

## Outcome of Minimally Invasive Locked Plate in Management of Proximal Tibial Fracture

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### ABSTRACT

**Background:** Proximal tibia being a prime component of knee joint, which is vital for weight bearing and mobility. Because of its superficial location and vulnerable position, proximal tibia is frequently injured, more frequently in road traffic accidents (RTA). Open reduction and internal fixation with plate can result in extensive devitalization of soft tissue leading to wound healing problems. Minimally invasive plate osteosynthesis (MIPO) is a new technique which is becoming widely accepted for treatment of proximal tibial fractures.

**Objective:** To evaluate functional and radiological outcome of fixation of proximal tibial fracture by minimal invasive plate osteosynthesis. **Patients and methods:** A prospective analysis of 12 patients with proximal tibial fracture. The right side was affected in 8 patients and left side in 4 patients, all of patients treated by MIPO technique by LCP. The patients were assessed clinically by Rasmussen score post-operatively.

**Results:** Functional evaluation was performed according to the criteria described by Rasmussen score. 7 cases (58.33%) had excellent result, 4 patients (33.33%) had good results and 1 patient (8.33%) had fair results. No patient had poor result. **Conclusion:** Minimally invasive plate osteosynthesis for proximal tibia fractures achieved good radiological and functional outcome. There was minimal soft tissue damage and minimal disruption of blood supply to fracture ends. The fractures treated with pure bridge plating and combined principle of compression and bridge plating healed rapidly by secondary fracture union.

**Keywords:** Proximal tibial, Fracture, Minimally invasive plate osteosynthesis (MIPO).

### INTRODUCTION

Proximal tibial fractures fall into two broad categories, high energy fractures and low energy fractures<sup>(1)</sup>. Extra-articular proximal tibial fractures account for 5% to 11% of the total number of tibial injuries. Intra-articular fractures (tibial plateau) represent 1% of all fractures and 8% of fractures in elderly population. The majority of tibial plateau fractures are secondary to high-speed velocity accidents and fall from a height where fractures result from direct axial compression, usually with a valgus (more common) or varus moment and indirect shear forces<sup>(2)</sup>. Extra-articular fractures of the proximal tibia were usually secondary to direct bending forces applied to the metaphysiodiaphyseal region of the upper leg. Older patients with the osteopenic bone are more likely to sustain depression type fracture because their sub-chondral bone is less likely to resist axial directed loads<sup>(3)</sup>.

Surgical treatment of proximal tibial fracture aims to restore congruent articular surfaces of the tibial condyles maintaining the mechanical axis and restoring ligamentous stability eventually achieving functional knee joint with a painless and good range of motion<sup>(4)</sup>. The various clinical studies established that bones beneath a rigid conventional plate is thin and atrophic which make them to be prone for secondary displacement due to insufficient buttressing and secondary fractures after removal of the plate. Fracture site take longer period to unite due to interruption of

vascular supply to bone due to soft tissue and periosteal stripping<sup>(5)</sup>. Conventional plates needed to be accurately contoured to achieve good fixation.

Osteoporosis also posed the same problem of poor fixation with conventional plates<sup>(6)</sup>. The concept of biological fixation using the plates, called minimally invasive plate osteosynthesis (MIPO) developed. Hence, this study was conducted to analyze the duration of union and functional outcome in proximal tibial fractures treated with LCP<sup>(7,8)</sup>.

### AIM OF THE WORK

This study aimed to evaluate functional and radiological outcome of fixation of proximal tibial fracture by minimally invasive plate osteosynthesis.

### PATIENTS AND METHODS

A prospective study of twelve patients, their ages ranged from 19 years to 65 years old with the mean of 39.25 years. The right side was affected in 8 cases and the left in 4 cases proximal tibial fractures treated by Locked compression plates at Zagazig University Hospital and Zliten Teaching Hospital during the period from September 2018 to July 2019. The fractures were classified according to AO classification as extra articular fracture type A (eight patients) and intra-articular fracture type C (four patients). One case was open fracture and the other 11 cases were closed fracture. We used locking compression plate and locking or non-locking screws.



