National Journal of Clinical Orthopaedics

ISSN (P): 2521-3466
ISSN (E): 2521-3474

www.orthoresearchjournal.com
2018; 2(3): 106-112
Received: 18-05-2018
Accepted: 19-06-2018

Dr. Krunal Soni
Senior Resident,
Department of Orthopaedics,
BJ Medical College, Ahmedabad,
Gujarat, India

Dr. Jil Patel
Orthopaedic Surgeon,
Shah Hospital, Ahmedabad,
Gujarat, India

Correspondence
Dr. Jil Patel
Orthopaedic Surgeon,
Shah Hospital, Ahmedabad,
Gujarat, India

Comparative study of distal tibia fractures managed by nailing vs plating

Dr. Krunal Soni and Dr. Jil Patel

Abstract
Introduction: Distal tibia fractures often caused by high energy axial compressive, direct bending or low energy rotation forces. These fractures constitute less than 7% of all the tibial fracture and less than 10% of all lower extremity fractures. Management of distal tibia fracture is challenging because of its subcutaneous location with precarious blood supply, proximity to the ankle joint and associated soft tissue injury. Numerous features are responsible for this, but perhaps none are as difficult as the accompanying soft tissue injury that is frequently present. They are associated with gross swelling, skin injury and blisters because of subcutaneous location. Skin condition determines the timing of surgery. The aim of treating the fracture is to preserve normal mechanical axis, ensure joint stability and restore a near full range of motion. This is a difficult task to accomplish in each and every case as we face compromised soft tissue condition and variable bone quality. Available options for stabilizing fractures are closed reduction and intramedullary interlocking (IMIL) nailing or open reduction and internal fixation (ORIF) with plating or closed reduction and percutaneous plating (MIPPO) or external fixators. The factors determining the fixation methods are pattern of fracture, quality of bone and condition of soft tissues. In our study, we are trying to evaluate and compare the results of fixation of distal tibia fractures with different modalities of treatment.
Aim: To compare the outcome of fracture distal tibia managed by various modalities.
Materials and Methods: This was a prospective study conducted in Department of Orthopaedics in Tertiary care hospital attached to a Medical college between July 2014 and June 2016.The study consisted of 30 consecutive patients with Distal tibia fracture managed surgically with either Intramedullary interlocking nailing (IMIL) or Open reduction and internal fixation (ORIF) or Minimally invasive percutaneous plating (MIPPO) or External fixation. Patients with open fractures were graded using the Gustilo Anderson classification for open fractures. All 30 patients were followed-up for clinical evaluation using The American Orthopedic Foot and Ankle Society (AOFAS) score[11] and Functional score of Olerud and Molander[12] and Clinico-Radiological evaluation at 1 month, 2 months, 3 months, 6 months.
Results and Discussion: In our study, patients were divided as Group I including the patients managed primarily by closed reduction and intramedullary nailing and Group II including patients managed primarily by plating. In this study in patients of Group I, 73.33% (11) had excellent results, 13.33%(1) had good and 13.33% (2) had poor results as per our scoring system of AOFAS and Olerud & Molander score. In patients of Group II, 60% (9) had excellent results, 20% (3) had good, 20% (3) had fair results as per our scoring system of AOFAS and Olerud & Molander score.
Conclusion: Due to small number of patients involved in our study, we cannot draw any definitive conclusions from our preliminary results but view them as valuable basis for further studies. Further research is necessary, in order to evaluate whether this surgical technique in long term provides us with the safe and effective management options for distal tibia fractures.

Keywords: Distal tibia fractures managed, nailing vs plating

Introduction

Distal tibia fractures often caused by high enesrgy axial compressive, direct bending or low energy rotation forces. These fractures constitute less than 7% of all the tibial fracture and less than 10% of all lower extremity fractures. Management of distal tibia fracture is challenging because of its subcutaneous location with precarious blood supply, proximity to the ankle joint and associated soft tissue injury. Numerous features are responsible for this, but perhaps none are as difficult as the accompanying soft tissue injury that is frequently present. They are associated with gross swelling, skin injury and blisters because of subcutaneous location. Skin condition determines the timing of surgery.

