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Original Article

Orthopaedics Section

Primary Nailing in the Open Fractures of the Tibia-Is it worth?

ATUL AGRAWAL, VIJENDRA DEVISINGH CHAUHAN, RAJESH K. MAHESHWARI, ANIL KUMAR JUYAL

ABSTRACT

Context (Background): The tibial shaft is one of the most common sites of open fractures. The specific methods of skeletal stabilization and soft tissue treatment of open fractures continue to be topics of debate in the orthopaedic traumatology.

Aims: To evaluate the results of the intramedullary nailing in the open fractures of the tibia, especially in the Indian scenario.

Settings and Design: An observational, descriptive study which was done at a tertiary care hospital from 2006 to 2010.

Material and Methods: A prospective study was done on thirty cases which had sustained open fractures of the Gustilo and Anderson grades I, II and III, who were operated for primary intramedullary interlocking nail fixation after thorough debridement and closure of their wounds with suturing, lateral skin release, split thickness skin grafting and muscle pedicle flap, where ever necessary. All the patients were followed up for a minimum of two years.

Statistical Analysis: Descriptive statistics and Fisher's Exact test were used.

Results: Of the total thirty cases, ten were of grade I, seven were of grade II, three were of grade IIIA, seven were of grade IIIB and three were of grade IIIC. Dynamization was done in nine cases. The average time to union was 16.0 weeks in the grade I cases, it was 18.3 weeks in the grade II cases, it was 23.6 weeks in the grade III A cases, it was 28.4 weeks in the grade III B cases and it was 32 weeks in the grade III C cases. The mean time to union was 20.7 weeks. Infection occurred in 3 cases. Delayed unions were observed in 4 cases. A non union occurred in 1 case of type IIIC. A mal union was observed in 1 case of type IIIB. 1 case of grade IIIC had the compartmental syndrome. No case had any implant failure (nail / screw breakage), or deep vein thrombosis.

Conclusion: We conclude that the unreamed intramedullary nailing in cases of open fractures of the tibia, with an early soft tissue coverage, results in a faster soft tissue and bony healing, an easier soft tissue coverage, a better biomechanical stability and early rehabilitation and infection rates as comparable to those which are seen with other methods.

Key Words: Open fracture, Tibia, Unreamed, Intramedullary nailing, Functional assessment

INTRODUCTION

The tibial shaft is one of the most common sites of open fractures [1]. The specific methods of skeletal stabilization and soft tissue treatment of open fractures continue to be topics of debate in the orthopaedic traumatology [2]. Of all the open fractures, 63% are seen in the tibia alone [3].

The precarious blood supply and the lack of soft tissue cover of the shaft of the tibia make these fractures vulnerable to nonunions and infections. The rate of infection may be as high as 50% in the grade III-B open fractures [3, 4]. Attempts which were made to reduce these complications have lead to aggressive protocols which include immediate intravenous antibiotics, repeated soft tissue debridement, stabilization of the fractures, early soft tissue covers and prophylactic bone grafting [5, 6].

External fixators have been popular because of their relative ease of application and the limited effect on the blood supply of the tibia, but these advantages have been outweighed by the high incidences of pin tract infections, the difficulties which relate to the soft tissue management and the potential for malunions/nonunions.

The use of reamed intramedullary nails in the management of open tibial fractures is contentious. While reamed nails offer an improved stability to the fractures, their use carries the theoretical risks of increasing infections and nonunions as a consequence of the disturbed endosteal blood supply [7]. The use of unreamed intramedullary nails may compromise the stability at the site of the fractures [8, 9]. The numerous methods which are used for treating open fractures of the tibia are an evidence of the ongoing efforts which are being made to improve the outcomes of the treatment of these fractures and of the continuing pursuit of more efficient and advanced methods for treating these fractures [10].

Intramedullary nail fixation in open fractures of the tibia is becoming a well-accepted treatment regimen in the western world. In the Indian scenario, this is still being debated. The purpose of the present study was to evaluate the results of unreamed intramedullary nail fixation in open fractures of the tibia, especially in the Indian scenario.