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### Ethical approval:

**Approval for performing the study was obtained from Orthopedic Surgery Departments, Zagazig University Hospitals after taking the Institutional Review Board (IRB) approval.** The work has been carried out in accordance with the code of ethics of the world medical association (Declaration of Helsinki) for studies involving humans.

### Patients' approval:

Every patient signed an informed written consent for acceptance of the operation.

**Inclusion criteria:** adult Patients >18 years old with Intra-articular/Extra-articular proximal tibial fractures (AO 41A and 41C), Closed/Open Gustilo-Anderson Type I and II.

**Exclusion criteria:** Patients below the age of 18 years, patients are unfit for surgery, Pathological fractures, open fracture type III.

### Methods:

On admission all patients were subjected to history taking, clinical examination, soft tissue evaluation, neurovascular assessment, and laboratory investigations.

**Assessment:** Radiological assessment by anteroposterior (AP) and lateral (Lat) knee joint X-ray was taken pre-operatively, immediate post-operative and at follow-up and CT scan was taken pre-operatively. Functional assessment was done at end of follow-up according to Rasmussen functional knee scoring system<sup>(9)</sup>.

### Surgical Technique:

All cases were under spinal anesthesia. In this work MIPO technique were used in 12 cases. First, reduction of the length, rotation, valgus-varus and procurvatum correction were achieved, before fragment fixation. Length is the key to proper reduction and was restored as the first step in most reductions. Most of the fractures were reduced by traction only, and some with aiding of the percutaneous reduction forceps or the colinear clamp. Reduction was performed under C-arm guidance and was assessed in both the AP and lateral views.

Minimally invasive anterolateral approach was done in eleven cases. Two main incisions were made, first proximal then distal. Proximal incision was started just proximal and lateral to Gerdy tubercle and extended distally for approximately 5 to 6 cm in a curvilinear (hockey stick) fashion. Distal longitudinal incision was made approximately 2 cm lateral and parallel to the tibial crest and its position was dependent on the fracture site and plate size and made after the reduction was done. In-between, small stab incisions were made for middle screws and their position was assessed by using the image intensifier control.

Minimally invasive anteromedial approach was done in two cases one with double plates fixation and another with one plate fixation. The plate was slid distally and then proximally, to find proper proximal

and distal plate placement. Clinically, tactile feedback-indicated proper plate placement on the flare of the lateral plateau was confirmed by A-P C-arm. A lateral C-arm confirmed proper posterior and anterior position of the end of plate. K-wires were inserted to provide preliminary fixation of the plate, the proximal K-wire was approximately parallel to the plateau. A minimum of 3 screws were inserted in each main fracture fragment through stab skin incision done under C-arm guidance. More screws were used in osteopenic bone. Self-drilling locking screws were inserted first proximally, then reduction was rechecked and distal screws were placed. Before fixing the plates with screws, sagging of distal fragment is prevented by putting towel roll under the fracture site. After insertion of the locking screws, fracture reduction, plate position and screws lengths were checked by C-arm. Finally, the proximal, distal and the stab incisions were sutured after releasing the tourniquet.

**Radiological evaluation:** X-ray of the operated tibia including knee joint in both AP and lateral view was checked.

**Case presentation:** A 32 years old male patient who sustained a closed fracture of left tibial plateau type 41-C1 according to AO classification after RTA (road traffic accidents). MIPO was done by LCP. Surgery was done one day after trauma, through anteromedial approach. ROM was 140 degrees and union time was 13 weeks. X-ray pre-operative (Figure 1), post-operative (Figure 2) and at end of follow-up (9 months) (Figure 3). Excellent results according to Rasmussen score.



**Figure (1):** Pre-operative x-ray.



**Figure (2):** Immediate post-operative x-ray.



**Figure (3):** At end of follow-up (9 months) x-ray.

**Statistical analysis**

Data collected throughout history, basic clinical examination, laboratory investigations and outcome measures were coded, entered and analyzed using Microsoft Excel software. Data were then imported into Statistical Package for the Social Sciences (SPSS version 20.0). P value was set at  $\leq 0.05$  for significant results &  $< 0.001$  for high significant result.

