Biological fixation of Distal Tibial Fractures by locking compression plate

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Abstract: A series of 30 patients of distal tibial fractures treated with minimally invasiveosteosynthesis techniquewith locking compression plate have been reviewed after surgery. The technique involves open reduction and internal fixation of the associated fibular fracture when present, followed by percutaneousplatting of the distal tibial fracture. The mean age was 37.3 years (range: 20 –65 years). Fractures were classified according to the Classification of Orthopaedic Trauma Association (OTA) system. The mean time to full weight-bearing was 12 weeks (range: 8–20 weeks) and to union was 23 weeks (range: 18–29 weeks), without need for further surgery. There was one malunion, no deep infections and no failures of fixation. Out of 30 patients, 18 had excellent results,8 had good results and 4patients had a fair result. This minimally invasive technique for treatment of distal tibial fractures proves to be a feasible and worthwhile method of stabilization while avoiding the severe complications associated with the more standard methods of internal or external fixation of those fractures.

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1. Introduction:

Tibial fractures are usually the result of high energy axial compression and rotation forces. They are usually associated with severe soft tissue compromise 1, 2. The limited soft tissue, subcutaneous location and poor vascularity render the tibial fractures very challenging. 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.3,4 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.5,6 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. Techniques of closed reduction and minimallyinvasive plate osteosynthesis (MIPO) with locking compression plate (LCP) has emerged as an alternative treatment option for distal tibia fracture. When applied subcutaneously, LCP does not endanger periosteal blood supply, respect fracture hematoma and also provides biomechanicalystable construct. 7,8 Numbers of previous clinical studies have established MIPO with LCP as a biologically friendly and technically sound method of fixation for distal tibia fracture. The aim of this prospective study is to assess the outcome of patients treated with MIPO technique for closed distal tibial fractures with or without articular extension.

2. Material and Methods:

Thirty patients with distal tibial fractures treated with minimally invasive techniques were analyzed in the present study. There were 21 male and 9 female patients with an average age of 37.3 years (range: 20 –65 years) (Table 1). There were 22 right-sided fractures and 8 left-sided fractures. Mechanism of injury included fall in 6 patients, road traffic accident RTA in 15 patients and motor vehicle accident in 9 patients (Table 2). All patients received first aid in casualty with thorough examination to rule out associated injuries and standard antero-posterior and lateral radiographs was did (Figure 1). The soft tissue assisted and classified according to Tscherne classification 9,10 of closed fractures and soft-tissue injury (Table 3). There were 14 cases (Grade C0), 10 cases were (Grade CI) and 6 cases were (Grade C II). According to classification of Orthopaedic Trauma Association (OTA) system (Figure 2) for distal tibial fractures there were21 fractures (type A), 6 fractures (type C1) andthree fractures (type C2). Five cases had associated injury resulting from the same trauma. The injuries noted were fracture of surgical neck humerus in onepatients, fracture distal radius in two patients, fracture pubic rami in one patient, contra-lateral fracture femur in one patient. Patients were subjected to routine pre-anesthetic investigations and additional investigations when indicated. The average injury surgery interval was 3 days range from (1 to 8 days post injury).

Figure 1: (a-b) Preoperative radiographs of 39 year old man shows distal tibial and fibular fractures classified as AO/OTA type C1

