

Study of Results of Unreamed Tibia Interlocking Nail in Open Tibia Fractures

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Abstract :

Objective: The purpose of the present study was to assess the outcome of compound fractures of tibia managed by UNREAMED interlocking intramedullary nailing with primary closure of open wound. **Materials and Methods:** This is a retrospective study of 33 patients with 34 open fractures of tibia operated primarily by UNREAMED tibia interlocking nail with debridement and primary suturing of open wounds during the period of January 2008 to May 2011 at Sheth V. S. Hospital. **Results:** In our study of 33 patients with 34 open tibial fractures, 25(75.76%) patients were in 20-50 years age group. Mean age was 37.3 years. 3(8.82%) patients had wound problem at final follow up and 31(91.18%) tibias had good wound healing. Of 34 tibial fractures, 29 fractures (85.29%) showed good radiological and clinical signs of bone union. 5(14.71%) patients with delayed/nonunion were noted. 38.24% fractures were open grade 1, 50% open grade 2 and 11.76% open grade 3. Infection was encountered in 3(8.82%) cases. Outcomes were assessed by Modified Ketenjian's Criteria where, out of all fractures 16(47.06%) were excellent, 10(29.41%) were good, 3 were (8.82%) fair and 5 were (14.7%) poor results. **Conclusion:** Open tibial fractures if given timely treatment, preferably within first 24 hours, can give gratifying results.

Key words : Open fracture, Tibia, Unreamed locked intramedullary nail

Introduction :

Management of tibial diaphyseal fractures has always held a particular interest for orthopaedic surgeons. Not only are these fractures relatively common, but also difficult to treat, especially open fractures. Open fractures mainly affect young males and are often complicated by nonunion and infection resulting in unemployment and other socioeconomic problems. These complications also place a considerable strain on the health services of all countries.

Fractures of the tibial shaft are the most common long bone fractures.⁽¹⁾ The subcutaneous location of the anteromedial surface of the tibia leads to a high incidence of open fractures compared with other long bones. Approximately 23% of tibial diaphyseal fractures are compound fractures⁽¹⁾ with majority being caused by vehicular accidents⁽²⁾ and high velocity trauma.

Various recommendations regarding compound tibial fracture management continue to be refined and redefined and management still remains controversial.

Presence of hinge joints at the knee and ankle allow little adjustment for deformities after the fracture.

Intramedullary nailing with reaming of the medullary canal is generally considered to be contraindicated for open fractures of the tibia, as the damage to the endosteal blood supply caused by reaming may theoretically increase the risks of non-union and deep infection. It has, therefore, been suggested that insertion of nails without reaming is safer.⁽³⁾ Reaming totally disrupts medullary blood supply of a long bone. But medullary blood supply has enormous ability to regenerate, so tight fitting nail in canal won't allow new blood vessels to regenerate along medullary canal while loose fitting unreamed nail will allow.^(4,5)

The purpose of the present study was to assess the outcome of compound fractures of tibia managed by UNREAMED interlocking intramedullary nailing with primary closure of open wound.

Materials and Methods:

This is a retrospective study of 33 patients with 34 open fractures of tibia operated primarily by UNREAMED tibia interlocking nail with debridement and primary suturing of open wounds during the period of January 2008 to May 2010 at our institute. Total 41 patients were operated during this period, including 3 females;

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but 8 patients including 3 females were lost to follow up. All patients were followed up from minimum 6 months to maximum 32 months with mean follow up time of 18.5 months.

Management protocol:

On admission, all patients were managed according to ATLS protocol. All patients were hemodynamically stabilized, thoroughly examined for other major associated injuries in head, thorax, abdomen or spine along with local limb examination including distal neurovascular status.

All wounds were initially washed with saline, povidone iodine and hydrogen peroxide under aseptic precautions and sterile dressings were kept. Fractured limb was immobilized in an above knee slab. All patients were given Injection tetanus toxoid and anti-tetanus human immunoglobulin and adequate antibiotic coverage.

After proper investigations, X-rays and stabilization of patients' condition, patients were treated by unreamed interlocking nailing, thorough debridement and primary suturing of the open wound.

