

Comparative Study of Middle Third Tibial Shaft Fractures with Reamed vs. Unreamed Interlocking Nailing

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ABSTRACT

BACKGROUND

Tibia is the most commonly fractured long bone, because of the exposed anatomical location which makes it vulnerable to the direct blow and high energy trauma as a result of vehicle accidents resulting in fractures. We wanted to compare the surgical management of middle third tibial shaft fracture and the time taken for union of fractures after reamed and unreamed nailing for tibial fractures.

METHODS

All confirmed cases of fracture shaft of tibia were taken up for the study. 30 cases including both males & females were studied. Cases were also followed up at an interval of 6 weeks, 3 months and 6 months which extended up to October 2020. Results were evaluated every 4 - 6 weeks from the date of discharge.

RESULTS

There was no significant difference in union rate and union time between reamed and unreamed nailing. Highly comminuted fracture pattern may be the cause of malunion. In our study, infection was the cause of delayed union of proximal end of nail prominence above cortex which is the major cause for anterior knee pain. 86% of patients in the reamed group had excellent results whereas only 66.6% had excellent results in the unreamed group; 6% of patients in the reamed group and 20 % of patients in the unreamed group have good results.

CONCLUSIONS

Overall functional results are good with closed reamed intramedullary interlocking nailing compared to unreamed interlocking nailing.

KEYWORDS

Reamed Intramedullary, Unreamed Interlocking Nailing, Functional Results

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BACKGROUND

As industrialization and urbanization are progressing year by year with rapid increase in traffic, incidence of high energy trauma is increasing with the same speed. The tibia is the most commonly fractured long bone, because of the exposed anatomical location which makes it vulnerable to the direct blow and high energy trauma as a result of vehicle accidents resulting in fractures.

In contrast to the rest of appendicular skeleton, tibia has precarious blood supplies due to inadequate muscular envelope. The presence of hinge joints at knee and ankle, allows no adjustment for rotatory deformity after fracture. The optimum method of treatment remains a subject of controversy. Among the various modalities of treatment such as conservative gentle manipulation and use of short leg or long leg cast, open reduction internal fixation with P&S, intramedullary fixation and external fixation. Surgeon should be capable of using all these techniques and must weigh advantages and disadvantages of each one and adapt the best possible treatment.

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.¹ Open reduction and internal fixation with Plate and screws has yielded unacceptably high rates of infection.² This method may be selected with more severe injuries associated with displaced intra-articular fractures of knee and ankle.

External fixation considered the treatment of choice by many traumatologists, has the disadvantage of bulky frames and frequent pin tract infections, non-unions and malunion.³ The intramedullary nailing, locked or unlocked has become an attractive option since image intensifiers have made closed intramedullary nailing possible.

Nail is a load sharing device and is stiff to both axial and torsional forces. Intramedullary nails such as Lotles and Enders nails, used without reaming have been employed successfully in the treatment of open tibial fractures and have been associated with low rates of postoperative infection. They are however contra- indicated for comminuted fractures, as there tends to be shortening, or displacement of such fractures around these small nails. Locked intramedullary nailing currently considered the treatment of choice for most type I, type II, type IIIA open and closed 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.⁴ Closed nailing involves least disturbance of soft tissue, fracture hematoma and natural process of bone healing as compared to other forms of internal fixation. We studied about Surgical management of middle third tibial shaft fractures in adults by reamed versus unreamed intramedullary interlocking nailing.

METHODS

All confirmed cases of fracture shaft of tibia in Department of Orthopaedics of Kakatiya Medical College and MGM Hospital, Warangal, admitted between September 2017-October 2020 was taken up for the study. 30 cases including both males & females were studied. Cases were also followed up at an interval of 6 weeks, 3 months and 6 months which extended up to October 2020. At 80% power of the study, with 20% of allowable error and taking the p value significant at 0.05, with prevalence of 16.9 tibial fractures.