MATERIALS AND METHODS

The patients who presented with open fractures of the tibia within the first 48 hours of being injured were included in the study. The patients with a) fractures of the tibia within the proximal fourth of the tibia or within four centimetres of the ankle joint b) a history of any previous bony surgery of the same tibia c) a stiff knee d) age

less than 14 years e) coagulation disorders and f) head injuries were excluded from the study. The fractures were classified according to the method of Gustilo and Anderson [3, 11]. In emergency, after taking a pus culture sensitivity sample, the wound was thoroughly washed with normal saline, covered with sterile dressing and the limb was splinted. This was followed by adequate analgesia, tetanus prophylaxis and injection Cefazolin 1 gm which was given intravenously 6 hourly.

After a routine workup, an unreamed tibial inramedullary nailing was done by using image intensifier guidance. Both proximal and distal interlocking were done by using two screws for each. The wound was closed in layers to cover the bone, wherever possible. In the cases where a primary closure of the wound was not possible, serial operations for bone coverage were carried out as soon as possible. The drain was removed on the third postoperative day and the drain tip was sent for culture and sensitivity analysis. The intravenous antibiotics were continued for seven days. If the cultures were positive for bacterial growth, then the antibiotics were continued accordingly till the cultures became negative. Physiotherapy was instituted from the third postoperative day, depending on the type of fracture, the requirement for plastic surgery and the presence of other injuries. The patients with the isolated type I, II and IIIA fractures that did not require plastic surgeries, were mobilized with appropriate walking aids, as soon as the pain permitted. Mobilization was started with a non-weight bearing crutch support walking, followed by a toe touch crutch support walking and progressive weight bearing, depending upon the callus formation. The patients with split skin grafts or skin flaps were mobilized as soon as the states of the soft tissues permitted.

The patients were followed up at monthly intervals of 6 months and 3 months and thereafter, upto two years. In every follow up, the patients were assessed both clinically and radiologically for infections and the union and the range of motion at the knee and the ankle. Dynamization was done only in those cases where the fractures did not show good signs of union between 6-10 weeks. Functional evaluations were done, based on the rating scale which was produced by Ketenjian and Shelton [12] and which was modified by Yokoyama et al., [13].

RESULTS

In our study, we included twenty-eight patients with thirty open tibial fractures, with a follow up of two years. Of the total thirty open tibial fractures, ten were of grade I, seven were of grade II, three were of grade IIIA, seven were of grade IIIB and three were of grade IIIC as per the Gustilo and Anderson classification. The interval between the injury and the surgery was < 8 hours in 10 cases, it was 8-16 hours in 7 cases, it was 16-24 hours in 3 cases and it was 24-48 hours in 10 cases.

The closure of the wound was done by primary closure in 18 cases; it was done by secondary closure with a lateral skin release in 2 cases; and it was done by secondary closure with a split thickness skin grafting in 3 cases and with secondary closure with muscle pedicle rotation flaps with split thickness skin grafting in 7 cases. There was a marginal flap necrosis in 3 cases, but all of them were managed by debridement and re-suturing.

Dynamization was done in 9 cases [Table/Fig-1], where no signs of union were present at 6-10 weeks. Out of these 9 cases, 4 cases showed union at 6 months of follow up; 4 cases were labelled as delayed unions at 6 months of follow up and they were treated

G & A Grading(*)	No. of cases	Status at 6 months	Management	Final Outcome at 24 months
Grade I	1	Union	-	United
Grade II	3	Union	-	United
Grade III A	-	-	-	-
Grade III B	3	Delayed Union	Cortico-cancellous bone grafting	United
Grade III C	2	Delayed Union in 1	Cortico-cancellous bone grafting	United
		Infected Non Union in 1	Repeated Debridement	Non Union & Infection Persisting

[Table/Fig-1]: Results of the Dynamized Cases {* Gustilo & Anderson classification for open fractures (3,11)}

