Evaluation of Minimally Invasive Percutaneous Plate Osteosynthesis in Treatment of Distal Tibial Fractures

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ABSTRACT

Background: Distal tibial fractures are usually the result of high-energy axial compression and rotation forces. They are usually associated with severe soft tissue compromise. The limited soft tissue, subcutaneous location and poor vascularity make these fractures very challenging.

Objectives: The aim of the current work was to evaluate clinically and radiologically the results of the minimally invasive percutaneous plate osteosynthesis (MIPPO) technique in fixation of distal tibial fractures.

Patients and methods: This prospective study included a total of 18 cases of type A distal tibial fractures treated by locked distal tibial plate, attending at ZAGAZIG University Hospitals. The fractures were classified using the method of AO classification. This study was conducted between February 2018 and April 2019.

Results: A comprehensive sample will be taken including cases that need minimally invasive percutaneous plate osteosynthesis in treatment of distal tibial fractures, 3 cases / month, sample equal 18 / 6 months who have traumatic fracture distal tibia on Orthopedic Surgery Department, Zagazig University Hospitals.

Conclusion: MIPO is simple, safe and effective method of treatment for diaphyseal & metaphyseal fractures. It does not require direct visualization of the fracture at the cost of extensive soft tissue dissection. We are confident in suggesting this alternative approach of plating. MIPPO through the deltoid-pectoralis approach seems superior to conventional ORIF through the deltoid-pectoralis approach in the treatment of PHF in elderly patients in terms of Constant-Murley score, NEER score, intraoperative blood loss, length of operation and SF36 score.

Keywords: Distal tibial fractures, Radiologically, MIPPO.

INTRODUCTION

The management of displaced distal tibial fractures is a controversial and debatable topic. The classic technique of open anatomic reduction and internal fixation of distal tibial fractures requires extensive soft-tissue dissection and often leads to subsequent periosteal injury. High rates of complications, including postoperative infection, delayed union, and nonunion [(1)].

Biological fixation principles advocate realigning by manipulation at a distance to fracture site, leaving comminuted fragments out of the mechanical construct, preserving soft tissues with limited operative exposure. Minimally Invasive Percutaneous Plate Osteosynthesis (MIPPO) is one such method in which percutaneously inserted plate is fixed at a distance proximal and distal to the fracture site through minimal exposure. Indirect reduction and biologic percutaneous plating without direct manipulation of the fracture fragments result in good clinical outcomes [(2)].

The main goal of biologic plating techniques is to maintain the soft- tissue attachments and vascularity of the cortical bone fragments, thereby reducing the risk of postoperative infection and nonunion [(3)].

Conventional plates such as narrow tibial dynamic compression plates or buttress T plates have been inserted via minimally invasive methods for treating distal tibial fractures, with encouraging results [(4)].

Gao *et al.* [(5)] have reported the use of locking plates in treating fractures of the distal tibial shaft and metaphysis. They have reported good clinical outcomes in distal tibial fractures treated with locking compression plates. They maintain a better periosteal blood flow by minimizing the contact of the plate with bone; however, the implants may be more prominent.

The aim of the current work was to evaluate clinically and radiologically the results of the minimally invasive percutaneous plate osteosynthesis (MIPPO) technique in fixation of distal tibial fractures.

SUBJECTS AND METHODS

This prospective study included a total of 18 cases of type A distal tibial fractures treated by locked distal tibial plate, attending at Zagazig University Hospitals. The fractures were classified using the method of AO classification. Written informed consent of all the subjects was obtained. This study was conducted between February 2018 and April 2019.

Ethical approval:

Approval of the ethical committee of Zagazig University was obtained.

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Inclusion Criteria:

- Age of patients: skeletally mature; above 18 years,
- Both Males and Females,
- Closed fracture,
- Extra-articular type A fractures.

Exclusion Criteria:

- Open fractures,
- Non union or Pathological fractures,
- Immuno-compromised patients.

On admission all patients were subjected to the following after offering informed consent.

Personal history:

- Name, Age, Sex, Address and Occupation: information on pre-fracture function, ambulatory status and living situation.

Present history:

- Date of trauma.
- Mode of trauma.
- Date of admission.

Clinical examination:

- General examination.
- Local examination.

Radiological examination:

Past history:

- Pre-fracture ambulatory status.
- Previous operations.

Investigations:

The routine laboratory investigations were performed to assess the fitness of the patient for surgical interference including blood picture (CBC), blood grouping, fasting plasma glucose, coagulation profile, ECG, renal and liver function tests.

Implant used for internal fixation.

