# Minimally Invasive Plate Osteosynthesis for Distal Tibial Fractures

Abdulla S. Abu Senna

Department of Orthopaedics, Faculty of Medicine, Alazhar University, Cairo, Egypt

**Abstract: Background**: Distal tibia fractures that require operative treatment is difficult to manage. Conventional osteosynthesis is not suitable because distal tibia is subcutaneous bone with poor vascularity. Closed reduction and minimally invasive plate osteosynthesis (MIPO) has emerged as an alternative treatment option because it respects biology of distal tibia and fracture hematoma and also provides biomechanically stable construct. Objectives: To find out suitability of MIPO for distal tibial fracture including union time and complications and compare with other available management options in literatures. Methods: Twenty patients with closed distal tibial fracture with or without intra articular extensions treated with MIPO were prospectively followed for average duration of 12.5 months (range 6-19 months). Results: Average duration of injury-hospital and injury-surgery interval was 12.9 hrs (range 2-24 hrs) and 4.5 days (range 1- 9 days) respectively. All fractures got united with an average duration of 17.5 weeks (range 14-21 weeks) except one case of delayed union which was managed by percutaneous bone marrow injection.There were one superficial and one deep post-operative wound infection. The infections cured with extended period of intravenous antibiotics besides debridement for deep infection. Conclusion: The present study shows that MIPO is an effective treatment method in terms of union time and complications rate for distal tibial fracture**.**

[Abdulla S. Abu Senna. **Minimally Invasive Plate Osteosynthesis for Distal Tibial Fractures.** *J Am Sci* 2013;9(10): 158-164]. (ISSN: 1545-1003). http://www.jofamericanscience.org. 20

**Key Words:** Distal tibial fractures- minimally invasive plate osteosynthesis

## 1.Introduction

Fracture is the result of mechanical overload with important biological consequences. Proper understanding of mechanical and biological aspects of fracture repair is the key for selection of particular type of treatment modality for a given fracture. [1]

Treatment of distal tibial fracture with or without articular extension is challenging because of its unique anatomical characteristics of subcutaneous location with precarious blood supply and proximity to the ankle joint. Most of these fractures are managed with an operative intervention such as closed reduction and intramedullary interlocking (IMIL) nailing or open reduction and internal fixation (ORIF) with plating or closed reduction and percutaneous plating or external fixators. Each of these techniques has their own merits and demerits. IMIL nailing has been reported with higher rate of malunion because it is difficult to achieve two distally locking screws and short distal segment.[2] Wound infection, skin breakdown and delayed union or non union requiring secondary procedures like bone grafting are some of the complications associated with conventional osteosynthesis with plates.[3-4] Similarly, pin tract infection, pin loosening, malunion and nonunion leading to osteomyelitis is potential complication of external fixators and hence not preferred as definitive fixation method.[5-6]

With the damage to soft tissues following the high energy of distal tibial fractures, conventional open reduction and internal fixation often result in substantial soft tissue complications such as wound breakdown and deep infection[7-8]. To avoid these complications, the hybrid or circular wire external fixator is a good option, but problems of nonunion, mal-union, and pin track infections are common. The Minimal Invasive Plate Osteosynthesis (MIPO) technique was developed not only to improve the rate of fracture healing, but also to limit soft tissue elevation at the fracture site [9,10]. Biological plating techniques are those in which blood supply to the fractured fragments is maximally preserved. The objective of biological fixation is to assist physiological process of bone healing wisely and optimally with minimal amount of operative Intervention. Thus the emphasis should be laid on maintaining a precarious balance between devascularization and mechanical perfection. [11]

The concept of biological osteosynthes is refers basically to the conservation of vascularity of the bone during surgical intervention to ensure the continued vitality of the individual fragments and to achieve improved fracture healing. The present study was carried out for evaluation & analysis of the role of minimally invasive plate osteosynthesis.

Total of twenty (20) patients were taken up & after proper pre-operative assessment percutaneous plating was done and the results were evaluated. On the basis of the finding of this study it was concluded that: MIPO technique preserves most of the osseous vascularity thus providing for a more biological repair.

