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Functional outcome of proximal 1/3rd, distal 1/3rd and diaphysial tibial fractures in adults operated with expert tibial nailing

Uduthala Sai Kiran[1], Surendra Babu S.[2]*, Kurakula Nitin[3], Tarun Desai[2], Kaushik Y. S.[2], Rinju Krishnan[2]

[1]Department of Orthopaedics, Government General Hospital, Nizamabad, India
[2]Department of orthopaedics, St John's Medical College, Bangalore, India
[3]Department of orthopaedics, Government General Hospital, Medak, India

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***Correspondence:**
Dr. Surendra Babu S.,
E-mail: surendra4u56@gmail.com

ABSTRACT

Background: Fractures of the tibial shaft are increasing due to high velocity trauma and industrialisation. Not only they are common but also difficult to treat. Until recently surgeons had to rely on non-operative treatment, V nailing, plates and screws and external fixator but they had their drawbacks like prolonged immobilisation infection, delayed union and non-union. Numerous modifications in nail and screw design have led to development of the expert tibial nail. Multidirectional interlocking screws ensure that alignment can be well maintained and stability preserved in short proximal or distal tibial segments.
Methods: 30 patients were admitted and operated during September 2014 to September 2016 in Mamata general hospital Khammam. All patients were evaluated with Klemm Borner's criteria and complications following surgery.
Results: 87% of patients achieved good or excellent results, fair results were obtained in 3 (10%) patient and poor result in one (3%) patient. 2 (6%) patients had malunion, 2 (6%) patients had delayed union, 1 (3%) patient had deep infection led to implant failure.
Conclusions: Intramedullary nailing is a safe and effective technique for the treatment of tibial metaphyseal fractures. It avoids the additional soft-tissue dissection associated with traditional open procedures as well as the complications associated with external fixators. Expert tibial nail can give excellent functional and clinical results. Complications such as failure of the bone-implant construct or post-operative malallignment are avoidable if careful pre-operative planning is allied with meticulous surgical technique.

Keywords: Expert tibia nail, Metaphyseal fracture, Klemm Borner's

INTRODUCTION

Tibia is the most commonly fractured long bone and the exposed anatomical location makes it vulnerable to direct blow and high energy trauma as a result of motor vehicle accident. Tibia has precarious blood supply due to inadequate muscular envelope. Tibial fractures may be associated with compartment syndrome, vascular or neural injury.[1] The presence of hinge joints at the knee and the ankle allows no adjustment for rotatory deformity after fracture. Because of high incidence of complications, management often is difficult. In spite of all the advances, proximal and distal fractures of tibia still pose a challenge to the orthopaedic surgeons due to the following reasons. As tibia is a subcutaneous bone, the fracture is often open.[2] In these fractures, there is the tendency of displacement of fracture fragments after swelling subsides. Increased incidence of delayed and non-union due to poor blood supply and less soft tissue coverage at the distal third. If the rotational alignment of the fragment is imperfect, there may be cosmetic and functional disability. Being a subcutaneous bone, the rate of post-operative infection is higher than in most other fractures. The conventional nails don't provide good stabilization of the short proximal and distal fracture fragments.[3] There is no universally accepted method of management of proximal and distal tibial fractures till date. Various modalities of treatment of fracture shaft of tibia are conservative gentle manipulation and use of short leg or long leg cast, open reduction and internal fixation with plates and screws, external fixation and intramedullary fixation with flexible nails (ender pins) and interlocking intramedullary nails with or without reaming.[4] Expert tibial nail is a newer implant that overcomes the problems encountered by the conventional nails. Several technical modifications compared to standard tibial nails are incorporated in the design of expert tibial nail. The numerous multiplanar locking options at the proximal and distal end allow for secure stabilization of metaphyseal fragments. Certain intraarticular tibial fractures can be addressed by intramedullary nailing in combination with other implants. It enables the surgeon to further extend the spectrum of fractures eligible for intramedullary nailing. Multidirectional interlocking screws ensure that alignment can be well maintained and stability preserved in short proximal or distal tibial segments. The end cap achieves angular stability between the proximal oblique screw and the nail. These changes in implant design enhance the stability of the bone-nail construct and reduce the risk for secondary malalignment. This new system has been regarded as technically mature. It offers numerous locking options and has proven to worth in complex fracture situations.

This was a prospective study to evaluate the results of expert tibial interlocking nailing in both proximal 1/3rd and distal l /3rd and diaphyseal fractures of tibia and to study the complications of expert tibial interlocking nailing in the same.

