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Original Research Article

Extended use of limb reconstruction system in management of compound tibia diaphyseal fracture as primary and definitive tool

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ABSTRACT

Background: The fractures of the tibia are among the most difficult fractures to treat effectively. The status of the soft tissues, the degree of comminution and level of contamination sustained at the time of injury affect the long term clinical results. The goal of operative treatment is to obtain anatomic realignment of the shaft of tibia while providing enough stability to allow early motion. This should be accomplished using techniques that minimize osseous and soft tissue devascularization in the hopes of decreasing the complications resulting from treatment.
Methods: A prospective randomized study was conducted between 2014-2016 on 20 patients admitted with compound tibia diaphyseal fracture and treated with Limb reconstruction surgery.
Results: In our study, the mean time of partial weight bearing was 3.5±2.97 weeks, full weight bearing was 8.55± 4.14 weeks and bone union time was 20.22±5.22 weeks. The pin tract infection was found in 5 (25%) cases. Delayed union was observed 06 (30%) cases. Shortening of more than 2 cm were recorded in 3 (15%) patients. Joint (knee or ankle) stiffness was observed in 6 (30%) cases. Loosening of pin was observed in 3 (15%) cases. Chronic osteomyelitis was observed in 3 (15%) cases. Secondary procedures were done in 11 (55%) cases. Bone marrow aspiration was done in 5 (25%) cases, iliac bone grafting in 5 (25%) cases.
Conclusions: LRS is found to be wonderful tool in management of compound tibia fractures as primary and definitive mode because of its safety, versatile nature, patient friendly and cost effectiveness.

Keywords: LRS, Compound tibia, Definitive treatment

INTRODUCTION

Open fractures of tibia remain a formidable injury in today's motorized society for two reasons - they are common and they can be very challenging fractures to unite with good functional outcome. It has been predicted that more than 4.5 million open fractures occur per year in India as compared to 3.5-6 million fractures occur in the United states annually.[1,2]

The tibia being the most commonly fractured long bone as one-third of its surface is subcutaneous, open fractures are more common in tibia than in any other major long bones and its fracture management has changed drastically from conservative to early surgical management and its fracture management contributes significantly to the cost of orthopaedic care being provided worldwide.[3,4] Epidemiological studies suggest that motor vehicle accidents are the most common causes of tibial diaphyseal fractures, followed by sports-related injuries.[2] High energy trauma which imparts more kinetic

energy that causes fractures which are often severe with associated soft tissue injury.

Treatment options for tibial fractures vary according to the type of fracture, age group, bone density, soft tissue status and associated complications.[5]

Cast immobilization and plate fixation have been proved to be unacceptable for the management of compound injuries, with high rates of nonunion, malunion, and infection.

Conventional external fixator is often initial method of skeletal stabilization in these injured, often in unstable patients. However, several studies have demonstrated that their value in the definitive management of these injuries is questionable, with high rates of pin loosening, sepsis, nonunion, and malunion.

Usually a sequential protocol of treating compound fractures are initial debridement, external fixation, closure of the wound, intramedullary interlocking nail with reaming.[6] The disadvantage of this technique is the need for several operative procedures and longer period of hospitalization. The infection rate of fractures which were first treated by external fixation and then with Intramedullary interlocking nailing was significantly much higher than those fractures treated with Intramedullary nailing alone.[7] A high incidence of infection is noted secondary to the delayed intramedullary nailing and the need for several procedures. External fixation alone helps to return the patient to full function as soon as possible and not make the patient to undergo several operative procedures [8,9] and burden the poor patients economically in which external fixation can be used as primary and definitive line of management for open fractures tibia which is very cost effective.[10]

The commonest complications that occur after external fixator in tibia are nonunion, deformity, shortening, knee-ankle stiffness following prolonged application of fixator.