The aim of treating the fracture is to preserve normal mechanical axis, ensure joint stability and restore a near full range of motion. This is a difficult task to accomplish in each and every case as we face compromised soft tissue condition and variable bone quality [1, 2]. Results of operative treatment are dependent on the severity of the initial injury, the quality and stability of the reduction. The mechanism of injury, status of soft tissues, the degree of comminution and articular damage affect the long term clinical outcome. A variety of treatment options are available. But there is no consensus on the best treatment modality [1, 2, 3]. Surgical fixation is considered for most distal tibia fractures which require meticulous preoperative planning. Available options for stabilizing fractures are closed reduction and intramedullary interlocking (IMIL) nailing or open reduction and internal fixation (ORIF) with plating or closed reduction and percutaneous plating (MIPPO) or external fixators. The factors determining the fixation methods are pattern of fracture, quality of bone and condition of soft tissues [3-8].

Each of these techniques has their own merits and demerits.

Although multiple options are described to treat these fractures, there is no consensus on the best method of treatment. Though there are studies comparing these methods in our population in the past.

A classic «catch 22» situation is obvious in choosing the modality of treatment most significant of which is soft tissue complications. The concern regarding soft tissues has led to less invasive methods of fracture stabilization. These have included percutaneous screw insertion, ring fixation, and most recently percutaneous plate insertion techniques.

Have we, at this time, solved our dilemma??? The answer, to a certain extent, is yes – but only to a certain extent. The final result of any lower-extremity joint injury is dependent upon the ability of the surgeon to achieve an anatomical reduction of the joint surface.

If this cannot be achieved by closed means, then open reduction is indicated. If we are to embark upon that course for the distal tibial fracture, it behooves us to pay particular attention to the timing of the operation, to the handling of the soft tissues, and to the precise details of the internal fixation. This, in turn, will avoid many of the complications and should improve the functional results. However, there will be some fractures in this area that will defy even the most expert surgeon. Also, the soft tissue injury in some patients may be so severe that open reduction is hazardous and therefore other techniques must be performed. In those cases, the prognosis resides more in the injury itself than in the treatment, and poor functional results, often ending in ankle arthrodesis, may be expected.

In our study, we are trying to evaluate and compare the results of fixation of distal tibia fractures with different modalities of treatment.

Aim: To compare the outcome of fracture distal tibia managed by various modalities.

Materials and Methods

This was a prospective study conducted in Department of Orthopaedics in Tertiary care hospital attached to a Medical college between July 2014 and June 2016. Ethical committee clearance was obtained and patient was included in study after informed and written consent.

The study consisted of 30 consecutive patients with Distal tibia fracture managed surgically with either Intramedullary interlocking nailing (IMIL) or Open reduction and internal fixation (ORIF) or Minimally invasive percutaneous plating (MIPPO) or External fixation.

All 30 patients were received in emergency room following which on admission of the patient, a careful history was elicited from the patient and/or attenders to reveal the mechanism of injury and the severity of the trauma. The patients were then assessed clinically to evaluate their general condition and the local injury. General condition was assessed with the vital signs and systemic examination. Methodical examination was done to rule out fractures at other sites. Local examination of the injured extremity revealed swelling, deformity and loss of function. Palpation revealed abnormal mobility and crepitus at the fracture site. Distal neurovascular status was assessed by the posterior tibial artery and dorsalispedis artery pulsations, capillary filling, local temperature, pallor and paraesthesia. Then trauma series, relevant X-rays including the affected leg with knee and ankle joints antero-posterior and lateral views were taken. Fracture patterns were classified based on the AO/OTA classification [9]. The limb was then immobilized in an above knee Plaster of Paris slab till definitive fixation was done.

Patients with open fractures were graded using the Gustilo Anderson classification for open fractures [10]. Antibiotics were started immediately for all patients. Injection cefuroxime 1.5gm intravenous thrice daily and injection Amikacin 750mg intravenous once daily and Inj Metronidazole 100mg intravenous thrice daily were the antibiotics. Single dose of tetanus toxoid was given. After obtaining the necessary radiographs, Type I and II open fractures were treated by cleaning of the wound with copious amount of normal saline, and Hydrogen peroxide, followed by painting of the skin around the wound with Povodine iodine and sterile dressing was done. The limb was then immobilized in an above knee Plaster of Paris slab till definite fixation was done. In the Type III fracture, patient was taken for emergency wound debridement and Joint Spanning External Fixator was applied primarily till definitive fixation was planned.

