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A study of management of tibial diaphyseal fractures with intramedullary interlocking nail: A study of 50 cases

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Abstract
Introduction: Tibia is the most commonly fractured long bone in the body. 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 mal-union, stiffness of the joint, and poor functional outcome. Closed Tibial diaphyseal fractures have been internally fixed with Plates or with Intramedullary fixation devices like centromedullary nails (K-nails, V-nails), Interlocking intramedullary nails (Reamed or Unreamed). Interlock nailing has proven to be the method of choice with advantages of early stabilization, early mobilization, with high union rates, less infection rate and implant failure.
Objectives: Aim of the current research was to study diaphyseal fractures and to assess functional outcome of patients with tibial shaft fracture treated with intramedullary interlocking tibial nail.
Materials and Methods: A prospective study of 50 patients presenting with tibial diaphyseal fracture at Tertiary Care Hospital were admitted and evaluated from May 2011 to July 2013. Patients fulfilling our inclusion criteria and were included in the study and treated with intramedullary interlocking tibial nail. An Alho and Ekeland[1] criterion was used to assess the functional outcome.
Results: The results of interlocking nail for fracture diaphyseal tibia were excellent in 40 patients (80%), good in 7 patients (14%) fair in 2 patients (4%) and poor in 1 patient (2%). The average healing time was 23.48 weeks. In our study valgus/valgus angulation deformity of $<5^0$ were noted in 3 patients and in one patient anterior/posterior angulation was noted less than 5^0. There was 1 superficial infection (2%), 8 patients had delayed union (16%), 4 patients had mal-union (8%), 1 patient had non-union (2%) and 1 patient had shortening of <2 cm due to comminuted fracture (2%).
Conclusions: Fracture diaphyseal tibia is seen in high velocity injury like road traffic accident and it commonly affects younger population. Tibial intramedullary interlocking nailing has advantages as it preserves periosteal blood supply, maintains length, rotation, alignment, lowers the infection and mal-union. Closed internal fixation with intramedullary interlocking tibial nail is a standard surgical procedure for management of tibial diaphyseal fractures. The advantage of rapid rehabilitation and relatively few complications serve to recommend it for wider use.

Keywords: Closed nailing, interlocking, diaphyseal fractures of tibia
Abbreviations: R.T.A – Road traffic accidents; OG – Open Grade

1. Introduction
As industrialization and urbanization are progressing year by year with rapid increase in traffic speed, incidence of high energy trauma are increasing with the same speed. Fractures of the tibial shaft are important for the reason that they are common. The exposed superficial anatomical location of the tibia makes it vulnerable to the direct blow and high energy trauma as a result of motor vehicle accidents. This may result comminuted fractures, which are frequently open with significant loss of skin and soft tissues.
In contrast to the rest of appendicular skeleton, tibia has precarious blood supply due to inadequate muscular envelope especially distal third. Tibial fractures may be associated 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.
However, the treatment for unstable closed tibial fractures has continued to evolve.

Intramedullary nailing, Compression plating and external fixation have been used in treatment of these fractures. The intramedullary nailing, locked or unlocked has become an attractive option since image intensifiers have made closed intramedullary nailing possible. Interlocking nail is a load sharing device and is stiff to both axial and torsional forces. So currently, interlocking nail is considered the treatment of choice for closed and most type I, type II, type IIIA open tibial shaft fractures. It preserves soft tissue sleeve around fracture site allows early motion of adjacent joints. Locking of nails proximally and distally provides control of length, alignment and rotations in unstable fractures. Closed nailing involves least disturbance of soft tissue, fracture hematoma and natural process of bone healing as compared to other forms of internal fixation. Insertion of tibia interlocking nails using reamed or undreamed technique seems to be acceptable mode of treatment for displaced tibial diaphyseal fractures.

2. Aims and Objectives

1. To study the method of intramedullary interlocking nailing
2. To evaluate the results of intramedullary nailing in terms of:
a. Time required for the union
b. Range of motion of Knee and Ankle joint
c. Rate of union
d. Any complication encountered
3. To study clinical outcome of intramedullary interlocking nailing in terms of:
a. Average immobilization period
b. Range of motion
c. Status of union

3. Materials and Methods

This study was carried out at Tertiary Care Hospital from May 2011 to July 2013, inclusive of both with sequentially selected 50 cases.

3.1 Study type: Observational Prospective Type.

3.2 Inclusion Criteria

- It includes patients of age between 18 – 70 years.
- Acute fractures of diaphysis of tibia.
- Open grade 1, 2 and 3A fractures (Gustilo-Anderson type) and Closed fractures.
- Segmental fractures and Comminuted fractures.