In present study, sample size was taken as 15 (which is above 14) in each group with a total of 30 tibial fracture patients. After obtaining a written informed consent patients were enrolled for the study and were allocated into one of the two groups. Simple random sampling by "Computer generated sequence method" was done to allocate the patients into 2 groups. The two groups were as follows as per surgery conducted.

Reamed Group

Closed reduction and interlocking nail by reaming of tibia.

Unreamed Group

Closed reduction and interlocking nail without reaming of tibia.

Inclusion Criteria

- Patient who has been diagnosed as fracture shaft of tibia.
- Age group of more than 20 years of and less than 70 years of either sex.
- Patient who are fit for surgery.

Exclusion Criteria

- Skeletally immature individual.
- Open fractures of shaft of tibia.
- Neurovascular injury.
- Pathological fracture.
- Non-union.
- Segmental fracture.
- Associated metaphyseal fracture or intraarticular fracture.

On admission general condition of the patient was assessed with regards to hypovolemia, associated orthopaedic or systemic injuries and resuscitative measures taken accordingly.

All patients received analgesia in the form of IM and antibiotics IV for open fractures. A thorough clinical examination was performed including detailed history relating to age, sex, occupation, mode of injury, past and associated medical illness.

The limb was immobilized in the form of above knee plaster of Paris posterior slab. Limb elevation over a pillow was given to all patients.

Routine investigations were done for all patients. All patients were 46 evaluated clinically and radiologically to assess injuries. X-rays were taken in two planes: AP view and lateral view. Patients were operated as early as possible once the general condition of the patient was stable and was fit for surgery. Preoperatively the length of the nail is calculated by measuring from just above the tibial tuberosity to the medial malleolus. Medullary canal is measured at the isthmus on X-ray for nail diameter. Accordingly a stock of interlocking nails 2 cm above and below the measured length and 1 mm above and below the required diameter were kept.

Preoperative Preparation

1. Patients were kept nil per oral for 8 to 10 hours before surgery.
2. Preparation of whole extremity/private parts and back was done.
3. Written informed consent was taken.
4. Soap water enema.
5. Tranquilizers.
6. IV antibiotics at night and 30 min before surgery in the morning.
7. Adequate amount of compatible blood if needed was arranged.

Surgical Technique

Patients were operated under spinal/general anaesthesia. Patient is placed in supine position over a radiolucent operating table. The injured leg is positioned freely, with knee flexed 90 degrees over the edge of operating table to relax the gastrosoleus muscle and allow traction by gravity. The uninjured leg is placed in abduction, flexion and external rotation to ensure free movements of the image intensifier from A.P. to lateral plane. The table is adjusted to a comfortable operating height.

AO pneumatic tourniquet/Esmarch rubber tourniquet was used in all patients. The affected limb is thoroughly scrubbed from mid-thigh to foot with Betadine scrub and savlon. Then limb is painted with betadine solution from mid thigh to foot. Rest of the body and other limb is properly draped with sterile drapes. Sterile gloves are applied to the foot and sterile-drape over the leg from knee joint to ankle.

Determination of Nail Length

Hold the radiographic ruler parallel to the tibial shaft of the uninjured leg in such a way that the proximal end comes to lie at the level of the insertion point. Mark the skin at the appropriate point. Position the image intensifier over the distal tibia. Align the measuring rule at the skin marking with correct reduction, we can now read off the required nail length on the image intensifier picture at the level of former epiphyseal cartilage. In another way to measure the length

of nail is if using the Hollow and Tubular nails, the exposed length of the guide road and subtract this from its total length of 950 mm.

Determination of Nail Diameter

The marking on the radiographic ruler may be used to determine the diameter of the medullary canal. Position the square marking over the isthmus. If the transition to the cortex is still visible both to the left and right of the markings, the corresponding nail diameter may be used.