The conventional AO external fixator can be now replaced with limb reconstruction system (LRS) depending upon the location of wound, need of much fracture stability. Due to its anterior placement on tibia, LRS is more accessible to patient for pin tract care. LRS may be the better option in primary management of compound tibia fracture in terms of initiation of early weight bearing, more rigid fixation. LRS has also been proven effective in treating commonest complication following compound injury in tibia i.e. nonunion, deformity correction, reconstructive procedure for gap nonunion using bone transport and limb lengthening.[12] The above methods have been carried out in infection. Hence, to avoid application of multiple fixator system in same patient, LRS may prove single tool method to deal with primary and definitive treatment tool to manage soft tissue wounds and bony discontinuities. The complication of bone–pin interface i.e. pin loosening are very less and occur very late in LRS system, hence the LRS can be used for multiple procedures after single application.

Hence, in this study we use LRS for primary and definitive management of compound tibia diaphyseal fractures for better fixation, problems while dealing with them intraoperatively and their post-operative effects on weight bearing, bone healing, functional recovery and rehabilitation to preinjury status.

METHODS

A prospective study conducted in department of orthopedic surgery at Grant Government medical college and sir J.J. group of hospital from 2014-2016. All patients attending the orthopedic department with compound tibial diaphyseal fractures who met the inclusion criteria were counseled regarding the disease and the study and those willingly consenting to participate in the study were selected. Informed and written consent was obtained from all patients with consent form approved by the Institutional ethical committee.

Inclusion criteria

- Compound diaphyseal fractures of tibia (Type I, Type II, Type III A, B as classified by Gustilo-Anderson grading.
- Compound diaphyseal fractures in the age group of 18-60 years.
- Compound tibial diaphyseal fracture without associated neurovascular injury.
- Compound segmental fractures of tibia.

Exclusion criteria

- Closed tibial diaphyseal fractures.
- Tibial fractures with intra-articular extension.
- Compound tibial fractures associated with ipsilateral fracture femur (floating knee).
- Compound tibia fracture (Type III c).

All 20 patients underwent routine investigations, were clinically evaluated in detail regarding the mode of injury and treatment taken prior to admission. A detailed examination was done to assess, soft tissue injury, bony injury, tendon and neurovascular injury around tibial and surrounding region. Standard antero-posterior and lateral roentgenographic views of the affected leg including distal ankle and upper tibia was taken and fractures were classified according to Gustilo and Anderson classification. Intra-aricular fractures were ruled out. Unstable patients were stabilized first and salvagebility of extremity was assessed with Mangled extremity severity score. Stable patients were subjected to all relevant preoperative investigations and were taken up for surgery as soon as he/she was fit for anesthesia. Surgery was performed under anesthesia Limb reconstruction system.

Wound swab was taken at a time of surgery and sent for culture and sensitivity testing.

The patient was placed in supine position with bump under ipsilateral hip. C-arm was placed on contralateral side. All patients were operated under Spinal anaesthesia without use of tourniquet. Once the patient is under the effect of spinal anaesthesia, proper scrubbing with Betadine scrub (10%) and painting with Betadine solution (7.5%) done. Affected extremity was properly drapped and then thorough debridement of wound and wound wash with 3-6 liters 0.9% normal saline done.

Steps for LRS application

Schanz pins of LRS were inserted by longitudinal stab incision and separating the soft tissue down to the bone by blunt dissection on the anteriomedial surface of tibia hence preventing the risk of neurological, vascular or tendon injuries.

First the proximal most, Schanz screw was inserted by sequentially predrilling with an appropriate-size bit, followed by manual insertion of the Schanz screw by the T handle, which lowers the risk of thermal necrosis and pin loosening. This proximal pin was placed parallel to knee joint at least 15 mm from the joint at the level of fibular head to avoid penetration of the joint capsule and avoid the pes tendons and patellar tendon (Figure 1).

Figure 1: First Schanz pin parallel to knee joint at the level of fibular head.

Figure 2: Second Schanz pin at 1 cm above and parallel to ankle joint.

Then the distal most, Schanz screw inserted in the same manner, parallel to ankle joint (Figure 2).