Minimally invasive plating techniques reduce surgical trauma and maintain a more biologically favorable environment for fracture healing, reducing risks of infection and nonunion. Fractures fixed by MIPO do not show primary bone healing as seen in rigidly fixed fractures with Dynamic Compression Plate (DCP). The bone healing in case of MIPO depends upon the formation of bridging callus[12]

**2.Patients and Methods**

Twenty (20) patients were operated by minimally invasive plate osteosynthesis after routine preoperative assessment and the results were observed.

There were twelve (12) males and eight (8) females patients (mean age 32 yrs), range18 - 47 yrs. According to AO classification, 12 (60%) of fracture were 43A1, 4 (20%) 43A2, 2 (10%) 43A3 and 2 (10%) 43B1. Half of the patients (50%) sustained injury in road traffic accident other modes of injury were fall injury in 8 (40%) patients and sports related injury in 2 (10%) each. (Table1)

Average duration of injury-hospital and injury-surgery interval was 12.9 hrs (range 2-24 hrs) and 4.5 days (range 1- 9 days) respectively.

Tabte:1 General data of the patients

| | |
|---|---|
| No. of patients | 20 Patients |
| Age | 18 - 47yrs |
| Sex | 12 Males & 8 Females |
| Mechanism of injury | 10 R.T.A, 8 fall from height,2 Sport injuries. |
| Soft tissues | all had medial swelling, ecchymosis or blisters |

The patients were placed supine on a fracture table to allow access to the image intensifier with complete dapping of the affected limb. Closed reduction of the fracture was done.

For minimally invasive plate osteosynthesis of distal tibial fractures, Open reduction and internal fixation of fibular fracture, (if present) was initially performed with the use of a 1/3$^{rd}$ semitubular plate through the lateral approach. Establishment of correct tibial length is accomplished by reducing and stabilizing the fibular fracture. Reduction and stabilization of fibula restores the length of lateral column and assist in reduction of anterolateral fragment of distal tibia (Chaput fragment) and posterior malleolar fragment (Wagstaffe's fragment). Restoration of fibula length also helps avoid valgus deformity of tibial plafond. Skin incision is taken at posterolateral aspect posterior to fibula and lateral malleolus to maximize the skin bridge between lateral and medial incisions. Fibular plating was done with 1/3$^{rd}$ tubular plate. Lag screw can be used to get anatomical reduction and interfragmental compression.

The attention was then directed to the tibia and the articular fragments were anatomically reduced by percutaneous method, utilizing fluoroscopy and pointed reduction forceps. Once articular reduction was achieved, if possible, the articular fragments were stabilized with lag screws. The appropriate length of the plate was determined by placing a plate along the anterior aspect of the leg and adjusting it so that under fluoroscopy the distal end of the plate is at level of the tibial plafond and the proximal end extends at least three screw holes beyond the proximal limit of the tibial fracture. A 2-3 cm incision was made along the antero-medial aspect of the tibia distally at the level of the medial malleolus and proximally about 2-3 cm incision proximal to the end of fracture line. Typically, a subcutaneous tunnel was created between the two incisions and along the medial aspect of the tibia by blunt dissection using a periosteal elevator or any other similar blunt instrument. The anatomical distal plate was placed and Cortical/cancellous screws were then placed at each end of the plate through the two incisions and in the mid position via small percutaneous stab incisions under fluoroscopy or by using other external identical plate to adjust screws, sterile dressings and posterior slab applied for 2- 3weeks.

Post operative check X-ray was taken to assess the reduction. Parenteral antibiotics were given for two days followed by oral antibiotics depending upon the condition of the wound.(Fig 2)

On 3$^{rd}$ post-operative day wound was examined and antiseptic dressing done. Sutures were removed between 10$^{th}$ to 14$^{th}$ days.

The splint was removed and physical therapy and gentle active assisted exercises started 2-3 weeks depending on toleration of patient.