Inclusion Criteria

1. All Skeletally mature patients (age ≥18) both males and females.
2. Involvement of distal 8cm of tibia.
3. All closed and Gustilo-Anderson type I fractures.

Exclusion Criteria

1. Skeletally immature patients.
2. Intra-articular fracture, Compond fracture, Pathological fracture, any other associated fracture except for ipsilateral fibula.
3. Patients with associated medical condition of Diabetis mellitus

All patients received treatment with Intramedullary interlocking nailing or open reducation and internal fixation or minimally invasive percutaneous plating or external fixator on surgeons choice and fracture pattern.

The patients who underwent intramedullary interlocking nailing were operated under regional anaesthesia with patients supine on standard radiolucent table. Patellar splitting approach was used in all patients. Under image intensifier nailing was done using standard technique and all fractures were fIxed with one proximal and two/three distal interlocking screws.

The patients who underwent plate osteosynthesis were operated under regional anaesthesia with patient supine on standard radiolucent table. Most commonly, through anteromedial

approach reduction of fracture was achieved and fixed using plates and appropriate screws under the guidance of image intensifier.

The patients who underwent MIPPO were operated under regional anaesthesia with patient supine on standard radiolucent table. Under image intensifier one anteromedial incision at proximal end of anticipated plate position and one at distal end. A tunnel connecting these two incisions at extra periosteal fashion is made by advancing a clamp from distal to proximal or vice versa. Plate is pulled through the subcutaneous tunnel under radiographic control. Through stab incisions plate is fixed with screws.

The patient who underwent external fixation were operated under regional anaesthesia with patient supine on standard radiolucent table. Under image intensifier a uniplanar rectangular external fixator spanning the ankle joint with proximal pin in tibial diaphysis and distal pin in calcaneum.

The decision for adjunctive fibular stablization as well as number of orientation of distal interlocking screws was made at surgeon's discretion. Duration of surgery and blood loss intraoperatively was estimated for all patients.

Postoperative Protocol

Radiographic evaluation was done with standard antero-posterior and lateral view of tibia with knee and ankle joint. Static quadriceps strengthening exercise were started on 2nd day in all patients. Active range of motion of knee and ankle exercises was started on next day of surgery in patients managed by intramedullary nailing. In patients managed with open reduction and internal fixation or MIPPO active range of motion of knee and ankle was started on 7th-10th day.

All patients were given 3-5 days of broad spectrum intravenous antibiotics. Wound inspection was done on 3rd and 5th postoperative day.

Suture removal was done on 12th to 14th postoperative day.

Patients were maintained on non- or toe-touch followed by partial weight bearing until clinical or radiographic signs of healing were seen after which full weight bearing was allowed.

Secondary surgeries like Bone grafting, Dynamization, Implant exchange or Implant removal were performed as needed and determined by the surgeon for failure of progression of healing, loss of fracture fixation or infection or need of patient.

Clinical and Radiographic Evalation

All 30 patients were followed-up for clinical evaluation using The American Orthopedic Foot and Ankle Society (AOFAS) score [11] and Functional score of Olerud and Molander [12] and Clinico-Radiological evaluation at 1 month, 2 months, 3 months, 6 months.

Fracture union was defined as healing of atleast 3 of 4 cortices on biplanar plain radiograph.

Delayed union was defined as a lack of healing on plain radiograph within 3 months.

Nonnion was defined as lack of any healing on plain radiographs within 6 months.

Malunion was defined as more than 5 degree of angular deformity or shortening of more than 1cm.

Follow Up Protocol

- Duration:
- Complaints: Pain/discharge/stiffness - Ankle/Knee/Other Complains
- Non Weight Bearing /Partial Weight Bearing with Walker or Crutches or Stick /Full weight bearing
- ROM: Knee
  Ankle
- Final AOFAS and Olerud & Molander Score:
- Xray: - Fracture site: Uniting/United/Visible malunion or nonunion Deformity: Varus/ Valgus /Rotational deformity Implant: In situ/Broken/Loose. Signs of Infection: Refracture:

Observations and Discussions

- All thirty cases were studied according to previously stated method and patients were divided in to 2 groups as per surgeon's choice of management.
- Group I included the patients managed primarily by closed reduction and intramedullary nailing and Group II included patients managed primarily by plating.
- Following observations were made:

Table 1: Age Wise Distribution of Patients in This Study.