**RESULTS**

**Table (1):** Outcome distribution according to Rasmussen score.

		N	%
<b>Rasmussen score</b>	<b>Fair</b>	<b>1</b>	<b>8.3</b>
	<b>Good</b>	<b>4</b>	<b>33.3</b>
	<b>Excellent</b>	<b>7</b>	<b>58.3</b>
	<b>Total</b>	<b>12</b>	<b>100.0</b>

(1) showed the age of the studied patients ranged from 19 to 65 years old with mean age 39.25 years old. The average time for follow-up was 8 months, ranging from (7 to 9) months. The right side was affected in 8 cases and the left in 4 cases, and 10 patients were males (83.3%), while 2 were female (16.7%). The 12 patients of the study 7 cases (58.33%) had excellent result, 4 patients (33.33%) had good results, and 1 patient (8.33%) had fair results according to Rasmussen score.

**Table (2):** Association and relation with outcome according to Rasmussen score

			Fair	Good	Excellent	F/ X <sup>2</sup> fisher	P
<b>Age</b>			65.0±0.0	45.0±9.09	32.28±10.8	5.140	0.032*
<b>Time before surgery</b>			5.0±0.0	5.0±1.6	4.14±1.2	0.190	0.831
<b>Time of union</b>			25.0±0.0	15.5±3.1	14.5±2.4	7.333	0.013*
<b>Range of motion</b>			60.0±0.0	105.0±12.9	124.28±15.1	9.507	0.006*
<b>Sex</b>	<b>F</b>	N	0	0	2		
		%	0.0%	0.0%	28.6%		
	<b>M</b>	N	1	4	5	1.71	0.42
		%	100.0%	100.0%	71.4%		
<b>Side</b>	<b>Lt</b>	N	0	2	2		
		%	0.0%	50.0%	28.6%		
	<b>Rt</b>	N	1	2	5	1.07	0.58
		%	100.0%	50.0%	71.4%		
<b>DM</b>	<b>No</b>	N	1	3	7		
		%	100.0%	75.0%	100.0%		
	<b>Yes</b>	N	0	1	0	2.18	0.33
		%	0.0%	25.0%	0.0%		
<b>HTN</b>	<b>No</b>	N	1	3	6		
		%	100.0%	75.0%	85.7%		
	<b>Yes</b>	N	0	1	1	0.42	0.82
		%	0.0%	25.0%	14.3%		
<b>Closed</b>	<b>NO</b>	N	0	0	1		
		%	0.0%	0.0%	14.3%		
	<b>Yes</b>	N	1	4	6	0.77	0.67
		%	100.0%	100.0%	85.7%		
<b>Mechanism injury</b>	<b>FFH</b>	N	1	1	1		
		%	100.0%	25.0%	14.3%		
	<b>RTA</b>	N	0	3	6	3.42	0.18
		%	0.0%	75.0%	85.7%		
<b>Ao Classification</b>	<b>A2</b>	N	0	1	2		
		%	0.0%	25.0%	28.6%		
	<b>A3</b>	N	1	3	1		
		%	100.0%	75.0%	14.3%		
	<b>C1</b>	N	0	0	2	6.28	0.61
		%	0.0%	0.0%	28.6%		
	<b>C2</b>	N	0	0	2		
		%	0.0%	0.0%	28.6%		
<b>Infection</b>	<b>No</b>	N	0	3	7		
		%	0.0%	75.0%	100.0%		
	<b>Sup. Infectuion</b>	N	1	1	0	1.35	0.5
		%	100.0%	25.0%	0.0%		
<b>Nonunion</b>	<b>NO</b>	N	0	4	7		
		%	0.0%	100.0%	100.0%		
	<b>Delayed union</b>	N	1	0	0	9.0	0.002*
		%	100.0%	0.0%	0.0%		
<b>Pain</b>	<b>No</b>	N	0	0	7		
		%	0.0%	0.0%	100.0%		
	<b>Occasional</b>	N	0	4	0	21.0	0.00**
		%	0.0%	100.0%	0.0%		
	<b>Throbbing</b>	N	1	0	0		
		%	100.0%	0.0%	0.0%		

Table (2) showed that a significant correlation between range of motion and functional outcome according to Rasmussen score [P.value = 0.006 (statistically significant)].