Radiographs, including anteroposterior and lateral views were taken at 2 weeks, 6 weeks and 3 months post-operatively to assess healing and alignment. Partial weight-bearing started depending upon their clinical and radiographic evaluation, but in general most patients had advanced to partial weight-bearing by 6-8 weeks

**3.Results**

Patients were followed up for average duration of 12.5 months (range 6-19 months). Average duration for fracture union was17.5 weeks (range14-21weeks) Immediate post operative complications of wound infection was found in two patients (10%); one superficial and one deep wound infection. The superficial wound infections healed with extended period of intravenous antibiotics but patient with wound breakdown needed debridement as well. Subsequent follow up was unremarkable in these two cases. Delayed union in one case (5%) managed by

bone marrow injection. No malunion was detected. Two patient (10%) had ankle stiffness requiring extensive physiotherapy to regain range of movement (Table 2).

Table: 2 Healing time & complications

| | |
|---|---|
| Healing time | 14- 21weeks |
| Malunion | No cases |
| Delayed union | One case 5% |
| Metal failure | No cases |
| Infection | Two cases 10% |
| stiffness | two cases 10% |

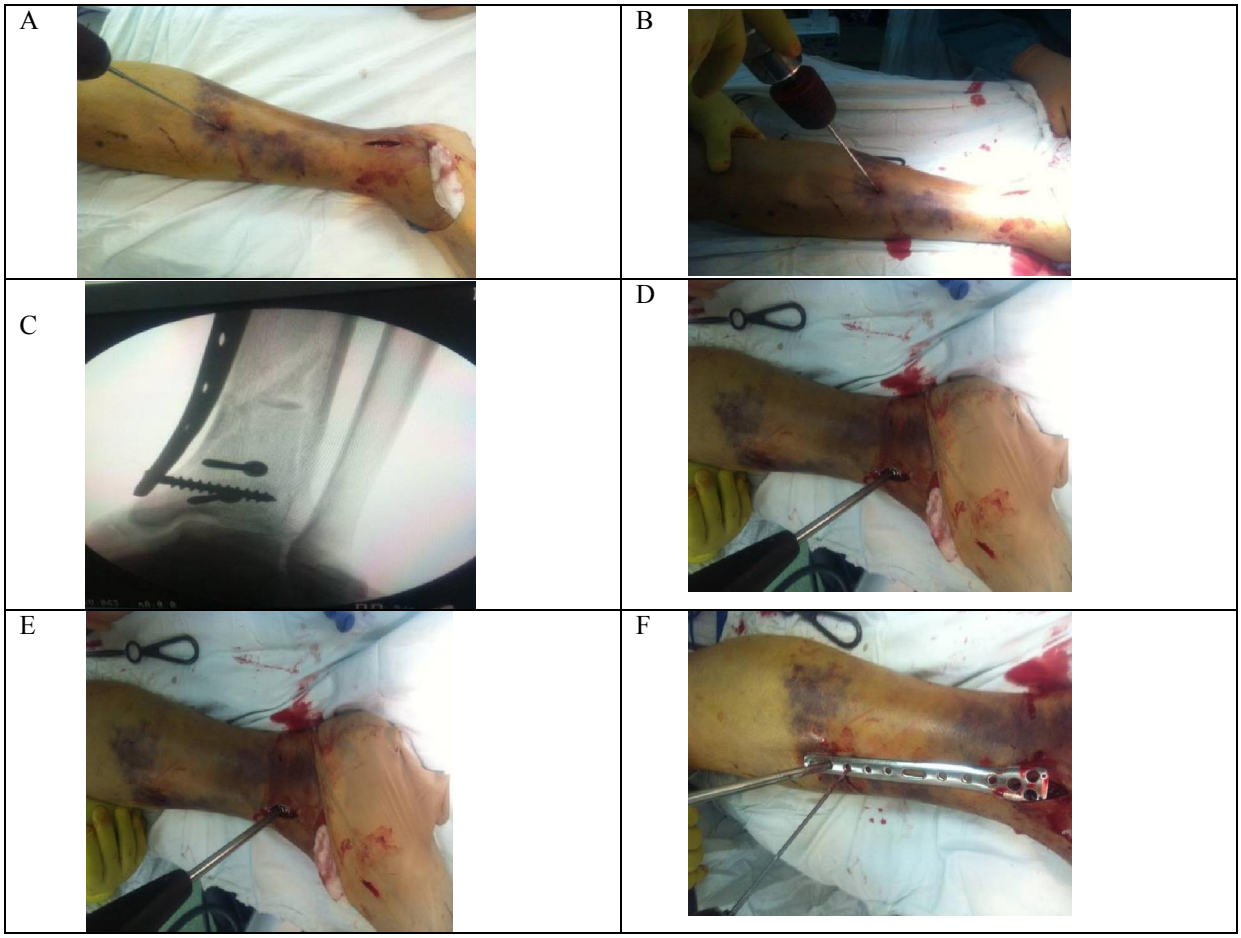
Overall 80% (16patients) of patients achieved excellent results with full range of motion and no pain without any deformity. 10% (2 patients) patients however had some restriction of movements, which were acceptable and did not require any intervention. Of the 10% (2 patients) poor results (tables 3- 4).