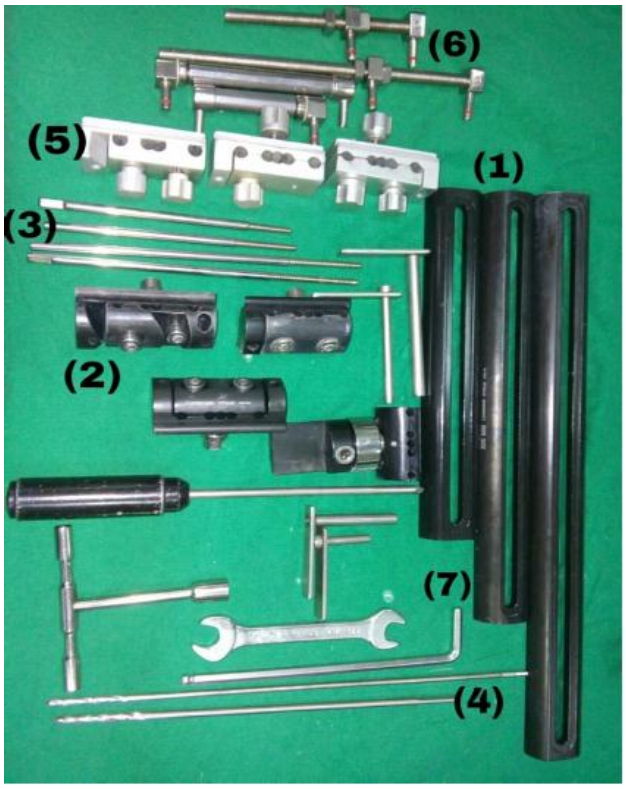

Figure 3: Necessary instruments set for LRS. (1: Rail: 240 mm, 300 mm, 400 mm; 2: Clamps: central, end, swivel, ball and socket; 3: Tapered threaded pins; 4: Drill bits; 5: Dummy clamps used as template; 6: Compression-distraction unit; 7: Allen key.)

The rod and assembly connected over these proximal and distal pins maintaining the leg length and this definitive fixator was used as a guide to pass the rest of the pins, to ensure that the rail is parallel to the long axis of the bone and all the remaining screws will be on the bone, in the same plane, perpendicular to the long axis of the tibia and parallel to the knee and ankle joints and aligning the tibial tuberosity with the second metatarsal.

The foot and ankle were manipulated to ensure the absence of musculotendinous tethering.

All Schanz screw were inserted under C arm control so that not more than about 2 mm was protruding beyond the distal cortex, as trying to back them out can cause pin loosening because of the tapering design of pins. After putting all the pins and the fixator on the limb, the pin holding nuts (clamps) were tightened.

In immediate post op period, all patients were given limb elevation, analgesics, injection cefuroxime 1 gm i.v. BD with injection gentamicin 80 mg i.v. BD with injection metronidazole 100 cc iv TDS for 5-14 days according to wound status. Repeat debridement was performed after 48 hours and VAC dressing was applied on 3rd post op

day if required for 6-7 days. All patients were taught quadriceps and hamstring strengthening exercises from second post op day along with straight leg raising exercises to avoid joint contracture and muscle atrophy. Then according to wound status, repeat debridement and need of other VAC dressing was assessed. Depending upon fracture configuration, partial weight bearing walking with walker or crutches was taught to patients. Wound coverage was planned once there was no evidence of infection in proximal or distal pin sites.

Patients were followed up at monthly intervals for a minimum of 6 months. Assessment of complications like muscle contractures, joint subluxation, axial deviation, neurological or vascular insult, premature consolidation, delayed consolidation, refracture and pin-site infection were done at each follow up visit and were managed accordingly. Assessment of quality of regenerate was done by plain radiography at monthly intervals. Healing was defined radiologically by the presence of a bridging callus. If there was no radiological progress of healing at fracture site during subsequent follow ups, bone grafting was done to achieve union at fracture site. Union was defined clinically by the absence of pain and motion at fracture site. The fracture was considered as united radiologically if three of four cortices showed bridging callus. Implant was removed after achieving union at fracture site.

Some patients with delayed union/ nonunion require secondary procedure like corticotomy and compression – distraction unit and started at the rate of 1 mm per day after latency period of 7 days and if required bone grafting procedures were done at compression site.