Make a vertical patellar tendon splitting incision over skin extending from central of the inferior pole of patella to the tibial tuberosity about 5 cm long. Split the patellar tendon vertically in its middle and retract it to reach the proximal part of tibial tuberosity. Next step is to determine the point of insertion, essential for the success of the procedure is the correct choice of the insertion point. As a general rule, the insertion point should be slightly distal to the tibial plateau, slightly medial and exactly in line with the medullary canal. If the insertion point is too distal, there is a danger of fracturing the distal cortex of the main proximal fragment. On the other hand, inserting too far proximally bears the risk of opening the knee joint, patella comes in the way of zig or removal of nail may be difficult. After selecting the point of insertion curved bone awl is used to breach the proximal tibial cortex in a curved manner, so that from perpendicular position its handle comes to be parallel to the tibial shaft. In the metaphyseal cancellous bone create an entry portal, in line with the center of medullary canal.

Point of entry is widened with curved tibial awl. After widened the medullary canal of proximal 1/3, the ball tip guide wire of 3 mm diameter x 950 mm length passed into the medullary canal of proximal fragment and reduce the fracture fragments under image intensifier by maintaining longitudinal traction in the line of tibia. After reduction, the tip of guide wire adjusted to pass in the distal fragment upto 0.5-1 cm above the ankle joint under image intensifier. Confirm its containment with in the tibia by anteroposterior and lateral views. Next step is to ream the medullary canal. Remaining is done with the help of flexible reamps. Normally we start from 8.5 mm and increase by increments of 0.5 mm. The medullary canal is reamed 1 mm more than the diameter of measure dististhmus an X-ray lateral view.

Procedure for AO Intramedullary Interlocking Nailing

Insert the connecting screw through the insertion handle and coupling block then screw this assembly into the proximal end of the selected nail. Ensure that the notches of the insertion hand fit into the grooves of the coupling block. The coupling blocks ensure a torque-resistant connection between insertion handle and nail. The insertion handle guides the nail and control rotation during insertion. Applied the insertion handle to the medial side of the tibial for insertion and proximal locking. Tighten the whole assembly with combination wrench. Checked that the assembly is firmly screwed together. Over tightening was not done.

Screw the inserter/extractor onto the proximal end of the connecting screw. Now introduce AOIMN manually into the medullary canal with the help of the mounted insertion instruments. Used the image intensifier to check passing of the fracture line. Insertion can be aided by gentle blows with the slotted hammer. Insert the nail until it is slightly counter sunk in the bone. Confirm the placement of nail in-situ under image intensifier in both AP and lateral planes. Routinely we prefer proximal locking carried out first, but if gap present at the fracture site we carried out distal locking first, it enables the use of the rebound technique to prevent diastasis.

The insertion handle is used to locate the holes for proximal locking bolts. The insertion handle of the insertion instrument is in the medial position. The skin is incised insert the trocar into the protection sleeve and push it down onto the insertion handle. Remove the trocar and insert the drill sleeve. To prevent the drill bit from sliding off the tibial surface, ensure that the drill guide is sitting firmly on the bone and is not deflected by skin or soft tissue. Drill through both cortices using the drill bit. Determine the required length of the locking bolt by reading it directly by measuring with the depth gauge. We added 2 mm to the measurement found so that the bolt can find purchase in the opposite cortex.

Insert the locking bolt with the hexagonal screw drive. Inserted the second locking bolt in the same way. After screwing the insertion handle off (AOIMN) insert the sealing screw into the proximal end. This prevents in growth of tissue and thus facilitates later implant removal. Incised wound washed with betadine and normal saline, patellar tendon sutured with absorbable sutures and skin is sutured. Next step is distal locking, several distal locking options are available to the surgeon. Using free hand technique with an image intensifier provides a convenient method for targeting the distal locking holes.

The leg is extended over the table from its flexed position. In the AOIMN, three distal locking holes present two medial lateral plane and middle anteroposterior plane. In our study all cases we locked anteroposterior hole. The image intensifier is placed in the anteroposterior position with the beam exactly at anterior aspect of the tibia with foot in neutral position. Adjust the image intensifier until the distal hole is clearly visible and appears completely round.

