Management of fracture shaft of tibia by closed interlocking intramedullay nailing non-reaming versus reaming

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Abstract

Introduction: Tibia and fibula have the highest incidence of diaphyseal fractures of long bones. Closed intramedulary nailing is the treatment of choice in stabilizing displaced diaphyseal fractures of tibia. Availability of unreamed nails has raised the issue of what effect reaming with intramedullay nailing has on the clinical outcome. The aim of the study was to compare rate of healing of fractures with two techniques of nailing, reaming versus non reaming.

Methods: Fifty acute fractures of shaft of tibia were treated with closed intramedulary interlocking nailing, out of which only 39 patients were available for follow up. Twenty one fractures were treated by reamed and eighteen by un-reamed technique. Patients were followed up till nine months after operation. Displaced closed fractures and Gustilo Type I and Type II open fracture were included in the study.

Results: The time to fracture union averaged 23.29 weeks in un-reamed and 23.33 weeks in reamed group. Thirty eight percent of un-reamed and 19% of reamed fractures united by 12 weeks .There were six (35.29%) delayed union in un-reamed and four (21.05%) delayed union in reamed but all united after dynamization. There was no non union. Infection occurred in four patients, three superficial (14%) in reamed group and one deep infection in un-reamed group (5%), there was one case of screw breakage in un-reamed group. There were five malunion (27.77%) in un- reamed and three (14.28%) in reamed group but functional outcome was unaffected.

Conclusion: The study has reveled that both procedures are equivalent in terms of functional outcome and un-reamed has slight advantage over reaming in terms of union and lower rate of infection.

Key words: fracture-shaft, tibia-interlocking, non reaming, reaming

Introduction

Tibia and fibula have the highest incidence of the diaphyseal fractures of the long bones[1]. They are frequently caused by high energy trauma and because of the subcutaneous location through out the diaphyseal length, open fracture ensues.[2] The blood supply to the Tibial shaft is relatively poor; therefore complications and major diability are frequent outcomes, particularly in open fractures. The problems that are faced in tibial shaft fractures are delayed union, non union,malunion with angular deformities; and infection more than most other bones especially after open reduction

and internal fixation[1,3,4,5]. The period of incapacitation and rehabilitations are very lengthy and that is the reason why tibial fractures are considered major injury[1].

The increased incidence of the open fractures causes great suffering by the patients and is an enormous economic burden necessitating improved treatment. It is important to the patient not only to have satisfactory end results but also to achieve it as soon as possible [6]. Most patients are young active member of the society and bread earning members of the family[2].

Various treatment methods have been used in the treatment of the fracture shaft of the tibia. Most tibial shaft fractures are treated non operatively; this is safe and resource sparing but not suitable for all cases. A number of fractures will require an operative treatment.[3]

Conservative treatment includes long leg cast with or without manipulation and wedging, pins and plaster. Cast bracing can be tried with good results in stable closed fractures with mild to moderate communition[7, 8, 9]. Surgical methods are external fixations, plating and various kinds of nails.

Many studies and biological proofs have proved beyond doubt the superiority of nailing over plating and even conservative methods in management of fracture shaft of tibia. Invention of interlocking systems especially closed technique has revolutionized the management of fracture shat of tibia[9]. It has eliminated most of the problems and complications associated with conservative methods and plating and made possible to stabilize even most difficult, segmental, severely comminuted and junctional fractures without jeopardizing its blood supply. These days interlocking nailing system uses the principle of closed technique of alignment with superadded advantage of immobilization and stabilization with locking bolts with out need of any external support (cast)[10]. Over the past few years debate has been focused on the use of interlocked nails in proximal and distal fourth fractures, mechanical failures of the interlocking nails and screws and indications for reamed versus non-reamed insertion techniques in closed and open fractures[4,11,12,13,14,15].

This study is an attempt to compare the two methods of closed interlocking intra-medullary nailing in terms of union rate in our setting where neglected orthopedic traumas are common scenario with deformities and infections.