Complication		Gustilo and Anderson Grading					Total	%
		I	II	III A	III B	III C		
Infection		0	0	0	2	1	3	10
Delayed Union		0	0	0	3	1	4	13.3
Non Union		0	0	0	0	1	1	3.3
Mal Union		0	0	0	1	0	1	3.3
Nail / Screw Breakage		0	0	0	0	0	---	---
Compartment Syndrome		0	0	0	0	1	1	3.3
Deep Vein Thrombosis		0	0	0	0	0	---	---
Anterior Knee Pain		1	0	0	4	2	7	23.3
Limb Length Discrepancy		0	0	0	1	0	1	3.3
Restriction of Knee Motion	75 to 50%	1	0	1	2	1	6	20
	Less than 50%	1	0	0	0	0		
Restriction of Ankle Motion	75 to 50%	1	0	0	2	2	5	16.6
	Less than 50%	0	0	0	0	0		

[Table/Fig-2]: Complications after intramedullary nailing in our series

with an autogenous cortico-cancellous bone grafting, after which all had union at 12 months of follow up. 1 case (grade III C) was labelled as a case of an infected non union at 6 months of follow up and it was managed with repeated debridements. In spite of these repeated debridements, the infection did not subside and finally, the patient opted for a below the knee amputation.

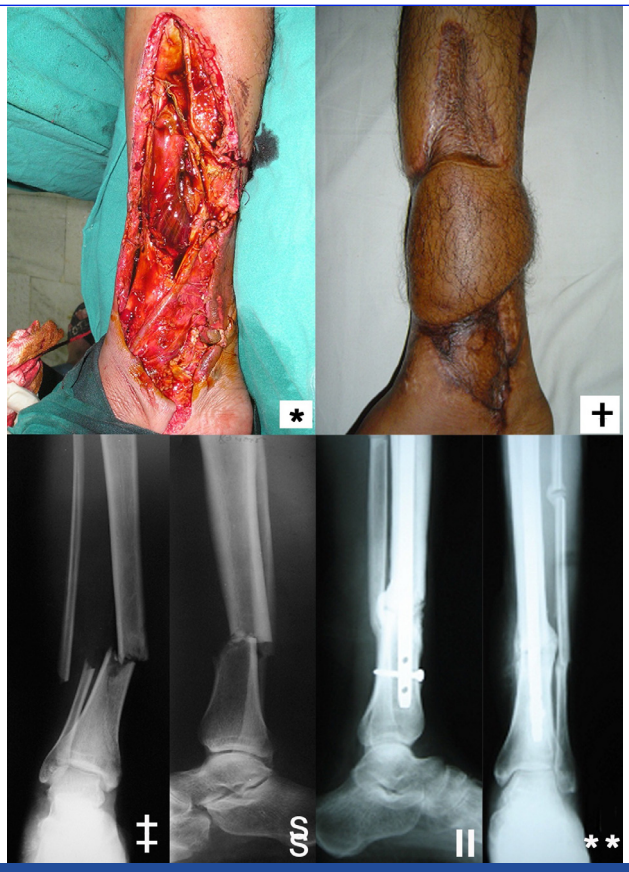
The average time to union was 16.0 weeks in the grade I cases, it was 18.3 weeks in the grade II cases, it was 23.6 weeks in the grade III A cases, it was 28.4 weeks in the grade III B cases and it was 32 weeks in the grade III C cases. The mean time to union was 20.7 weeks.

The main complication was infection, which occurred in three cases. Two cases of grade III B got infected (1 case with Coagulase Negative *Staphylococcus* and 1 case with *Pseudomonas aeuroginosa*). Both were successfully managed with repeated debridements and antibiotics. One case of grade III C got infected with *Escherichia* coli. It was also managed with debridements and antibiotics. At 12 months of follow up, it still had infected non-unions and finally, the patient opted for a below the knee amputation.