3.3 Exclusion Criteria

- It excludes patients of age less than 18 years.
- Open Grade 3B fractures (Gustillo-Anderson).
- Pathological fractures, fracture non-union and delayed union.
- Patients not willing or medically unfit for surgery.

3.4 Primary & Pre-operative Management

Patients satisfying the selection criteria were identified after emergency management as per ATLS protocol in the casualty. History taking, general examination and local examination were conducted in the trauma care centre. Once stabilized, relevant X-rays were asked for. Necessary investigations for surgical fitness were conducted. Closed fractures with edema were splinted and regular calf girth charting was done with oral proteolytic enzymes, intravenous antibiotics and limb elevation. Surgery was done after swelling subsided. The closed fractures were operated as soon as the fitness for anesthesia was obtained. Open fractures were dressed daily after primary thorough debridement. Once the wounds healed surgery was planned.

3.5 Surgery

All surgeries were done under image control on plain table in supine position.

3.6 Postoperative regime

The patient was immobilized with an above knee posterior slab and care was taken to prevent dependent edema of limb. Intravenous antibiotics were given for first 3 days followed by oral antibiotics in closed fractures. However in open fractures intravenous antibiotics were given till trauma wound showed signs of healing. A post-operative X-ray was advised when the patient could be shifted comfortably, usually after 48 hours of surgery. Depending on the post-operative fracture stability and pain tolerance of the patient, quadriceps strengthening exercises, knee and ankle mobilization exercises and non-weight bearing-crutch walking were started. After suture removal between 10-15th day, the patient was discharged with either partial or non-weight bearing-crutch walking depending upon the stability of the fixation.

3.7 Data collection, Follow-up & Evaluation:

Data related to demographics, mechanism of injury, details of trauma, hospitalization detail, operation description, post-operative rehabilitation, complications, clinical and functional outcome were collected during the period of hospital stay and follow up visits in the Outdoor clinic. Follow up was conducted regularly at the interval of 4 weeks. The patients were followed up in the outpatient department. At the time of follow up a thorough clinical evaluation was done for progress of union, healing of trauma wound and joint stiffness. Once the fracture had shown early signs of union, partial weight bearing was started on the injured limb. On follow up the patients were evaluated according to Alho and Ekeland[1] Score.

3.8 Statistical Analysis: Descriptive statistical methods and expression of results in terms of mean, chi-square test and others using Microsoft excel software with significant p value <0.05 were used for computation of data.

4. Results

- A sample size of 50 (42 male, 8 female) patients were selected to evaluate Tibia diaphyseal fractures.
- Majority (23) of the patients were in the age group 18-30 years (Range 18-70 years).
- The predominant cause of trauma was a road traffic accident (66%) followed by fall (26%) and Assault (8%).
- We had 14 cases of open fractures (OG I, II and IIIA).
- We had 35 cases of Right side injury while Left side was involved in 15 patients.
- 15 patients had associated injuries sustained during trauma which could have directly or indirectly influenced the functional outcome of the patients.
- The predominant fracture pattern was transverse (19 cases - 38%), followed by oblique (14 cases - 28%), spiral (5 cases - 10%) and comminuted (12 cases – 24 %).
- Majority of fractures occurred at distal third of tibia (32 cases - 64%) followed by middle third (11 cases – 22%) and proximal third of tibia (7 cases – 14%).
- In our study most of the cases were associated with fibula fracture (80%).
- Average time period from injury to surgery was 3.0 days.
- In all cases midline patellar tendon splitting approach was used for nail insertion site. Reamed closed intramedullary interlocking nailing is done in all the cases. In three cases

there was guide wire bending during nail insertion. In two cases drill bit was broken, while drilling the hole. Our mean operating time was 90 minutes (Range 60 min to 90 min).