Methods

This study was conducted in the Department of Orthopedics Tribhuvan University Teaching Hospital, Kathmandu Nepal. All isolated tibial shaft fractures without other major trauma that were presented to emergency and trauma and orthopedic outpatient department were assessed clinically and radiologically and were randomly selected using envelope into two groups.

Radiographs were taken in both antero-postetior and lateral projections including both knee and ankle in same film. Fractures of tibia were classified into high energy and low energy. Highway accidents like head on collisions and crush injuries were considered high energy trauma. Low energy trauma resulted from falls on the ground, house wives or elderly people who fall while walking or when a twisting injury takes place when the foot is anchored on the ground.[1]

The fractures were classified into open and closed. The open fractures were classified according to the system devised by Gustillo and Anderson. Classification of soft tissues in closed fractures was done according to Tscherne and Gotzen. The tibia was divided into three zones of equal length after excluding proximal and distal 5 cm [1, 4, 5].

Comminution was graded according to modified Winquist and Hansen Method[5]. After admission patients were put on calcaneal traction under local anesthesia, open fractures were treated with preoperative antibiotics.

Inclusion criteria includes (1) All isolated tibia fractures(not with ipsilaretal femur and contralatera tibia) (2) Fracture between 5 cm below knee joint and 5 cm above ankle joint (3) Open fractures Gustilo Type I and II (4) All closed fractures but not pathological fractures and (5) Age above 16 years

Operative technique and post operative

Spinal or general anesthesia was given, tourniquet was routinely used. Limb was prepared and draped. Medial parapatellar incision was routinely used. With standard operative technique tibial nail was inserted either with reaming or with out reaming according to randomization. India made GK type tibial nail of 9mm or 10 mm diameter and appropriate length nails were used for all fractures. After alignment of the fracture proximal locking was done with help of the zig in both the holes and distal locking was done using fluoroscopy and free hand technique .Two distal locking bolts were used where ever possible. Wounds were routinely closed over the suction drain. Drain was removed in 48 hours and sutures were removed in 12-14 days post operative. Partial weight bearing on crutches was allowed according to degree of comminution, immediately or at six weeks. No external support was used after the operation. Physiotherapy with range of motion for knee and ankle were taught along with quadriceps and hamstring strengthening exercises.

X-rays including antero-posterior and lateral view were taken immediate post operative, at six weeks, three months, six months and nine months and correlated with clinical signs of union.

Clinical union was judged to occur when pain, tenderness and swelling at the fracture site disappeared and patient can do full weight bearing without pain. Radiological union was judged to have occurred when there is bridging callus on both sides of the nail complete or incomplete. Delayed union was defined as the absence of clinical or radiological signs of union within 6 months (24 weeks). Non union is defined as absence of clinically and radiologically evident union within nine months (36 weeks). Mal union is defined as a varus or valgus deformity greater than five degrees and antero-posterior angulations greater than five degrees or shortening of more than 1 cm. Deep infection is complicated by symptoms of inflammation with systemic features. Superficial infection has minimum symptoms with out systemic features. Calf and thigh muscle wasting were measured and considered mild if there was less than 2 cm wasting, moderate for more than 2 cm and severe for marked muscle atrophy. Range of motion of knee and ankle were measured at each follow up and divided into full range of motion ,slight loss of ankle or knee range of motion (mild), moderate(<250) loss of motion and marked loss of ankle or knee range of motion(>250). Angular deformities were measured with radiography, and divided into mild (<50) moderate (5-100) and severe (>100).Those parameters were used for functional rating Using Klemm and Borner criteria[16].

The rates of non union, delayed union, mal union, infections and hardware failures were assessed and duly evaluated. The statistical software SPSS 10.0 was used to enter and analyze data. Cross table was used extensively, all categorical comparisons were done by using chi-squire and Fisher's exact test)

Results

After observing the inclusion criteria fifty cases of tibial diaphyseal fractures were chosen for the study, out of which eleven cases dropped out leaving thirty nine cases for analysis; reamed twenty nine and un-reamed eighteen.