Place a scalpel on the skin with the top of the blade over the center of the hole to determine the stab incision point. Make a stab incision in addition, it also ensures that the surgeon's hand remain outside the central radiation field of the image intensifier. Place the tip of the 2.5 mm 'K' wire cantered in the locking hole image. Adjust it until the K wire is in line with the X-ray beam and appears as radio opaque solid circle in the center of the outer ring, hit the K-wire into the bone. The drill sleeve passed over the K wire holds sleeve firmly over the bone. The K wire removed and hole drilled though both cortices with drill bit. Measure the hole with depth gauge for locking bolts. Add 2 mm to this reading to ensure that the locking bolt will engage the far cortex. Insert the locking bolt and tighten with the hexagonal

screwdriver. Position of the screw is again confirmed under image intensifier. The entire leg and the fracture site. Visualized finally in both views for the proper placement of nail. Incised wound is washed with betadine and normal saline skin is sutured. Sterile dressings applied over the wound. Compression bandage given. Tourniquet is deflated. Capillary filling and peripheral arterial pulsations checked.

RESULTS

The present study includes 30 patients with fractures of tibial shaft surgically treated with closed intramedullary interlocking nailing for one year.

Young age in 20-29 years are most common group in study. Majority of patients (66%) are males. The remaining 34% patients are females. The most common side is left in this study (16; 53.33%). In our study, motor vehicle accident was the major cause for tibial fracture and it constituted 76% of cases. Second common mode of injury was fall from height and it was 14%. And third type was pedestrian hit by motor vehicle and it was 10%.

In our study, head injury was the common associated injury. Another patient had bilateral fracture tibia. He was also treated with nailing. One patient had fracture clavicle, treated conservatively. Proper evaluation and treatment of head injury was done. Patients were posted for surgery after head injury treatment and once they are fit for operation.

Most of the patients in our study were operated within one week of trauma. For associated head injury patients (3 cases) operation was delayed for 2 to 3 weeks. Thirty cases were operated under sub-arachnoid block (spinal anaesthesia) and 10 cases under general anaesthesia.

In all cases fracture table is used and Tourniquet is also used. Under C-arm guidance fracture reduction and distal locking was done. In our study 34 cm nail size (length) is commonly used (in 20 cases). No 9 mm is commonly used diameter of nail (in 22 cases). Depending upon the fracture pattern, comminution, fitting of nail into medullary cavity locking was done. In 18 cases static locking was done. Screws were applied both proximally and distally. In 22 cases dynamic locking was done. Only one screw was applied either proximal or distal. Proximal locking was done in medio-lateral direction. Distal locking was done in antero-posterior direction. In only 2 cases double proximal bolts were applied. In 6 cases double (2) distal bolts were applied. Our mean operation time was one hour (range 45 to 90 minutes).

PWB (Days)	Reamed	Unreamed
6 weeks	12	11
10 weeks	3	2
12 weeks	0	2
Total	15	1
Commencement of full weight bearing		
12 weeks	14	11
14 weeks	1	2
16 weeks	0	2
Total	15	15

Table 1. Commencement of PWB and Full Weight Bearing

In our study most of the cases are mobilized (non-weight bearing crutch walking) on next day after operation. Majority of our patients, 26 out of 30 (72%), 12 in the reamed category and 11 in the unreamed category started partial weight bearing (PWB) within 6 weeks. Three patients out of 15 (14%) patients in the reamed nailing and two patients in the unreamed nailing started PWB at 10 weeks. In these patients PWB was delayed because stability of fixation was not good. Two patient in our study in the unreamed nailing started PWB after 12 weeks as patients had deep infection. So they were treated with IV antibiotics and above knee posterior slab application till infection healed so PWB was delayed.

