. of patients	Percentage
1.	Proximal third	17	14
2.	Middle third	62	52
3.	Distal third	41	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 6: Injury Surgery interval.

S. No.	Fixation time after trauma	No. of patients	Percentage
1.	Within 48 hours	54	45
2.	2-7 days	46	38
3.	8-1 5 days	10	8
4.	16-23 days	5	4
5.	24-31 days	2	2
6.	>1 month	3	3

Associated Injuries

Table 7: Associated Injuries

S. No	Injuries	No. of Cases
1.	Contralateral fracture both bones leg	2
2.	Fracture superior rami of pubis	1
3.	Ipsilateral femur fracture	2
4.	Fracture of upper limb Long bones	3
5.	Fracture of skull bones	2
6.	Fracture of cervical spine	1
7.	Fracture of Metacarpal or Phalanx	4

Supplementary Internal Fixation

No supplementary internal fixation was done in the present series. Fibular fracture was also not fixed. Two patients had associated ipsiiatera! 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 6-12 weeks).

Time of Weight Bearing

Table 8: Time of Weight Bearing

No. of Patients	Partial weight bearing	No. of patients	Full weight bearing
17	2 - 4 weeks	89	6-12 weeks
74	4-6 weeks	28	13- 16 week
19	> 6 weeks	3	> 16 weeks

Time of the Fracture Union

The union of the fracture was assessed by standard radiological and clinical criteria (Edwards, [34] 1965; Court Brown *et al* [21] 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, [41] 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

			Weeks 14-16	Weeks 16-18	Weeks 18-20	>20 weeks	Mean
S. No			No. of patients	No. of patients	No. of patients	No. of patients	Weeks
1	Close Fracture	95	34	43	12	6	17
2	Compound Fracture	25	-	-	-	-	-
a	Grade I	20	14	5	0	1	15
b	Grade II	4	2	1	1	0	17
c	Grade III A	1	0	0	1	0	19

Union Time with Level of Fracture

Table 10: Union time with level of fracture

		14-16 weeks	16-18 week	1 8 -20 weeks	>20 weeks	Mean (weeks)
	Level	No. of patients	No. of patients	No. of patients	No. of patients	
1.	Proximal lll	0	19	7	0	17
2.	Middle Ill	8	36	18	0	17
3.	Distal lll	4	20	12	5	19

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.

Complications

Table 11: Post-Operative Complications

S.no	Complications Early		No. of patient
1	Infection Superficial		09
	Deep		01
2	Compartment syndrome		01

3	Neuro vascular injury/ Neuropraxia	01
4	Thromboembolism/ Fat Embolism	01
5	Stiff knee joint	02
6	Implant failure	02
	Delayed	
1	Delayed union	08
2	Mal union	02
3	Non-union	02
4	Shorting Limb >1cm	02
5	Instability	00
6	Poor function	01
7	Hardware failure	
	Nail breakage/Bent nail	02
	Locking bolt breakage	01
8	Deformities	
	Angular	01
	Rotational	01
9	Knee Range of motion	
	<20%restriction of full flexion -	02
	>20%restriction of full flexion -	00
	Ankle Range of motion	
	<25% restriction	04
	25-50% restriction	01
10	Pain	08

A. Implant Failure

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).

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 for 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 12: Final Follow-Up

Criteria	Grade 1	Grade II	Grade III		Grade IV	
	No. of patients	No. of patients	No. of patients		No. of patients	
A	Tibial malalignment and shortening					
	Varus Valgus(degree)	0	1	0	0	
	Shortening(cm)	2	1	0	0	
B	Range of Knee motion					
	Flexion	117	2	1	0	
	Extension deficit	2	0	0	0	
C	Range of ankle motion					
	Dorsiflexon	115	4	1	0	
	Planter flexion	116	3	1	0	
D	Foot motion (as compared to	119	1	0	0	
	normal)					
E	Pain in the limb					
	Ant. Knee Pain	104	11	4		1
	Pain at # site	116	4	0		0
F	Swelling	108	9	3		0

Grade I - Excellent, Grade II -Good, Grade III - Fair, Grade IV - Poor.

