Original Article

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MINIMALLY INVASIVE PLATE OSTEOSYNTHESIS (MIPO) FOR COMMINUTED FRACTURES OF DISTAL TIBIA

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ABSTRACT

Objective: To report experience with minimally invasive plate osteosynthesis (MIPO) for comminuted distal tibia fractures with specific reference to fracture union, complications encountered and functional outcome.

Design: Descriptive case series using purposive non-probability convenient sampling.

Place and duration of study: Study was conducted in the Department of Orthopaedic Surgery at Combined Military Hospital Multan and Muzaffarabad from March 2006 to October 2010.

Patients and Methods: Twenty three patients underwent MIPO for comminuted distal tibial fractures. Fractures were classified according to AO system. Open fractures were graded using Gustilo and Anderson classification. A 4.5mm Narrow Dynamic Compression Plate (DCP) was used for fixation in 16 cases whereas 7 fractures were fixed with 4.5mm Narrow Locking Compression Plate (LCP). Post-operative clinical and radiological assessment was done at monthly interval until radiological union and three monthly thereafter. The minimum follow-up period was eight months with a mean of 18 ± 4.1 months. Functional outcome was assessed in each case at final follow-up.

Results: There were 16 males and 7 females with mean age of 30.3 ± 9.2 years. Radiological and clinical union was achieved in all cases. Twenty one cases (91.3%) achieved union (primary) at mean of 17.5 ± 2.6 weeks whereas two cases (8.7%) required augmentation cancellous bone grafting before achieving union (secondary) at mean of 33 ± 2.8 weeks. Unsatisfactory radiological alignment (Coronal > 5°/ Sagittal > 5°) was observed in one (4.3%) case. There was one (4.3%) case of infection treated successfully with antibiotics. Single screw breakage was seen in 2 cases where conventional DCP had been used for fixation but neither led to loss of position nor affected the outcome adversely. Functional results were "excellent to good" in 91.3% cases and fair in two cases.

Conclusion: MIPO may be used successfully for treatment of high-energy peri-articular distal tibial fractures. The approach aims to preserve bone biology and minimize surgical soft tissue trauma. The technique certainly provides an answer to treat this challenging group of fractures.

Keywords: MIPO, Comminuted fractures, Distal Tibia, Union

INTRODUCTION

The distal third tibial fractures are unique. The location is close to the ankle joint and there is relatively thin soft tissue coverage as compared to rest of the tibia. Often these fractures are comminuted and unstable. Disturbingly they can be associated with severe closed or open soft tissue injury. Hence, these complex fractures of distal tibia are difficult to treat[1].

Traditionally, these difficult fractures have been managed by open reduction and rigid internal fixation. However, this technique has provided variable outcomes and shown high incidence of complications, including infection, poor wound healing and nonunion[2,3].

For the last two decades, intramedullary nailing has become the mainstay of treating tibial shaft fractures. This has been very successful and indications have been extended to include the proximal and distal metaphyseal region. However, not all distal tibia fractures are suitable for this kind of fixation and problems with stability and malalignment have been reported[4,5].

To deal with these complex fracture patterns of distal tibia which are potentially unstable, and to improve the results associated with open reduction and internal fixation, minimally invasive plate osteosynthesis (MIPO) technique has been developed and shown to

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have good results. This technique results in minimal additional injury at surgery, emphasizes meticulous soft tissue dissection, limits the stripping of fracture fragments and achieves fracture alignment with indirect reduction methods[1].

Cadaveric studies in the past have suggested that the circulation of the distal tibia is mainly from extraosseous anastomosis of branches from anterior and posterior tibial in arteries, which enter tibia from the medial surface. Essentially, open plating causes significantly greater disruption of blood supply of metaphyseal region than percutaneously applied plates[6,7]. Consequently, MIPO appears to have higher rates of union, lower rates of post-op complications and lower incidences of bone grafting as compared with the traditional approach[1,2,8-10].