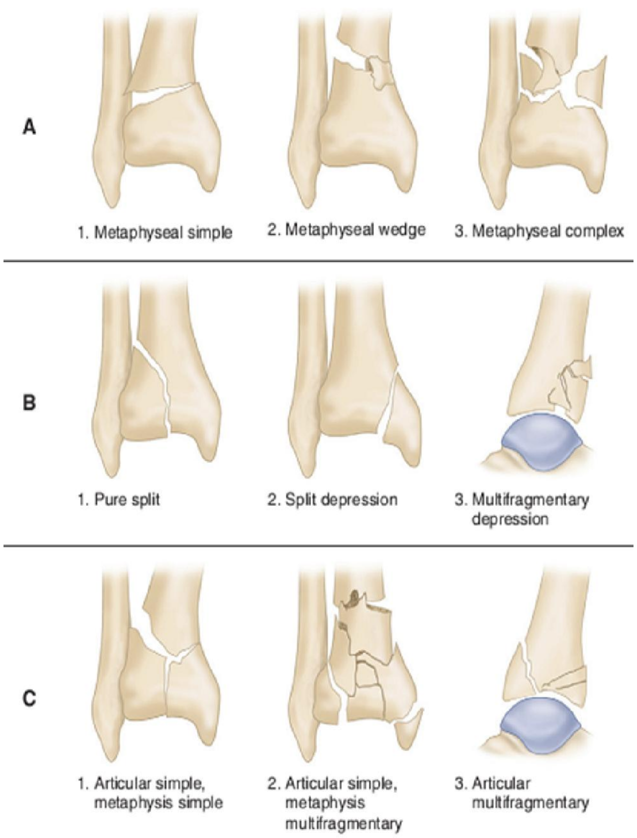

Figure 1: Classification of Orthopaedic Trauma Association (OTA).
(A) Tibia/fibula, distal extraarticular. (B) Tibia/fibula, distal, partial articular. (C) Tibia/fibula complete articular. (From Orthopaedic Trauma Association Committee for Coding and Classification: Fracture and dislocation compendium, J Orthop Trauma10 (Suppl 1):1, 1996).

Table-1: Age and sex distribution of cases

AGE	MALE	FEMALE	%
20 - 30	6	1	23.3
31 - 40	9	3	40
41 - 50	6	2	26.7
51 - 65	1	2	10

Table-2: Mechanism of injury

Mechanism of injury	No. of cases	%
RTA	15	50
Motor vehicle	9	30
Fall	6	20

Table 3: Tscherne classification of closed fractures and soft-tissue injury

Grade	Description
C0	Little or no soft-tissue injury
CI	Superficial abrasion
CII	Deep, contaminated abrasion with local contusion damage to skin or muscle
CIII	Extensive skin contusion or crushing or muscle destruction

Surgical technique:

The technique involves open reduction and internal fixation of the associated fibular fracture when present, followed by percutaneous platting of the distal tibial fracture. Initial attention was directed to fracture lines which extend into the tibial plafond. The articular fragments anatomically reduced by percutaneous method, utilizing fluoroscopy and pointed reduction forceps. Once articular reduction had been achieved, thearticular fragments were stabilized with 3.5 mm lagscrews. The appropriate length of the platewas determined by placing a plate along the anterioraspect of the leg and adjusting it so that under fluoroscopythe distal end of the plate was at level of the tibial plafond and the proximal end extends at least three screw holes beyond the proximal limit of the tibial shaft fracture. The plate was precontoured to match the contour of the distal tibia. A 2-3 cm incision was made along theanteromedial aspect of the tibia, proximal to the fractureand distally at the level of the medial malleolus. Typically, a subcutaneous tunnel was created between the two incisions and along the medial aspect of the tibia by blunt dissection. On occasion this was unnecessary and the plate could be advanced directly beneath the soft tissues without making a tunnel. The position of the plate was adjusted under fluoroscopy in both the coronal and saggital planes so that it lies along the medial aspect of the tibia. The distalmetaphyseal articular fragment could be indirectlyreduced to the proximal shaft in this way.

Table 4: Tenny&Wiss[11] Criteria Symptoms and functional evaluation of Ankle

Parameters	Points
1. Pain	
a) No pain	50
b) Slight or occasional pain	45
c) Mild pain with walking or running	40
d) Mild pain required daily non-narcotic pain medicine. No night pain.	30
e) Moderate pain occasional weak narcotic needed.	20
f) Continuous pain Dependent onnarcotic pain medicine	10
g) Disabled because of pain. Constant pain, no relief with medicines	0
2. Distance	
a) Unlimited	8
b) Limited, but greater than 6 blocks	6
c) 4 - 6 blocks	4
d) 1 - 3 blocks	2
e) Indoors only	1
f) Bed-chair, or unable to walk.	0
3. Supports or Orthosis	
a) None	8
b) Soft wrap needed for long walk	7
c) Cane or orthosis, only for long walks	6
d) Cane, single crutch or orthosis full time	4
e) Two canes or two crutches	2
f) Walker or unable to walk	0
4. Running	
a) Unlimited, as such as desired	5
b) Limited, but able to run	3
c) Unable to run	0
5. Toe raising	
a) Able to raise on toes x 10 repetitions	5
b) Able to raise on toes x 5 repetitions	3
c) Able to raise on toes x 1 repetition	1
d) Unable to raise on toes	0
6. Hills (up or down)	
a) Up and down normally	3
b) Climbs and/or descends with foot externally rotated	2
c) Climbs and/or descends on toes or by side stepping	1
d) Unable to climb and/or descend hills	0
7. Stairs (up or down)	
a) Climbs and descends normally	3
b) Needs banister	2
c) Steps down and/or up with normal foot only	1
8. Limp	
a) None	8
b) Only when fatigued	6
c) Slight, constant	4
d) Moderate, constant	2
e) Marked	0
9. Swelling	
a) None	3
b) Only in the evening or after walking	2
c) Constant, mild (less than 1 cm difference around calf)	1
d) Marked	0
10. Plantar range of motion	
a) Greater than	302
b) Greater than 10	1
c) Less than 10, or presence of equinus contracture	0
11. Dorsal range of motion	
a) Greater than or equal to 15	5
b) Greater than or equal to 10, less than	154
c) Greater than or equal to 0, less than 10	3
Rating	**Results**
Excellent	(>92 points)
Good	(87-92 points)
Fair	(65 - 86 points)
Poor	(<65 points)