Result

Table 13

Result	Percentage of Cases
Excellent	85%
Good	12%
Fair	2%
Poor	1%

Result

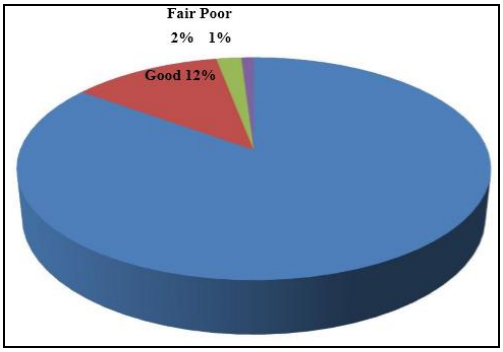

Fig 1

The parameters examined were as follows:-

A. Tibial Malalignment and Shortening

One of the patients treated with interlocking nail had valgus angulation [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 communited 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 possíble ínterventions, short hospitalization and convalescence, and the end result should be comparable with the more complicated methods (Roíf 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 íhe fracture being hígh velocity road traffic accidents. ín our series, 73% of the fractures groups were due to high velocity road traffic accidents. In these accidents, a íremendous 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 availabilííy of the new broad spectrum aníibiotics, 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 nőt 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 applíed patellar tendon bearing cast (Sarmientio 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 funtional brace result an average shortening of 6.4mm, an average angulation of 8.0 and an average unión lime of 5.7 moníhs (Austin RT- Sariento Plaster; 1981).

These days there is a trend towards more use of AO compression osteosynthesis. Thís 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 insuíficient experience (Thunold *et al* 1975). Also open reduction and internál fixation is not tolerated by high energy fractures which are common in the tibia (Bauer *et al* 1962) [7]. Besides, howsoever attractive the possibilties 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 ön 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 complicatíons of opening the fracture. Perfect anatomic reduction and rigid fixation may be achieved by reaming the medullary cavity and inserting a nail with wíde 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 reamíng 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) [14]. Merle D, Aubigne *et al* (1974) first used the method of closed nailing without reaming ín fracture of tibial shaft. Thís 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 b one stabilízation, but when associated with a plaster cast, símplictiy of technique, nearly complete elímination of infecíion, the security it provides ín reduction and immobilizaíion and the superiority of results determines its use in preference to all other methods of treatment of fracture of tibial shaft.

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 techníque vis a vis, operating time and complicaíions; over, Sarmiento's patellar tendon bearing cast in terms of malalígnment and being suitable for unstable fractures; and over conventional conservative treatment by groin-to-toe cast in terms of avoíding joint síiffness, 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 aduíts. 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 (1986) [15]; Court Brown *et al* (1991) [16] series were Grosse-Kempt nail was used ín 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 (1972) [17], Puno ét ál. [18] (1986), Klemn and Borner (1986) [19], Ekeland ét ál. (1993) [12] and Renner *et ál.* (1993) [20]. Used unreamed tibial nail while Court-Brown ét al. (1996) [21] 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.

Author	Nail	Fracture Closed		Gustilo's Type	
			l	ll	lll
Klemn & Borner	Klemn - Schellmann	0.9%	6.4%	-	-
Bone & Johnson	AO Grosse-Kempf	4.4%	4.7%	10.5%	25.0%
Court Brown ét al	Grosse- Kempf	1 .8%	3.8%	9.5%	-
Our Series	Various	4%	12%	8%	-

In our series 9 patients (7.5%) had superficial wound infection of the proximal incísion síte. This responded to the usual oral antibioíics 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 wiíh the above three studies. Nine cases had superficial infection. Of these 3 cases was Gustilo's grade l and 2 was grade II. The injury surgery interval in two of these cases was 7days 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 wiíh a proper antibiotics cover is a must when considering a case of compound tibial fracture for nailing.