Patients with no other injury to the same limb, and where good reduction was obtained, were immobilized in a below knee slab in immediate postoperative period with strict elevation. Bed side knee bending and non-weight bearing walking was allowed on 2nd and 3rd postoperative day in case of isolated tibial fractures. After 6 weeks, full weight bearing walking was allowed in patients with isolated tibial fracture.

All patients were followed up every 4 weeks for 3 months with X-rays. At every follow up, patients were assessed radiologically as well as clinically. Some patients were lost to follow up in between; so assessment could not be carried out regularly and time to fracture union could not be calculated. No tenderness at fracture site and solid bridging callus at fracture site in X-ray were considered as criteria for union.^(6,7,8) Fractures not showing union between 24 and 36 weeks were considered delayed union^(9,10) and fractures not united at 9 months with no signs of progression of union for last 3 months both clinically as well as radiologically were considered nonunion.⁽⁶⁾ Shortening > 10mm, Rotation > 15 degrees, AP angulation > 5 degrees, varus-valgus angulation > 5 degrees were

considered as malunion.⁽¹¹⁾ After 6 weeks, full weight bearing walking was allowed in patients showing signs of union with no other injuries.

Implants and Instruments:

Interlocking tibia nails, usually solid titanium were used in all cases except in 4 cases, where hollow stainless steel nails were used due to economic constraints. Reaming was not done in any case.

Final follow up, outcomes were assessed by Modified Ketenjian's Criteria and rated as excellent, good, fair or poor based on pain, knee/ankle stiffness, swelling/deformity and gait of patient.

- Excellent - no notable abnormality.
- Good - Occasional pain with prolonged use
 - Joint motion 75% of normal
 - Trivial swelling
 - Normal gait
- Fair - Pain with ordinary activity
 - Joint motion 50% of normal
 - Small amount of swelling
 - Slight limp
- Poor - Constant pain
 - Joint motion less than 50% of normal
 - Any visible deformity
 - Limp, gait on cane or crutches.

Results :

Demographic Parameters:

In our study of 33 patients with 34 open tibial fractures, 25(75.76%) patients were in 20-50 years age group. Mean age of patients was 37.3 years which is comparable to Whittle et al⁽¹²⁾ (34 years), Joshi et al⁽¹³⁾ (30 years) and Vineet et al⁽¹⁴⁾ (40.3 years). People in this age group are highly active and use vehicle more than children and elderly and also have passion for speed. These factors contribute to higher incidence of open tibial fractures in this group.

All patients in current study were males. 3 females also had open tibia fracture but could not be included in the study, as they were lost to follow up. If they would have been included, then there would have been

91.67% males; which is comparable to other studies. Vineet et al⁽¹⁴⁾ (92.5% males), Joshi et al⁽¹³⁾ (92.86% males) and Whittle et al⁽¹²⁾ (72.34% males); which have also shown higher incidence in males. Males are usually bread earners of the house and travel more than females especially in Indian society. Moreover in India, taxi and rickshaw drivers are almost exclusively males. Motorbikes are more popular amongst males. These factors contribute to higher incidence of open tibial fractures in males.

In this study, 30 (90.91%) patients had open tibia fracture due to road traffic accident and rest of the fractures were due to assault. None occurred by simple fall or sports injury. Vineet et al⁽¹⁴⁾ (87.5% due to road traffic accident) and Joshi et al⁽¹³⁾ (100% due to road traffic accident) have also shown road traffic accidents as the main cause for open tibial fractures. In study of Whittle et al,⁽¹²⁾ 87.23% open tibial fractures were due to road traffic accidents. High speed vehicular traffic and use of high speed two wheelers has increased in the last decade making high velocity trauma more common. Thus road traffic accident is the major contributor to open tibial fractures in this study.

In this study, all the 33 patients with 34 open tibial fractures were treated by unreamed tibia interlocking nail (either solid titanium or stainless steel) and primary wound closure after adequate wound debridement was done.

Wound Healing:

From these 34 tibias, 5 tibias had skin necrosis. 1 tibia healed by dressing and flap was done in 4 others within 4 weeks of injury. Out of these 4 patients with flap coverage, 3 patients had open grade 2 and one patient had open grade 3 tibial fracture. This could be because in 3 patients of open grade 2 fractures severity of soft tissue injury would have been misjudged and should have been actually classified as open grade 3. But debridement and flap coverage solved the problem in 2 patients of open Grade 2 fractures. At final follow up, 2 patients had persistent discharge, one being open grade 2 and the other being open grade 3 fracture.

