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Dr. Channabasava Patil
Professor and HOD, Department
of Orthopedics, Oxford Medical
College, Bangalore, Karnataka,
India

Dr. Srinivas Pandurangiah
Assistant Professor, Department
of Orthopedics, Oxford Medical
College, Bangalore, Karnataka,
India

Primary interlocking nailing of open fractures of the tibial shaft at a tertiary care hospital

Dr. Channabasava Patil and Dr. Srinivas Pandurangiah

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Abstract

The use of interlocking nailing for open fractures is controversial. The accepted standard treatment has been External Fixation followed by definitive treatment. This is especially true when there is severe soft tissue injury or severe contamination. Also reaming was considered contraindicated for open fractures. This is because it is thought to destroy the end steal blood supply. Thus it theoretically increases the risks of infection and nonunion. However recent studies have indicated that the results are similar whether nonreamed or reamed technique is used. Patients were excluded if they had a fracture in the proximal fourth of the tibia or a fracture within four centimeters of the ankle, neither of which was judged to be amenable to interlocking nailing; if the patients did not turn for follow up; if the patients had significant medical or surgical disorders to minimize their influence on fracture healing and union; or if they had open growth plates. The average time to union was 26 weeks for type I fractures(fifteen in number), 29 weeks for type II fractures(nineteen in number), 34 weeks for type III A fractures(nine), 38 weeks for type III B fracture (One). There were 2 non-unions (Both Type II), both of them had middle third fractures, for one of them the original nail was replaced with a larger diameter Grosse Kempf nail with reaming and cancellors bone grafting was done, the donor site being the upper end of the contralateral tibia. The other nonunion patient which was infected was treated with removal of the nail, thorough washing with hydrogen peroxide and betadine solution, freshening of the fracture ends, fibular resection and cancellors bone graft application and Ilizarov frame application this united later at about 105 weeks.

Keywords: Primary Interlocking nailing, open fractures, tibial shaft

Introduction

Since the advent of image intensifiers, closed intramedullary technique for tibial fractures has become possible and simple. It has become an attractive and popular option for treating tibial fractures. The results of this technique are excellent for treating closed fractures of the tibial shaft. The addition of interlocking nails has made it possible to include the more proximal and distal fractures of the tibial shaft as indications for treatment with interlocking nails retaining adequate stability^[1].

The use of interlocking nailing for open fractures is controversial. The accepted standard treatment has been External Fixation followed by definitive treatment. This is especially true when there is severe soft tissue injury or severe contamination. Also reaming was considered contraindicated for open fractures. This is because it is thought to destroy the endosteal blood supply. Thus it theoretically increases the risks of infection and nonunion. However recent studies have indicated that the results are similar whether nonreamed or reamed technique is used^[2].

The *advantages* of closed interlocking nailing are that it reduces morbidity, it allows early mobility and weight bearing of the limb, it solves the problem of malunion because it provides the ability to control length, angulation and rotation. The union rate is uniformly high in most of the reported series^[3].

However the *limitations* to this technique is its association with higher prevalence of rates of infection. Concomitant severe skin and soft tissue loss will limit the indications for the above technique.

This technique of closed primary interlocking nailing has been adopted in many centres for treating open fractures of the tibial shaft. But references which specifically mention the

Correspondence

Dr. Channabasava Patil
Professor and HOD, Department
of Orthopedics, Oxford Medical
College, Bangalore, Karnataka,
India

indications, the methods and the results are limited. References are scanty regarding the incidence of infection/nonunion related to the specific type of open injury^[4].

Bone *et al.* reported good results after closed primary interlocking in open tibial fractures. Theoretically primary interlocking nailing in open fractures after thorough debridement is a good method as it gives stability needed for healing of soft tissues and bone and reduces morbidity.

Methodology:

Patients were excluded if they had a fracture in the proximal fourth of the tibia or a fracture within four centimeters of the ankle, neither of which was judged to be amenable to interlocking nailing; if the patients did not turn for follow up; if the patients had significant medical or surgical disorders to minimize their influence on fracture healing and union; or if they had open growth plates. There were no other exclusion criteria.