Aims and objectives

The aims and objectives were to study the functional outcome following the use of expert tibial nails for proximal 1/3rd and distal 1/3rd and diaphyseal fractures in adults, to study the duration of union in the above mentioned fractures and to study the complications of expert tibial intramedullary nailing of tibial.

METHODS

A prospective study conducted at Mamata general hospital, Khammam between September 2014 to September 2016. Written consent was taken from all subjects for publication of clinical and radiological data and ethical committee and research committee appropriate permissions taken.

Data entered in MS excel and analysed using standard statistical software. Mean, median, standard deviation, interquartile range was used to describe continuous-variables. Categorical data was described as n (%). Results were depicted in tables.

Study sample size

30 patients who were admitted between September 2014 to September 2016, who met inclusion criteria were included in the study and operated. There were 22 males (73%) and 8 females (27%). All patients were followed up till union.

Inclusion criteria

Adult patients above age 18 years with proximal and distal tibial metaphyseal and diaphyseal fractures and patients with open fracture tibia-Gustilo Anderson type I and type II were included in the study.

Exclusion criteria

Patients aged less than 18 years, patients medically unfit for surgery, patients with comminuted and segmental fractures and patients with type III compound fractures were excluded from the study.

Pre-operative protocol

Subjects were initially screened in the casualty or outpatient department. X-ray of leg with knee and ankle joint anteroposterior and lateral views were taken. All patients with tibia fracture were immobilised with above knee slab. Open fractures are thoroughly irrigated with normal saline and non-vital tissue and foreign bodies removed and sterile dressing applied in casualty. Routine haematological investigations, chest X-ray, ECG, ECHO in indicated cases, pre-anaesthesia evaluation and physician fitness was taken. Patients were kept NBM for 8-10 hours before surgery, IV fluids as per the need were given, adequate amount of compatible blood if needed was arranged, preparation of whole extremity, private parts and back was done, Written and informed consent was taken. Soap water enema HS, tranquillisers HS, IV antibiotics half an hour before surgery, shifting of the patients 30 minutes before surgery to operation theatre was done. All patients are operated with expert tibial nail.

Surgical technique

Patients were operated under spinal/general anaesthesia. Patient was placed in supine position over a radiolucent operating table. The injured leg was positioned freely, with knee flexed 900 over the edge of operating table to relax the gastrocnemius and soleus muscle and allow traction by gravity. The uninjured leg was placed in abduction, flexion and external rotation to ensure free movements of the image intensifier from AP to lateral plane. The table was adjusted to a comfortable operating height.

Determination of nail length the radiographic ruler, the markings on the radiographic ruler may be used to determine the diameter of the medullary canal.

Made a vertical patellar tendon splitting incision over skin extending from centre of the inferior pole of patella to the tibial tuberosity, about 5 cm long. Split the patellar tendon vertically in its middle and retracted it to reach the proximal part of tibial tuberosity. Next step was to determine the point of insertion. In the AP view the entry point is in line with the axis of the intramedullary canal and with the lateral tubercle of the intercondylar eminence. In lateral view the entry point was at the ventral edge of the tibial plateau. If the insertion point was too distal, there was a danger of fracturing distal cortex of the main proximal fragment, particularly in the case of proximal fractures. On the other hand, inserting too far proximally bears the risk of opening the knee joint, patella came in the way of zig or removal of nail may have been difficult. After selecting the point of insertion, curved bone awl was used to breach the proximal tibial cortex in a curved manner, so that from perpendicular position, its handle came to be parallel to the tibial shaft.

The ball tipped g wire 3 mm diameter×950 mm length passed into the medullary canal of proximal fragment and the fracture fragments reduced under image intensifier by maintaining longitudinal traction in the line of tibia.

After reduction, the tip of ball tipped guided distal fragment upto 0.5 to 1 cm above the ankle joint under image intensifier. Medullary canal was then reamed starting from 8 mm reamer size to 0.5 to 1 mm larger than the diameter measured using radiographs. Reaming was done in 0.5 mm increments. Then the ball tipped guide wire was exchanged with smooth guide wire using the medullary tube. Next step was to pass an assembled nail into the medullary canal over the smooth guide wire.

Now introduced the tibial nail as far as possible manually into the medullary canal with the help of the mounted insertion instruments. Using the image intensifier checked passing of the nail through the fracture site. Insertion can be aided by gentle blows with the slotted hammer. Insert the nail until it was slightly counter sunk in the bone.