One more patient with open grade 1 fracture developed infection at fracture site after 3 months who was treated by debridement, flap coverage and ultimately ankle arthrodesis. This patient was then lost to follow up and

at final follow up he presented to us with below knee amputation done elsewhere.

In our study, there were 13(38.24%) patients with open grade 1 fractures and all had good wound healing. Of 17(50%) open grade 2 fractures, 3 had wound problems, but by regular dressing at final follow up only one patient had persistent discharge. Of the 4(11.76%) open grade 3 fractures; one tibia had persistent wound problems.

Thus out of 34 open tibial fractures; 3(8.82%) patients had wound problem at final follow up. Leong et al⁽¹⁵⁾ and Vineet et al⁽¹⁴⁾ have done primary closure in 70% and 53%, respectively with good wound healing. Primary suturing after adequate debridement in operation theatre with precondition of noncontaminated wound and absence of tension on suture line has been favoured by many.

Following our protocol of thorough debridement and primary closure with immediate rigid fixation by nail; 31(91.18%) tibias had good wound healing at the final follow up.

Time for Full Weight Bearing:

Time for full weight bearing in current study varied from 15 days to 11 months with average time of 15.5 weeks. Factors contributing to delay in full weight bearing are fracture type, severity of soft tissue injury, polytrauma with ipsilateral or contralateral lower limb or axial injury and patients' psychology. 4 patients in our study required flap in whom average time to full weight was 33 weeks. In this study, 9 polytrauma patients had ipsilateral or contralateral lower or upper limb fractures and one patient had bilateral tibial shaft fracture. Among these patients, average time to full weight bearing was 20 weeks. Moreover there are patients in this study who started weight bearing on their own in the 1st postoperative month and some others who were afraid and delayed full weight bearing despite surgeon's advice. As and when possible, especially in isolated tibial shaft fractures; non weight bearing crutch walking was started within the first 2 weeks. These factors directly affect the time to full weight bearing.

Bone Healing:

Of 34 tibial fractures, 29 fractures (85.29%) showed good radiological and clinical signs of bone union. Time taken for fracture union could not be found out because

many patients were lost to follow up for variable time in between. 5(14.71%) patients with delayed/nonunion were noted and all the patients were advised bone grafting. Of these, only 2 patients underwent bone grafting and at final follow up showed early signs of union. Rest refused for bone grafting.

Nonunion and delayed union rate in study of Whittle et al⁽¹²⁾ is 4%, Joshi et al⁽¹³⁾ is 21.42% and 10% in study by Vineet et al.⁽¹⁴⁾ Thus, this is comparable to other studies. In our study, nonunion was observed in 7.69% patients with open grade 1, 17.65% patients with open grade 2 and 25% of patients with open grade 3 fractures. Thus, open grade 3 fractures have poor union rate owing to severity of initial soft tissue trauma.

Outcome with Regards to Soft Tissue Injury:

In the current study, 38.24% fractures were open grade 1, 50% open grade 2 and 11.76% open grade 3. In our study, patients with open grade 1 fractures had 100% wound healing, 7.69% infection and 7.69% of non/delayed union; with open grade 2 fractures 17.64% patients had major wound problem, 11.76% infection and 17.65% nonunion and in open grade 3 fractures 25% had wound problems and 25% infection and nonunion. This explains the impacts of soft tissue injury on functional outcome and rate of complications.

Complications:

Nonunion observed in 5(14.71%) patients has been discussed with bone healing.

2(5.88%) malunion were noted in this study. One patient had anterior and valgus angulation and the other had external rotation >15°. Only later patient had a limp, while former was asymptomatic. Deformity in patient with external rotation was detected when patient started full weight bearing walking. It is comparable to Keating et al⁽³⁾ (2.3%) and Farooq et al⁽¹⁶⁾(13%).