Most of the patients (25, 83%) in our study commenced protective FWB at 12 weeks after evidence of healing was seen. Three patients (8%), one in the reamed category and two in the unreamed category commenced FWB after 14 weeks. In these three patients, there were no signs of union radiologically and clinically. So FWB was delayed. Two patients had deep infection both in the unreamed category and for them as partial weight bearing was delayed full weight bearing was delayed till radiological evidence of healing was seen

Weeks	Reamed Nailing		Unreamed Nailing	
	No. of Patients	%	No. of Patients	%
10-12 Weeks	12	80.00%	10	66.66%
12-16 Weeks	2	13.33%	3	20.00%
16-32 Weeks	1	06.66%	2	13.33%
Non union	0	0.00%	0	0.00%
Mean time for Union	12 weeks (11.8)		12 weeks	

Table 2. Time Taken for Fracture Union

In the study most of the of reamed interlocking nailing cases united within 10-14 weeks i.e., out of 15 cases, only 1 case took more than 15 weeks for union. And no non-unions were reported.

Out of 15 unreamed interlocking tibia 13 cases united by 15 weeks and 2 cases took more than 15 weeks (fractures with deep infections). No non-unions were reported.

Klemm and Baur Criteria	Reamed		Unreamed	
	No. of Patients	%	No. of Patients	%
Excellent	13	86.66%	10	66.66%
Good	1	06.66%	3	20.00%
Fair	1	06.66%	2	13.33%
Poor	0	0.00%	0	00.00%
Mean Score	43.33		39.93	

Table 3. Results in the Present Study

t - value = 2.3 , P- value - 0.015 Significant

86% of patients in the reamed group had excellent results whereas only 66.6% had excellent results in the unreamed group, 6% of patients in the reamed group and 20 % of patients in the unreamed group have good results, 1% of patients in the reamed group and 2% of patients in the unreamed group have fair results and no patient in both the groups have poor results.

Because of infection patients were delayed for partial weight bearing and full weight bearing. Immobilized in splint for long period. So they developed quadriceps wasting. Their

knee and ankle range of movements are also restricted. Radiologically also signs of union were delayed.

Patients Satisfaction	Reamed	Unreamed	%
Pleased	12	11	76.6
Satisfied	3	1	13.3
Unhappy	0	2	6.6
Total	15	15	100

Table 4. Patients Satisfaction after Surgery in Both Groups

Patient satisfaction is pleased in reamed group than in unreamed but it is not significant. Were as satisfied in reamed group than in unreamed which is significant.

In our study, 2 patients developed infection and their union time was delayed. Their PWB and FWB was delayed. Their hospital stay was prolonged. They were advised for frequent follow-up to hospital. Overall the morbidity of the patients was more. So they were unhappy with the treatment.



DISCUSSION

Treatment of diaphyseal fractures of tibia evolved since many years. There are several methods of treatments and there are many modifications in each treatment method. Closed reduction and cast application which was practiced for many years based on Sermiento functional cast bracing. But its main disadvantage was development of fracture disease. External fixator application is another treatment option. It has the disadvantage of development of pin tract infection. Most of time it is used as temporary fixation. Plate and screws fixation for fracture tibia is another method used. It gives rigid fixation. But chances of infection are very high because periosteum stripping is more, soft tissue damage is more. Intramedullary nailing has many advantages. Closed reduction, reaming, inter- locking all have advantages. Close reduction is also called as indirect reduction, it preserves fracture site hematoma. 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 with screws maintains axial length and rotation of fracture fragments. But they also have disadvantages, closed reduction is technically demanding. It needs C-arm guidance for reduction. Hazards of X-ray are another problem. Reaming destroys endosteal blood supply. Like other methods this method also has both advantages and disadvantages. So we conducted the study closed reamed intramedullary nailing versus closed unreamed intramedullary nailing in our hospital to know the results and complications.

In current series 30 cases of fracture of shaft of the tibia were treated by closed reamed interlocking intramedullary nailing. They were followed up for an average of 12 months. The purpose of this study was to evaluate the end results of treatment in these patients. These cases were of different age groups, occurred in both sexes, and the fracture were of different types and at middle third level of shaft of tibia.