Final assessment for bone results and functional results were done using ASAMI score (Association for the Study and Application of the Method of ilizarov).

Statistical methods and data analysis

The data were imported into OpenEpi software; all analyses were performed with this software. Demographic characteristics of the study group were summarized with means and standard deviations (SDs) for interval level variables and with percentages for categorical variables. Normal ranges for differences were established as within 95% confidence interval; the Gaussian approximations of the means±1.96 SDs were also calculated. A Chi-square test (χ^2) test was used for the analysis of categorical variables. Comparison with two groups was done by t test for continuous variable and chi-square test for categorical variable. A p value of less than 0.05 was considered statistically significant.

RESULTS

All patients are ranged from 18-59 years of age, maximum patients being in the age group of 30-49 years. The mean (SD) age was 37.85 years. There were 13 (65%) male and 7 (35%) female patients had undergone surgery. The mode of trauma was road traffic accident in 13 patients and fall from height in 7 patients. According to AO classification, 9 (45%) cases were included in type A, 6 (30%) cases were of type B and 5 (25%) cases were of type C. According to Gustilo Anderson classification, 5 (25%) cases were of grade I, 3(15%) cases were of grade II, 5 (25%) cases of were grade IIIA and 7 (35%) cases were of grade IIIB. Out of 20 cases, 13 patients were operated within 12 hours, 04 patients were operated within 12-24 hours and 03 patients were operated >24 hours. The mean time of partial weight bearing was 3.5±2.97 weeks, full weight bearing was 8.55±4.14 weeks and bone union time was 20.22±5.22 weeks. In our study pin tract infection was found in 5 (25%) cases. Delayed union was observed 06 (30%) cases. Shortening of more than 2 cm were recorded in 3(15%) patients. Joint (knee or ankle) stiffness was observed in 6 (30%) cases. Loosening of pin was observed in 3 (15%) cases. Chronic osteomyelitis was observed in 3 (15%) cases. Secondary procedures were done in 11(55%) cases. Bone marrow aspiration was done in 5(25%) cases, iliac bone grafting in 5 (25%) cases. Corticotomy, distraction osteogenesis was done in 3(15%) cases.

Bony outcomes

Table 1: Outcome of patients in both groups.

ASAMI score	Group I	Group II
Excellent	6	12
Good	5	4
Fair	0	2
Poor	9	2

Bony outcome was assessed by ASAMI score. In our study, 6 (30%) patients had excellent, 5 (25%) patients had good and 9 (45%) had poor bony outcome from Group I. In group II, 12 (60%) patients had excellent, 4 (20%) patients had good, 2 (10%) patients had fair, and 2 (10%) had poor bony outcome.

Functional outcome

Table 2: Outcome of patients in both groups.

Functional outcome	Group I	Group II
Excellent	3	9
Good	8	7
Fair	5	2
Poor	4	2

In our study, 3 (15%) patients had excellent, 8 (40%) patients had good, 5 (25%) patients had fair, 3 (15%) had poor bony outcome from Group I.

In group II, 9 (45%) patients had excellent, 7 (35%) patients had good, 2 (10%) patients had fair, and 2 (10%) had poor bony outcome.

Figure 4: Immediate post-operative X-ray showing diaphyseal tibia fracture with bone loss treated with LRS.

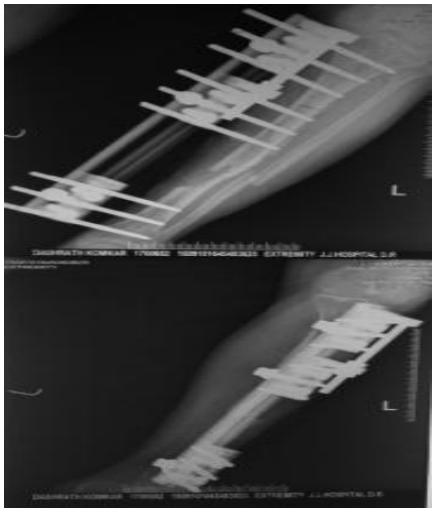

Figure 5: Showing corticotomy done at proximal meta-diaphyseal junction.