Table3: Following criteria's were used to assess the results. Grading of the Results:

| Result | Pain | Deformity | X-ray | Stiffness |
|---|---|---|---|---|
| Excellent | No pain | No deformity | Normal | No stiffness |
| Good | Pain with intense activity | No deformity | Minimal changes | Minimal stiffness |
| Poor | Pain while walking | Clinical and Radiological deformity | Arthritis | Restriction of 50% or more ankle motion |

Table 4(Results of the patients):

| Result | No. of Patients | Percentage |
|---|---|---|
| Excellent | 16 | 80% |
| Good | 2 | 10% |
| Poor | 2 | 10% |




(Fig 1) A: 2-3 cm incision was made along the antero-medial aspect of the tibia.
B: Screws were placed in the holes via percutaneous separate stab incisions.
C: Adjustment of the plate under fluoroscopy after insertion of 2 lag screws.
D&E: Screws were placed at distal end of the plate.
F: Similar external plate was used for adjustment of other screw holes.

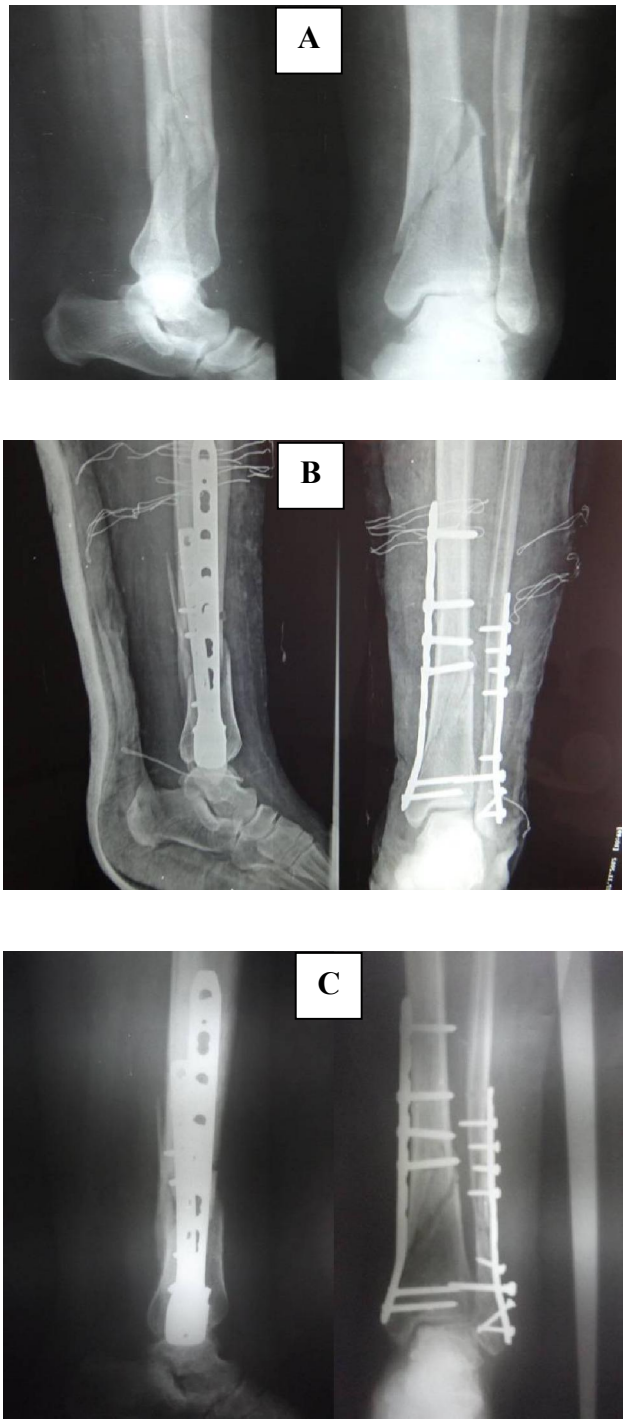



Figure (2). A: preoperative; B: Immediate post; C:3 months post.