In current study, Screw breakage occurred in 1(2.94%) patient. It was observed in 8 mm diameter nail. Reported screw breakage by Joshi et al⁽¹³⁾ was 14.3%, by Keating et al⁽³⁾ 29% and by Farooq et al⁽¹⁶⁾ 20%. Our series has comparatively less screw breakage because we have been using 9 or 10 mm diameter nails whenever possible. 8 mm nail allows smaller diameter screws and so has higher chances of fatigue failure.

No cases of compartment syndrome were noted similar to Vineet Jain et al⁽¹⁴⁾ (0%). While Joshi et al⁽¹³⁾ (3.6%) and Farooq et al⁽¹⁶⁾ (7%) have reported higher rates. We follow strict protocol of elevation and knee and ankle mobilization and moreover compartment pressures are not measured at our institute and thus missing subclinical or impending compartment syndrome but no clinical compartment syndrome with sequel were observed.

Anterior Knee pain was seen in 6(17.64%) patients. 3 of them had tibial plateau fracture and 3 had nail tip projecting from bone at knees, and it was aggravated particularly while squatting. Joshi et al⁽¹³⁾ (17.8%) have reported similar rate, while Keating et al⁽³⁾(41%) have reported higher incidence of knee pain. Inserting larger diameter nail and trauma to patellar tendon during entry and insertion of nail, inserting longer nail and thus tip abutting on patellar tendon and early arthritis in patients with tibial plateau fractures could be the contributing factors.

Osteomyelitis was noted in 1(2.94%) patient at final follow up. This patient had open grade 2 fracture, but as been discussed earlier severity of soft tissue injury must have been misjudged initially. He had open wound on posterior aspect, size was 4 cm and was communicating with fracture. Posterior wound require much larger amount of force to communicate with fracture than anterior wounds and thus posterior wound would mean a more severe soft tissue injury.

Table 1: Complications during Study

Complication	Early		Late						
	Infection	Wound Necrosis	Delayed/Nonunion	Malunion	Knee/Ankle stiffness	Nail Breakage	Infection	Infection	Infection
No. of patients	3	5	5	2	3	0	1	6	4
Percentage	8.82	14.71	14.71	5.88	8.82	0	2.94	17.64	11.76

Table 2: Impact of time interval to First Treatment and Surgery

Time interval	Total No of Patients	Time to FWBW* (weeks)	No. of second procedure	Complications		Functional outcome	
				Delayed or non union	Infection	Excellent+ Good	Fair+ poor
Time to 1st Rx							
<6 hrs	31	12.6	29.03%(9)	12.9%(4)	9.68%(3)	77.41%(24)	22.59 %(7)
<6 hrs	3	16	33.33%(1)	33.33%(1)	33.33%(1)	66.67%(2)	33.33%(1)
Time to 1st Surgery							
< 24 hrs	20	10.4	30%(6)	15%(3)	15%(3)	80%(16)	20%(4)
< 24 hrs	14	16.79	28.57%(4)	14.28%(2)	14.28%(1)	71.43%(10)	28.57%(4)

* FWBW : Full Weight Bearing & Walking

Time to primary treatment and nailing:

In our study, we also documented time between the initial trauma and presentation to hospital. In this study, 91.18% tibial fractures presented within **6 hours** of injury but only 58.82% tibias were operated before **24 hours** owing to poor general condition, polytrauma and economic constraints.

Delay in primary treatment and interlocking nailing is associated with worse outcome as compared to early treatment and nailing. Infection is clearly attributed to delayed primary treatment.

3 patients who presented beyond 6 hours of primary injury had 33.3% infection, 33.3% nonunion rate. In the 91.18% patients who presented within 6 hours, immediate wound management was done; though only 58.8% could be nailed immediately. These patients had 9.68% rate of infection and 12.9% rate of nonunion which is fairly acceptable.

It is believed that delay in primary treatment of more than 6 hours and delay of fracture fixation more than 24 hours increases rate of complications. Following injury, initial 6 hours are considered as golden period. With impaired vascularity in the zone of injury, body's immune system is compromised. During first 2 hours, host defense works to decrease overall bacterial load. Next 4 hours number of bacteria remains constant. After 6 hours their number increases faster as they grow on necrotic tissue. Any open wound presented after 6 hours is considered contaminated.^(17,18,19) So wound

management and fixation within 6 hours would be ideal.

