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Unreamed Tibial Intramedullary Nailing (UTN) In Grade I, II And IIIA (Gustilo-Anderson) Compound Diaphyseal Fractures of Tibia- Is It Beneficial?

Dr. Kamal Kumar Arora[1], Dr. Priti Chaudhary[2], Dr. Rajesh Kapila[3], Dr. Dharam Singh[4], Dr. Mandeep Mittal[5],

[1]*Assistant Professor, Deptt. Of orthopaedics, Govt. Medical College, Amritsar*
[2]*Additional Professor, AIIMS, Bathinda.*
[3]*Professor, Deptt. Of orthopaedics GMC Amritsar*
[4]*Associate Professor,. Govt Medical College, Amritsar*
[5]*Junior Resident, Govt Medical College, Amritsar*
Corresponding Author: Dr. Rajesh Kapila

Abstract: *The tibial shaft is one of the most common sites of open fractures of all the open fractures, 63% are seen in the tibia alone. Ramon Gustilo has laid down the foundations of open fracture management; thorough debridement and irrigation, fracture stabilization, early soft tissue coverage and rehabilitation. The optimum treatment for open fractures of the tibia remains controversial; treatment options include closed reduction and cast immobilization, open reduction and fixation either with plate or external fixators and closed reduction with intramedullary nailing. With the advent of image intensifier, high-class antibiotics and meticulous debridement technique, stabilization of fractures, and soft tissue cover many orthopaedic surgeons are now using intramedullary interlocking nailing as a primary method of fixation in open fractures of tibia especially Grade I and II (Gustilo–Anderson Classification). Ultimate functional outcome depends on timely union and joint movements' preservation. The aim of present study was to study the clinical and functional outcome of unreamed tibial intramedullary nailing (UTN) in grade I, II and IIIA (Gustilo-Anderson) compound diaphyseal fractures of tibia & to study the incidence of complications. In this study, 20 patients with open fractures of both bones of the leg were included for (UMN). The results were evaluated as per "Modified Johner and Wruh's criteria." In 85% patients excellent to good results were obtained, fair in 10% and poor in 5%. It was concluded that UTN for open tibia fracture is good option, With, proper and early debridement and fixation very excellent to good results can be obtained in open tibial diphyseal fractures grade I, II and IIIA.*

Key Words: *unreamed, open tibia fractures, unreamed tibial intramedullary nailing,*

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I. Introduction

The tibial shaft is one of the most common sites of open fractures of all the open fractures, 63% are seen in the tibia alone.[1] Ramon Gustilo has laid down the foundations of open fracture management; thorough debridement and irrigation, fracture stabilization, early soft tissue coverage and rehabilitation.[2] According to him progression from grade 1 to 3C implies a higher degree of energy involved in the injury, higher soft tissue and bone damage and higher potential for complications. [3] The management of open fractures is regarded as an orthopaedic emergency.[4] The traditional method of treating open tibial fractures was with an external fixator.[5,6] Monolateral external fixation has been employed to treat open tibial fractures with great success; however, not without significant complications like frequent pin tract infection, non-union, malunion and angular instability.[7, 8]

With improvements in soft tissue care and wound coverage techniques, number of patients going for limb amputations has reduced.[10] Ultimate functional outcome depends on timely union and joint movements preservation.[11,12] Restoration of length, axial alignment, and rotation is essential, but anatomical reduction of every fracture fragment is not very essential[13]. In unreamed nailing, there is less risk of fat embolism and several studies suggest better preservation and more-rapid recovery of the intraosseous blood supply after insertion of a small diameter nail.[14]

PATIENT SELECTION

All fresh compound tibial diphyseal fractures grade I, II and IIIA (Gustilo and Anderson were selected.

INCLUSION CRITERIA :

- Gustilo and Anderson Grade I, II and IIIA compound tibia fractures.
- Fractures distal to the tibial tuberosity and 7cm proximal to the ankle joint.
- Skeletally mature patients.

Exclusion Criteria :

- Skeletally immature patients.
- Gustilo and Anderson Grade IIIB, IIIC compound tibia fractures.
- Pathological fractures.
- Fractures proximal to tibial tuberosity.
- Fractures within 7 cm of the distal articular surface of tibia.