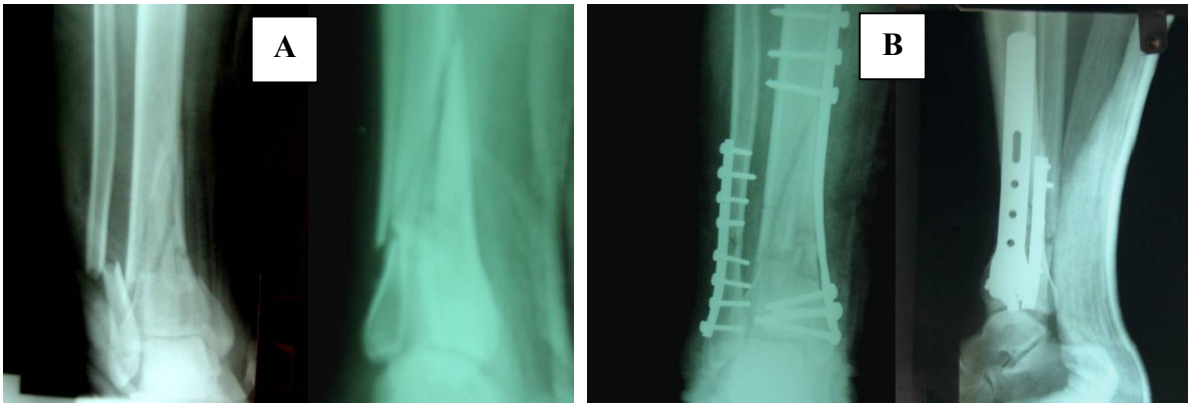



Figure (3). A: pre operative; B: 2 months follow up

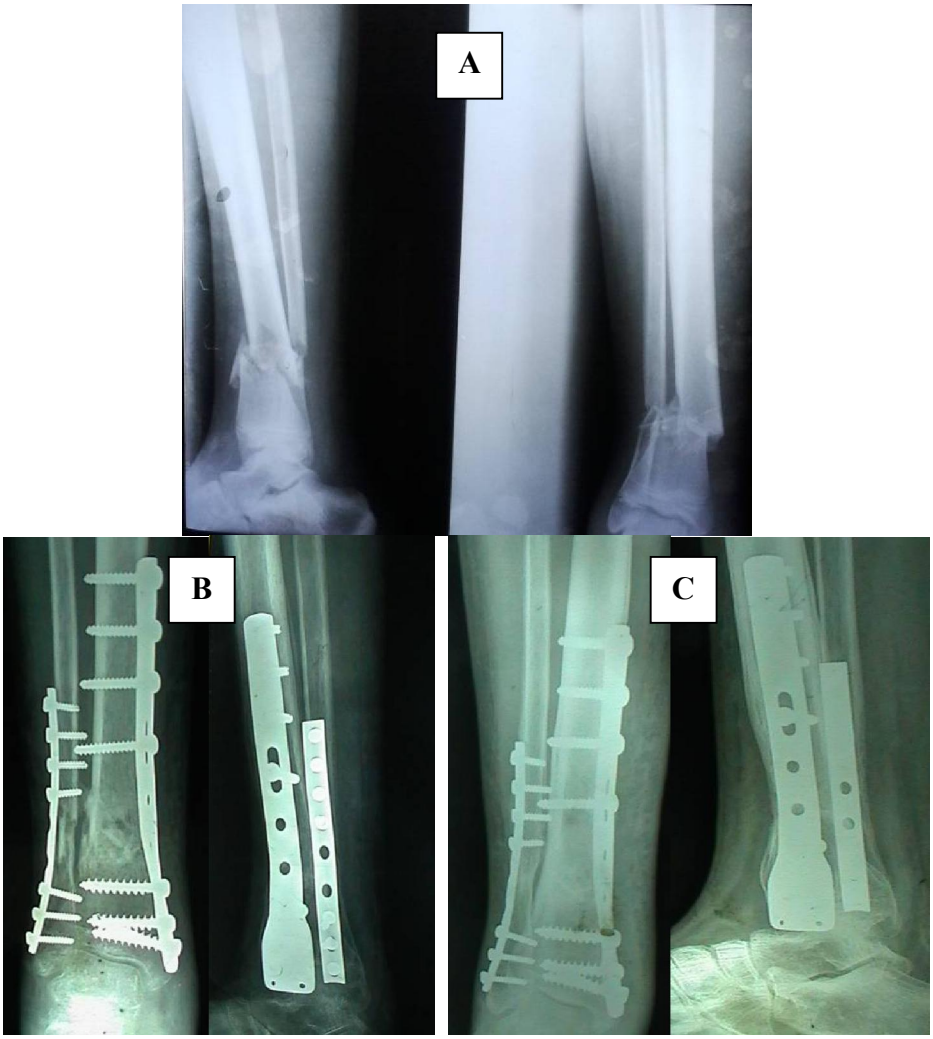



Figure (4). A: Preoperative; B: post operative; C: 6 months post operative.

**4. Discussion**

Distal tibial fracture with or without intra articular extension is one of the difficult fractures to manage. None of the treatment options available perfectly fulfill requirements of fracture characteristics of distal tibia. Distal tibia has got

circular cross sectional area with thinner cortex as compare to triangular diaphysis with thicker cortex. So, intramedullary nail which is designed for tight interference fit at diaphysis cannot provide same stability at distal fracture.[13] Other potential complications of IMIL nailing are malunion (0-29%) and implant failure (5-39%). ORIF with conventional plate which needs striping of periosteum is also not an ideal treatment option because tibia is subcutaneous bone and periosteum provides 2/3 rd of blood supply. Non union, delayed union and infection are reported with the range of 8.3-35% and 8.3-25% respectively with ORIF with plating.[14] Similarly external fixators as a definitive method of treatment for distal tibia fracture are also reported with higher rate of infection, implant failure and stabilization in open fracture with severe soft tissue injury.[14]

With the development of technique of MIPO which preserve extraosseous blood supply, respect osteogenic fracture haematoma, biologically friendly and stable fixation method is available for distal tibia fracture. Indirect reduction method and sub-cutaneous tunneling of the plate and application of screws with small skin incisions in MIPO technique prevents iatrogenic injury to vascular supply of the bone.[15]

MIPO for distal tibia fracture has been found to be an effective treatment option.[16].