Figure 3: (c-d) 2 weeks Post operative radiographs shows the distal tibia stabilized with LCP using minimally invasive technique and the fibular fracture stabilizes with semi tubular one third plate using ORIF technique, (e-f) Fifteen months postoperative radiographs shows successful union with good alignment.

Lag screws were then placed across the fracture planes to maintain the reduction, to provide inter fragmentary compression, and to increase the stability of the construct. Post-operatively the limb was maintained in the elevated position while the patient was in bed and ambulation begun on first post-operative day in the form of toe-touch weight-bearing with crutches. On second post-operative day, gentle exercises for the ankle were begun. Radiographs, including anteroposterior and lateral views were taken at 2weeks, 6 weeks and 3 months post-operatively (Figure 3) to assess healing and alignment. Partial weight-bearing started depending upon their clinical and radiographic evaluation, but in general most patients had advancedto partial weight-bearing by 6 weeks.

3. Results:

Final evaluation was done for distal tibial fractures as per Teeny and Wiss 11 (Table 4) clinical assessment criteria which are based on 100 points system. Most of the patients were in age group of 20-40 years (63.3%) with mean age of 36 years. High energy injury (Road traffic accidents and motor vehicle accidents) were found to be the commonest mode of trauma (80%). Right limb was involved more often (73.3%) than the left. The mean time to full weight-bearing was 12 weeks (range: 8–20 weeks) and to union was 23 weeks (range: 18–29 weeks), without need for further surgery. One patient required subcutaneous bone marrow injections as satisfactory callus was not visualized up to 16 weeks follow up. He subsequently had progressive callus formation. There was one malunion, no deep infections and no failures of fixation. Out of 30 patients, 18 had excellent results 8 had good results and 4 patient vs had a fair result Table 5.

Table 5: results description

Item	Description
Time taken for weight bearing (wks) mean Partial Full	 6.4 12
Time for radiological union (wks) mean	23
Range of motion at ankle (degrees) Dorsiflexion (Average) Plantar flexion (Average)	 15.5 30
Complications	One malunion
Result grading Excellent Good fair	 18 8 4

Table 6: Comparison of current study with previous clinical series

Study	**No of fractures**	**Study Method**	**Fixation**	**Union average (wks)**	**Complications**
Ronga *et al.* [13	19	retrospective	MIPO	18	Nonunion:1 No malunion (≥7° deformity or ≥1 cm LLD) Deep infection:3
Ahmad *et al.* [23}	18	retrospective	MIPO	15	Delayed union: 3 Superficial wound infarction: 1 Chronic wound infection: 1 Implant failure: 1
Hasenbohehler *et al.* [21}	32(open fracture8)	retrospective	MIPO	29	Nonunion: 2 No malunion (≥ 5° deformity or ≥ 1 cm LLD) Plate bending (18°): 1 Pseudoarthrosis: 2
Hazarika *et al.* [24]	20(open fracture8)	retrospective	MIPO	23	Nonunion: 2 Delayed wound break down: 2 Wound infection: 1 Implant failure: 1 Secondary procedure: 2
Bahari *et al.* [25]	42(open fracture8)	prospective	MIPO	19	No malunion Superficial wound infection: 2 Deep infection: 1 Implant failure: 1
Collinge *et al.*[19]	38(open fracture8)	prospective	MIPO	20	Malunion (≥ 5° deformity) : 1 Secondary procedure: 3
Mushtaq *et al.* [26]	21(open fracture 4)	prospective	MIPO	23	Delayed union: 1 Non union :1 Wound infection: 2 Secondary procedure: 2
Lau *et al.* [22]	48(open fracture9)	retrospective	MIPO	25	Delayed union: 5 Wound infection: 8 Secondary procedure:1
Gupta *et al.*[20]	80(open fracture19)	retrospective	MIPO	22	Delayed union :7 Non union: 3 Malunion (≥ 5° deformity or ≥ 1 cm LLD): 2 Wound infection:1 Wound breakdown: 2 Secondary procedure: 2
Current study	30	prospective	MIPO	23	Malunion 1
Study	**No of fractures**	**Study Method**	**Fixation**	**Union average (wks)**	**Complications**