The average age of all cases in this series was 31 years. The fracture is more common in the age group of 20 - 39 years. The average age in a study of 50 fractures of tibia conducted by Whittle et al., showed that the average age was 34 years. In a study of 43 fractures of tibia conducted by Singer and Kellam, the average age was 36 years.

In another study of 72 fracture of tibia conducted by Borratus et al.⁵ the average age was 30.3 years. There were 33 male and 17 female patients showing male predominance in our series. The sex distribution in a study by Borratus et al., showed that there were 52 men and 19 women. In a study by Singer and Kellam,⁶ there were 30 males and 11 females.

Seven patients who sustained fracture after a fall and 5 patients sustain fracture due to hit by vehicle. Among R.T.A. motor vehicle accidents 38 cases (76%) was most common mode of injury in present series. High velocity, road traffic accident is the major cause of injury. Many of them were involved in 2 wheeler accidents. In present series, 28 out of 30 cases (93.3%) fractures united within 5 months of injury.

Studies	Union (Weeks) In Reamed	Union (Weeks) in Unreamed
Anglen J O et al ⁷	22.5	34.5
Larson LB et al ⁸	16.7	25.7
Present study	12	12
Malunion after IM Nailing of Series of Tibial Fractures		
Anglen J.O. et al ⁷	4	4
Blachut PA Ricards et al ⁹	4	4
Present study	1	1

Table 5. The Time for Union After IM Nailing of Series of Tibial Fractures

Two cases (8%) went for delayed union. As these cases not shown signs of union with in normal time they were considered for secondary procedures. These cases required dynamization which was done at 8 weeks.

In this study, 2 cases developed malunion, one in the reamed and one in the unreamed category. In one cases, 6-8 of valgus angulation was noted. In one case >1 cm (1.4 cm) shortening was noted.

Causes for Malunion

- a) Improper reduction before locking.
- b) Despite the difference in total number of cases in various series the malunion rate and percentage is comparable with other series.

In the present study, no cases went for non-union.

Studies	Non-Union (%)
Gross and Kempf	3.7
Kutty S et al ¹⁰	2.2
Present study	0

Table 6. The Non-Union after IM Nailing of Series of Tibial Fractures

In this study, 26 patients out of 30 (86.6%) have full range of knee motion at 12 weeks. 27 patients out of 30 (90%) has full range of ankle motion. In 4 patients (13.3%) there was restricted range of movements in knee. In 3 patients (10%) ankle movements restricted after intramedullary interlocking nailing.

Major Causes for Restricted Range of Motion in This Series

- a) Non cooperative patients.
- b) Delayed union requiring long period of immobilization.
- 5. Infection.

In this study, 2 patients developed deep infection (4%). In current study no failure of implant was observed. In this study, 12 out of 50 patients (24%) developed anterior knee pain. In Jarmo AK Toivanen study it is 56%. The cause for knee pain was Proximal endonail prominence above the cortex may be the cause for anterior knee pain. It was done on the basis of criteria by Klemm and Borner.¹² 86% of patients in the reamed group had excellent results whereas only 66.6% had excellent results in the unreamed group, 6% of patients in the reamed group and 20 % of patients in the

unreamed group have good results, 1% of patients in the reamed group and 2% of patients in the unreamed group have fair results and no patient in both the groups have poor results.

CONCLUSIONS

Active young individuals were the main sufferers in leg fractures. Bread winning working men without door activities are the majority in tibial fractures. High velocity road traffic accident is the major cause of these fractures. Mid diaphyseal fractures are common. Closed intramedullary interlocking nailing is an effective mode of treatment in closed tibial fractures. There was no significant difference in union rate and union time between reamed and unreamed nailing. Highly comminuted fracture pattern may be the cause of malunion. In our study, infection was the cause of delayed union. Proximal end of nail prominence above cortex is the major cause for anterior knee pain. Overall functional results are good with closed reamed intramedullary interlocking nailing compared to unreamed interlocking nailing.

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