MIPO however relies primarily on the indirect reduction of the fractures using various techniques and in this way, the fracture environment is better, as well as the blood supply to the bony fragments is not disturbed, which finally leads to decreased infection rate better fracture healing. MIPO offers several theoretical advantages compared to conventional open plating technique. A mechanically stable fracture-bridging osteosynthesis can be obtained without significant dissection and surgical trauma to the bone and surrounding soft tissues. As a consequence, the vascular integrity of the fracture and the osteogenic fracture hematoma are preserved [17,18]. However MIPO does not allow direct visualization of the fracture and the surgeon is dependent on intraoperative fluoroscopy to confirm that an adequate reduction has been achieved. Additional radiation exposure during application of the plate to the bone and screw fixation are the disadvantages of this technique.

## Conclusion

On the basis of the finding of this study it can be concluded that MIPO technique preserves most of the osseous vascularity and fracture hematoma thus providing for a more biological repair. There is rapid fracture consolidation due to preserved vascularity. There are fewer incidences of delayed unionand non-union. There is a decreased need for bone grafting and incidence of infection is less due to limited exposure.

The technique of MIPO is relatively safer and efficacious modality of the treatment for distal tibial fractures with following advantages:

(1) Biological reduction with least disruption of soft tissue and fracture hematoma
(2) Early ankle mobilization leading to complete restoration of joint motion.
(3) Reduced surgical time and tourniquet time along with smaller incision.
(4) Reduced incidence of wound complications.
(5) Early union of fracture.