4. Discussion:

Distal diametaphyseal tibia 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 diametaphyseal 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.[4,12] Other potential complications of IMIL nailing are malunion (0-29%) and implant failure (5-39%).[4,13] 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 35% and 25% respectively with ORIF with plating.[14-15,16]Similarly external fixators as a definitive method of treatment for distal tibia fracture are also reported with higher rate of infection, implant failure and malunion or non union and hence recommended only for temporary method of stabilization in open fracture with severe soft tissue injury.[4,17]With the development of technique of MIPO with LCP 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 locking screws with small skin incisions in MIPO technique prevents iatrogenic injury to vascular supply of the bone. Unlike conventional plates, LCP is a friction independent self stable construct which provides both angular and axial stability and minimizes risk of secondary loss of reduction through a threaded interface between the screw heads and the plate body.7MIPO with LCP for distal tibia fracture has been found to be an effective treatment option.[4,14,15,18](Table 7) shows comparison of current study with some of the previous studies. But unlike the present study, most of the previous studies have included both open and closed fractures and are retrospective study. MIPO technique can restore alignment in high velocity distal tibia fracture and patients can expect predictable return of function. However, Collinge *et al.*[19] reported increased secondary procedure rate like bone grafting for delayed union. Rate of secondary procedures like iliac crest bone grafting or percutaneous bone marrow injection for delayed union or non union or change of hardware has been reported 3.8% to as high as up to 35%. 19,20 In the current study, one patient required subcutaneous bone marrow injections as satisfactory callus was not visualized up to 16 weeks follow up. He subsequently had progressive callus formation. The average time for fracture union in the present study is comparable to other studies (Table 6). Hasenboehler *et al.*[21] found MIPO with LCP though reliable for distal tibia fracture can prolong union time in simple fracture pattern when it was used only as a bridging plate. Hence, percutaneous interfragmentary screw, independent to plate and LCP in a neutralization mode or application of LCP in a compression mode by utilizing non locking screw on one side of the fracture is recommended to avoid delay in fracture union. Though skin and soft tissue injury at the time of conventional osteosyn thesis has been found to be significantly associated with higher rate of wound infection as compare to IMIL nailing, effect of same on MIPO with LCP has not been studied yet.[10]Lau *et al.*[22] did not find fracture union time in MIPO to be affected by presence of late infections occurring after one month of complete wound healing. Reported rate of wound infection varies between 2.6% to 14.6% depending upon whether open fracture are included in the study or not.

The present study which included only closed fracture found no wound infection. Other potential complications like injury to sephaneous nerve and great sephaneous vein has been reported in cadaver studies and can be avoided by careful attention towards selection of skin incision site, dissection of vein, dissection of stab incision up to the plate and atraumatic placement of drill sleeve.26No case of sephaneous nerve and great sephaneous vein was found in the current study.

Conclusion

Distal tibia fracture with or without intra articular extension is one of the difficult fractures to manage with all currently available treatment options. Fracture pattern, concomitant articular extension, condition of soft tissue are important factors to be considered before selection of fixation method. The present case series though small in number shows that MIPO with LCP is an effective treatment method in terms of union time and complications rate which is comparable to other studies.

Conflict of Interest:

The authors declare that they have no conflict of interest.

Ethical approval:

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/ or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standers.

Informed consent:

Informed consent was obtained from all individual participants included in this study.

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