Routinely we prefered proximal locking first, but if gap was present at the fracture site, we carried out distal locking first, which enabled the use of the rebound technique to prevent diastasis.

Mediolateral locking was used for diaphysial fractures. Proximal oblique locking was preferred in more proximal tibial fractures. For mediolateral locking options 4.0 mm locking screws were used. For proximal oblique locking all nails utilised the 5.0 mm cancellous locking screws.

For distal locking 4.0 mm screws were utilized. In proximal lesions distal interlocking with two mediolateral screws was sufficient. However in distal tibial fractures three or four screws were recommended to achieve adequate stability.

Position of the screw was again confirmed under image intensifier. The entire leg and the fracture site was visualized finally in both views for the proper placement of nail. Incised wound was washed with betadine and normal saline, skin was sutured. Sterile dressing applied over the wound. Compression bandage was given. Elastocrepe bandage was applied for stable fractures and good fixation. Above knee slab was also considered if the fracture fixation was not stable. Tourniquet was deflated. Capillary filling and peripheral arterial pulsations were checked.

Postoperative care

Postoperatively elastocrepe bandage was applied and limb was kept in elevation. IV antibiotic was given for 5 days post-operatively. Switching over to oral antibiotics was done on the 5 day. Adequate analgesics were given. Active knee, ankle and toe mobilization started after recovery from anaesthesia. Patient was allowed non weight bearing with crutch walking/walker on next postoperative day according to the general condition and tolerance of patient. Post-operative antero-posterior X-ray of operated leg was done. Post-operative investigations as required done. Skin sutures/staples were removed on 10-12th post-operative day. Partial weight bearing with crutch walking/walker commenced after 10 days, upon the type of fracture, rigidity of the fixation and associated injuries.

Table 1: Klemm Borner's criteria.

Klemm Borner's criteria	
Excellent	Full knee and ankle motion; no muscle atrophy; normal radiological alignment
Good	Slight loss of knee and ankle motion (<25); less than 2 cm of muscle atrophy; angular deformity (<5%)
Fair	Moderate loss of knee of ankle motion, more than 2 cm of muscle atrophy; angular deformity (5°-10°)
Poor	Marked loss of knee or ankle motion (>25°) Marked muscle atrophy; angular deformity (>10°)

Follow up protocol

Post-operative visits were scheduled at 6 weeks, 12 weeks, 24 weeks, 6 months and 12 months. Clinico-radiological and functional assessments were carried out. All patients functionally assessed with Klemm Borner's criteria and complications, if any, were documented. X-ray leg AP and lateral view taken.

RESULTS

A total of 30 patients with tibial fractures were treated with closed expert tibial intramedullary interlocking nailing followed up for at least 10-12 months. All the patients were available for follow up. There were 22 (74%) males and 8 (26%) females, mean age was 38.1 years. There were 20 (67%) right sided and 10 (33%) left sided injury. There were 11 (37%) proximal and 19 (63%) distal 3rd fracture, distal tibial fracture were more common. 8 (26%) transverse fracture, 16 (54%) oblique fracture, 6 (20%) spiral fracture, oblique fracture was more common in our study.

We classified tibial fractures into closed and open. The open fractures were classified according to Gustilo and Anderson grading. Open fractures of tibia treated definitely with external fixator were excluded from the study.

There were three patients with head injury and were operated immediately after neurosurgical clearance. One patient had ipsilateral femoral fracture which was treated by closed intramedullary interlocking nailing. One patient with calcaneal fracture was treated by open reduction and internal fixation with screw in same sitting. Fibula fracture associated with distal tibia fractures were fixed with or plate and screw. Ribs and clavicle fracture were treated conservatively.

Majority of the nails inserted were 9 mm, 4 nails were of 10 mm diameter and 2 were of 8 mm diameter. 22 fractures were locked in static mode and 8 fractures were locked dynamically.

All the cases were started with joint mobilization exercises on 2nd post-operative day. Partial weight bearing was delayed till 6 weeks irrespective of fracture configuration. The average period of commencement of full weight bearing was 13.1 weeks.

Secondary procedure

Skin grafting was done in 3 cases, dynamization was done in 10 cases between 12 and 16 weeks depending on the progress of fracture healing.

Table 2: Mode of injury.

Mode of injury	Number of cases	Percentage
RTA	23	77
Fall	7	23

Table 3: Level of fracture.