**Relation of outcome according to Rasmussen score:**

**Age:**

Twelve patients were included in this study and their age ranged from 19 to 65 with the mean of  $39.25 \pm 12.9$ . There was a significant correlation between age at time of surgery and the final results according to Rasmussen score [P. value = 0.032 (statistically significant)].

**Time of union:**

The mean time of union in the studied group was  $15.42 \pm 3.94$  weeks with range of 11-25 weeks. There was 7 patients within  $14.5 \pm 2.4$  showed excellent results, 4 patients that united within  $15.5 \pm 3.1$  showed good results and 1 patient united within  $25.0 \pm 0.0$  showed fair results. There was significant correlation between union time and final clinical results according to Rasmussen score [P. value = 0.013 (statistically significant)].

**Range of motion:**

The mean range of motion in the studied group was  $112.5 \pm 23.01$  degrees with a range of 60-140. There was 7 patient within range of  $124.28 \pm 15.1$  degrees showed excellent results, 4 patient within range of  $105.0 \pm 12.9$  degrees showed good results and 1 patient within range of  $60.0 \pm 0.0$  degrees showed fair results. There was significant correlation between range of motion and functional outcome according to Rasmussen score [P. value = 0.006 (statistically significant)].

**Table (3):** Distribution of complication among the studied group

		N	%
<b>Infection</b>	<b>No</b>	<b>10</b>	<b>83.3</b>
	<b>Sup. infection</b>	<b>2</b>	<b>16.7</b>
<b>Delayed union</b>	<b>No</b>	<b>11</b>	<b>91.7</b>
	<b>Delayed union</b>	<b>1</b>	<b>8.3</b>
<b>Implant failure</b>	<b>No</b>	<b>12</b>	<b>100.0</b>
	<b>Yes</b>	<b>0</b>	<b>0.0</b>
<b>Pain</b>	<b>No</b>	<b>7</b>	<b>58.3</b>
	<b>Occasional</b>	<b>4</b>	<b>33.3</b>
	<b>Throbbing</b>	<b>1</b>	<b>8.3</b>
<b>Knee stiffness</b>	<b>≥ 90°</b>	<b>11</b>	<b>91.6</b>
	<b>&lt; 90°</b>	<b>1</b>	<b>8.4</b>
<b>Total</b>		<b>12</b>	<b>100.0</b>

Table (3) showed that there were 2 cases with superficial infection (16.7 %), one case with delayed union (8.3%), 5 cases with pain and 1 case with knee stiffness (8.3 %) (0-60) degrees.

**DISCUSSION**

The incidence of Proximal tibial fractures are increasing regularly due to RTA and at the same time surgical treatment options also being modified

continuously. Extra-articular fractures of the proximal tibia usually secondary to direct bending forces applied to the metadiaphyseal region of the upper leg are the most common. Any fractures around weight bearing joint like knee joint result in significant morbidity and affects the quality of life. Hence the treatment of proximal tibial fractures has become challenge for orthopedic surgeons<sup>(10)</sup>.

Knee joint injuries, as regard the bony and ligamentous structures result in many complications like infection, wound breakdown, joint stiffness, joint instability, malunion, nonunion and post traumatic arthrosis. These complications depend on the age of the patient, quality of the bone, mechanism of injury, associated ligamentous injuries, method of the treatment and post-operative rehabilitation<sup>(11)</sup>. To overcome these difficulties and early restoration of strength of bone and function of knee joint with minimal injury to soft tissues, the development of the LCP, which has been available for clinical use since 2001 was of great interest. Thus a single implant gives the surgeon access to the entire range of options for internal fixation, from compression screw osteosynthesis with the principle of absolute stability to biological osteosynthesis with relative stability<sup>(12)</sup>.

This study presented the clinical study of surgical treatment of 12 proximal tibial fractures fixed with locking plates. The analysis of the results were made in terms of age of patients, sex distribution, laterality of fracture, mode of injury and type of fracture according to AO classification.