Implant description:

The locked anatomical medial distal tibial plate 4.5 mm is part of the Synthes Small Fragment LCP system that merges locking screw technology with conventional plating techniques. The combi-holes in the LCP plate shaft combine a dynamic compression unit hole with a locking screw hole. Combi-holes provide the flexibility of axial compression and locking capability throughout the length of the plate shaft. Fixation with the 4.5 mm locked anatomical medial distal tibial plate has many similarities to traditional plate fixation methods, with a few important improvements. Locking screws provide the ability to create a fixed angle construct while using standard AO plating techniques.

Plate features:

- Head of plate is low profile for minimal prominence on medial malleolus.
- 3.5 mm cortex screws sit flush with plate in the locking distal holes to minimize screw prominence.
- Rounded edges to minimize soft tissue irritation.
- Limited-contact shaft profile.
- It is either stainless steel or titanium.

Combiholes in the shaft and head accept the following:

- 4.5 mm cortical screws.
- 4.5 mm locked cortical screws.

Five round locking holes in the head accept the following:

- 3.5 mm locking screws.

Surgical procedure:

The protocols of surgical treatment were:

Preoperative planning:

- Laboratory investigations as mentioned above.
- Medical consultations were done if needed.
- Preoperative intravenous antibiotics: 2 g of 3rd generation cephalosporine were given.

Anesthesia:

Spinal or general anaesthesia was used according to patient condition.

Position:

Position the patient supine on a radiolucent operating table. The leg should be freely movable. Visualization of the distal tibia in both the lateral and AP views is necessary. Support the knee with towels to flex it into the appropriate position.

Technique:

The technique of surgery was MIPO (minimally invasive plate osteosynthesis).

Approach: All cases were performed through medial approach of the tibia.

Rules used during Screw Placement in Locked Plating:

- Conventional screws are usually placed before locking screws.
- Conventional screws can reduce the bone to the plate.
- Locking screws will not reduce the bone to the plate.
- Locking screws form a fixed-angle construct with the plate analogous to a blade plate, remarkably increasing stability in poor quality bone.
- After placing locking screws, no additional compression or reduction of fragments is possible.
- Locking screws should be placed as the final step of osteosynthesis.

- Following this initial stabilization, assesses the quality of reduction in all planes. If the reduction is satisfactory, locking screws are placed proximally and distally to increase the stability of the construct.
- The locking screw placement by using drill guides that thread into the threaded plate holes. The drill is used to drill both cortices, and then the locking screws are implanted by a manual screwdriver.

Follow up:

Routine follow up visits done with X-rays were taken at 4 weekly intervals to assess healing and alignment. On each follow-up, patients were subjected to clinical and radiological assessment:

Statistical analysis

Data collected throughout history, basic clinical examination, laboratory investigations and outcome measures coded, entered and analyzed using Microsoft Excel software. Data were then imported into Statistical Package for the Social Sciences (SPSS version 20.0) (Statistical Package for the Social Sciences) software for analysis.

According to the type of data qualitative represent as number and percentage, quantitative continues group represent by mean ± SD , the following tests were used to test differences for significance;. difference and association of qualitative variable by Chi square test (X2) . Differences between quantitative independent groups by t test. P value was set at <0.05 for significant results & <0.001 for high significant result.

RESULT

Prospective study included 18 cases of type A distal tibial fractures. They were 12 (66.7%) men and 6 (33.3%) women patients with a mean age of 40.16±11.62 (18-60) years. They were evaluated both clinically and radiologically. The clinical results were assessed according to the functional grading of Ankle Hindfoot Scale.

Smoker were 55.5% and non-smoker 44.5%. 66.7% with no comorbidity and 33.3% with comorbidity 16.7% with DM and 11.1 (2 cases) with HTN and 1 case with DM & HTN. 72.2% with no associated injuries and 27.8% with associated injuries 11.1% with skeletal and 16.7% with no skeletal. Regarding side, studied subjects were divided as 50% were right side and 50% were left side. Cause road traffic was the majority (72.2%) and fall from height was 27.8%. Regarding AO classification, A2 was 38.9% and A3 was 61.1%. Time before operation was distributed as 3.0±1.2 with minimum 1 day and maximum 7 days. Time of union was distributed as 19.5±3.18 with minimum 16 and maximum 28 weeks. Delay union founded in 2 cases 11.1% and superficial infection in 4 cases 22.2% and 12 cases without complication 66.7%. Satisfactory were 77.8% (10cases excellent and 4 cases good) and Unsatisfactory were 22.2% (2 cases fair and 2 cases poor)

Table (1): Demographic data distribution among studied ***subjects*** (N=18)

Age (years)	**Mean± SD**	**40.16±11.62**	
	Median (Range)	**40.0 (18-60)**	
Sex	**Male n %**	**12**	**66.7%**
	Female n %	**6**	**33.3%**
Smoking	**Smoker n %**	**10**	**55.5%**
	Non n %	**8**	**44.5%**
Total		**18**	**100.0%**