The aim of this study was to evaluate the radiographic, clinical and functional outcomes in 23 patients with comminuted distal tibial fractures treated with MIPO.

PATIENTS AND METHODS

Between March 2006 and October 2010, 23 patients with comminuted fractures of distal tibia were included in this study. All of these patients were treated with minimally invasive plate oteosynthesis at Combined Military Hospital, Multan and Muzaffarabad. These fracture patterns were unsuitable for locked intramedullary rod fixation due to degree of comminution and distal location of fracture. The fractures were classified according to Muller's AO classification system[11]. There were 19 patients with Type A3 fractures and 4 with Type A2. Twenty-one patients had closed injuries graded according to Tsherne's classification[12]. Fifteen were grade 1 and six were grade 2 injuries. Two patients had open fractures which were graded Type 2 according to Gustilo and Anderson classification (Table-1)

Surgery was performed as soon as the swelling subsided in closed injuries. In both cases with open injuries, wounds were debrided initially and fixation performed as soon as they healed in the third week. A standardized technique was used for all patients in this series. A tourniquette was applied in all cases and external fixator or distractor was not used. In two cases fibula was fixed initially by using standard AO fixation technique. The 4.5mm Narrow Dynamic Compression Plates (DCPs) were used 16 cases and 4.5mm Narrow Locking Compression Plates (LCPs) in 7 cases. They were contoured by hand using bending irons with the help of malleable templates shaped over the contralateral intact tibia.

Small curved incision was made over medial malleolus. Care was taken to preserve long saphenous vein. An extra-periosteal or subcutaneous tunnel was created along the medial aspect of the tibia by blunt dissection using a large Bristow or a periosteal elevator. The contoured plate could then be advanced directly beneath the soft tissue. Initial fixation was carried out with a distal screw passed parallel to the ankle joint under image intensifier guidance. The fracture was then indirectly reduced onto the plate using axial traction and counter-traction. Once the sagittal, coronal and rotational alignment appeared to be satisfactory, the proximal screws were passed percutaneously under image intensifier guidance.

Post-operatively, all patients were treated in a below knee resting slab for two weeks. After two weeks, stitches were removed and slab discarded. The range of motion (ROM) exercises of ankle and knee joint. Patients were assessed clinically and were started radiologically at monthly intervals until radiological healing and three monthly thereafter. Any angulation in coronal (varus-valgus) or sagittal (anterior-posterior) planes were measured and noted. More than 5° angulation in any plane was considered to be unsatisfactory radiological alignment or malalignment.

At the time of final follow-up functional evaluation was done using the criteria (Table-2) designed in one of earlier published study by the author for functional assessment of treated patients with segmental tibial defects[13]. Patients were said to have excellent, good, fair and poor functional outcome depending on pain, weight-

bearing, gait and range of movement at knee and ankle.

Patients were followed up for an average period of 18 ±4.1 months with minimum of 8 months and maximum of 27 months.

RESULTS

Twenty three patients included in this study had mean age of 30.3 ±9.2 years. The youngest was 17 years old and the oldest was 56 years. Male to female ratio was 16:7. Important clinical data is summarized in Table-1. The right leg was involved in twelve cases and left in eleven.

Features depicting clinical, radiological and functional outcome in this series of patients are presented in Table-3. All twenty three treated tibial fractures healed eventually. Fracture healing was defined as presence of bridging mature callus across fracture ends in antero-posterior / lateral radiographs and non-tender fracture site. In 21 patients (91.3%), the fracture united primarily with no need of any further operation or bone grafting (Fig. 1and Fig. 2)). The mean duration to achieve primary union was 17.5 ±2.6 weeks (Range 18-23 weeks). Mean time to full weight-bearing in this group of patients was 19.4 ±2.7 weeks (Range: 16-26 weeks). However, delayed union was observed in 2 cases (8.7%) (Fig.3). In both these cases, cancellous bone grafting was done to achieve secondary union at an average of 33 ±2.8 weeks (Range: 31-35 weeks). Full weight-bearing was also delayed to an average of 37 ±4.2 weeks in these two patients.