- Females required smaller sizes of nail 8mm and 9mm and males required larger than females 10mm. Female required less length nail (less than 340mm) and males required more length nail (>340mm). Reamed closed intramedullary interlocking nailing was done in all the cases.
- All the patients were mobilized post operatively as early as possible depending upon the fracture stability, general condition, associated injuries and tolerance of the patient. All patients were mobilized on next day except 1 case having ipsilateral shaft femur fracture and 1case of polytrauma. In most of the patients PWB started on 21 to 30 days postoperatively (76%). 34 (68%) patients were commenced to protective FWB at 8 to 12 weeks postoperatively. Dynamization of the nail was done in two patients usually between 8-12 weeks.
- Out of 50 patients, 49 fractures united. The time to union ranged from four to nine months, with an average of 5 months. 41 fractures healed before 20 weeks, and 8 fractures healed between 24 weeks to 30 weeks.
- Out of 50 cases, 40 cases (80%) had excellent results. 7 cases had good results (14%), 2 cases had fair (4%) result. 1 case had poor results. 40 patients (80%) were pleased, 8 patients (16%) were satisfied and 2 patients (4%) were unhappy with surgery.
- In Three patients, varus/valgus angulations were noted less than 5^0. In one patient, anteroposterior angulation was noted less than 5^0. Shortening noticed in one patient which was less than 2 cm because of comminuted fracture. One patient developed superficial infection. This healed with oral antibiotics and fracture was united. In our study 14 patients (28%) noticed pain at the knee joint and 11(22%) patients noticed pain at the ankle joint.
- In 96% of the patients, knee flexion was 120^0 and above. None of the patients had any extension leg. Only two patients had mild restriction in terminal flexion. In 92% of cases had ankle dorsiflexion $>20^0$ while 96% had planter flexion $>30^0$ i.e. full range. And 2% of the Patients had restriction of ankle motion.

5. Discussion

In this era, high velocity trauma and industrial accidents lead to increased number of diaphyseal tibia fractures and Fractures of the tibia are the commonest among the major long bones fractures. The aim of the study was to evaluate the results of closed interlocking nailing in tibial diaphyseal fractures. The treatment programme of these fractures should ensure a low incidence of complications; it should require minimum possible interventions, short hospitalization and convalescence, and the end result should be comparable with the other studies.

Very often, these fractures are open owing to the subcutaneous location of the tibia. Due to the availability of the new broad spectrum antibiotics, the 6 hours "golden-period" can now safely be extended for open fractures. This gives the treating surgeon adequate time to plan and tailor a suitable treatment regimen for a patient. Closed reduction preserves fracture site haematoma hence fracture unites by indirect healing. Chances of infection are very less in this method as soft tissue around fracture is undisturbed. Reaming prepares the canal into uniform diameter for proper fitting of nail. Interlocking nail with screws maintains axial length and rotation of fracture fragments.

The commonest cause of the fractures remains high velocity road traffic accidents. In our study, 66% of the fractures groups were due to high velocity road traffic accidents. Also, all grades of comminution are encountered. About 24% of the tibial fractures in our study were comminuted ranging from mild to severe grade. These cases were of different age groups, occurred in both sexes, and the fracture were of different types and at different levels.

The average age of all cases in this series was 27 years. The fracture was more common in the age group of 18-30 years. The average age in a study of 50 fractures of tibia conducted by Whittle *et al*., [60] showed that the average age was 34 years. There were 42 male and 8 female patients showing male predominance. This was comparable to Bonatus *et al*. [8] Duwelius *et al*., [22] and Singer and Kellam study [50].

Majority of the cases sustained fractures from road traffic accidents. 13 patients had sustained fracture due to fall and four patients had fracture due to assault. Among R.T.A. 66% was most common mode of injury in present series. This was similar to Court-Brown study [18] which showed 66.6% of fractures of diaphyseal tibia were due to R.T.A. and 33.4% due to fall.

Out of 50 patients, 49 had union. The time to union ranged from four to nine months, with an average of 5 months. 41 fractures healed before 24 weeks, and 8 fractures healed between 24 – 30 weeks. Healing was judged to have occurred when the fracture was clinically stable and did not elicit pain on palpation or manual stress Henley [27]. **(**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*. [63] compared closed nailing with conservative treatment and observed average union at 15.19 weeks and 23.46 weeks respectively. All the fractures in our series united with an average time interval of 20 weeks. We believe that reaming helps to shorten union time. This has been supported by other studies also. Bone LB and Johnson KD [9] in one of the earliest large series of interlocking 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) [18] made a prospective study in 50 cases and concluded that reamed is better than undreamed nailing in tibial closed fractures. Blachut *et al*. [7] concluded that there is a higher prevalence of delayed union and breakage of screws after nailing without reaming. Larsen *et al* (2004) [34] studied 45 patients and concluded that the average time to fracture healing was 16.7 weeks in reamed group and 25.7 weeks in the unreamed group. The difference was significant (P=0.004). In our study 8 fractures had delayed union, which were comminuted, and mostly located at distal one third. In seven patients, no any treatment required for union and in one patient dynamization was done which united at 28-30 weeks. One patient having spiral fracture located at distal third of tibia had non-union was lost to follow up. No percutaneous bone grafting required in any patients. Puno at al., (1986) [63] analysed the incidence of delayed union/non-union in tibial fractures treated by intramedullary nailing and cast treatment and proved 2% non-union with nailing compared to cast treatment (9%). Oleurd and Karlstrom (1972) [64] used compression plating for their study and reported non-union/delayed union rate of 3.73%. Melher (1993) used AO unreamed tibial nail and reported a case of non-union (5%). Court Brown *et al*. (1996) [18] did a comparative study of

reamed and unreamed 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 study.