Mean age in reamed group was 37.29 (-/+. 14.26) years and that of non-reamed was 32.33(+/- 10.53) years which was not statistically significant. Age of the patient ranged from 18 year to 65 year.

There were more females in the reamed group and more males in un-reamed group (table 1)

Table 1: Sex wise distribution of techniques

Sex	Reamed (n=21)	Unreamed (n=18)	Total (n=39)
Male	62.0	88.9	74.4
Female	38.0	11.1	25.6

Motor vehicle accidents were most common 26 (66.7%), followed by physical assault 8 (20.5%) cases were minimal 2 (5.12%).

Twenty (54%) out of 39 cases had injury in the distal third followed by middle third. 14 cases (34%) and proximal third were 5 cases.

Table 2: Statistical analysis with site of fracture and technique of fixation:

Site	Technique		Total
	Reamed	Un-reamed	
Proximal third	2	3	5
Middle third	7	7	14
Distal third	12	8	20
Total	21	18	39

$\chi 2=0.77$, $p=0.6079$

There was no statistically significant difference in both groups regarding site of injury.

Table 3: Type of fracture and nature of fixation

Type of fracture	Nature of fixation(Technique)		Total
	Reamed	Un-reamed	
Tranverse	5	6	11
Oblique	11	10	21
Spiral	5	2	7
total	21	18	39

At three months follow up

Pain at fracture site disappeared in both groups, two in reamed group still complained of pain. Six in un-reamed and four in reamed group had anterior knee pain. Tenderness was found only in four reamed and three un-reamed; so twenty six fractures were clinically united by 12 weeks.

Table 4: Radiological union at three months (callus formation)

Callus	Reamed	Un-reamed
No visible callus	2	0
Visible callus in one side	3	2
Visible callus in both sides	12	9
Fracture union	4	7
Total	21	18

Four reamed and seven un-reamed fractures united by 12 weeks, two in reamed group showed no callus in 12 weeks time.

Table 5: Range of motion (ROM) of Knee at three months

ROM of Knee	Reamed	Un-reamed
No Loss	16	11
Mild loss	3	4
Moderate loss(<25^0)	2	3
Severe (marked=>25^0)	0	0

No statistically significant difference $\chi 2$ =0.676 P=0.713

Table 6: ROM Ankle at three months

ROM of ankle	Reamed	Un-reamed
No Loss	11	12
Mild loss	7	6
Moderate loss(<25^0)	3	-
Severe (marked=>25^0)	-	-

At six months follow up:

There was complaint of anterior knee pain, six in undreamed group and four in reamed group. There was no complaint of tenderness in both groups.

Table 7: Radiological union

Callus	Reamed	Un-reamed
No visible callus	0	0
Visible callus in one side	1	0
Visible callus in both sides	3	6
Fracture union	15	11

There were 15 reamed and 11 un-reamed fractures united by six months out of 18 reamed and 17 un-reamed; i.e. 65% of the undreamed and 79% of the reamed united.

Dynamization:

Dynamization was done for five cases at six months, four in reamed and one in reamed. Three in undreamed group were segmental fractures. Indication for dynamization was delayed union only.

Table 8: Angular deformity

Angular deformity	Reamed	Un-reamed
<5^0	19	15
5-10^0	2	2
>10^0	0	1

Table 9: Shortening

Shortening	Reamed	Un-reamed
<1 cm	2	2
1-2 cm	2	3
>2 cm	0	0

Functional ratings

At six months functional rating was done using Klemm and Bomer method16 (36 fractures) 19 reamed and 17 un-reamed.