Nonetheless by strict protocol of immobilization in above knee slab, washing the wound with povidone iodine solution and saline and if needed bedside debridement and primary closure of the wound; we have been able to achieve comparable infection rate with other studies even in patients with delayed surgery. Thus, wound management within first 6 hours is of utmost importance for ultimate favourable outcome.

Fracture location and Outcome:

Proximal third fractures had worst outcome. Patients with middle third fractures had favourable outcome. In proximal and distal third tibia canal is wider and so in these fractures treated by intramedullary nailing stability is compromised and chances of delayed/ nonunion are higher. Proximal third location was associated with worst outcome and had highest rate of infection and nonunion. Though patients with middle third fractures had more complications, they had better functional outcome. Segmental fractures had the best outcomes.

Orthopaedic Trauma Association (OTA) Type C fracture group had worst outcome and maximum complication, while type B fracture group had more secondary procedures and late full weight bearing walking. Patients with open grade 1 fractures required less secondary procedures had fewer complications and best results. Open grade 3 fractures had highest rate of infection and nonunion. Time for full weight bearing did not differ in these groups.

Table 3: Impact of Location and Fracture Morphology and Soft tissue Injury

Variable	Time to FWBW (weeks)	No. of second procedure	Complications		Functional outcome	
			Infection	Delayed or nonunion	Excellent+ Good	Fair+ poor
Location						
Proximal(4)	22	50%(2)	25%(1)	25%(2)	50%(2)	50%(2)
Middle(14)	15.39	28.57%(4)	14.29%(2)	7.14%(1)	78.57%(11)	21.43%(3)
Distal(13)	14.46	23.07%(3)	7.69%(1)	15.38%(2)	76.97%(10)	23.07%(3)
Segmental(3)	12	33.3%(1)	0%(0)	0%(0)	100%(3)	0%(0)
OTA type						
Type A(14)	13.29	21.43%(3)	0%(0)	7.14%(1)	85.71%(12)	14.29%(2)
Type B(4)	17.5	50%(2)	25%(1)	25%(1)	75%(3)	25%(1)
Type C(16)	12.24	31.25%(5)	18.75%(3)	18.75%(3)	68.75%(11)	31.25%(5)
Open grade						
OG 1(13)	14.15	30.77%(5)	7.69%(1)	7.69%(1)	84.61%(11)	15.39%(2)
OG 2(17)	13.65	42.86%(4)	11.76%(2)	17.65%(3)	70.59%(12)	29.41%(5)
OG3(4)	12.5	25%(1)	25%(1)	25%(1)	75%(3)	25%(1)

Functional Outcome:

In our study, we have assessed outcome of 34 open tibial fractures by Modified Ketenjian's criteria. Out of 34 open tibial fractures, 16(47.06%) were excellent, 10(29.41%) good, 3(8.82%) fair and 5(14.7%) had poor results. Thus, 76.47% had good to excellent results which is lower than that reported by Joshi et al⁽¹³⁾ (85.8%excellent to good) and Vineet Jain et al⁽¹⁴⁾(90% excellent to good). One patient with amputation, as discussed earlier is included in poor results.

Table 4: Functional Outcome

Outcome	Excellent	Good	Fair	Poor
Number of patients	16	16	16	16
Percentage	47.06	29.41	8.82	14.7

Poor functional outcome must have been because many of our patients were lost to follow up in intervening period and so vital time was lost for management of problems like nonunion and infection. Some of them have also refused for further management of nonunion and infection.

Conclusion:

In this study of 34 open tibial fractures; following strict protocol of thorough debridement, primary wound closure and unreamed interlocking nailing; it was observed that at final follow up fracture union rate was 85.29%(29 tibias). 31(91.18%) tibiashad well healed wound. Osteomyelitis was noted in 1(2.94%) patient and malunion in 2(5.88%) patients. Excellent to good outcome was observed in 26(76.47%) tibias.

It can be concluded that open tibial fractures (open grade 1, 2,3a and 3b) if given timely treatment; preferably within first 24 hours, with main focus on wound management within the first 6 hours and

stabilization with unreamed interlocking tibial nails as early as possible can give gratifying results in form of well healed soft tissue with well-aligned and solidly united bone which allows pain-free weight-bearing, and functional range of motion of the knee and ankle joints.

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