A mal union was observed in 1 case of type IIIB. 1 case of grade IIIC had the compartmental syndrome. No case had any implant

Criteria	Gustilo and Anderson Grading					Total	%
	I	II	III A	III B	III C		
Excellent • Normal	7	7	2	2	0	18	60
Good • Occasional pain with prolonged use • Joint motion, 75% normal • Trivial swelling • Normal gait	2	0	1	2	2	7	23.4
Fair • Pain on ordinary activity • Joint motion, 50% normal • Small amount of swelling • Slight limp	0	0	0	3	0	3	10
Poor • Constant pain • Joint motion, < 50% normal • Any visible deformity • Limp, gait on cane or crutch	1	0	0	0	1	2	6.6

[Table/Fig-3]: Functional Results as per Ketenjian and Shelton [12] Criteria modified by Yokoyama et al,. [13]



[Table/Fig-4]: A 26 year male with Gustilo & Anderson grade III C Open fracture in our series.
* Post debridement wound showing extensive loss of soft tissues with exposed muscles, tendons and neurovascular structures.
† Final wound after soft tissue coverage with muscle pedicle rotation flap with split thickness skin grafting
‡ § Preoperative Skiagram showing transverse fracture both bones leg, lower one third.
|| ** Skiagram at final follow up at two years, showing good signs of union in both bones leg

failure (nail/screw breakage) or deep vein thrombosis. Reduced ranges of motion were observed at the knees in 6 cases. 5 cases had reduced ranges of motion at the ankles. Anterior knee pain was seen in 7 cases. A limb length discrepancy was observed in 1 case of type IIIB, which was less than 1cm [Table/Fig-2].

Based on the functional grading scale which was produced by Ketenjian and Shelton [12] and which was modified by Yokoyama et al., [13], we recorded excellent results in 18 cases (60%); good results in 7 cases (23.4%); fair results in 3 cases (10%); and poor results in 2 case (6.6%), as shown in [Table/Fig-3].

DISCUSSION

In our study, we operated only 10 cases (33.3%) within the golden time period (0-8 hours interval). About 2/3 of our cases (66.6%) were operated after the 'golden period time interval for surgery'. One aspect of this study was to evaluate the incidence of the complications in these open fractures which were treated with unreamed intramedullary nailing after 8 hours of being injured. Despite a thorough debridement and an adequate soft tissue coverage, there was overall 10.0% infections, all of which were in the type III open fractures and all these patients had been operated after the golden time period interval. The delay in the surgery could be the reason, because our institute is a tertiary referral centre where patients come after a primary management outside and secondly, the hilly terrain of Uttaranchal also precludes the delay in the transport of injured patients to the institute. The delayed management of these high velocity type III injuries with extensive tissue damage and contamination exacerbates bacterial colonization and chronic deep infections.

Gustilo and Anderson [11] reported a 2-16% incidence of infections, a majority of which were type III compound injuries. Whenever a significant disruption of the bony vascularity was present, the normal process of a bony union could be hampered to a considerable extent, which was observed in our cases of delayed unions and non-unions, that subsequently required bone graft supplementations.

Sargeant et al., [14] suggested that cortical necrosis is less likely to occur with a loosely fitted intramedullary nail than a snugly fitted reamed nail. Reaming of the open fractures has been found to spread the contamination from the open wounds along the medullary canal and to strip the small fragments of bone from the soft tissue attachments.

An 8-mm diameter nail was used in 11 (37%) cases in our series, because of the narrow medullary canals of the relatively small-built Indian patients as compared to those of their western counterparts. Because the mechanical strength of the nail is proportional to its diameter, these 8-mm diameter nails are relatively weak, particularly in the bending mode. The nails at the site of the locking holes are also more prone to breaks, because the stresses are concentrated at the screw hole junctions and at the sites of the empty holes which are not filled by bolts. The minimal endosteal contact of these unreamed nails further concentrates the stresses at the screw hole junctions, which could be responsible for the nail failure or screw breakage. Hahn et al., [15] advocated a cautious approach for such fractures by filling all the screw holes with bolts, to reduce the concentration of the stress distally. In our series, both the proximal and the distal interlocking holes were interlocked with two screws in the proximal and distal fragments and there were no case of any nail or screw breakage.

We were able to achieve primary closure of the wound in 60% cases and a secondary closure with lateral skin release/ skin grafting/ flaps was done in 40% of the cases. These results were comparable to those of Yokoyama et al., [13] who reported successful primary closures in 70.2% cases and secondary closures with Split skin grafts/ flaps in 29.8% cases. It was easier for us to do soft tissue procedures, as there were no external fixator frames around the injured legs [Table/Fig-4].