II. Aims And Objectives

1. To study the clinical and functional outcome of unreamed intramedullary nailing in grade I, II and IIIA (Gustilo-Anderson) compound diaphyseal fractures of tibia.
2. To study the incidence of complications.

III. Materials & Methods

In this study, 20 patients with post-traumatic open fractures of both bones of the leg were included. All the cases were treated at a tertiary institute of Punjab and were followed for 9 months. An informed consent was taken. Associated head injury/ chest injury/ abdominal injury were evaluated for proper management. Every case was given prophylactic intra-venous antibiotic. Careful evaluation of the injured limb as per Gustilo and Anderson classification was done and documented. Meticulous debridement and copious irrigation of the wound with minimum 3 litres of normal saline solution was done in the emergency department fracture immobilized temporarily with the help of POP back-slab. Roentgenography was done in two views: antero-posterior and lateral.

Patients were operated under spinal/general anaesthesia. Patient was placed in spine over a radiolucent operating table. The injured leg was positioned freely, with knee flexed 90° over the edge of operating table to relax the gastro soleus muscle and allow traction by gravity. The uninjured leg was placed in abduction, flexion and external rotation to ensure free movements of the image intensifier. Reduction of fracture was carried. Vertical skin incision was given over center of patellar tendon from centre of the inferior pole of patella to the tibial tuberosity about 3 cm long. Patellar tendon splitted vertically in its middle in the direction of fibers and retracted to reach the proximal part of tibial tuberosity. Correct insertion point identified. Entry portal created, making sure it is in line with the centre of medullary canal. Thereafter nail insertion was different for solid and cannulated nail. In cannulated nail procedure, the guide wire 3mm diameter x 950 mm length passed into the medullary canal of proximal fragment and the fracture fragments reduced under image intensifier. Nail was inserted over a guide wire. Nail diameter was 1 mm less than isthmus diameter.

In solid nail procedure, nail was inserted directly with the help of jig through entry point and then through the fracture site, without guide wire. Nail diameter was 2 mm less than isthmus diameter. In both groups 2 proximal locking and 2 distal locking screws inserted for interlock the nails. All nails were statically locked. Surgical wound closed in layers after achieving complete haemostasis.

Postoperatively patient's vitals monitored and foot end elevated in-case of spinal anaesthesia. Broad-Spectrum antibiotics were given systemically. Analgesics were given as per patient needs. Check X-ray was taken 24 hours later. Daily anti-septic dressing of the wound was done till the clearance of all the dead and necrotic tissue and then shifted to alternate day dressings. Partial weight bearing walker was individualised as per fracture type and nail diameter, Split-skin grafting were considered in case of skin loss after the wound was covered by healthy granulation issue. The patients were motivated for the active and passive exercises of the joints distal and proximal to the injury. Further follow-up was done at 4, 8, 12, 24 and 36 weeks for a minimum of 9 months. With each follow up, clinical and radiological evaluation was done as per modified **Johner and Wruh`s criteria**.

The presence of bridging callus on both radiographic view anteroposterior and lateral view defined union of fractured bone.

CASE I

PRE-OPERATIVE POST-OPERATIVE

PRE-OPERATIVE WOUND HEALED WOUND

RANGE OF MOTION

CASE II

IV. Observations And Results

The age of the patients ranged from 18 years to 70 years with average age being 39.85 years.

AGE

Age	No. Of cases	Percentage
18-30	5	25%
31-40	6	30%
41-50	4	20%
51-60	4	20%
>61	2	10%
Total	20	100%

SEX INCIDENCE

15(75%) of the patients were male and 5 (25%) of the patients were females.

Sex	No. Of cases	Percentage
Male	15	75%
Female	05	25%
Total	20	100%

MODE OF INJURY: Majority of the fractures (16) were due to road side accidents.

Mode of injury	No. Of cases	Percentage
Road side accidents	16	80%
Fall from height	3	15%
Assault	1	5%
Total	20	100%

TYPE OF FRACTURE (GUSTILO AND ANDERSON CLASSIFICATION)

Out of the 20 fractures, 10(50%) were type I, 8(40%) were type II and 2(10%) were type IIIA.