Level of fracture	Proximal 3rd	Distal 3rd
Number of cases	11	19
Percentage	37	63

Table 4: Associated injuries.

Nature of injury	Number of cases	Percentage
Ipsilateral fibula fracture	26	86
Ribs fracture	1	3
Ipsilateral femur fracture	1	3
Clavicle fracture	3	10
Calcaneal fracture	1	3
Head injury	3	10

Table 5: Fracture union.

Type of fractures	Average time (in weeks)	Union rate
Closed	18	100
Type I	18.4	100
Type II	20	90.9
Total	18.8	96

Table 6: Functional results.

Functional results	Number of cases	Percentage
Excellent-full knee and ankle motion no muscle atrophy normal radiological alignment	21	70
Good-slight loss of knee and ankle motion (<25) less than 2 cm of muscle atrophy angular deformity (<5%)	5	17
Fair-moderate loss of knee of ankle motion, more than 2 cm of muscle atrophy angular deformity (5°-10°)	3	10
Poor-marked loss of knee or ankle motion (>25°) marked muscle atrophy angular deformity (>10°)	1	3

Figure 1: Pre-op case 1.

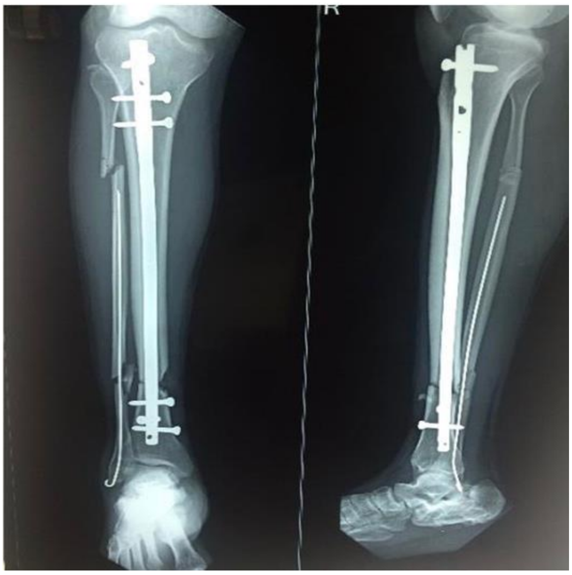

Figure 2: Post-op case 1.

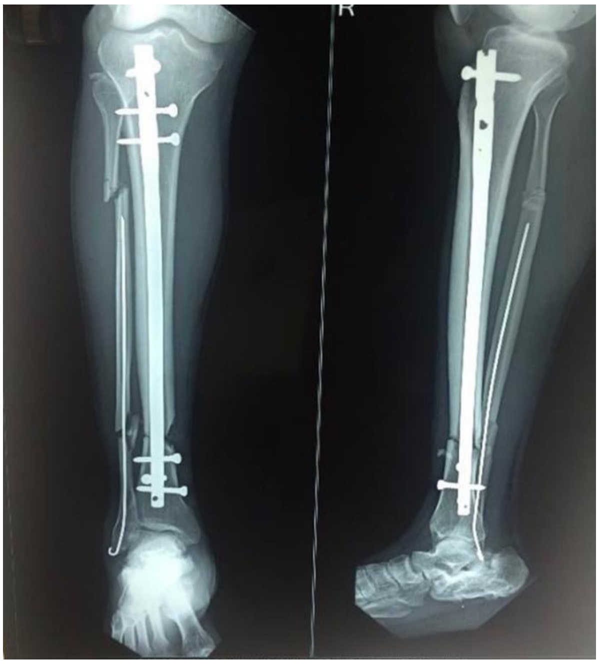

Figure 3: 6 weeks post-op case 1.

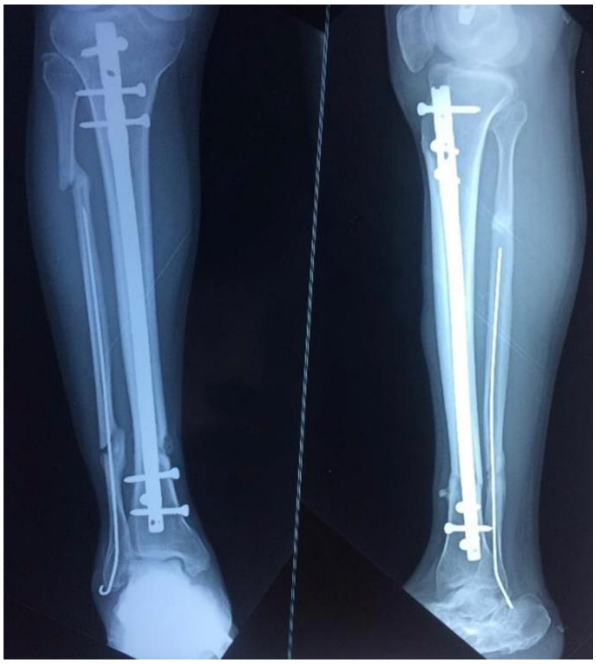

Figure 4: 6 months post-op case 1.