Age-Group	Nailing		Plating	
(years)	No. of Cases	Percentage	No. of Cases	Percentage
21-30	5	33.33	3	20
31-40	6	40	6	40
41-50	1	6.66	3	20
51-60	3	20	2	13.32
61-70	0	0	1	6.66
Total	15	100	15	100

Table 2: Gender wise Distribution of Patients in This Study**.**

Gender	Nailing		Plating	
	No. of Cases	Percentage	No. of Cases	Percentage
Male	11	73.32	14	93.32
Female	4	26.66	1	6.66
Total	15	100	15	100

Table 3: Occupation wise Distribution of Patients in This Study

Occupation	Nailing		Plating	
	No. of Cases	Percentage	No. of Cases	Percentage
Daily Wage Labourers	0	0	4	26.66
Housewives	4	26.66	1	6.66
Factory Workers	4	26.66	2	13.32
Farmers	3	20	4	26.66
Others	4	26.66	4	26.66
Total	15	100	15	100

Table 4: Nature of Injury and Distribution of Patients in This Study.

Nature of Injury	Nailing		Plating	
	No. of Cases	Percentage	No. of Cases	Percentage
Road Traffic Accidents	3	20	8	53.32
Blunt Trauma	5	33.32	3	20
Fall	6	40	4	26.66
Assaulted	1	6.66	0	0
Total	15	100	15	100

Table 5: Affected Side Distribution of Patients in This Study

Affected Side	Nailing		Plating	
	No. of Cases	Percentage	No. of Cases	Percentage
Right	10	66.66	6	40
Left	5	33.32	9	60
Total	15	100	15	100

Table 6: Incidence of Open/Closed Fracture in This Study

Type of Injury	Nailing		Plating	
	No. of Cases	Percentage	No. of Cases	Percentage
Closed	13	86.66	12	80
Open Type-I	2	13.32	3	20
Total	15	100	15	100

Table 7: Fracture Type According To Ao Classification in This Study

Ao Type	Nailing		Plating	
	No. of Cases	Percentage	No. of Cases	Percentage
AO43-A 1.1	7	46.66	5	33.32
AO43-A 1.2	1	6.66	3	20
AO43-A 1.3	2	13.32	2	13.32
AO43-A 2.1	2	13.32	2	13.32
AO43-A 2.2	1	6.66	2	13.32
AO43-A 2.3	2	13.32	1	6.66
AO43-A 3.1	0	0	0	0
AO43-A 3.2	0	0	0	0
AO43-A 3.3	0	0	0	0
Total	15	100	15	100

Table 8: Associated Fibular Fracture Distribution in Patients In This Study

Associated fibular Fracture	nailing		plating	
	No. of Cases	Percentage	No. of Cases	Percentage
Upper One Third	0	0	0	0
Middle One Third	0	0	0	0
Lower One Third	8	53.32	12	80
Not Associated	7	46.66	3	20
Total	15	100	15	100

Table 9: Admission-Surgery Interval in Patients in This Study.

Admission Interval	Nailing		Plating Surgery	
	No. of Cases	Percentage	No. of Cases	Percentage
1-2 days	8	53.32	2	13.32
3-4 days	7	46.66	11	73.32
>4 days	0	0	2	13.32
Total	15	100	15	100

Table 10: Complication in Patients in This Study

Complications	Nailing		Plating	
	No. of Cases	Percentage	No. of Cases	Percentage
Pain	13	86.66	6	40
Infection	3	20	4	26.66
Ankle Joint Movement Restriction	2	13.32	5	33.32
Implant Impingement	2	13.32	6	40
Difficulty in Cross Leg Sitting	2	13.32	5	33.32
Difficulty in Squatting	2	13.32	5	33.32
Implant Irritation	0	0	1	6.66
Screw Backout	1	6.66	0	0
Secondary Procedure	2	13.32	7	46.66