Table 10: Functional rating

Results	Parameters	Number		Percentage	
		Reamed	Un-reamed	Reamed	Un-reamed
Excellent	Full knee or ankle motion No muscle atrophy Normal x-ray alignment	15	12	79	70.9
Good	Slight loss of knee or ankle motion Less than 2 cm of muscle atrophy angular deformity <5^0	3	3	15.78	17.6
Fair	Moderate /25^0, loss of knee or ankle motion more than 2 cm muscle atrophy Angular deformity 5-10^0	1	2	5.2	11.7
Poor	Marked loss of ankle or knee motions marked muscle atro-phy angular deformity>10^0	0	0	0	0

79 % fractures in reamed group and 71 % fracture in undreamed group have excellent functional results and there is no poor result in both the group.

At nine months:

At nine month all fractures united both in reamed and undreamed group.

Result of union: over all

Table 11: Result of union at three months (12 wks)

	Reamed	Un-reamed
United fractures	4	7
Uniting fractures	2	1

Fisher's exact test= 0.0795, P=0.5384

Here seven in un-reamed and four in reamed group had already united.

Table 12: At six months (24 wks)

	Reamed	Un-reamed
United fractures	11	4
Uniting fractures	4	6

Fisher's exact test =1.56,P=0.122

Those were the fractures which took six months to unite.

At nine months (36 wks), all fractures were united where reamed were 4 and un-reamed 6.

Average time to union was 23.29 weeks for undreamed. Average time to union was 23.29 weeks for reamed group.

Complications

Table 13: Complications

Delayed union		Malunion		Infection		Shortening		Bolt breakage		Anterior knee pain	
Reamed	Un-reamed	Reamed	Un-reamed	Reamed	Un-reamed	Reamed	Un-reamed	Reamed	Un-reamed	Reamed	Un-reamed
4	**6**	**2**	**2**	**1**	**3**	**2**	**3**	**0**	**1**	**4**	**6**
Total 10		**4**		**4**		**5**		**1**		**10**	

Discussion

Diaphyseal fractures of the tibia can be managed by different methods. Superiority of nailing over plating has been a proven fact from many clinical studies. Intra-medullary nailing has now become an established method of internal fixation[1,4,11,17,18]. There has been considerable debate about the merits of the reaming in the treatment of tibial diaphyseal fractures. Proponent of the un-reamed nailing have suggested that intramedullary nailing is detrimental to the endosteal circulation and is associated with the higher rate of non- union and infection [18,19,20,21].

Experimental studies showing that cortical blood flow greatly reduced by reaming and that there is compensatory blood flow has further increased the controversy[15,22]. Despite the importance of these studies, others factors including the personality of the fracture, patient nutritional status, age amount of trauma and whether the fracture is open or closed all influence the outcome in fracture healing.

In this study there were 39 patients twenty one reamed and eighteen un-reamed. Age of the patients ranged from 18 years to 65 years. In undreamed group average age was 32.33 years and reamed group 37.39 years. In the study of Alho and Ekland et al 23 with 93 tibial fractures median age was 35 years (range 16-83 years).Court Brown et al 24 found average age 35 years in reamed and 36.1 years in undreamed group. These figures are comparable to the present study indicating that most patients are young. The reason is this age group is more active out door, naturally exposing them to trauma.

In the present study there were more males than females (Fig.1); thirteen out of twenty one in reamed group (62%), sixteen out of 18 in undreamed group (88%). In Court Brown et al [24] study 78 % were male in reamed and 68 % male in un-reamed. There were 63 men and 30 women in Ekland et al [23] study. Reason may be males have more out door activities than females exposing themselves to trauma.

The present study strongly shows road traffic accident as the major cause of the fracture shaft of the tibia, majority of which are high energy, producing open fractures (Fig.2). Twenty six out of thirty nine (66.66%) fractures were caused by road traffic accidents. Seventy percent of the fractures were due to road traffic accidents in Klinger Kach et al[25] study of 53 tibial shaft fractures. Forty nine percent of 45 fractures in Ekland et al[23] study; fifty % of 93 fractures in Alho et al[3] study. Twenty percent were due to RTA (road traffic accients) in %) Tscherne type C1 fractures in Court Brown et al study [24].