Table (2): Co-morbidity and associated injuries distribution

		N	%
Co-morbidity	**No**	**12**	**66.7**
	DM	**3**	**16.7**
	HTN	**2**	**11.1**
	HTN&DM	**1**	**5.6**
Associated injuries	**No**	**13**	**72.2**
	Non skeletal	**3**	**16.7**
	Skeletal	**2**	**11.1**
	Total	**18**	**100.0**

Table (3): Complication distribution among studied subjects

		N	%
Delay union	**No**	**16**	**88.9**
	Yes	**2**	**11.1**
Infection	**No**	**14**	**77.8**
	Yes	**4**	**22.2**
	Total	**18**	**100.0**

Table (4): Outcome distribution among studied subjects

		N	%
Outcome	**Excellent**	**10**	**55.6**
	Good	**4**	**22.2**
	Fair	**2**	**11.1**
	Poor	**2**	**11.1**
Overall	**Satisfactory**	**14**	**77.8**
	Unsatisfactory	**4**	**22.2**
	Total	**18**	**100.0**

Table (5): Relation of demographic data with outcome

			Satisfactory	Unsatisfactory	t/ X^2	P
Age			37.5±10.86	49.5±10.24	-1.968	0.067
Sex	Male	N	10	2		
		%	71.4%	50.0%		
	Female	N	4	2	0.64	0.42
		%	28.6%	50.0%		
Smoking	Non	N	8	0		
		%	57.1%	0.0%	4.11	0.04*
	Smoker	N	6	4		
		%	42.9%	100.0%		
Total		N	14	4		
		%	100.0%	100.0%		

Table (6): Relation of clinical and injury characters with outcome

			Satisfactory	Unsatisfactory	t/ X^2	P
TIME_BEFORE_OP			2.35±0.8	5.25±1.65	-4.355	0.00**
Side	L	N	8	1		
		%	57.1%	25.0%		
	R	N	6	3	1.28	0.25
		%	42.9%	75.0%		
Cause	Road traffic accident	N	10	3		
		%	71.4%	75.0%		
	FFH	N	4	1	0.02	0.88
		%	28.6%	25.0%		
AO classification	A2	N	7	0		
		%	50.0%	0.0%		
	A3	N	7	4		
		%	50.0%	100.0%		
Co morbidity	No	N	12	1		
		%	85.7%	25.0%		
	DM	N	1	1	6.87	0.076
		%	7.1%	25.0%		
	HTN	N	1	1		
		%	7.1%	25.0%		
	HTN&DM	N	0	1		
		%	0.0%	25.0%		
Associated injuries	No	N	11	2		
		%	78.6%	50.0%		
	Yes	N	3	2	1.26	0.26
		%	21.4%	50.0%		
Total		N	14	4		
		%	100.0%	100.0%		

Table (7): Relation of union time and complication with outcome

			Satisfactory	Unsatisfactory	t/ X^2	P
TIME_UNION			18.21±1.62	24.0±3.36	-4.937	0.00**
DELAY_UNION	No	N	14	2		
		%	100.0%	50.0%		
	Yes	N	0	2	7.87	0.005*
		%	0.0%	50.0%		
INFECTION	No	N	13	1		
		%	92.9%	25.0%		
	Yes	N	1	3	8.28	0.004*
		%	7.1%	75.0%		
Total		N	14	4		
		%	100.0%	100.0%		

Table (8): Relation with infection

			INFECTION		Total	X^2	P
			-VE	+VE			
AO classification	A2	N	7	0	7		
		%	50.0%	0.0%	38.9%		
	A3	N	7	4	11	3.27	0.07
		%	50.0%	100.0%	61.1%		
Smoking	Non	N	8	0	8		
		%	57.2%	0.0%	44.4%		
	Smoker	N	6	4	10	4.11	0.04*
		%	42.8%	100.0%	65.6%		
Associated injuries	Absent	N	11	2	13		
		%	78.6%	50.0%	72.2%		
	Present	N	3	2	5	1.26	0.26
		%	21.4%	50.0%	27.8%		
Co morbidity	No	N	12	1	13		
		%	85.7%	25.0%	72.2%		
	DM	N	1	1	2		
		%	7.1%	25.0%	11.1%		
	HTN	N	1	1	2	6.87	0.07
		%	7.1%	25.0%	11.1%		
	HTN&DM	N	0	1	1		
		%	0.0%	25.0%	5.6%		
Total		N	14	4	18		
		%	100.0%	100.0%	100.0%		

DISCUSSION

Biological osteosynthesis, which emphasizes the biological environment at the fracture site, is a new biological fixation principle that is comparable to the traditional AO principle. A number of new methods for treating fractures based on biological osteosynthesis have been developed. The MIPPO technique is a typical method based on biological fixation, which involves minimal soft tissue dissection with preservation of the vascular integrity of the fracture as well as preservation of osteogenic fracture hematoma [(6)].