Thus 44 patients with 44 fractures were included in the study. The data of the patients were recorded as shown in the proforma Form A and Form C. These are as per the AO guidelines and are in the appendix.

After the initial clinical assessment, all patients began receiving one gram of cefotaxime intravenously every 8 hours and were given prophylaxis against tetanus with tetanus toxoid 0.5 cc I.M. and immunoglobulin 250/500 iu I.M. Patients were also given amikacin 15 mg/kg body weight every 12 hours. Antibiotic therapy maintained postoperatively for 72-120 hrs. The same antibiotic regimen was used at each subsequent operative intervention. All of the operative procedures were performed by, or under the direct supervision of the consultants. A standard operative protocol was followed. Wound debridement and nailing were performed as soon as possible after admission to the hospital.

Operative Technique

As part of the debridement protocol, a minimum of 5 liters of saline solution was used for irrigation. A separate trolley was used for the debridement, after which the limb was repainted and redraped.

After debridement, nailing was performed with the patient on a fracture table with knee flexed and supported over a stand, hip flexed to 90 degrees. A 2 cm longitudinal incision over the patellar ligament was used for insertion of the nail. A parapatellar or ligament-splitting approach was used to gain access to the intramedullary canal. All the fractures were stabilized with a Grosse Kempf nail

The canal was broached with a large bone awl, the point of entry being just behind the insertion of the ligamentous patellae and the point of entry was widened with a front cutting 12 mm diameter reamer for the metaphysis to facilitate entry of the nail. Then tipped guide rod was passed, negotiated through the fracture site to reach the distal end. Reaming was done with an electric pneumatic reamer. Usually beginning from 8 or 9 mm and progressively increasing in 0.5 mm increments. The decision regarding the size of the diameter of the nail was made intraoperative on the basis of the size of the reamer that first made cortical contact at the isthmus of the medullary canal. It was found that 9, 10 and 11 mm nails were suitable and sufficient to fix all fractures. Nails were inserted without reaming when there was severe comminution or when the medullary canal was wide enough or when there was a segmental fracture which risked rotation or when there was polytrauma which risked fat embolism and especially in COPD

patients.

After reaming the tipped guide rod was exchanged with a smooth that is non-tipped guide rod with the help of exchange tubes. Then the nail that has the correct length and diameter was inserted by pushing and hammering. Hammering was not done during the passage of nail in the segment part of the segmental fractures.

As and when required c-arm images were taken so that nail was positioned in the center of the medullary cavity. View for confirming the central passage of the Nail in the medullary canal. Care is taken to avoid splintering which is common while negotiating across the fracture site.

The decision to perform static or dynamic was now made depending upon the fracture stability. Nails were dynamically locked in only the proximal or distal fragments whichever was closer to the fracture line as it provided better stability. After this the proximal locking was done with the help of a jig. The proximal locking screw used was an all threaded self-tapping 4.5 mm cortical screw. Next the supporting stand was removed, the knee straightened and the distal holes visualized in the c-arm image screen. Single or double distal locking was done, again depending on the requirement for fracture stability.

Bone grafting was performed if the combination of the fracture was >50%, or when the bone loss was more than 2 cm. Routinely suction drain was applied at the entry portal, and the tip was sent for culture and sensitivity on removal of the drain. The operative blood loss; transfusion requirement; duration of the operation; and tourniquet time were recorded.

Early perioperative complications, including compartment syndrome, fat embolism, and pulmonary embolism were recorded.

Patients who had only fractures in leg were discharged from the hospital when they had evidence of satisfactory wound healing and were able to walk with crutches. These patients stayed in the hospital for a median of 11 days (range 8 to 25 days). Patients were advised to remain on partial weight bearing for first six weeks irrespective of their fracture configuration. Patients who had multiple injuries were mobilized and discharged as soon as the other injuries allowed it.

After discharge we examined the patients clinically and radiographically at 6 wks, 12 weeks, 18 weeks, 26 wks, 40 wks, and 72 wks.