Radiological assessment revealed satisfactory alignment (Coronal/Sagittal angulation <5°) in all but one case. Eight patients had varus-valgus angulation or recurvatum-antecurvatum of less than 5°. One patient had 8° of recurvatum after consolidated union.

There was one case (4.3%) of infection in this series of patients. This was successfully treated with the help of parenteral / oral antibiotics. Single screw breakage was observed in two cases where conventional 4.5mm Narrow DCP had been used for fixation. Nevertheless, none warranted refixation or affected the outcome adversely.

Eventually the functional outcome determined at final follow-up, using the criteria given in Table-2, was "excellent" in four patients (17.4%), "good" in seventeen patients (73.9%) and "fair" in two (8.7%).

Table-1: Salient Features of patients included in the study

Age	30.3 ±9.2 years (range: 17-56)
Male : female ratio	16:7
Mechanism of injury	
Road Traffic accidents	18 (78.3%)
Direct Blow	04 (17.4%)
High velocity missile	01 (4.3%)
Type of Injury	
Closed (Tscherne)	**21**
Grade 1	15
Grade 2	06
Open (Gustilo 2)	**02**
Fracture type (AO)	
A2	04
A3	19
Fixation	
Tibia only	21
Tibia & Fibula	02
Type of Plate	
4.5 Narrow DCP	16
4.5 Narrow LCP	07
Average duration of surgery	55 ±15.6 minutes (range: 40-120)
Hospital Stay	4 ±1.5 days (range: 3-12)

DISCUSSION

The management of complex multifragmentary fractures has continually been a problem for the orthopaedic surgeons. If this type of fracture is located in peri-articular segment of the bone, problem is further compounded. These have been treated by conservative methods earlier in the form of casts or traction, but poor results with regard to joint motion and prolonged recumbency were observed[14,15].

Conventional plating in which the fragments of the broken bone were put together like doing the jigsaw, irrespective of the soft tissue attachments, also led to a lot of problems like nonunion, delayed union, increased chances of implant failure, etc. In view of this, biological plating techniques have been introduced for treating such fractures. Closed

Table-2: Functional evaluation method

Criterion	Score				Functional Outcome*
	1	**2**	**3**	**4**	
1. Pain	Severe	Moderate	Mild	No pain	
2. Weight-bearing	Nil	Walking with bilateral walking aid/ Toe-touching only	Walking with unilateral aid / brace	Walking without aid	
3. Limp	Not able to walk at all	Gross limp	Minor limp	No limp	
4. Joint mobility	Knee joint restriction of movement >50° Ankle joint restriction >30°	Knee joint restriction of movement <50° Ankle joint restriction <30°	Knee joint restriction of movement <20° Ankle joint restriction <20°	Knee joint restriction of movement <5° Ankle joint restriction <10°	

* Functional Outcome Grading: Score > 14 = Excellent Score 11-14 = Good Score 8-11 = Fair Score < 8 = Poor

2a.

2b.

2c.

2d

Fig. 1: (a) Comminuted fracture distal tibia Type A3. (b) Per-operative photograph showing small MIPO incisions. Note the fracture blisters on the skin around fracture. (c) Post-op X-rays (AP and Lateral views). (d) Consolidated fracture union is seen at 24 weeks.

interlocking intramedullary nailing is also an established minimal invasive method in treatment of comminuted diaphyseal fractures. Extended indications also cover the proximal and distal metaphyseal fractures. However, in case of peri-articular comminution, minimally

Table-3: Clinical, radiological and functional outcomes in patients included in the study