Table 11: Deformity in Patient In This Study

Deformity	Nailing		Plating	
	No. of Cases	Percentage	No. of Cases	Percentage
Valgus	1	6.66	0	0
Varus	0	0	0	0
External Rotation	0	0	0	0
Internal Rotation	0	0	0	0
Recurvatum	0	0	1	6.66
Procurvatum	0	0	0	0
Shortening	2	13.32	1	6.66

Table 12: Time Taken For Partial and Full Weight Bearing In Patients in This Study

Mobilization	Nailing		Plating	
	No. of Cases	Percentage	No. of Cases	Percentage
Knee & Ankle Mobilization (Days)				
1-3	13	86.66	0	0
3-10	2	13.32	13	86.66
>10	0	0	2	13.32
Total	15	100	15	100
Partial Weight Bearing (Weeks)				
8-10	4	26.66	10	66.66
10-12	9	60	5	33.32
12-14	2	13.32	0	0
>14	0	0	0	0
Total	15	100	15	100
Full Weight Bearing (Weeks)				
12-14	4	26.66	10	66.66
14-16	9	60	4	26.66
>16	2	13.32	1	6.66
Total	15	100	15	100

Table 13: Time to Union in Patients in This Study

Time to Union (weeks)	Nailing	Plating
18-20	3	9
20-22	10	4
22-24	2	1
>24	-	1
Total	15	15

Table 14: Results of Patients in This Study

Results	Nailing		Plating	
	No. of Cases	Percentage	No. of Cases	Percentage
Excellent	11	73.33	9	60
Good	2	13.33	3	20
Fair	-	-	3	20
Poor	2	13.33	-	-

Discussion

In our study, patients were divided as Group I including the patients managed primarily by closed reduction and intramedullary nailing and Group II including patients managed primarily by plating.

In both Groups maximum number of patients fall in age group of 21-40 years (Group I = 73.33%, Group II = 80%) with youngest patient of 21 years age and oldest patient of 63 years with average age being 40 years. This can be explained because of active engagement and exposure to outdoor life, road traffic accidents and industrial misfortune in this active age group. These findings are consistent with almost every series of studies regarding distal tibia fracture for example: Mean age of Jassen *et al*. study [13] mean age was 43.3 years, and Mohammed *et al*. [14], in which mean age of cases was 42 years.

The gender distribution in Group I was males (73.32%) and females (26.66%) and in Group II males (93.32%) and females (6.66%).Sex distribution with other study was compared. Guo *et al*. [15] had 40% female and 59% male in nailing group, 41% female and 59% male in plating group. Predominant involvement of male sex in both the groups can be explained, as males are more frequently exposed to outdoor activities and hence more involved in road side accidents, industrial misfortunes and assaults.

Group I majority of patients were factory workers (26.66%) and housewives (26.66%) and in Group II majority of patients were

daily wage labourers (26.66%) and farmers (26.66%) which is consistent with Bahari *et al*., study [16].

in Group I, 40% (6) patients sustained injury by Fall from height, 32.32% (5) sustained injury by blunt trauma, 20% (3) by road traffic accident and 6.66% (1) by assaulted trauma.In Group II, 53.32% (8) patients sustained injury by Road traffic accidents, 26.66% (4) by fall from height and 20% (3) patients sustained injury by blunt trauma. In the study by Bahari *et al*. [16], 57% of the patients sustained injury due to fall from height. In this study Road traffic accidents and Fall are the most common mode of injury for fracture distal tibia in both the groups of patients with both amounting to almost 1/3rd-1/3rd of the cases.

In our study in Group I, 13.32% (2) patients had Gustilo open type 1 injury and in 86.66% (13) patients had closed injury. In Group II, 20% (3) patients had Gustilo open type 1 injury and 12 (80%) had closed injury. In comparison with study by Bahari *et al*. [16], in which 15% patients were open fractures. The fracture was classified according to the AO classification and the decision whether to manage the patient with intramedullary nailing or plating was surgeons choice.