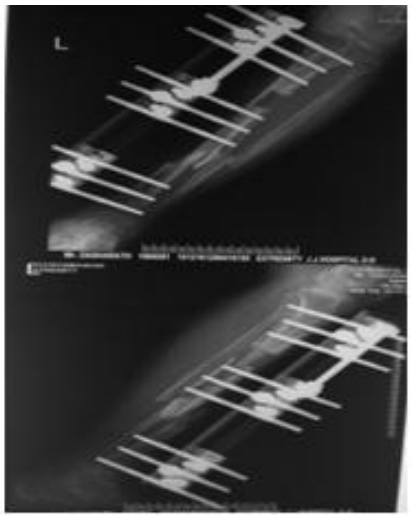

Figure 6: Showing gradual distraction at corticotomy site at post-operative 12 weeks.

Figure 7: Showing consolidation at distraction site with bony union at fracture site at 20 weeks.

Figure 8: Showing bony union with acceptable alignment and well consolidation at distraction site.

Figure 9: Clinical photograph showing good range of movements of affected limb.

DISCUSSION

Age distribution

In our study, maximum patients (50%) being in the age group of 30-49 years. The mean (SD) age was 37.85 years. Present study is comparable to Mehtab et al, Beltsios et al and Shikari et al where mean age were 34.75 years, 36 years and 35.5 years respectively.[13-15]

Gender

In group II 13 (65%) male and 7 (35%) female patients had undergone surgery. Present study finding is comparable to the findings of Pal et al and Memon et al where maximum cases were male (80%).[16,17]

Mode of injury

We had 13 (65%) patients who had sustained road traffic accident and 7 (35%) patients fall from height, it is comparable with study of Mehtab et al and Beltsios et al where mode of injury was found to be road traffic accident in 76.66% and 76.42% cases respectively.[13,14]

Type of fracture

Our study is compared with Mehtab et al and Iqbal et al study where maximum patients had type III B Gustilo Anderson type of compound tibial diphyseal fractures as compared to study by Tekan et al and Fredrico Neto et al where maximum patients were of type IIIA.[13,18-20]

Trauma- surgery interval

The time elapsed between injury and surgery at the hospital varied from 4-72 hours. Majority of patients 13 (65%) operated within 12 hours. Delay in surgery was due to the excessive time taken in transportation of patient from rural location to a tertiary care hospital and associated life threatening conditions which does not allow to intervene early for management of compound fractures. The timing of initial surgical intervention has wide variance within the literature. Historically, the 6-hour rule has been employed as the time limit within which an open fracture should be taken to the operating room for initial debridement. Many factors influence this parameter including the operating room availability, surgeon availability, and the patient's physiologic status. Harley et al found no increase in infection rate and non-union rate, when debridement took place up to 13 hours after the injury.[4] The study also concluded that the strongest predictor for deep-seated infection was the grade of the fracture and not the time to debridement. Patzakis and Wilkins further confirmed, that the greatest determining factor was the timing of antibiotics and not the delay of debridement for more than 12 hours.[21] Naique et al compared debridement of compound fractures within 6 hours and between 6 and 24 hour and excluded any difference in infection rates.[22] Lastly, an extensive literature review by Crowley, investigating the time to debridement, showed that the 6 hour rule needs to be re-evaluated.[23]

Soft tissue coverage

In our study all patients who require secondary wound closure procedure were put on vaccum assisted closure (VAC) dressing for 5-6 days in one sitting and once wound is healthy and granulating then it is closed with fascio-cutaneous flap in 9 (45%) patients, Myocutaneous flap in 8 (40%) patients, and secondary suturing in 3 (15%) patients. Hou et al recommended use of VAC therapy to reduce the flap size and need for a flap transfer for type III B open tibial fractures.[24] Steiert et al and Schlatterer et al also recommended use of vacuum assisted closure therapy to decrease wound site infection and contract wound area.[25,26] They found no significant difference in outcome of flap reconstruction procedure performed within 72 hours and those delayed beyond 72 hours.