Type	Cases	Percentage
I	10	50%
II	08	40%
IIIA	2	10%
Total	20	100%

TIME OF PRIMARY WOUND CARE

Out of 20, 14(70%) wounds were primarily treated in the hospital and 6 (30%) were referred from smaller centres around the hospital.

Admissions	Within 6 hours	6-12 hour	12-24 hours	Percentage
Direct	8	5	1	70%
Referrals	1	3	2	30%
Total	9	8	3	100%

TIME OF UTN

Time of fixation	Cases	Percentage
<12 hours	6	30%
12-24 hours	9	45%
24-48 hours	4	20%
>48 hours	1	5%
Total	20	100%

ASSOCIATED INJURIES

Associated injuries	No. of cases	Percentage
Clavicle fracture	1	5%
Distal radius fracture	2	10%

PATTERN OF WOUND HEALING

Out of the 20 wounds, 15(75%) healed with primary intention.

Wound healing	Cases	Percentage
Primary intention	15	75%
Secondary Granulation tissue	1	5%
Split skin grafting	3	15%
Rotation flaps	0	0
Total	20	100%

NAIL DIAMETER

Diameter of the nail	No. of cases
8mm	12
9mm	8

TIME OF WEIGHT BEARING

Time of partial weight bearing	No. of patients
4-6 weeks	7
7-10 weeks	11
>10 weeks	2

Time of full weight bearing	No. of patients
12-15 weeks	6
15-18 weeks	8
>18 weeks	5

TIME OF FRACTURE HEALING

The average time taken by type II fractures was 23.8 weeks or 5.75 months. One of the two of type IIIA united by 33 weeks.

Fracture type	United cases	Percentage	Average duration
Grade I	10/10	100%	22.2 weeks
Grade II	8/8	100%	23.87 weeks
Grade IIIA	1/2	50%	33 weeks
Total	19/20	95%	23.3 weeks

Complications:

TABLE 16
COMPLICATIONS

Complications	Cases			Total
	Grade I	Grade II	Grade IIIA	
Superficial infections	0	1	1	2(10%)
Deep infections	0	0	1	1(5%)
Anterior knee pain	1	2	2	5(25%)
Fracture site pain	2	1	0	3(15%)
Non-union	0	0	1	1(5%)
Delayed union	1	2	1	4(20%)
Mal-union	0	1	1	2(10%)
Knee stiffness	2	2	1	5(25%)
Ankle stiffness	2	1	1	4(20%)
Shortening >1cm	0	0	0	0
Neuro-vascular def.	0	0	0	0
Screw breakage	0	1	0	1(5%)
Compartment syndrome	0	1	0	1(5%)

V. RESULTS

The results were evaluated as per "Modified Johner and Wruh's criteria.
In 85% patients excellent to good results were obtained. Fair in 10% and poor in 5%.

Outcome	No. of Cases			
Grade	Grade I	Grade II	Grade IIIA	Total
Excellent – no non-union, no infections, no deformity, no shortening, no pain, full range of ankle and knee movements, no neurological deficit and normal gait	6	2	0	40% (n=8)
Good - no non-union, mild infections, mild deformity, <10mm shortening, occasional pain, range of ankle(>75%) and knee (>80%)movements, no neurological deficit and normal gait	3	5	1	45% n=9)
Fair - no non-union, moderate infections, moderate deformity, shortening 10 to 20mm , moderate pain, range of ankle (>50%)and knee movements (>75%), no neurological deficit and mild limp	1	1	0	10% (n=2) (n=)
Poor - non-union, deep infections, significant deformity, >20mm shortening, severe pain, range of ankle(<50%) and knee (<75%)movements, neurological deficit and significant limp	0	0	1	5%
Total	12	8	2	20

VI. Discussion

Either reamed [17] or unreamed intramedullary nailing technique [18] is used in the treatment of compound tibial diphyseal fractures. There is continued controversy regarding the use of reamed and unreamed nailing techniques for the management of open tibial fractures.[19,20]

The majority of cases were young adult male in the 3rd and 4th decade, comparable to other study series by Keating[21], Freedman and Johnson[22] and Whitelaw et al[23]. Mean age of the patient was 39.87 years, similar to the study conducted by Mohamed A. Abdelaal[24] (33 years) and A Aggarwal et al[25] (40.3 years). Majority of the patients were male (75 %), only 25% patients were females similar to studies by Joshi V[35] (52 out of 56 patients), Mohamed A. Abdelaal[24] (80% male), Madhukar K. T et al[26] (86%). The majority of fractures were due to roadside accidents.