Incidence of distal tibial fractures, one of the commonest periarticular fractures is increasing regularly due to RTA and at the same time surgical treatment options also being modified continuously. Hence the treatment of distal tibial fractures has become challenge for orthopedic surgeons as a difficult fracture to manage [(7)].

MIPPO for distal tibia fracture has been found to be an effective treatment option. 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 and better fracture healing. MIPPO 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 [6, 8].

Most common mode of injury was road traffic accident (70%), fall from height (30%). Hence distal tibia fracture most commonly occurs after high energy trauma especially RSA so soft tissue insult is also quite high, here lies importance of appropriate management of such fracture. We used AO/ATO classification system. Most common fracture type was Type-A (70%) Type-B (20%) and Type-C(10%). Studies conducted by **Leung *et al.* [7] and Ronga *et al.* [8]** has similar pattern of fracture's.

Malunion was observed in 2 patients. Valgus mal alignment was observed on immediate post operative radiographs of this patient which healed with no change in alignment. The other patient had varus malunion at 6 months follow up. In present study, AOFAS score was used to analyse the functional outcome of the cases. It was observed that final average AOFAS score at 6 month was 85.11. similar results were reported by **Bahari *et al.* [9], and Collinge *et al.* [10]**.

The mechanism of injury in most cases was road traffic accident which occurs in 13 cases (70.2%) and trivial injury due to simple falling down in 5 cases (27.8%). In laterality of the fracture being both sides equal. And there was no significant difference between mode of injury, and laterality of the fracture as regarding the results.

Venkata *et al.* [11]; all of the 50 patients had an AOFAS score **Kitaoka *et al.* [12]** of 90 or greater out of a possible 100 points. The mean score was 95.06. The authors concluded that there was reduced incidence of infection due to limited exposure. Infection can also be prevented by careful handling of soft tissues and by minimizing the operating time.

Collinge and Protzman [13] reported a good to excellent result with a mean AOFAS score of 85. In the study undertaken by **Redfern *et al.* [14]** all patients returned to their pre-injury occupation or level of activity. The mean AOFAS score in the MIPPO group of the study by **Guo *et al.* [15]** was 83.9.

Walia *et al.* [16] published that locking plates provide excellent fixation in difficult situations like comminuted fractures, osteoporotic fractures and periarticular fractures.

Lau and colleagues [17] noted a delayed union rate of 10%, deep infection in 8%, and hardware removal in 48% in a series of 48 patients treated with medial locked plating, although prolonged healing times were observed in simple fracture patterns. Similarly, a study by **Ahmad and Colleagues [18]** demonstrated an average time to union of 23.1 weeks in 16 of 18 patients treated with the MIPPO technique.

One hardware failure, 2 superficial infections, one deep infection, and appropriate alignment in all 42 patients managed with medial locking plates. **Collinge and colleagues [19]** found a high infection rate of 19%, although these were all high-energy fractures; higher complication rates were expected.

Cheng and colleagues [20] compared MIPPO with open plating and found no malunion or loosening in either group and concluded that there was no significant difference between the 2 methods of fixation.

CONCLUSION

MIPO is simple, safe and effective method of treatment for diaphyseal & metaphyseal fractures. It does not require direct visualization of the fracture at the cost of extensive soft tissue dissection. We are confident in suggesting this alternative approach of plating.

MIPPO with DTLP is a reliable fixation approach to fractures of the distal third tibia when used in conjunction with locked plates, preserving most of the osseous vascularity and fracture haematoma and thus providing for a more biological repair. The bone healing, though slightly delayed, was universal with this type of fixation. This technique can be used in fractures where locked nailing cannot be done like distal tibia fractures with small metaphyseal fragments, vertical split and markedly comminuted fractures.

The LCP can be used for different techniques and biomechanical principles: A conventional technique (compression principle): if precise "anatomical" reduction is necessary for the functional outcome. Bridging technique (internal fixator principle): if a non precise reduction is sufficient for the functional outcome.

The correct use of LCP with proper technique and proper instruments is mandatory. Otherwise, complications will arise. The LCP encourage early range of motion at ankle joint as it provide stable fixation. MIPPO through the deltoid-pectoralis approach seems superior to conventional ORIF through the deltoid-pectoralis approach in the treatment of PHF in elderly patients in terms of Constant-Murley score, NEER score, intraoperative blood loss, length of operation and SF36 score.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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