A routine dynamization was not done in our study. Dynamization was done in 9 cases where no signs of union were present at 6 -10 weeks. Whittle et al., [16] have stressed that in unreamed nailing for open tibial fractures, the locking bolts should be removed only if there is minimal callus at the fracture site at 12-16 weeks of follow up. Yokoyama et al., [13] reported a mean union time of 15 months in more than 50% of the type-III fractures, whereas the overall mean union time in their series was 6.6 months, which was comparable with that in our series (5 months).

Court-Brown et al., [17] presented their results on 51 type III open tibial fractures which were treated with external fixations. The overall mean time to union was 36.7 weeks: there was a 17.6% incidence of osteomyelitis, of which 71.4% were caused by gram negative organisms; and 35% of the patients had signs of pin tract infections. In our series, in the type III cases, we had an average time to union of 28 weeks and a 10% incidence of infections. These results suggest that the nailing in open fractures of the tibia has faster union rates and lower rates of infections in comparison to the fixation with external fixators. This has been supported by the results of other similar studies [Table/Fig-5].

S. No.	Authors	Fixation Method	Union Time (Weeks)	Nonunion %	Infection %
1.	Davis [18]	Plate & Screw	-	24	13
2.	Lottes et al., [19]	Plate & Screw	-	35	35
3.	Edwards et al., [20]	External Fixation	37	-	13.5
4.	Blick et al., [21]	External Fixation	45.2	-	9.5
5.	Joshi et al., [22]	Intramedullary Nailing	32	10.7	10.7
6.	Our Study	Intramedullary Nailing	20.7	3.3%	10%

[Table/Fig-5]: Comparative analysis of our results with other studies using different methods of fixation

The spectrum of the pathogens which were cultured from the infections in this series provided evidence, as in other studies [23] that an antibiotic regime for open fractures should protect against the penicillin resistant *staphylococci, streptococci* and some gram negative organisms. The single most important factor in the reduction of the infection rate is the early institution of antibiotics that provide antibacterial activities against both gram positive and gram-negative organisms. On statistical analysis, on comparing the injury surgery interval and the infection prevalence and by using the Fisher exact test, the p- value was calculated to be 0.74, which was not significant [Table/Fig-6]. This further reinstated that although antibiotics are helpful, it is generally agreed that they are no substitute for an adequate debridement. If a prolonged period passes between the injury and the attempts which are made towards a soft tissue reconstruction, the wound may well become contaminated or infected in spite of the surgeon's best efforts [4]. Leaving the debrided wound open to allow wound healing by a secondary intention was the standard treatment prior to World War II, but since then, a delayed primary closure or a split thickness skin graft at five to seven days have proved to be safe and effective methods of the wound management after the initial debridement in both civilian and military injuries [24].

N=30	No infection occurred	Infection occurred
Operated within 8 hours of injury	10	0
Operated after 8 hours of injury	20	3
	Fisher exact test p Value - 0.74	

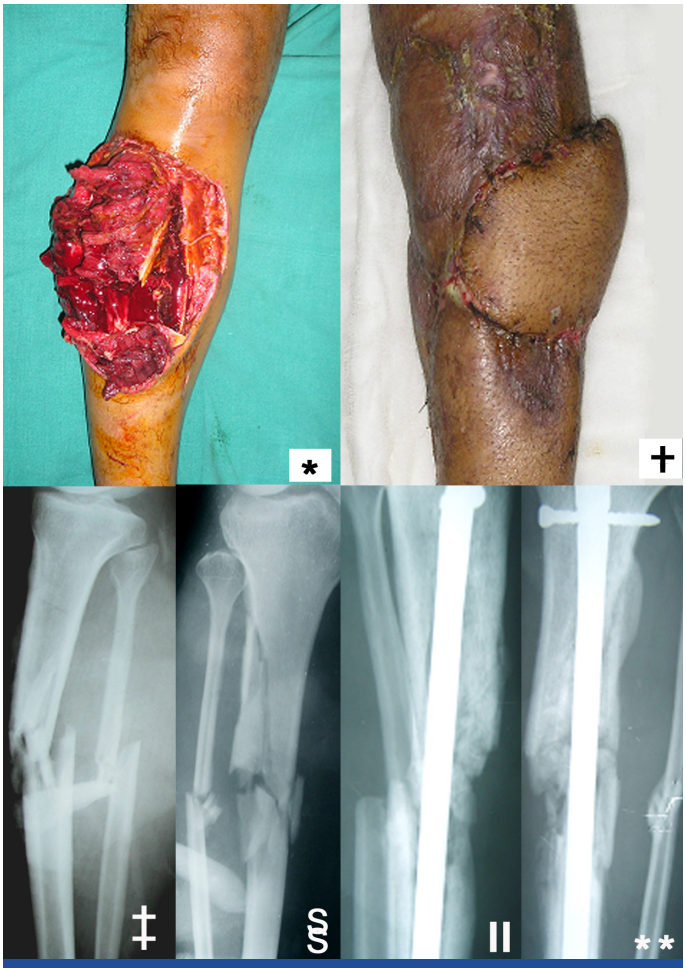
[Table/Fig-6]: Correlation between injury surgery interval and incidence of infection