Drosos et al.[27] identified fracture gap, comminution, screw failure and dynamisation as potential risk factors for non-union in tibial fractures treated with intramedullary nails. Sargeant et al[28] (1994) suggested that cortical necrosis is less likely to occur with a loosely fitted intramedullary nail than a tightly fitted reamed nail. In our study 19 of the 20 fractures united. 95% union rate was achieved comparable to study Kaeting et al[21] (88%), Blachut et al[14] (89%), Abdealaal[24] (94.5%). The average union time in our study was 23.31 weeks or 5.6 months, comparable with the mean union time in studies by Donimath[29] 24 weeks, Blachut[14] (22 weeks), Singer and Kellam[30] (union rate 6.1 months), Schandelmaier et al[31] (25.8±14 weeks), and Osterman PA et al[32] (23.5weeks). This was found to be better than the various studies using external fixators such as in the study by Court Brown et al.[33] (36.7 weeks), Karlstrom and Olerud[34] (34.2 weeks) and Chan et al.[35] (38.1 weeks).

Court-Brown et al[36] regarded any tibial fracture that unites without grafting or exchange nailing as healed uneventfully. Others report non-union if healing does not occur after three (Blachut et al., 1997)[14], six (Greitbauer et al., 1998)[37], nine (Wiss and Stetson, 1995)[38] or 12 (Duwelius et al., 1995)[39] months. Because of the different protocols regarding dynamisation, grafting or exchange nailing, non-union was here defined on time basis whether the fracture has united or not at the end of 9 months. In our study only one case (5%) developed non-union which was grade IIIA, probably due to soft tissue stripping and infection comparable to A. Abdelaal[24] (5.5%), T Zaman et al[40] (3.34%), Joshi et al[41] (6/56). 14(70%) Of the fractures were united by 6 months, rest 5 (25%) fractures were united between 6 to 9 months. The average time taken by type I fractures was 22.15 weeks or 5.2 months. The average time taken by type II fractures was 23.8 weeks or 5.75 months. One of the two of type IIIA united by 33 weeks. We encountered 4 (20%) cases of delayed union in which, after waiting for about 20 weeks when abundant callus was not visible in the radiograph and the patient had persistent tenderness over the fracture site. Bone grafting was done in 2 and autologous bone marrow aspirate was injected in 2 of the cases. The reason in the cases was probably was a small diameter nail and soft tissue stripping in open fractures. This indicates that a proper diameter, well-fitting nail should be used in all cases. Abdelaal et al[24] achieved union in 52 cases (94.5%) at an average time of 20 weeks, Madhukar K[26] 48(80%) fractures united within 6 months of injury, 9(15%) cases diagnosed as delayed union which eventually united within 36 weeks. Similarly in a study by T Zaman[40] et al union was seen in 51 (85%) patients and delayed union was observed in 7 (11.66%) subjects. In another study by Kakar S et al[42], 143 fractures were followed to union. 76(53%) fractures united in less than 6 months, 35(24.4%) took between 6 and 9 months. Joshi et al[41] observed 44 of the 56 fractures, healed within 32 weeks; 6 (4 in type II and 2 in type IIIA) had delayed union, 6 fractures still failed to unite despite dynamisation. Primary skin closure was reported in 16 (80%) of cases, split skin grafting was required in 3 cases and 1 wound was allowed to heal with secondary granulation due to its small size and these results were comparable to those of Yokoyama et al.[43] (1994) who reported successful primary closures in 70.2% cases and secondary closures with Split skin grafts/flaps in 29.8% cases. Emphasis has been placed on the soft tissue management in open tibial fractures in the recent literature. [44-46] Open fractures were traditionally left open so as to allow for wound drainage and inspection, and primary wound closure was forbidden due to the fear of osteomyelitis.[46] This practice has been challenged due to the recent advances in systemic antibiotic use, local antibiotic beads, the so-called 'fix and flap' technique, negative pressure wound care and more effective methods of fracture stabilisation.[47,48] Rajasekaran et al[44] closed wounds primarily in high energy open tibial fractures with 86.7% excellent results. Hohmann et al[46] reported low infection rates with primary wound closure in low energy open tibial fractures in selected cases.