Our study correspond the study in literature indicating that RTA is major cause of fracture shaft of tibia in our setting also. Traffic precaution and safety that's why may have major role to play for prevention.

The present study showed that most fractures occurred at distal third of the tibia (Fig.3/Table 1). More than half i.e. twenty out of thirty nine (57.3%) were in the distal third which also corresponds to the study by Angel JO et al[26] study. The reason may be that this part is less protected by soft tissue than proximal part more over this part is away from the body exposing to trauma from protection.

Almost half of the fractures (18 of 39 fractures) were open fracture Type I or Type II in our study; nine in each group. As the type III open fractures were excluded from the study number of open fractures were more in hospital presentation. There were 30 open fractures out of 63 in a study of Gleesen N et al [17]. Nineteen of 93 fractures were compound type I and type II Gustilo in Alho et al[3] study. In 61 patient's study of Ruhcholtz et al[20], 38 % were type I open fractures in un-reamed group and 3% were open in

reamed group in a series of 76 acute fractures of Bone LB et al[27], treated by reaming eight were Type II to Type III open fractures.

High incidence of open fracture indicates high energy pattern of injury which has also been reflected in the present study. High energy nature of trauma is also reflected by degree of comminution, which also has bearing on fracture union. In the present study most fractures were comminuted, six were segmental fractures (15.38%).Five segmental cases were in un-reamed group (27%) and one in reamed group (4%). Maximum fracture patterns were oblique. (Table 2)

At three months (Table 4, 5) pain and tenderness subsided in most patients with improved range of motion of ankle and knee. Tenderness was found in only in four reamed and three un-reamed group. Two patients in reamed group complaint of pain in fracture site. So, thirty patients had clinical fracture union by three months (12 weeks). At three month four reamed 4/21 (19%) and 7 un-reamed (7/18) 38.8% in un-reamed had radiological union (Table 3). Though statistically not significant, this is highly clinically relevant .But at six month (Table 6) 15 reamed out of eighteen and 11 undreamed out of 17 were already united. Here the result is towards reamed group but the reason may be five uniting fractures in undreamed group were segmental (29%).There were six delayed union 6/17 in undreamed and four delayed in reamed.

At nine months all fracture were united (Table 12), which were followed up for nine months. Klinger K, Kach et al [25] observed bridging callus at an average age of 6 weeks and cortical bridging at 18 weeks. In Ekland et al [23] study it was 16 weeks. The mean time to union for patients treated with reamed intramedullary technique was 15.4 weeks (range 11-25 weeks), which was significantly less ($P<0.01$) than 22.8 weeks (range 12-36 weeks) for undreamed group. There were no non unions.

Similar observations were made by Blachut et al [28] in a study of 154 closed fractures comparing reamed and un-reamed technique. There was higher prevalence of delayed union after nailing without reaming. In another comparative retrospective study by Angel JO, Blue JM et al[26] in 45 patients, there was significant difference in healing time, with undreamed taking an average of 242 days (34.34 weeks) and reamed took 158 days (22.6 weeks). There were six non unions one in reamed and five in undreamed.

Gregory P et al [29] studied 47 closed unstable fractures treated with un-reamed interlocking nailing, 87% fractures united within six months, there were five % delayed union and 8% non union .Union time was 23 weeks in un-reamed nailing in Krettek C et al [21] study. Three out of 21 fractures required bone grafting. However Rucholtz S et al [13] found earlier osseous union after un-reamed nailing which took 12 weeks and reamed took 18 weeks. Rate of non union was almost same 6% in each group.