Regaining the length of the traumatized and the swollen muscles after intramedullary nailing with intact or partially ruptured fascial envelopes may elevate the compartmental pressure. Blick et al., [25] reported a 9.1% incidence of the compartment syndrome in open fractures which were treated by intramedullary nailing. We had one case in which a fasciotomy was done due to a high compartmental pressure. The low incidence of the compartmental syndrome may be because we had always closed the wounds with loose stitches and had never closed the fascial compartments. A high level of suspicion is required, as the incidence of the compartment syndrome may be higher; especially, under the prevalent misunderstanding that a compartmental auto-decompression would occur after open fractures of the tibia.

In our series, Anterior Knee Pain was observed in 23.3% cases. Court-Brown et al., [26] reported a 36% incidence of anterior knee pain and they advocated the techniques of using a more proximal and a lateral entry point, hyper flexing the knee during the nail insertion and extending the knee during the screw insertion to lessen the irritation of the overlying tendons.

We recorded restricted motions at the knees in 6 cases (20%) and restricted motions at ankles in 5 cases (16.6%). Joshi et al., [22] reported an incidence of 14.3% knee stiffness in a similar study. This incidence can further be reduced with an early institution of knee and ankle mobilization with the use of quadriceps drill exercises.

Based on the functional scale of Ketenjian and Shelton [12], which was modified by Yokoyama et al., [13], we encountered 1 poor result in a case of type I injury. This patient had an associated ipsilateral fracture at the lower end of the femur (closed). In this case, the tibial fracture was found to be united at 18 weeks of follow up, but the femoral fracture went into a delayed union. This patient could not do knee mobilization early, resulting in a decreased range of motion at the knee (less than 50% of the normal). There was a poor result in 1 case of a grade IIIC injury. This case had a non union and so, he was not able to bear weight on the involved extremity. In our series, 3 patients of grade IIIB showed fair results. Two of these cases had fractures in the lower third of the tibia. After the nailing, they did not follow the physiotherapy instructions properly and had reduced ranges of motion at the ankles (75-50% range of the normal range of motion). One patient among these had continued anterior knee pain and subsequently, he developed a decreased range of motion at the knee (75-50% range of the normal range of motion).



[Table/Fig-7]: A case of Gustilo & Anderson grade III B Open fracture in our series.
* Open wound showing skin loss with tethered muscles and loose bony fragments.
† Two years follow up status with good flap uptake.
‡ § Skiagram showing comminuted fracture both bones leg (middle one third) extending to upper one third.
II ** Two years follow up Skiagram showing fracture well united with

Joshi et al., [22] reported 85.8% overall good to excellent functional results in a similar study by using the same criteria. Yokoyama et al., [13] reported 89% good to excellent results. These results are comparable to our results (good to excellent results in 83.4% of the cases).

The major factors which affect the prognosis of open tibial fractures after high- energy trauma, are the severity of the soft tissue injury, the degree of contamination, the fracture configuration and the extent of the comminution. In the presence of significant trauma to the local tissues, any operative intervention such as a plate or a screw fixation can further devitalize the already compromised tissues. Therefore, it is extremely important to avoid such operative interventions for preventing sepsis and for promoting the healing of the tibial fractures [27].