Fracture union

The average time taken for union was 18. 2 weeks, closed fracture united earlier at (18 weeks) type I and type II fracture took 18.2 weeks and 20 weeks respectively for union. 96% of the fractures united with 2 fractures showing a delayed union and 1 (4%), fracture going for implant failure due to infection.

Range of motion

The average range of motion in the knee joint was 136.6 degree, full ankle motion was observed in 21 patients. One patient showed a loss of >25° of motion at ankle compared to the normal side while 3 patients showed <25° of loss of joint motion, 5 patients showed slight loss of knee and ankle motion.

One case (3%) of deep infection and implant failure, which required revision surgery with Ilizarov ring fixator was noted in the present study. Three patients (10%) showed a superficial soft tissue infection which resolved with IV antibiotics. Two cases (6%) of malunion was found with an anteroposterior angulation of 10 degrees, one case (3%) with a distal 3rd showed a shortening of <1 cm. No cases of significant rotational deformities and varus or valgus angulation deformities was noted. Seven cases (28%) complained of pain in the knee joint at final follow up. All were of mild variety and occurred on kneeling down.

Functional results were graded according to the criteria by Klemm and Borner (1986). 87% of patients achieved good or excellent results, fair results were obtained in 3 (10%) patients and in one patient the functional results were poor.

DISCUSSION

Fractures of the proximal third of the tibial shaft are difficult to treat with intramedullary nails for several reasons. The nail is significantly smaller than the area within the proximal fragment. This makes alignment in both sagittal and coronal planes dependent on the operative reduction. Valgus malalignment is due to the medial nail entry point and the laterally directed nail insertion angle in the proximal fragment, mainly because of the medial parapatellar approach commonly used for nailing. The flared and widened proximal tibial metaphysis offers little resistance to deforming forces because relatively small diameter nails have no endosteal contact. Valgus malalignment may also be due to inadequate reduction before nailing. In addition, the origins of the musculature of the anterior compartment act as a tether on the lateral tibial surface proximally, which may contribute to the valgus angulation. Varus angulation at the fracture site occurs if the nail entry is lateral, with the use of the lateral approach for tibial nailing.

In proximal tibial fractures, it is important to insert the nail slightly lateral to the usual starting point, to avoid valgus angulation. In the antero-posterior view, the nail should be inserted in line with the medial edge of the lateral tibial spine. This will not only prevent valgus angulation at the fracture site, but also help avoid the tendency to anterior translation of the proximal fragment. The entry hole should be placed on the tibial plateau more posteriorly than usual, so that it encroaches on the joint surface. This facilitates the positioning of the reamer and nail parallel to anterior tibial cortical surface.

To reduce the apex angulation, a posterior poller screw is inserted in the mediolateral direction and placed in the distal portion of the proximal fragment slightly posterior to the longitudinal axis. To prevent valgus angulation, a lateral poller screw is inserted in the anteroposterior direction and placed in the distal portion of the proximal fragment slightly lateral to the longitudinal axis.

The interlocking is carried out with the limb in semi flexion. A minimum of two screws should be inserted in the proximal fragment; 60° angulated screws are preferred. Two mediolateral screws are also disadvantageous because of poor bone hold when the nail is anterior. Ideally, 60° angulated screws should be placed at a very high level. The proximal bend of the nail plays an important role in the management of these fractures. Ideally the proximal bend should be in the proximal fragment.