In our study, despite a thorough debridement and an adequate soft tissue coverage, there was overall 3 (15.0%) infections. 2 of which are superficial, which were treated with anti-septic dressings and antibiotics. One patient (5%) had deep infection. Despite regular dressing, oral antibiotics and guarded weight bearing continued, fracture was unable to unite. Then the nail was removed, sequestrectomy done and LRS was applied. Joshi[41] observed incidence of infection in 6 of 56 (10.7%) cases, all of which was in type-III open fractures (75% of all type III cases). In a study by Madhukar K[26] 6 patients developed superficial infection which healed with antibiotics and regular dressings. One patient with Gustilo type II open fracture developed deep infection. Donimath et al[29] observed 2 out of 25 cases, 2 cases of infection of which one was superficial and one deep.

In the present work, nail size 8 was used in 12 cases (60%). Hahn et al (1996) advocated a cautious approach for such fractures by filling all the screw holes with bolts, to reduce the concentration of the stress distally at screw hole sites which may leads to fracture.[47] In the present study, both the proximal and the distal interlocking holes were interlocked with two screws in the proximal and distal fragments. One patients (5%) had

screw breakage after they started full weight bearing. The same nail was continued but with guarded weight bearing until the fracture united. Fractures united in <6 months. We had compartment syndrome in 1 patient, which required fasciotomy.

In our study, 15(75%) Out of the 20 patients were able to attain full range of motion at knee with all patients attained >75% range of movement as compared to opposite side and designated as good and fair, 16(80%) had full range of ankle motion. A little better than other studies, Kakkar et al observed, 30(20%) out of 143 patients with decreased ankle motion when compared with the uninjured side.[42]Madhurkar et al in their study observed in 36(60%) patients attained full knee motion, out of the rest 24 patients 8 (13%) attained 80% of knee motion in 6(10%) of cases less than 75% of knee motion were achieved.[26] 48 patients (80%) full range of ankle motion attained, more than 75% of ankle motion attained in 9 cases (15%). less than 50% of ankle motion attained in 3 cases (5%). We started knee and ankle exercise on the 2nd/3rd post-operative day.

Few patients experienced anterior knee pain, pain at fracture site & locking bolt in treatment phase, most of them were controllable with rest and analgesics. Anterior knee pain, in our series, it was seen in five (25%) cases. We used the midline longitudinal incision made over the patellar tendon for nail insertion and used a tendon splitting approach for insertion. Oarfley et al showed that paratendinous approach is related with less knee pain and nail position in relation to the anterior cortex and tibial plateau had no influence on knee pain.[49] Toivannen et al showed that, a paratendinous approach for nail insertion does not reduce the prevalence of chronic anterior knee pain or functional impairment by a clinically relevant amount after intramedullary nailing of tibial shaft fracture.[50] Devitt et al found arthroscopic evidence of chondromalacia patellae in a small number of patients with anterior knee pain after tibial nailing.[51]

Sarmiento had demonstrated that early weight bearing did not increase initial shortening.[52] In present series, 2 patients had shortening of less than 1cm, both were having severe comminution. Melcher et al (interlocking AO UTN nail) shortening of 0.5-1cm - 5 cases (25%). Shortening in different series of interlocking nail were mostly due to screw breakage incidence.[53] One of our cases treated by nailing had varus angulation of 10° which was AO type 42 C and was located near distal third of the leg.

Results

Results were excellent in 8 patients (40%), Good in 9 patients (45%), fair in 2 patients (10%) and poor in 1 patient (5%) of patients assessed by Johner & Wruh's criteria. Means 85% patients had good to excellent results with UTN. Final result showed comparable final results of various series of treatment of tibial fractures with UTN; conducted by Joshi et al[35] 85.8 good to excellent results, Madhurkar KT et al[50] with 90% excellent results, Donimath et al[48] 19(86%) cases had excellent results, 3(12%) cases had good results, 2(8%) cases had fair result and 1 case a poor result and T Zaman et al51 47 (78.34%) patients had excellent, 7(11.66%) patients had good and 6 (10%) patients had poor results.