The external fixator, being versatile, had been extensively used in the past. However, it has been associated with high rates of pin tract infections (16%) and there is a need for a secondary definitive procedure. Hence, it is not cost effective [28].

Our results show that the aggressive management of the severe open fractures among the tibial fractures is effective. We accept that this approach is radical and that it has been claimed that an immediate soft tissue coverage is not safe. However, the analysis of our results showed good union rates and low rates of infections, thus supporting the concept that a delay is not necessary if the healthy soft tissues can be imported reliably into the zone of the injury [Table/Fig-7].

Overall, these results show that in the grade I and II open tibial fractures, a primary unreamed intramedullary nailing can be safely done, with minimal complications and excellent functional results. For the grade III open fractures of the tibia, the modern techniques of management, combined with the skills of experienced orthopaedic and plastic surgeons, can consistently restore excellent limb functions in a very high proportion of patients. In some of the most severely injured limbs, a salvage is possible and a useful functional limb can be obtained, as was shown in our study.

It is important to analyze such cases of compound injuries when they come to us in emergency. Such cases should be taken up only if the centre has both orthopaedic and plastic surgeons' skills available and then a fairly good outcome can be expected.

CONCLUSIONS

We conclude that unreamed intramedullary nailing in cases of open fractures of the tibia, with an early soft tissue coverage, results in faster soft tissue and bony healing, an easier soft tissue coverage, a better biomechanical stability and early rehabilitations and infection rates as compared to other methods.

REFERENCES

[1] Chapman MW, Oslon SA. Open Fractures. In: Rockwood's and Green's Fracture in adults. 4th ed. Philadelphia: *Lippincott-Raven*; 1996; 305-52.
[2] Anderson LD, Hutchins WC, Wright PE, Disney JM. Fractures of the tibia and fibula treated by casts and transfixing pins. *Clin Orthop*. 1974; 105: 179-91.
[3] Gustilo RB, Mendoza RM, Williams DN. Problems in the management of type 3 (Severe) open fractures: a new classification of type 3 open fractures. *J Trauma.* 1984; 24: 742-46.
[4] Esterhai JL, Queenan J. Management of soft tissue wounds associated with type III open fractures. *Orthop Clin North Am*. 1991; 22: 427-32.
[5] Fischer MD, Gustilo RB, Vareeka TF. The timing of flap coverage, bone grafting and intramedullary nailing in patients who have a fracture of the tibial shaft with extensive soft tissue injury. *J Bone Joint Surg Am*. 1991; 73: 1316-22.
[6] Patzakis MJ, Wilkins J, Moore TM. Considerations in reducing the infection rate in open tibial fractures. *Clin Orthop*. 1983; 178: 36-41.
[7] Rhinelander FW. Tibial blood supply in relation to fracture healing. *Clin Orthop*. 1974; 105: 34-81.
[8] Fairbank AC, Thomas D, Cunningham B, Curtis M, Jinnah RH. Stability of reamed and unreamed intramedullary tibial nails: a biomechanical study. *Injury.* 1995; 26: 483-85.
[9] Whittle AP, Wester W, Russell TA. Fatigue failure in small diameter tibial nails. *Clin Orthop*. 1995; 315: 119-28.
[10] Rand N, Mosheiff R, Leibergall M. The role of intramedullary nailing in modern treatment of open fractures of the tibia and femur. *Mil Med*. 1994; 159: 709-13.
[11] Gustilo RB, Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones, *J Bone Joint Surg Am*. 1976; 58: 453-08.
[12] Ketanjian AY, Shelton MJ. Primary internal fixation of open fractures: a retrospective study of the use of metallic fixation in fresh open fractures. *J Trauma.* 1972; 12: 756-63.
[13] Yokoyama K, Shindo M, Itoman M, Yamamoto M, Sasamoto N. Immediate internal fixation for open fracture of the long bones of the upper and lower extremities. *J Trauma.* 1994; 37: 230-36.
[14] Sargeant I D, Lovell M, Casserley H, Green A D L. The AO unreamed tibial nail: a 14 month follow up of the 1992 TT experience. *Injury*. 1994; 25(7): 423-25.