Case No.	AO fracture type	Implant used	Primary union (duration in weeks)	Secondary union* (duration in weeks)	Radiological malalignment	Complication If any	Functional Outcome**
1.	A3	DCP	18	--	Varus 4°	1 screw breakage	Good
2.	**A2**	DCP	15	--	--	--	Excellent
3.	A3 (Open)	DCP	--	31	Recurvatum 4°	--	Good
4.	A3	**LCP**	14	--	--	--	Excellent
5.	A3	DCP	16	--	--	--	Good
6.	A3	DCP	--	35	--	--	Fair
7.	A3	**LCP**	17	--	--	--	Good
8.	**A2**	DCP	16	--	Valgus 3°	1 screw breakage	Good
9.	A3	DCP	20	--	Recurvatum 8°	--	Good
10.	A3 (Open)	DCP	22	--	--	Infection	Good
11.	A3	**LCP**	16	--	--	--	Good
12.	A3	DCP	19	--	Varus 2°	--	Good
13.	A3	DCP	18	--	Varus 3°	--	Good
14.	**A2**	DCP	14	--	--	--	Excellent
15.	A3	**LCP**	20	--	--	--	Good
16.	A3	DCP	18	--	Recurvatum 3°	--	Fair
17.	A3	**LCP**	16	--	--	--	Good
18.	**A2**	DCP	13	--	--	--	Good
19.	A3	**LCP**	17	--	--	--	Excellent
20.	A3	DCP	20	--	Varus 4°	--	Good
21.	A3	**LCP**	15	--	--	--	Good
22.	A3	DCP	22	--	Varus 2°	--	Good
23.	A3	DCP	20	--	--	--	Good

*Achieved after augmentation with cancellous bone grafting
** According to Functional Evaluation method given in table-2

invasive plate fixation has evolved to become treatment of choice.

With regards to tibia, it has been shown that outer one third of the cortex receives its blood supply from the surrounding soft tissues[16]. In displaced fractures, there is disruption of the intramedullary blood supply and the fracture fragments must rely on the surrounding soft tissues for their nutrition. This soft tissue is disrupted with surgical dissection; the more extensive the dissection, the higher the chance of devascularizing the bone[6,7]. With minimally invasive plate fixation, the amount of dissection around the fracture fragments is minimized due to indirect reduction techniques. Whiteside and Lesker[17] have shown that increasing the amount of dissection in a tibial model increases healing complications. Clinical studies have confirmed that the incidence of wound healing problems, infection and nonunion is high in these fractures, with the reported incidence as high as 4.5%, 22% and 8% respectively[2,3,10,18,19].

These results are consistent with at least seven series reported in the literature in the last five years[1,20-25].

Augmentation bone grafting was required to enhance fracture healing in 8.7% of tibial fractures which had delayed union in this series. This rate is slightly higher as compared to few other reported series[21,24]. One reason for this offset could be inclusion of relatively larger