VII. Summary And Conclusion

The results of the study are summarized as follows:

1. The average age of the patients was 39.85 years.
2. Most Of them were males (75%).
3. Mode of injury was road side accidents in 80% patients,
4. On the basis of Gustilo & Anderson Classification, 10 patients were graded as Type I, t8 patients type II and 2 patients were graded type IIIA.
5. 75% wounds, healed with primary intention,
6. 75% Of the fractures were united by 6 months,
7. The average time of union was 23.31 weeks or 5.6 months.
8. 08% patients showed mal-union.
9. 12%patients had infection as complication, 08% of them were superficial infection, 04% had deep infection.

Thus, it can be concluded that the UTN as a treatment in open tibia fracture is a valuable tool & is always beneficial as it gives advantage:-

1. High union rate.
2. Fewer infections.
3. Less intraoperative blood loss.
4. less stripping of soft tissues.
5. Easy wound management.
6. Stable fixation.
7. Less malunion and shortening.

Bibliography

[1]. Chapman MW, Oslon SA. Open fractures. In: Rockwood and Green's Fracture in Adults. 4th ed. Philadelphia: Lippincott-Raven; 1996. p. 305-52.
[2]. Gustillo RB, Merkow RL, Templeman B. Current concept review: The management of open fracture. JBJS. 1990; 72 A: 299-303.
[3]. Kim PH, Leopold SS. Gustilo-Anderson Classification. Clinical Orthopaedics and Related Research. 2012;470(11):3270-4.
[4]. Harley BJ, Beaupre LA, Jones CA, Dulai SK, Weber DW. The effect of time to definitive treatment on the rate of nonunion and infection in open fractures. J Orthop Trauma. 2002;16:484-90.
[5]. Lang GJ. Knee and leg: bone trauma. In: Koval KJ. Orthopaedic Knowledge Update 7. Am Acad Orthop Surg 2002, p.483-7.
[6]. Khan MA, Khan SW, Qadir RI. Role of external fixator in the management of type-II & III open tibial fracture. J Postgrad Med Inst 2004;18:1.
[7]. Clifford R, Lyons T, Webb J. Complications of external fixation of open fractures of the tibia. Injury. 1987;18(3):174-6.
[8]. Holbrook JL, Swiontkowski M, Sanders R. Treatment of open fractures of the tibial shaft: Ender nailing versus external fixation. A randomized, prospective comparison. J Bone Joint Surg Am. 1989;71-A:1231-8.
[9]. Henley MB, Chapman JR, Agel J, Harvey EJ, Whorton AM, Swiontkowski MF. Treatment of type II, IIIA, and IIIB open fractures of the tibial shaft: a prospective comparison of unreamed interlocking intramedullary nails and half-pin external fixators. Journal of orthopaedic trauma. 1998;12(1):1-7.
[10]. Swanson TV, Speigel JD, Sutherland TB, Bray TJ, Chapman MW. A prospective, comparative study of the Lottes nail versus external fixation in 100 open tibial fractures. Orthop Trans. 1990;14:716-7.
[11]. Fischer MD, Gustilo RB, Varecka 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.
[12]. Patzakis MJ, Wilkins J, Moore TM. Considerations in reducing the infection rate in open tibial fractures. Clin Orthop Relat Res. 1983:36-41.
[13]. Kenwright J, Richardson K, Spriggins AJ. Mechanical healing patterns of tibial fractures treated using different mechanical environments. EUR SOC Biomech. 1986; 5:173-6.
[14]. Blachut PA, O'Brien PJ, Meek RN, Broekhuyse HM. Interlocking Intramedullary nailing with and without reaming for the treatment of open fractures of the tibial shaft. A prospective randomized study. J Bone Joint Surg Am. 1997;79(5):640-6.
[15]. Gustilo RB, Mendoza RM, and Williams DN. Problems in the management of type III (severe) open fractures: a new classification of type III open fractures. J Trauma. 1984;24(8):742-6.
[16]. Gustilo RB and Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones.
[17]. Orhun H, Bayhan IA. Treatment of adult tibial diaphysis fractures with reamed and locked intramedullary nailing. Acta Orthop Traumatol Turc. 2009;43(1):7a13.
[18]. Salem KH. Unreamed intramedullary nailing in distal tibial fractures. International Orthopaedics. 2013;37(10):2009-15.