Intramedullary nailing of open and closed tibial shaft fractures has been associated with high rates of radiographic and clinical success, but the use of this procedure has not become widely accepted for distal metaphyseal fractures. While external fixation has been used successfully to treat open distal tibial fractures, intramedullary nailing has been associated with a decreased number of secondary surgical procedures to achieve healing and better maintenance of limb alignment. The distal segment of these fractures is more difficult to control with intramedullary implants because of the metaphyseal flare above the plafond. In addition, the poorer soft tissue coverage in this region is associated with wound complications. The proximity to the ankle joint may amplify the bending moment of the short distal segment and may allow fracture propagation into the ankle joint. Percutaneous plate osteosynthesis is an excellent alternative for the treatment of these distal fractures as allows reduction and stable fixation of short distal metaphyseal segments, facilitating predictable healing. However, intramedullary nailing may offer fixation advantages for patterns involving noncontiguous proximal tibial fractures or proximal extension of the fracture.

The mean age of the patient's in the present study was 38.1 years, majority of the patients were males accounting for 22 (74%) cases. The average age of patients was 42 years in a study of epidemiology of proximal metaphyseal by Nork et al[5] The average age in a study of 52 distal metaphyseal fractures conducted by Mosheiff et al was 37 years.[6] The worldwide incidence of tibial fractures in males is 41 per 100,000 per year.[7]

The leading cause of the injuries was road traffic accident in the present study accounting for 77% of cases. The common cause of proximal metaphyseal fractures was road traffic accidents (34.61%) in Mosheiff et al study whereas Vidyadhar et a1 reported that 95.5% of their cases were due to road traffic accidents.[6,8]

Majority of the fractures involved distal third of the tibia 19 (62%). Twenty one of the fractures were associated with ipsilateral fibula fractures. The outcome of the isolated fractures of tibia was not different from rest of the fractures. Other associated injuries were rib fracture in 1 patients (3%), ipsilateral fem calcaneum fracture in one patient (3%) and head injury in 3 patients (12%).

Average diameter of the nails used in the present study was 9 mm (80%). Reaming allows insertion of larger stronger nails with larger bolts which produce tight bone implant contact that provide load sharing and resistance to bending or angulation at the fracture site.[9] In our study all 30 patients had reamed nailing, 8 (26%) nails were dynamically locked in the present study.

In our study partial weight bearing weight was delayed till 6 weeks irrespective of the fracture configuration. Full bearing was allowed based on clinical and radiological assessment of fracture healing. There were no cases of compartment syndrome, fat embolism or of peroneal nerve palsy in the present study.

Larsen et al allowed partial weight bearing of 15 kgs for 6 weeks in early post-operative period.[10] McQueen et al reported that there is no evidence of an increased incidence of compartment syndrome with reamed intramedullary nailing.[11] He opined that increase in compartment pressure associated with nailing is produced by reduction of the fracture and stretching of the adjacent muscles.

In the study by Mosheiff et al, full weight bearing was started at 6 weeks for the extra articular fractures with no communition and in case of fractures which involved articular surface; it was extended by 6 more weeks.[6] In the study by Dogra et al, full weight bearing was started at a mean of 5.5 months (1-14) months.[12]

Dynamization allows the fracture site to be compressed during early weight bearing and enhance fracture healing. Dynamization was done in 8 cases by removing either the proximal or distal bolts between 12 and 16 weeks depending on the progress of fracture healing. Templeman et al in their study performed dynamization between 6 and 12 weeks.[13] Singer et al recommended dynamization between 8 and 12 weeks if the healing is delayed.[14]

The average range of knee joint was 141 degrees (range 128-161 degrees) and that of ankle movements was 84 degrees (range 45-109 degree) in tibial fracture treated by reamed nailing in a study reported by Larsen et al.[10] In the study by Mosheiff et al 5 patients had mild loss of ankle motion and the range of motion of knee was full in all the 52 cases.[6]

The average range of knee joint motion in present study was 135 degrees and 70% of patients showed full ankle motion compared to the normal limb. One patient showed a loss of more than 25 degree of motion at ankle compared to normal side, while 3 patients showed less than 25 degree of loss of ankle joint motion.

Larsen et a1 reported a malunion in 2 of 22 patients treated by reamed nailing.[10] In our study two cases (6%) of malunion was found with as anteroposterior angulation 10 degree had a fracture of upper third of tibia close to the tibial tubercle.

CONCLUSION

Metaphyseal fractures of tibia represent a complex problem and optimal management is essential if the patient is to regain significant pre-injury level of function. Newer nail designs like that of expert tibial nail allow proximal and distal segment to be controlled through placement of multiple interlocking screws within a small distance. Expert tibia nail can give excellent functional and clinical results. Complications such as failure of the implant construct or post-operative malalignment are avoidable if careful operative planning is allied with meticulous surgical technique.

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