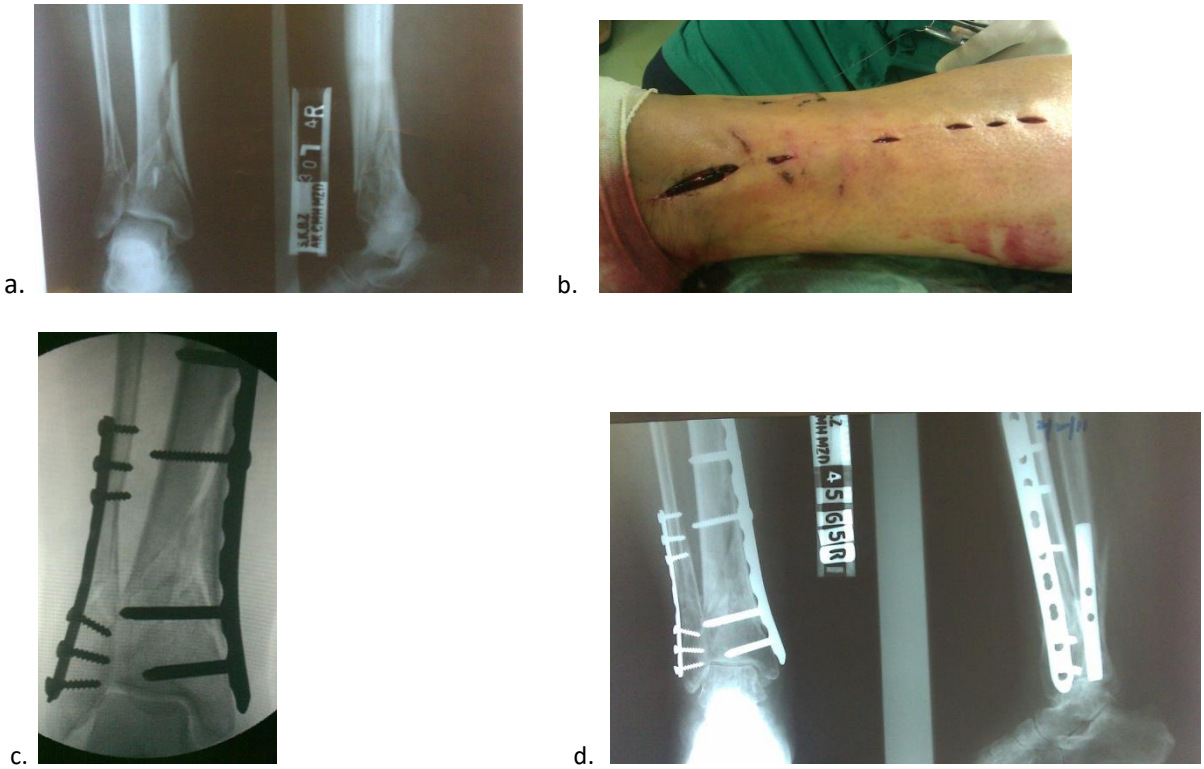

Fig. 2: (a) Type A3 distal tibial fracture with distal fibular fracture. (b) Small foot-prints visible on skin with good radiological alignment after MIPO. Note 1/3rd tubular plate fixation of fibular fracture and 4.5mm narrow LCP on tibia. (c) Union is visible on X-rays at 14 weeks.

Fig. 3: (a) Per-operative photograph of MIPO wounds for open (Gustilo 2) fracture distal tibia. (b) Nicely healed wounds after 16 weeks. (c) X-rays after cancellous bone grafting done at 18 weeks for delayed union. (d) Consolidated secondary union at 36 weeks..

number (84.6%) of Type A3 fractures in present study. It has been reported earlier that following high-energy injuries, the comminuted nature of fractures may result in increased chances of delayed/ nonunion[19].

The rate of infection observed in this series was 4.3%. Similar and even higher rates have been reported in various studies in the past[21,23,25]. Single case which developed sepsis in the present study, had open injury initially, that could have influenced this occurrence.

It is encouraging to note that none of the patients in this study required revision fixation due to implant failure. Although conventional DCP was used in 69.6% of cases, only minimal screw backing out and single screw breakage without any adverse outcome was observed in two cases. However, no such occurrence was observed in 30.4% cases where LCP had been used. Similarly, insignificant or minor angular mal-alignment of <5° was not observed in any of the seven cases where LCP was used for fixation. This is surely attributed to better angular stability and pull-out strength of locking devices.

Criticism against minimal fixation is inability to achieve anatomical reduction as in open method. However, literature is not clear about the acceptable reduction in fracture tibia. Milnar et al[26] studied 164 tibial fractures with long term follow up of 30 years and found no significant univariate association between malunion of the tibia and the development of osteoarthritis of knee or ankle. Nevertheless, only one fracture fixed with minimal invasive technique united with 8° of recurvatum in this series which was quite comparable to earlier published reports[21-24].

CONCLUSION

MIPO is an effective and safe treatment method for comminuted distal tibial fractures not amenable to intramedullary rod fixation either because of distal location of fracture or concern about coronal / sagittal / rotational mal-alignment. Good functional results can be achieved with low complication rate.

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