Sir Watson Jones (1982) [2] 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 fór about 16 weeks when abundant callus was not visible in the skiagram and the patient had persistent tenderness over the fracture site. Phemister boné 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 nőt 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 díameter, well-fitting nail shouid be used in all cases. Puno at

al [18] (1986) analysed the incidence of delayed union/nonunion in tibial fracturs treated by intra medullary nailing and cast treatment. The results were:

	No. of patients	Avg. Union Time (Weeks)	NonUnion & Delayed Union (%)	Mal Union (%)
Intra medullary nailing	17	15.19	1.7	0
Cast treatment	124	23.46	9.9	4.3
Our series	120	17.0	09	1.5

Oleurd and Karlstrom (1972) [17] used compression plating for their study and reported nonunion/delayed union rate of 3.73% Melher (1993) [22] used AO unreamed tibial nail and reported a case of non unión (5%). Court Brown *et al*. (1996) [21] did a comparative study of reamed and unremed tibial nails and reported 20% incidence of nonunion 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 Compíications

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.

Author	Technique	Union Time(Average)	Range
Present Series	Closed interlocking naíling	17wks	14-32wks
Edward [8, 13] series	Closed IM nailing	75% fracture ín 16 wks	
Puno *et al*. (1986) [18]	Closed iníeríocking Vs	10-8wks (Nail)	
	Casting	16.8 wks (Cast)	
Ekeland *et al*. (1988) [12]	Closed ínlerlocking naíl	16 wks	8-40 wks
Bra'dford Henley (1989) [23]	Closed interlocking nail	22 wks	12-36wks
Melcher *et al*. (1993) [22]	Closed interlocking nail	65% ín 16 wks	
		30% Ín 32 wks	
'Court Brown	Closed	22.8 wks	12-35 wks
et al. [21] (1996)	interlocking nail	(Unreamed)	11-25 -wks
	Reamed V/s Unresrned	15.4 wks(reamed)	

Healing was judged to have occured when the fractures was clinically stable and díd not elicit pain on palpatíon 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) [21] showed shorter union time wiíh reamed nails (15.4 weeks) than unreamed (22.8 weeks). The unión time of present seríes 17 wks is comparable with the above series.

Fifteen of our cases had associated fractures. Anderson *et al* (1974) [4] 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 [15] 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) [21] made a prospective study in 50 cases and concluded that reamed is better than unreamed nailing in tibial closed fractures.Blachut *et al*. [24] 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 healingwas 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*. [25] (2008) conducted a multicenter, blinded randomized trialof 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* [26] 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* [27] 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*. [28] 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 Paratendinuous approach was used and on the medial facet with a Transtendinuous 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 from1.30 min to 5min. Kwang *et al*. [29] measured the radiation exposure during femoral nailing and the total duration of the fluoroscopy averaged fiveminutes (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 iníerlocking nails.

1. Joínt 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 tó ischemic muscle damage i.e. compartment syndrorne (Ellis, 1958; Karisírom and Oierum 1974) [30] őr other associated injury át the ankle.

2. Muscle atrophy

There was no diffrence 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 communition. Sarmiento [31] (1967)-Average shortening- 1.5cm. Ekeland *et al*. [12] (interlocking nailing) shortening of 1cm - 3 cases while 2 cm - 1 case. Melcher *et al*. [22] (ínterlocking 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 angulaiion of 5° őr more.

Final Result

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

Author	Technique	Excellent-	Fair-Poor
Present Series	Closed Ínterlocking nailing	97%	3%
Edward[8] series (1965)	Closed intramedullary nailing	85%	15%
Olerud & Karlstrom [17]	Compression platíng	91%	9%
Puno ét ál. [18] (1986)	Closed Ínterlocking nailing Vs	98.3%	1 .7%
Klemn and Broner [19]	Closed Ínterlocking nail	94.3%	6.7%
Ekoland ét ál. [12] (1988)	Closed interlocking nail	94%	6%
Melcher ét ál. [22] (1993)	Closed ínterlocking nail	85%	15%

Court Brown *et al*. [21] (1996 reported excellent result of reamed interlocking nail (percentages were not mentioned). Olerud and Karisfrom's series [17] (1972) represented AO-compression plate method which required technical expertíse and complications were due to technical faiíures (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 [17], 1972 and 1976).

On the other hand, closed unreamed interlocking tibial nailing gives favourable end result funtionally and anatomically.

Conclusion

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.

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