## References


1. ***Ronga M, Longo UG, Maffulli N***. Minimally invasive locked plating of distal tibia fractures is safe and effective. Clin Orthop Relat Res 2010, 468:975-82.
2. ***Kneifel T, Buckley R.*** A comparison of one versus two distal locking screws in tibial fractures treated with unreamed tibial nails: a prospective randomized clinical trial. Injury 1996, 27:271-273.
3. ***Redfern DJ, Syed SU, Davies SJM.*** Fractures of the distal tibia: minimally invasive plate osteosynthesis. Injury 2004, 35:615- 620.
4. ***Yang SW, Tzeng HM, Chou YJ, Teng HP, Liu HH, Wong CY.*** Treatment of distal tibial metaphyseal fractures: Plating versus shortened intramedullary nailing. Injury 2006, 37:531-535.
5. ***Guo JJ, Tang N, Yang HL, Tang TS.*** A prospective, randomised trial comparing closed intramedullary nailing with percutaneous plating in the treatment of distal metaphyseal fractures of the tibia. J Bone Joint Surg Br 2010, 92-B:984-8.
6. ***Watson JT, Moed BR, Karges DE, Cramer KE.*** Pilon fractures. Treatment protocol based on severity of soft tissue injury. Clin Orthop Relat Res 2000, 375:78-90.
7. ***Wagner M, Frigg FR.*** Locked plating: Biomechanics and biology and locked plating: Clinical indications. Techniques in Orthopaedics 2007, 22(4) :209-218.
8. ***Littenberg B, Weinstein L P, McCarren M, Mead T, Swiontkowski M F, Rudicel S A, Heck D.*** Closed fractures of the tibial shaft: Ameta-analysis of three methods of treatment. J Bone Joint Surg (Am) 1998; 80: 174-83.
9. ***Krettek C, Schandelmaier P, Tscherne H.*** New developments in stabilization of dia-metaphyseal fractures of long tubular bones. Orthopade 1997; 26(5):408-21.

10. ***Farouk, Osama; Krettek, Christian; Miclau, Theodore; Schandelmaier, Peter; Guy, Pierre; Tscherne, Harald.*** Minimally Invasive Plate Osteosynthesis: Does Percutaneous Plating Disrupt Femoral Blood Supply Less Than the Traditional Technique? Journal of Orthopaedic Trauma: August 1999 - Volume 13 - Issue 6 - pp 401-406.
11. ***Oh CW, Kyung HS, Park IH, Kim PT, Ihn JC.*** Distal tibia metaphyseal fractures treated by percutaneous plate osteosynthesis. Clin Orthop Relat Res 2003; ( 408):286-91.
12. ***Redfern DJ, Syed SU, Davies SJ.*** Fractures of the distal tibia: minimally invasive plate osteosynthesis. Injury 2004; 35:615-20.
13. ***Megas P, Zouboulis P, Papadopoulos AX, Karageorgos A, Lambiris E.*** Distal tibial fractures and non-unions treated with shortened intramedullary nail. Inter Orthop 2003, 27:348-35.
14. ***Joveniaux P, Ohl X, Harisboure A, Berrichi A, Labatut L, Simon P, Mainard D, Vix N, Dehoux E.*** Distal tibia fractures: management and complications of 101 cases. Inter Orthop 2010, 34:583-588.
15. ***Borrelli J, Prickett W, Song E, Becker D, Ricci W.*** Extra osseous blood supply of the distal tibia and the effects of different plating techniques: Human cadaveric study. J Orthop Trauma 2002, 16:691- 695.
16. ***Mushtaq A, Shahid R, Asif M, Maqsood M.*** Distal tibial fracture fixation with locking compression plate (LCP) using the minimally invasive percutaneous osteosynthesis (MIPO) technique. Eur J Trauma Emerg Surg 2009, 35:159-64.
17. ***Hazarika S, Chakravarthy J, Cooper J.*** Minimally invasive locking plate osteosynthesis for fractures of the distal tibia-results in 20 patients. Injury 2006, 37:877- 887.
18. ***Helfet D, Paul Y S, David L, Joseph B Jr.*** Minimally invasive plate osteosynthesis of distal fracture of tibia.Injury 1998:28:S42- S48

9/1/2013