[19]. Bhandari M, Guyatt GH, Swiontkowski MF, Schemitsch EH. Treatment of open fractures of the shaft of the tibia: a systematic overview and meta-analysis. The Journal of bone and joint surgery. British Volume. 2001;83(1):62-8.
[20]. Bhandari M, Guyatt G, Tornetta III P, Schemitsch EH, Swiontkowski M, Sanders D, Randomized trial of reamed and undreamed intramedullary nailing of tibial shaft fractures. By the study to prospectively evaluate intramedullary nails in patients with tibial fractures (SPRINT) investigators. J Bone Surg. 2008;78A: 2567–78.
[21]. Keating JF, O'Brien PJ, Blachut PA, Meek RN, Broekhuyse HM. Locking intramedullary nailing with and without reaming for open fractures of the tibial shaft. J Bone Joint Surg Am. 1997;79(3):334-41.
[22]. Freedman EL, Johnson EE. Radiographic analysis of tibial fracture malalignment following intramedullary nailing. Clinical orthopaedics and related research. 1995;315:25-33.
[23]. Whitelaw GP, Wetzler M, Nelson A, Segal D, Fletcher J, Hadley N, Sawka M. Ender rods versus external fixation in the treatment of open tibial fractures. Clinical Orthopaedics and Related Research. 1990;253:258-69.
[24]. Abdelaal MA, Kareem S. Open fracture tibia treated by unreamed interlocking nail. Long experience in El-Bakry General Hospital. Open Journal of Orthopedics. 2014;4(03):60-5.
[25]. Agrawal A, Chauhan VD, Maheshwari RK, Juyal AK. Primary Nailing in the Open Fractures of the Tibia-Is it worth? Journal of clinical and diagnostic research: JCDR. 2013;7(6):1125-8.
[26]. Madhukar KT, Mitra D, Bhattacharya S, et al. Study of management of compound fractures of tibia with unreamed intramedullary interlocking nailing. Journal of Research in Orthopedics and Sports Medicine 2015;1(1):26-30.
[27]. Drosos GI, Bishay M, Karnezis IA, Alegakis AK. Factors affecting fracture healing after intramedullary nailing of the tibial diaphysis for closed and grade I open fractures. The Journal of bone and joint surgery. British volume. 2006;88(2):227-31.
[28]. Sargeant ID, Lovell M, Casserley H, Green AD. The AO unreamed tibial nail: a 14-month follow-up of the 1992 TT experience. Injury. 1994;25(7):423-5.
[29]. Donimath VS, Desai R. Surgical management of open tibial shaft fractures in adults by reamed versus unreamed intramedullary interlocking nailing: A comparative study. International Journal of Orthopaedics. 2017;3(1):290-6
[30]. Singer RW, Kellam JF. Open tibial diaphyseal fractures. Results of unreamed locked intramedullary nailing. Clinical orthopaedics and related research. 1995;315:114-8.
[31]. Krettek C, Schandelmaier P, Tscherne H. Nonreamed interlocking nailing of closed tibial fractures with severe soft tissue injury. Clinical Orthopaedics and Related Research. 1995;(315):34-47.
[32]. Richter D, Ostermann PA, Ekkernkamp A, Hahn MP, Muhr G. Distal tibial fracture--an indication for osteosynthesis with the unreamed intramedullary nail?. In Langenbecks Archiv fur Chirurgie. Supplement. Kongressband. Deutsche Gesellschaft fur Chirurgie. Kongress 1997; 114:1259-61.
[33]. Court-Brown CM, McQueen MM, Quaba AA, Christie J. Locked intramedullary nailing of open tibial fractures. The Journal of bone and joint surgery. British volume. 1991;73(6):959-64.
[34]. KarlstrÖm G, Olerud S. External fixation of severe open tibial fractures with the Hoffmann frame. Clinical orthopaedics and related research. 1983;180:68-77.
[35]. Chan KM, Leung YK, Cheng JC, Leung PC. The management of type III open tibial fractures. Injury. 1984;16(3):157-65.
[36]. Court-Brown CM, Wheelwright EF, Christie J, McQueen MM. External fixation for type III open tibial fractures. The Journal of bone and joint surgery. British volume. 1990;72(5):801-4.
[37]. Greitbauer M, Heinz T, Gaebler C, Stoik W, Vécsei V. Unreamed nailing of tibial fractures with the solid tibial nail. Clinical orthopaedics and related research. 1998;350:105-14.
[38]. Wiss DA, Stetson WB. Unstable fractures of the tibia treated with a reamed intramedullary interlocking nail. Clinical orthopaedics and related research. 1995;315:56-63.