Keating JF et al [30] studied 112 open fractures treated by reamed interlocking nailing. Mean time to union was 29 weeks for Type I f racture,32 weeks for Type II, 34 weeks for Type IIIA and 39 weeks for type III B. Non union complicated nine(8%) fractures, 1(3%) Type I fracture, 2(5%) type II fractures, 3 (13%) Type IIIA fractures, and, 3(17%) grade IIIB fractures. Conclusion was reamed locking nailing is safe and effective technique for management of open tibial fractures.

Most of the above literature is in favor of reamed intramedullary interlocking nailing [21, 23, 25, 26, 28 29, 31]. But Rucholtz S, Nast Kolb et al[20] found earlier osseous union after un-reamed nailing. Union time ranged from 11 weeks to 36 weeks.

Open fractures took more time to unite. Bridging callus started to form as early as six weeks in most fractures. By three month 39.8% fractures with unreamed and 19% with reamed were united. The trend is strongly in favor of un-reamed nailing. However trend seemed reversed in six month's observation where reamed fractures were united more than unreamed. There is strong favor for reamed fracture then. Most unreamed fractures which were delayed uniting were segmental fractures naturally giving disadvantage to union. Therefore, we should still consider that undreamed has advantage if similar fractures were there. At nine months, all the fracture united in about same time in both the groups.

At six months functional rating was done and two groups are compared (Table 9). Functional outcomes are comparable in two groups. Seventy nine % of fractures in reamed group and seventy one percent in undreamed group have excellent functional results. There was no poor result in both groups (Klemm and Borner criteria[16]).Rucholtyz S,Nast Kolb D et al[20] found same proportion of good and very good results (criteria of Johner and Wruhs), i.e., 89 % in reamed and 88% in undreamed nailing.

Complications

Present study does not have any case of non union in both the groups. In court Brown et al[24] study, there were no non union but 20 % un-reamed nailing required exchange nailing to facilitate union. In Blachut et al study[28] of 154 closed fractures there were four % non union in reamed and 11 % in un-reamed. Rate of non union was 6 % in each group in Rucholtz et al[20] study.

In Angel JO, Blue JM et al[26] study of 45 nailing there were six non unions, one in reamed and five in unreamed; most were in the distal third. Non union and malunions were 10.3% in reamed and 27.6 % in undreamed in Weekback A, Blattert TR et al[32] study.

In this study mal union was found in six un-reamed and four reamed groups (Table 7 & 8). This is not significant statistically. Also they did not affect the functional outcome. Mal union occurred in three nailing procedures with reaming and two without reaming in study of 154 closed fractures by Blachut et al.[28] Three patients had angular deformities after nailing 45 closed fractures in Gregory P, Sander R et al[29] study. Our result of mal union corresponds to the literature; more over mal union which included angular deformities more than 50and less than ten degree and shortening less than 2 cm in five patients, did not affect the functional out come.

Infections

In the present study there were only four cases of infections i.e. 10.2%. There were three superficial infections in reamed group (14%) and one deep infection in un-reamed group (5%). This shows there are more infections in reamed group than undreamed group. Though statistically not significant because of small sample size; was clinically significant. There was no infection in Rucholtz S,NastKolb et al[20] study and Court Brown et al[24] study in both the groups. There was only one case of deep infection in undreamed group in study of Alho A,et al[3] study. In Wiss DA, Stenson WB et al[18] study of 134 fractures treated with reaming, infections developed in 10 % of the closed fractures and 21 % in open fractures; authors conclude, reamed nailing should be restricted to unstable closed tibial shaft fractures. In study of Gregory P,Sanders R 29 of 47 closed fractures ,infection was 2.6 % superficial infection and 2.6 %(1 case) of osteomyelitis.