Clinical union was defined as the ability to bear full weight with no pain at the site of the fracture and radiographic union was defined as evidence of bridging of three of the four cortices on standard anteroposterior and lateral radiographs. We defined nonunion as motion at the site of the fracture on manual manipulation and no evidence of healing as seen on roentgenograms that were made six months after injury. The fracture was converted to a dynamic status at 12 weeks with removal of the proximal or distal locking screws at the discretion of the treating surgeon, and this was not taken to be an indication of nonunion unless the fracture subsequently failed to heal. 1 was converted to a dynamic status. Early bone grafting was done at 6-12 wks. When delayed union was suspected.

Malunion was defined as any angulation of more than 5 degrees in any direction as seen on the radiographs or shortening of more than one centimeter or rotation deformity of more than 15 degrees on clinical measurement.

Failure of the implant and any action necessary as a result were recorded. It could be breaking/bending of the nail or breaking/backing out of screws, or cut through with proximal or distal migration of the nail.

A soft tissue infection was defined as the presence of purulent discharge from the wound with positive bacteriological findings. Deep infection was diagnosed if the infected site communicated with the fracture site.

The ranges of motion of the knee and ankle were recorded for each patient. It was designated as normal or reduced at the time of the most recent follow up examination. The patient's occupation and level of recreational activity postoperatively were compared with those before the injury. The patients were designated as having returned to the same occupation as before the injury, as having changed occupation, or as having not returned to any occupation as a direct result of the injury.

Similarly, the level of recreational activity was defined as the same as before the injury or as reduced or none as a consequence of the injury. The prevalence of pain in the knee and the necessity for the removal of the implant were also recorded.

Results

The average duration of time between injury and nailing was 6 hours (range 2 hours to 8 days).

Table 1: Duration

	Number of Fractures
2 – 4 hours	23
4 – 12 hours	18
>12 hours	3

41 of fractures were fixed after reaming, 3 without reaming.

Table 2: Reamed

	Number
Reamed	41
Undreamed	3

The average interval from the time of the injury to the nailing procedure was 6 hrs (range 2 hours to 8 days). Among the patients 10 nine mm nails, 30 ten mm nails and 4 eleven mm nails were used.

Table 3: Diameter of nail

Diameter Of Nail	Number Of fractures
Nine mm	10
Ten mm	30
Eleven mm	4

Nine of the nails were dynamically locked.

Table 4: Locking

	Number
Static	35
Dynamic	9

Four wounds were not closed by primary suturing. Local flap cover was used in one patient and Split thickness skin graft was used for 2 fractures. 1 was treated with delayed primary closure. None of the cases required secondary debridement. Bone grafting was performed in seven patients as they were comminuted. All united uneventfully except one which got infected and required Ilizarov + Fibular resection for union. The average duration of hospitalization was 11.86 (522 for 44 patients) days. The range being 8 to 25 days.

The average time to union was 26 weeks for type I fractures (fifteen in number), 29 weeks for type II fractures (nineteen in number), 34 weeks for type III A fractures(nine), 38 weeks for type III B fracture (one). There were 2 non-unions (both Type II), both of them had middle third fractures, for one of them the original nail was replaced with a larger diameter Grosse Kempf nail with reaming and cancellors bone grafting was done, the donor site being the upper end of the contralateral tibia. The other nonunion patient(which was infected was treated with removal of the nail, thorough washing with hydrogen peroxide and beta dine solution, freshening of the fracture ends, fibular resection and cancellors bone graft application and Ilizarov frame application this united later at about 105 weeks.

Table 5: Type of Fracture

Type of fracture	Weeks
Type I	26
Type II	29
Type III A	34
Type III B	38

Infection

There were three deep infections: two developed in Type II fractures and the other in Type III A fracture. One patient in type II group developed cellulitis after 3 months and had a purulent discharge, which contained staphylococcus on culture. The patient was managed with cephalosporins and repeated dressings. The infection resolved and fracture united in 38 weeks. Another patient (Type II) developed nonunion was treated with nail removal, fibular resection and Ilizarov frame as stated previously. In the third patient infection subsided and union occurred.