Knee pain remains the most common complication of intramedullary tibial nailing. Court-Brown *et al.* (103) found that 82.3% of patients either had no or mild pain. Väistö *et al.* [17] followed a cohort of patients for eight years after tibial nailing. They found that anterior knee pain resolved with time in many patients. This complication is seen exclusively in nailing group. As the etiology is not obviously clear, it is suggested that anterior knee pain may be due to patellar tendon and retropatellar fat pad damage. In our study, anterior knee pain was in acceptable limits according to the literature, and pain was mild and did not affect life or working quality in any of our patients. We suggest that protection of the patellar tendon, appropriate nail length, and correct nail entry point were essential for decreasing the complaints. The complication are comparable with the results of study by Janssen *et al*., 2006 [13], Bahari *et al*., 2007 [16], Guo *et al*., 2010 [15].

In this study in Group I, 66.66% (10) patients achieved union between 20-22 weeks, 20% (3) patients achieved union between 18-20 weeks and 13.33% (2) patients achieved union between 22-24 weeks. In Group II, 60% (9) patients achieved union between 18-20 weeks, 26.66% (4) patients achieved union between 20-22 weeks and 6.66% (1) patients achieved union between 22-24 weeks and in 6.66% (1) patients union took more than 24 weeks. Vallier *et al*., [18] had 12% delayed and non union with nailing group. 2.5% non union with plating group. Kasper *et al*., (52) in his study found 25% delayed union with nailing and 16.5% plating. Kasper *et al*., [13] study mean time of radiographic union was 19 weeks with plate group and 21 week with nail group. Guo *et al*., [15] study 17.7 weeks for mean radiographic union with nailing and 17.6 weeks for plate group. Vallier *et al.* [18] shown his study that mean union time is 19 weeks for both plate and nail group. In our study, it was observed that time to union was more in majority of patients managed with nailing as compared to majority of patients managed with plating. This does not seem logical as in nailing the time to union should be less as compared to plating. But a larger study is required to validate our findings.

In this study in patients of Group I, 73.33% (11) had excellent results, 13.33% (1) had good and 13.33% (2) had poor results as per our scoring system of AOFAS and Olerud & Molander score. The contributing factors observed in poor outcome are persistent discharging sinus, constant pain and swelling, difficulty in walking, climbing stairs and difficulty in crossleg sitting and squatting. In this study in patients of Group II, 60% (9) had excellent results, 20% (3) had well, 20% (3) had fair results as per our scoring system of AOFAS and Olerud & Molander score. In our study in Group I, 73.32% (11) of patients could return to their same occupation as before injury and 26.66% (4) of patients had to change to a simpler job. Out of the 4 patients, one patient had discharging sinus at proximal and distal leg with severe constant pain and swelling in leg with difficulty in walking, climbing stairs and weight bearing on operated limb with difficulty in squatting and cross leg sitting since 1 year, 2nd patient had discharging sinus at distal leg with moderate pain and swelling at distal leg with difficulty in walking, climbing stairs and weight bearing on operated limb with use of support for walking since 3-4 months, 3rd and 4th patients had pain around distal leg and difficulty sitting and squatting since 3-4 months. In Group II, 80% (12) of patients could return to their same occupation as before injury and 20% (3) of patients had to change to a simpler job. Out of the 3 patients, one patient had discharging sinus at distal leg with constant moderate pain and swelling at distal leg with difficulty sitting cross leg and squatting, 2nd patient had persistent multiple discharging sinus at distal leg with constant pain and swelling around distal leg with difficulty in crossleg sitting and squatting for which implant removal was done and 15 days later patient presented with recurvatum deformity for which secondary procedure was done and 3rd patent had pain around distal leg and difficulty in cross leg sitting and squatting.

Conclusion

Distal Tibia Fracture is a complex injury and often poses many challenges in form of significant soft tissue injury apart from bony injury and requires proper planning and execution of tailor made management for a patient.

1. Both modalities of fixation deserve place in management of distal metaphyseal tibia fractures.
2. Overall results were comparable in both groups.
3. Intramedullary nailing has an advantage in restoration of ankle motion and reduced wound problems.Better alignment can be achieved with the use of Intramedullary nails by careful attention to the technique of central guide wire placement and avoiding eccentric reaming
4. Plate and screws can restore alignment better than intramedullary nails but the long term effect of malalignment needs further evaluation
5. Functional ankle scores were higher in nailing group compared to plating group.
6. Anterior knee pain is noted only with intramedullary technique and no knee complications were noted with plating group.
7. Implant impingement was more common with Plating group
8. Infection and Ankle joint restriction was seen as a complication more frequently in Plating group
9. Time to partial and full weight bearing and time to union was shorter in Plating group
10. Additional procedures for union were required higher in plating group.