Above results indicate, infection is not the problem in closed tibial fractures though reaming has slightly more infections. Present study also suggests that the reaming has more chances of infection. Superficial infections in reaming group were easily controlled with dressing and antibiotics and they did not alter the final outcome. The deep infection in un-reamed nailing was an open fracture probably with contamination, which may be the reason for deep infection. Here also fracture united and infection controlled after nail removal. From the above result it can be observed that reaming has slightly greater chance of infection in closed; Type I and Type II Gustilo open fracture of the tibia but can safely be done. For severe open fracture (Type III Gustilo) undreamed nailing should be the preferred technique.

In the present study there was only one case screw breakage, which occurred in undreamed nailing. Screws broke after two procedures with reaming and 10 without reaming in Blachut et al[28] study of 154 fractures. High incidence (50%)of implant failure occurred in unreamed group in court Brown et al[24] study. Wekback A, Blattert TR et al[32] found 6.2% in reamed and 17.2 % in undreamed group.

Considering the literature it is the accepted fact that un-reamed nailing has more implant failure.

But Kuner EH et al [33] conclude that observed breakage f interlocking bolts lead spontaneously to dynamization favorable as to time and there fore better bone healing process.

One bolt breakage in the present study may be because here only single distal screw was used, which could have been prevented by using two distal screws.

In the present study there were ten cases of anterior knee pain (25%) six in un-reamed and 4 in reamed group. Keating JF et al[30] in one study of 110 tibial shaft fractures found 57% patient with anterior knee pain .Insertion of the nail through the patellar tendon was associated with higher incidence, but causes may be multifactorial. In the present study there were few cases where the nails were prominent at the entry site; may be causing tendinitis due to irritation, using proper size nail or inserting deeper could have prevented this complication.

Conclusion None Declared

Conflict of interests:

The authors declare that they have no competing interests.

References

1. Kulkarni G.S: Text book of Orthopedics and Trauma, Jaypee Brothers, Medical publishers (P.) Ltd 1999, New Delhi
2. Rand N, Mosheff R, Liebsgall M. The role of intramedullary nailing in modern treatment of fractures of tibia and femur, Mil Med 1994; 159 (11): 709-13
3. Alho H, Ekeland A, Stromsoe K, Folleras G, Thoresen BO. Locked intramedullary nailing for displaced tibial shaft fractures, JBJS (Br) Sept 1990: 805-809
4. Charles A, Rockwood Jr et al. Rock wood and Greens fractures in adults,4th ed,Lippincott Raven 1996
5. Terry Canale S. Campbell's Operative orthopedics, 9th Edition, 1998 Mosby-year Book Inc.
6. Krettek C, Gluer S, Schandelmier P, Tscherne H.

Intramedullary nailing of open fractures,orthopade 1996; 25 (3): 223-33.