[39]. Duwelius PJ, Schmidt AH, Rubinstein RA, Green JM. Nonreamed interlocked intramedullary tibial nailing. One community's experience. Clinical orthopaedics and related research. 1995;315:104-13.
[40]. Zaman T, Farooq OK, Hussain FN. Usage of Unreamed Interlocking Nails for the Management of Gustilo Anderson Grade 2 and 3 Open Fractures of Shaft of Tibia â€“A Prospective Study. Annals of King Edward Medical University. 2016;22(3):78-81.
[41]. Joshi D, Ahmed A, Krishna L, Lal Y. Unreamed interlocking nailing in open fractures of tibia. Journal of Orthopaedic Surgery. 2004;12(2):216-21.
[42]. Kakar S, Tornetta III P. Open fractures of the tibia treated by immediate intramedullary tibial nail insertion without reaming: a prospective study. Journal of orthopaedic trauma. 2007;21(3):153-7.
[43]. Yokoyama K, Itoman M, Uchino M, Fukushima K, Nitta H, Kojima Y. Immediate versus delayed intramedullary nailing for open fractures of the tibial shaft: a multivariate analysis of factors affecting deep infection and fracture healing. Indian Journal of Orthopaedics. 2008;42(4):410-4.
[44]. Rajasekaran S, Dheenadhayalan J, Babu JN, Sundararajan SR, Venkatramani H, Sabapathy SR. Immediate primary skin closure in type-III A and B open fractures: results after a minimum of five years. The Journal of bone and joint surgery. British volume. 2009;91(2):217-24.
[45]. Weitz-Marshall AD, Bosse MJ. Timing of closure of open fractures. JAAOS-Journal of the American Academy of Orthopaedic Surgeons. 2002;10(6):379-84.
[46]. Hohmann E, Tetsworth K, Radziejowski MJ, Wiesniewski TF. Comparison of delayed and primary wound closure in the treatment of open tibial fractures. Archives of Orthopaedic and Trauma Surgery. 2007;127(2):131-6.
[47]. Hahn D, Bradbury N, Hartley R, Radford PJ. Intramedullary nail breakage in distal fractures of the tibia. Injury. 1996;27(5):323-7.
[48]. Orfaly R, Keating JE, O'Brien PJ. Knee pain after tibial nailing: does the entry point matter?. The Journal of Bone and Joint Surgery. British Volume. 1995;77(6):976-7.
[49]. Orfaly R, Keating JE, O'Brien PJ. Knee pain after tibial nailing: does the entry point matter?. The Journal of Bone and Joint Surgery. British Volume. 1995;77(6):976-7.
[50]. Toivanen JA, Väistö O, Kannus P, Latvala K, Honkonen SE, Järvinen MJ. Anterior knee pain after intramedullary nailing of fractures of the tibial shaft: a prospective, randomized study comparing two different nail-insertion techniques. JBJS. 2002;84(4):580-5.
[51]. Devitt AT, Coughlan KA, Ward T, McCormack D, Mulcahy D, Felle P, McElwain JP. Patellofemoral contact forces and pressures during intramedullary tibial nailing. International orthopaedics. 1998;22(2):92-6.
[52]. Sarmiento A. Functional bracing of tibial fractures. Clinical Orthopaedics and Related Research. 1974;105:202-19.
[53]. Melcher GA, Ryf C, Leutenegger A, Rüedi T. Tibial fractures treated with the AO unreamed tibial nail. Injury. 1993;24(6):407-10.

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