Bone union time

In our study, bone union time was 20.22±5.22 weeks after injury. Results are comparable to study by Ajmera et al, Thakur et al, Chandraprakash et al where Limb reconstructive system was used as definitive mode of treatment with mean bony union time of 24 weeks, 20 weeks and 22 weeks respectively.[12,16,27] Earlier union with was due to large diameter of Schanz pin with tapering nature and less pitch which holds the cortical bone more firmly with each advancing turn. Low pitch of tapered schanz screw allows use in osteoporotic bone and metaphysial bone with adequate stability.

Complications

Due to the more stability provided by tapering schanz pins in LRS, incidences of pin tract infection (25%), pin loosening (15%) and pin breakage (0%) are much lesser as compared to AO monolateral fixator where pin loosening was found in 40% and pin breakage in 10% cases. As the patients of group II where allowed to weight bear early due to strong fixation, incidence of joint stiffness (20%) and delayed union (30%) was lesser. Chronic osteomylitis was found to be associated with delay in surgery. Trauma to surgery interval of 24 hours was crucial to prevent persistant bone infection.

Bony and functional outcomes

Bony and functional outcome was assessed by ASAMI score. In our study, bony outcome in 12 (60%) patients had excellent, 4 (20%) patients had good, 2 (10%) patients had fair, and 2 (10%) had poor bony outcome. Functional outcome in 9 (45%) patients had excellent, 7 (35%) patients had good, 2 (10%) patients had fair, and 2 (10%) had poor functional outcome.

Results of ASAMI score was comparable to study by Ajmera et al, Patil et al and Pal et al where they found excellent results in 76%,67% and 68.75% respectively; good results in 12%, 25% and 18.75% respectively; fair result in 4%, 4% and 10% respectively; poor results in 8%, 4% and 2.5% respectively.[12,16,28] Functional results was also satisfactory in 80% cases which is comparable to functional outcome by Chandraprakash et al (75%) and Lakhani et al (75%).[16,29]

CONCLUSION

Limb reconstruction system is a very effective tool for management of compound tibia diaphyseal fracture as it allows ease of application, versatility, provides stronger fixation, allows early weight bearing and helps in early bony union. The fixator related complications are much less and multiple procedures like limb lengthening and deformity correction is also possible.

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Ethical approval: The study was approved by the institutional ethics committee