7. Wilson JN, Watson –Jones. Fractures and Joint injuries 6th Edition, B.I, Churchill Livingstone, Longmann group limited 1982.
8. Kent K Wu. Technique in surgical casting and splinting LEA and FEBIGER 1987 Philadelphia USA
9. Whittle AP, Russel TA, Taylor JC. Treatment of open fractures of the tibial shaft with the use of interlocking nail without reaming, JBJS (Am) 1992; 74 (8): 1162-71.
10. Kessler SB, KKJ Hallfeldt Et al. Effect of reaming and intramedullary nailing on fracture healing, Chirungische Klinik Innenstadt and policlinik der LMU, D-8000, Munich Federal Republic of Germany.
11. Reudi T. Intramedullay nailing with interlocking, Arch Orthop Trauma Surgery 1990; 109 (6): 317-20
12. Habernek H , Walch G, Dengg M,Dengg C. Indications for surgical management of lower leg fractures, Unfall Chirugie 1988; 14 (4): 211-17
13. Nast-Kolb D, Ruchholtz S, Schweibereer L. Stabilization procedure in large soft tissue and bone defects, ORTHOPADE 1994; 2396: 308-9
14. Henley MB, Chapman JR, Angel J,Harvey EJ, Warton AM, Swiontkowski MF. Treatment of type II, IIIA, and IIIB open fractures of the tibial shaft :a prospective comparision of un-reamed interlocking intramedullary nails and half pin external fixations, J.Ortho Trauma 1998; 2(1): 1-2
15. Seibold R, Schlegel U, Kessler SB, Cordey J, Parren SM, Schweiberer L. Healing of spiral fractures in sheep tibia comparing different methods ,osteosynthesis with internal fixation,interlocking nailing and dynamic compression plate.Unfallchirury 1995; 98 (12): 620-6
16. Klemm KW, Borner M. Interlocking nailing of complex fracture of femur and tibia, Clin Orthop 1986; 212:89-100
17. Glesson N FR, Nachinolcar UG. Management of fracture shaft of tibia interlocking nailing versus plating, Indian Journal of Orthopedics 1998: 103-106.
18. Wiss DA, Stetson WB: Unstable fracture of the tibia treated with reamed interlocking nailing,Clin orthop 1995; 315: 56-63
19. O'Briene J, Seigne P,Mc EL Wain JP. Interlocking intramedullary nailing for the treatment of tibial fractures, Ir J Med Sci 1992; 16911: 5-8
20. Ruchholtz S, Nast Kolb D, Schweiberrr L. Intramedullary nailing of lower leg fractures with minimal soft tissue injuries,Orthopade 1996; 25 (30): 197-206
21. Krettek C, Schandelmaier P, Tscherne H. Non reamed interlocking nailing of closed tibial shaft fracthres with sevre soft tissue injury,Cl;in Orthop 1995; 23150: 34-47
22. Klein MP, Rahn BA, Frigg RJ, Kessler S, Parren SM. Reaming versus nonreaming in intramedullary nailing :interference with cortical circulation in canine tibia,Arch Orthop Trauma Surg 1990;109 (6): 314-16.
23. Ekeland A, Thoresen BO, ALho A, Stromsoc K,FollerasG, Hankebo A. Interlocking intramedullary nailing in treatment of tibial fractures ,a report of 45 cases,Clin Orthop 1988; 231: 205-15
24. Court brown CM, Will E, Cristie J, Mc Queen MM. Reamed or undreamed nailing for closed tibial fractures, A prospective study on Tscherne C1 fractures; 1996; 78: 580-583.
25. Klinger K, Kach K, Eberle H: Indications for and results of interlocking intramedullary nailing in lower leg fractures, Z Unfall chir Versicherungs Med Burufskr 1989; 82 20: 116-6
26. Anjel JO. Blue JM. A comparision of reamed and undreamed nailing of tibia,J.trauma 1995; 39 (2): 351-5
27. Bone LB, Johnson KD. Treatment of tibial fractures by reaming and intramedullary nailing, JBJS (Am)1986; 68 (6): 877-87
28. Blachut PA, o'Brien PJ, Meek RN, Broekhyse HM. Interlocking intramedullary nailing with with out reaming for the treatment f closed fracture of the tibial shaft, a prospective randomized study ,JBJS (Am)1997; 79 (5): 640-6
29. Gregory P, Sanders R. Treatment of closed unstable shaft fractures with un-reamed interlocking nails, Clin Orthop1995; 315: 48-55
30. Keating KF, Obrien PI, Meek RN, Broekhyse HM. Reamed interlocking nailing of open fractures of tibia, Clin Orthop, May, 1997; 338:182-191
31. Moed Br, Wastson JT, Goldschmidt p, van Holsbeck M. Ultrasound for early diagnosis of fracture healing after interlocking nailing of tibia without reaming,Clin Orthop 1995; 315: 137-144.
32. Weckback A, Blatteret TR, Kunz E. Differential indications for intramedullary nailing of tibia with reamed and undreamed technique,Zentralbl Chir 1994; 119(8):556-63
33. Kuner EH, Serif el_Nasr MS, Munst P, Staiger M: Tibial intramedullary nailing without open drilling , Unfall chirargie 1993; 19 (5): 278-83