Due to small number of patients involved in our study, we cannot draw any definitive conclusions from our preliminary results but view them as valuable basis for further studies. Further research is necessary, in order to evaluate whether this surgical technique in long term provides us with the safe and effective management options for distal tibia fractures.

References

1. Barie DP. Pilon fractures. In: Bucholz RW, Court-Brown CM, Heckman JD, Tornetta P Rockwood and Green's Fractures in Adults. 7th edition Philadelphia Lippincott Williams and Wilkins, 2010, 1928-74.
2. Sarmiento A, Latta LL. 450 closed fractures of the distal third of the tibia treated with a functional brace. Clin Orthop Relat Res. 2004; 428:261-71.
3. Ruedi TP, Allgower M. The operative treatment of intra articular fractures of the lower end of tibia. Clin Orthop. 1979; 138:105-10.
4. Court-Brown CM, Walker C, Garg A, McQueen MM. Half-ring external fixation in the management of tibial plafond fractures. J Orthop Trauma. 1999; 13:200-06.
5. Bedi A, Le TT, Karunakar MA. Surgical treatment of nonarticular distal tibia fractures. J Am Acad Orthop Surg. 2006; 14:406-16.
6. Maffuli N, Toms A, McMurtie A, Oliva F. Percutaneous plating of distal tibia fractures. Int Orthop. 2004; 28:159-62.
7. Redfern DJ, Syed SU, Davies SJM. Fractures of the distal tibia: minimal invasive plate osteosynthesis. Injury. 2004; 35:615-20.
8. Hazarika S, Chakravarthy J, Cooper J. Minimally invasive locking plate osteosynthesis for fractures of the distal tibia. Injury. 2006; 37(9):877-87.
9. Raja BK, Arun KC, Dheenadayalan J. Classification of distal femur fractures and their clinical relevance. Trauma International. 2016; 2(1):3-6.
10. Kim, PH, Leopold SS. Gustilo-Anderson Classification. Clinical Orthopaedics and Related Research. 2012; 470(11):3270–3274. http://doi.org/10.1007/s11999-012-2376-6.
11. Van Lieshout EMM, De Boer AS, Meuffels DE *et al.* American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score: A study protocol for the translation and validation of the Dutch language version BMJ Open 2017; **7:**012884. doi:10.1136/bmjopen-2016-012884
12. Nilsson G, Jonsson K, Ekdahl C, Eneroth M. Outcome and quality of life after surgically treated ankle fractures in patients 65 years or older. BMC Musculoskeletal Disorders. 2007; 8:127. http://doi.org/10.1186/1471-2474-8-127
13. Kasper W.Janssen, Jan Biert, Albert van Kampen. Treatment of distal tibial fractures: plate versus nail A retrospective outcome analysis of matched pairs of patients International Orthopaedics (SICOT). 2007; 31:709-714.
14. Mohammed A, Saravanan R, Zammit J *et al*. Intramedullary tibial nailing in distal third tibial fractures: distal locking screws and fracture non-union. Int Orthop. 2008; 32(4):547-549.
15. Guo JJ, Tang N, Yang HL, Tang TS. A prospective, randomized trial comparing closed inramedullary nailing with percutaneous plating in the treatment of distal metaphyseal fractures of the tibia. J Bone Joint Surg Br. 2010; 92(7):984-88.
16. Bahari S, Lenehan B, Khan H *et al*. Minimally invasive percutaneous plate fixation of distal tibia fractures. Acta Orthop Belg. 2007; 73(5):635-640.
17. Vaisto O, Toivanen J, Kannus P, Jarvinen M. Anterior knee pain after intramedullary nailing of fractures of the tibial shaft: an eight-year follow- up of aprospective, randomized study comparing two different nail- insertion techniques. J Trauma. 2008; 64:1511-16.
18. Vallier HA, Le TT, Bedi A, Radiographic and clinical comparisons of distal tibia shaft fractures (4 to 11 cm proximal to the plafond): plating versus intramedullary nailing. J Orthop Trauma. 2008; 22(5):307-11.