[15] Hahn D, Bradbury N, Hartley R, Radford PJ. Intramedullary nail breakage in distal fractures of the tibia. *Injury*. 1996; 27: 323-27.
[16] Whittle AP, Russel TA, Taylor JC, Lavelle DG. Treatment of open fractures of the tibial shaft with the use of interlocking nailing without reaming. *J Bone Joint Surg Am*. 1992; 74: 1162-71.
[17] Court-Brown CM, Wheelwright EF, Christie J, Mcqueen MM. External fixation for type III open tibial fractures. *J Bone Joint Surg Br*. 1990; 72: 801-04.
[18] Davis AG. Primary closure of compound fracture wounds. *J Bone Joint Surg Am.* 1948; 30: 405.
[19] Lottes JO, Hill LJ, Key AJ. Closed reduction, plate fixation and medullary nailing of fractures of both bones leg. *J Bone Joint Surg Am*. 1952; 34: 861.
[20] Edwards CC, Simmons SC, Browner BD, Oreck SL, Weigel MC. 203 open tibial tibial fractures treated by Hoffman external fixation. *Orthop Trans.* 1984; 8: 383- 84.
[21] Blick SS, Brumback RJ, Lakatos R, Poka A, Burgess AR. Early prophylactic bone grafting of high energy tibial fractures. *Clin Orthop*. 1989; 240: 21-41.
[22] Joshi D, Ahmed A, Krishna L, Lal Y. Unreamed interlocking nailing in open fractures of tibia. *J Orthop Surg (Hong Kong).* 2004; 12(2): 216-21.
[23] Patzakis MJ, Harvey JP, Ivler D. The role of antibiotics in the management of open fractures. *J Bone Joint Surg Am*.1974; 56: 532-41.
[24] Davis GL. Management of open wounds of joints during the Vietnam war- a preliminary study. *Clin Orthop*. 1970: 68: 3-9.
[25] Blick SS, Brumback RJ, Poka A, Burgess AR, Ebraheim NA. Compartment syndrome in open tibial fractures. *J Bone Joint Surg Am*. 1986; 68: 1348-53.
[26] Court-Brown CM, Mcqueen MM, Quaba AA, Christie J. Locked Intramedullary nailing of open tibial fractures. *J Bone Joint Surg Br*. 1991; 73: 959-64.
[27] Behrens F, Comfort TH, Searls K, Denis F, Young JT. Unilateral external fixation for severe open tibial fractures, Preliminary report of a prospective study. *Clin Orthop*. 1983; 178: 111-20.
[28] Maurer DJ, Merkow RL, Gustilo RB. Infection after intramedullary nailing of severe open tibial fractures initially treated with external fixation. *J Bone Joint Surg Am*. 1989; 71: 835-38.

AUTHOR(S):

1. Dr. Atul Agrawal
2. Dr. Vijendra Devisingh Chauhan
3. Dr. Rajesh K. Maheshwari
4. Dr. Anil Kumar Juyal

PARTICULARS OF CONTRIBUTORS:

1. Assistant Professor, Department of Orthopaedics, Himalayan Institute of Medical sciences, Doiwala, Dehradun, Uttarakhand, 248140, India.
2. Professor & Head, Department of Orthopaedics, Himalayan Institute of Medical sciences, Doiwala, Dehradun, Uttarakhand, 248140, India.
3. Professor, Department of Orthopaedics, Himalayan Institute of Medical sciences, Doiwala, Dehradun, Uttarakhand, 248140, India.
4. Professor, Department of Orthopaedics, Himalayan Institute of Medical sciences, Doiwala, Dehradun, Uttarakhand, 248140, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Atul Agrawal,
Assistant Professor, Department of Orthopaedics,
Himalayan Institute of Medical sciences,
Doiwala, Dehradun, Uttarakhand, 248140, India.
Phone: 0135-2471214,2471252
E-mail: atulscastle@gmail.com

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