Failure of the implant

Breakage of a screw was noticed in 1 patient. In another patient with infection, sinus developed at the distal screw site and the screw backed out on its own. It was removed under local anesthesia. Infection subsided and the fracture united.

Malunion

There was malunion in two patients and both were in the middle third of tibial shaft. One healed in 7 degrees of valgus angulation and the other had 5 degrees varus and 10 degrees of external rotation and 1 cm of shortening. None necessitated a corrective operation.

Functional outcome

The range of motion of knee was decreased in three patients. In the patient with type III A fracture the range of motion was 10 degree flexion to full flexion, two other patients which had a delayed union which had a nonunion) with type II fractures also had 10 degree and 15 degree loss of terminal flexion.

The range of motion at the ankle was reduced in 5 patients, four had restricted dorsiflexion of 15 degrees and the plantar flexion was reduced by 10 –20 degrees. The other patient had only limited dorsiflexion of 10 degrees.

All but two patients returned to their original occupation after an average of 3.5 months, one patient had to change the occupation and had a partial disability.

With respect to recreational activity except two all returned to their preoperative level of recreational activity or sports.

Early Post-operative complications

Compartment syndrome developed in no patient. None of the

patients had Pulmonary emboli nor fat embolism syndrome.

Assessment

Based on the patients’ assessment we had no poor results, one fair, three good and forty excellent results.

Table 6: Outcome

Results	Number
Poor	Nil
Fair	1
Good	3
Excellent	40

As per the surgeons assessment among the 44 patients, one had a poor result, four were grouped under the good result heading had extension deficit of 10 degrees at knee, united in 34 wks, one

had reduced plantar flexion of 20 degrees, another had reduced dorsiflexion of 15 degrees and thirty nine under excellent. 15 patients had pain in the knee, in 10 of them it subsided in 4 months, 3 had persistent pain even after 12 months, none necessitated nail removal.

Discussion

In our study we attempted to do the nailing as soon as possible provided the status of the wound after debridement was good. There were two cases where there was a delay of 120 hrs and 196 hrs to allow soft tissue healing, hence the average shot up from the usual 2-3 hours to 6 hours. In the Whittle’s study there were a larger number of Type III fractures that required delay to perform interlocking nailing for the wounds to heal. The Keating *et al.* study was almost similar to ours.

Table 7: Comparison of Duration from injury to nailing

Study	Duration from injury to nailing	
	Average	Range
Present	6 hrs	2 hrs – 8 days
Keating <i>et al.</i> [5]	9.5 hrs	3.43 – 28.75 hrs
Singer <i>et al.</i> [6]	5.6 hrs	-
Whittle <i>et al.</i> [7]	7.5 hrs for W.D., For ILN <8 hrs-25#, 8-13 hrs – 17#, 4-21 days – 8 #	

The average diameter of the nail in our study of Indian patients was lesser than the Keating *et al.*’s study as the western population had a better built than ours. However in the Whittle’s study all patients underwent undreamed nailing which obviously fitted smaller diameter nails.

Table 8: Comparison of Diameter of nail

Study	Diameter of nail (mm)					
	9	10	11	Others (8 – 13)	Total	Average
Present	10	30	4	0	44	9.86
Keating <i>et al.</i> [5]	23	19	24	28	94	10.4
Singer <i>et al.</i> [6]	8 and 9 mm dia – 38 #s, smaller dia – 5 #s					
Whittle <i>et al.</i> [7]	18	13	0	16	47	8.9

The more recent studies as by Keating *et al.*, Court Brown *et al.* have shown same results withreamed technique with no significant increase in nonunion. Whittle’s study had only unreamed ones as they believed that reaming destroys the endosteal supply which was affirmed in the experimental study

by Schemitch *et al.* [8] on sheep models. In our study we used undreamed technique only when there was severe contamination or severe soft tissue injury.

Majority of our study cases were statically locked as a routine to enhance stability and provide early weight bearing and ambulation. Dynamisation was advocated only when fracture stability was adequate. Other authors like Keating, Whittle, Court Brown have followed the same principle. In the study by Bone and Johnson, 84 cases which were done in the early part of the study before 1980 had the AO nail which did not require static locking. In the later part of the study GK nails were used and static locking was used routinely.