In current study no failure of implant was observed. The results are assessed on the basis of Alho and Ekeland [1] criteria. The parameters examined were as follows:-

(A) Tibial Malalignment and Shortening

In Three patient varus/valgus angulations were noted less than 5^0. In one patient anterior/posterior angulation was noted less than 5^0. Shortening noticed in one patient, which was less than 2 cm because of comminuted fracture.

(B) Range of Knee Motion

One of the essential aspects of closed reduction and internal fixation with interlocking intramedullary nailing is the ability to mobilize the patient early. 48 patients were mobilized by active knee bending and quadriceps exercises were initiated after patient came out from anaesthesia. Mobilization was delayed in 2 patients because of associated injuries. 96% of the patients had knee flexion 120^0 and above. None of the patients had any extension leg. Only two patients had mild restriction of motion.

(C) Range of Ankle Motion

92% of the patients had ankle dorsiflexion >20 degree while 96% had planter flexion >30 degree i.e. full range. And 2% of the patients had restriction of ankle motion.

(D) Range of Foot Motion

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

(E) Pain

In our study 14 patients (28%) noticed pain at the knee joint and 11(22%) patients noticed pain at the ankle joint which was tolerable or occasionally needed oral analgesic.

(F) Swelling

About 8 of the patients had minor swelling around ankle and foot which gradually subsided with mobilization and was never significant to become worrisome to the patient.

Patient satisfaction: 40 patients (80%) were pleased, 8 patients (16%) were satisfied and 2 patient 4% was unhappy.

Table 1: The Results of Reamed Intramedullary Nailing In the Treatment of Diaphyseal Tibial Fractures

Authors	No. of Patients	Union (Weeks)	Infection (%)	Nonunion (%)	Malunion (%)
Court-Brown *et al*.,[18]	25	15.4	0	0	0
Blachut *et al*., [7]	73	18	2	4	4
Bone *et al*., [9]	47	18	0	2	2
Present study	50	20	2	2	8

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

Table 2

Author	Technique	Excellent-Good	Fair-Poor
Present study	Closed interlocking nailing	94%	6%
Edward series (1965)	Closed intramedullary nailing	85%	15%
Olerud &Karlstrom(1972) [64]	Compression plating	91%	9%
Puno *et al*[63] (1986)	Closed interlocking nailing Vs casting	98.3%	1.7%
Klemn and Broner(1986)	Closed interlocking nail	94.3%	6.7%
Ekoland *et al* (1988)	Closed interlocking nail	94%	6%
Melcher *et al* (1993)	Closed interlocking nail	85%	15%

Court Brown *et al* [18] 1996 reported excellent result of reamed interlocking nail. Olerud and Karisfrom's [64] series (1972) represented AO-compression plate method which required technical expertise and complications were due to technical failures (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 Karisfrom, 1972 and 1976) [64].

But Interlocking nail is not free of disadvantages as closed reduction is technically demanding. It needs C-arm guidance for reduction. Reaming may destroy endosteal blood supply.

6. Conclusion

Fracture shaft of tibia are commonly seen in road traffic accident and are common in young people. Closed intramedullary interlocking nailing is feasible in fracture of shaft of tibia. Image intensifier has revolutionized the treatment of tibial shaft fractures by making the technique easier. The present study shows that closed fractures of the diaphyseal tibia managed with interlocking intramedullary nailing involves minimal surgical trauma and negligible blood loss. It provides the advantages of early ambulation, lower rates of infection, delayed union, non-union and malunion compared to other treatment modalities. To achieve these goals, we recommended early stabilization with reamed interlocked nail. Fracture should be dynamized at 8 –10 weeks, if union does not progress to prevent the unwanted complication of non-union or delayed union. A significant advantage of interlocking in addition to early joint motion, early weight bearing allows earlier return to work. In our study we found that reamed interlocking nailing in fractures of tibial shaft is feasible as showed excellent and good results in 94% patients with minimal complications.

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