REFERENCES

1. Praemer A, Furner S, Rice DP. Musculoskeletal conditions in the United States. Park Ridge, Ill: American Academy of Orthopaedic Surgeons; 1992.
2. Court-Brown CM, Rimmer S, Prakash U, McQueen MM. The epidemiology of open long bone fractures. Injury. 1998;29:529–34.
3. Whittle PA, Wood II GW. Fractures of lower extremity. 10th ed. In: Campbell's Operative orthopedics, Canale TS, ed. Philadelphia: Mosby Publications; 2003: 2761-2767.
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. Satyanarayana J, Rao TN, Vadlamani KVP, Kiran MC, Moorthy GVS. Management of complex open fractures: A prospective study. J Evol Med Dent Sci. 2015;4(79):13863-78.
6. Blachut PA, Meek RN, O'Brien PJ. External fixation and delayed intramedullary nailing of open fractures of the tibial shaft. A sequential protocol. J Bone Joint Surg Am. 1990;72(5):729-35.
7. Reuss BL, Cole JD. Effect of delayed treatment on open tibial shaft fractures. Am J Orthop. 2007;36(4):215-20.
8. McGraw JM, Lim EV. Treatment of open tibial-shaft fractures. External fixation and secondary intramedullary nailing. J Bone Joint Surg Am. 1988;70(6):900-11.
9. 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(6):835-8.
10. Padhi NR, Padhi P. Use of external fixators for open tibial injuries in the rural third world: panacea of the poor? Injury. 2007;38(2):150-9.
11. Mark R. Brinker. Textbook Review of orthopaedic trauma. Second edition. 2013: 143-161.
12. Ajmera A, Verma A, Agrawal M, Jain S, Mukherjee A. Outcome of limb reconstruction system in open tibial diaphyseal fractures. Indian J Orthop. 2015;49(4):429-35.
13. Piwani M, Bhutto IA, Ahmed I. Evaluation of AO external fixator in the management of open diaphysial fracture of tibia gustilo type IIIA and IIIB. Gomal J Med Sci. 2015;13(1):66-9.
14. Beltsios M, Savvidou O, Kovanis J, Alexandropoulos P, Papagelopoulos P. External fixation as a primary and definitive treatment for tibial diaphyseal fractures Strategies Trauma Limb Reconstr. 2009;4(2):81–7.
15. Shikari A, Wani A, Padha K, Bhatti M, Dang H. Fixation Of Compound Fractures Of Distal Tibia Using A Delta External Fixator As A Definite Modality Of Treatment With Or Without Fibular Plating/ Limited Internal Fixation With K- Wires. Int J Orthopedic Surg. 2010;18(2):1-7.
16. Chandra Prakash Pal et al. Comparative study of the results of compound tibial shaft fractures treated by Ilizarov ring fixators and limb reconstruction system fixators. Chinese J Traumatol. 2015;18:347-51.
17. Abbas Memon et al. Functional Outcome of Open Diaphyseal Tibial Fracture Treated By A.O Fixation VS N.A Fixation. Medforum 9-article: 64.
18. Iqbal HJ, Pidikiti P. Treatment of distal tibia metaphyseal fractures; plating versus intramedullary nailing: a systematic review of recent evidence. Foot Ankle Surg. 2013;19(3):143-7.
19. Tekin AC, Saygılı MS, Adaş M, Çabuk H, Arslan SM, Dedeoğlu SS, et al. Outcome of type 3 open tibial diaphyseal fractures managed with a Limb reconstruction system: analysis of a 49- patient cohort. Med Princ Pract. 2016;25:270-5.
20. Neto FCJ, Canal MP, Alves BAF, Ferreira PM, Ayres JC, Alves R. Analysis of the characteristics of patients with open tibial fractures of Gustilo and Anderson type III. Rev Bras Ortop. 2016;51(2):143-9.
21. Patzakis MJ, Wilkins J. Factors influencing infection rate in open fracture wounds. Clin Orthop Res. 1989;243:36–40.
22. Naique SB, Pearse M, Manachalal J. Management of severe open tibial fractures: The need for combined orthopaedic and plastic surgical treatment in specialist centers. J Bone Joint Surg Br. 2006;88:351–7.
23. Crowley DJ, Kanaakaris NK, Giannoudis PV. Irrigation of the wounds in open fractures. J Bone Joint Surg Br. 2007;89:580–5.
24. Hou Z, Irgit K, Strohecker KA, Matzko ME, Wingert NC, DeSantis JG, et al. Delayed flap reconstruction with vacuum-assisted closure management of the open IIIB tibial fracture. J Trauma. 2011;71(6):1705-8.
25. Steiert AE, Gohritz A, Schreiber TC, Krettek C, Vogt PM. Delayed flap coverage of open extremity fractures after previous vacuum-assisted closure (VAC) therapy: worse or worth? J Plast Reconstr Aesthet Surg. 2009;62:675-83.
26. Schlatterer DR, Hirschfeld AG, Webb LX. Negative Pressure Wound Therapy in Grade IIIB Tibial Fractures: Fewer Infections and Fewer Flap

Procedures? Clin Orthop Relat Res. 2015;473(5):1802–11.
27. Thakur AJ, Patankar J. Open tibial fractures. Treatment by uniplanar external fixation and early bone grafting. J Bone Joint Surg Br. 1991;73:448-51.
28. Patil M. Definitive Management of Open Tibia Fractures Using Limb Reconstruction System. J Clin Diagnos Res. 2016;10(7):1-4.
29. Lakhani A, Singh D, Singh R. Outcome of rail fixator system in reconstructing bone gap. Indian J Orthop. 2014;48:612-6.

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