In the classic study by Gustilo *et al.* [9] it was found that 20% of the patients treated with secondary closure were infected while only 6% of the patients treated with primary closure were infected. Hence we advocated primary closure for all open fractures except when the surgeon thought that the wound was not satisfactory after thorough debridement and irrigation. There was no failure of the SSGs or flap in our study.

Table 9: Comparison of Type of wound closure

Study	Type of wound closure				
	SSG	Flap	Others	Delayed primary closure	Average duration
Present	2	1	0	1	Immediate
Keating <i>et al.</i> [5]	9	1	10	-	5 days (No primary closure)
Singer <i>et al.</i> [6]	-	-	-	-	12.3 days for III B #s, range 5-18 days
Whittle <i>et al.</i> [7]	4	1	5	-	Attempted to close < 7 days
Court Brown <i>et al.</i> [10]	-	2	-	-	3 primary closure, 48 sec.

The % of union, the average time to union of various Gustilo types in the present study as well as other studies has been tabulated below which is almost self-explanatory. The results of our study are similar to other studies and are better than few studies described in the table.

The various data of results has been tabulated. As is evident it can be said that the common causes for nonunion are infection, bone defect/loss/distraction, etc. Now the usual accepted treatment as can be deduced from the various studies would be

Exchange nailing + BG uninfected cases and Ilizarov/Ext. Fixn. + BG for infected ones.

The criticism that nailing after reaming is associated with high rates of infection and nonunion is theoretical. It is based on limited reports with small numbers of patients managed mostly with unlocked nails. Kaltenecker *et al.* [5] reported no infections after treatment of sixty six type I and II open tibial fractures with nailing after reaming. Court Brown *et al.* [10] recently reported a rate of infection of six percent for type III A fractures and

thirteen percent for type III B fractures treated with insertion of a Grosse Kempf nail after reaming. Rates of union and malunion compared very favourable with those reported with current designs of external fixation. In Whittle *et al.*^[7] study of 50 open fractures with 68% Type III #s which were treated with ILN without reaming, only 4 infected cases were reported. Keating,

Blachut *et al.*^[5] reported three infections (4%) after treatment of open fractures of tibial shaft with locked intramedullary nailing with or without reaming. In the present series there were three infections (7%) showing a favourable result when compared to previous studies^[11, 12].

Table 10: Comparison of Infection

Study	Infection							
	No.	%	Type I	II	III A	III B	Nonunion	
Present	3	7%	0	2	1	0	1	
Keating <i>et al.</i> ^[5]	2	4%	0	1	0	1	1	
Singer <i>et al.</i> ^[6]	5	12	1	1	1	2	-	
Whittle <i>et al.</i> ^[7]	4	8%	0	0	1	3	0	
Court Brown <i>et al.</i> ^[10]	4	11%	-	1	0	3	-	
Veliskakis <i>et al.</i> ^[7]	8	10%	Gustilo classification did not exist at that time					

As per the surgeons assessment we had 39 excellent results i.e., 89% of patients which can be considered satisfactory. This could not be compared with the similar studies like Keating *et al.*, Singer *et al.*, Whittle *et al.*, Court Brown *et al.* and Bone *et al.* since it was not available in the literature. Similarly the patient's assessment was not available in the literature.

Although this is the largest retrospective study of Primary Interlocking Nailing for Open Fractures of the Tibial Shaft for Gustilo Type I, II, IIIA and B which we are aware, the number of patients may not be large enough to be statistically significant.

Conclusion

- Primary Interlocking Intramedullary nailing for open fractures of the tibial shaft is an excellent mode of therapy as it provides better alignment of limb and avoids shortening.
- Intramedullary locking nailing reduces the incidence of complications like infection (7% in our series), nonunion (5%), malunion (5%) which are acceptable.
- It is more acceptable to patients than external fixators and wound management is better and easier.
- Primary nailing provides early stabilization of fracture and thereby helps early soft tissue healing and early rehabilitation.
- Reaming allows larger implant to be inserted and hence provides better stability and early return to function with no increase in complications.

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