The majority of fractures occurred between the ages of 19 to 65 years with the mean age of 41 years. The majority of fractures occurred in males (10 cases) (83%) while females (2 cases) (16.7%). In comparable with study of **Deokate et al.**<sup>(13)</sup> which included 32 patients of proximal tibia fractures and was treated with MIPO, there were 10 females and 22 males with mean age of 45.12 years. Our results are also comparable with study of **Mohammad et al.**<sup>(14)</sup> in which the total number of cases studied were 20 with the youngest 22 years and oldest 55 years old. It is also comparable with the study of **Nandiraju et al.**<sup>(15)</sup> where there were 27 males (90%) and only 3 females (10%) and the average age was 33 years.

In this study, the fracture was classified according to AO classification system where there were two types in this study type A and type C (66.66% extra articular fracture, 33.33% intra-articular fracture respectively) most common type A3 (41.7%), type A2 (25%) , type C1 (16.7%) and type C2 (16.7%).

The commonest mode of injury was RTA in 9 cases (75%) and fall from height in 3 cases (25%). In laterality of the fracture the right side was commonest in 8 cases (66.7%), while the left was 4 cases (33.3%). There was no significant difference between mode of injury and laterality of the fracture.

The MIPO technique had done in 12 patients, using the anterolateral approach in 11 cases and anteromedial approach in 2 cases and one case with double plating.

All patients in the study had excellent union with mean 15.42 week (range; 11-25 weeks) except one patient developed delayed union within 25 weeks which might be due to his old age and being a smoker. This is comparable with the study of **Mohammad and Kulkarni** <sup>(14)</sup> who reported that the average time for union of fracture was 19 weeks (range; 16-24 weeks). Also, this is comparable with study of **Deokate et al.** <sup>(13)</sup> who reported that the radiological union in all cases took a mean time of 18 weeks. Moreover, this is comparable with the study of **Girisha et al.** <sup>(1)</sup> who reported that average time for union of fracture was 14 weeks (range: 12-24 weeks).

In this study 91% had ROM of the knee joint  $\geq 90$  degrees. This is in agreement with study of **Mohammad et al.** <sup>(14)</sup> who reported that the mean range of motion of 0-121° was achieved. Results are also in agreement with the study of **Upendra et al.** <sup>(16)</sup> who reported that ROM at knee was more than 90° degrees in 85% of the cases. Besides, this is comparable to the study of **Nandiraju et al.** <sup>(15)</sup> who reported that all patients had ROM of the knee joint  $\geq 120^\circ$ . **Girisha et al.** <sup>(1)</sup> also reported that ROM at knee was more than 90° degrees in 90% of the cases.

The end results achieved were 58.3% excellent and 33.3% good (overall 91.6% acceptable results). In addition, there were 8.33% fair (Unacceptable results). These results in term of functional outcome according to Rasmussen scoring system were comparable with other documented studies. **Deokate et al.** <sup>(13)</sup> published that the final results were evaluated according to Rasmussen score; 32 patients had excellent or good clinical results (overall 81% acceptable results). 4 patients had fair results (12.5% Unacceptable results) while 2 patient (6.25%) had poor functional outcome. **Mohammad et al.** <sup>(14)</sup> reported that the functional outcome according to Rasmussen functional score was excellent in 10 patients, good in 8 patients with 85.7% acceptable results, 2 patients fair and 1 patient poor result (14.3% unacceptable results). **Girisha et al.** <sup>(1)</sup> published that the final results were evaluated according to Rasmussen score where 30 patients had excellent or good clinical results with MIPO technique (over all 96.7% acceptable results) and fair results were 3.3% unacceptable result. **Nandiraju et al.** <sup>(15)</sup> reported the functional outcome according to Rasmussen functional score in 30 patients were excellent in 18 patients, good in 9 patients (90% acceptable results) and fair 3 patients (10% unacceptable results).

As regards complication in this study, there were 10 patients (83.3%) had no complications and 2 patients (16.7%) had complications (superficial infection) who were treated with close follow up. The infection subsided and wound healed after 2 weeks.

One patient developed delayed union, which united within 25 week without bone graft nor surgical intervention. Delayed union was probably because the patient was old and he was a heavy smoker. One case had knee stiffness (the same patient who had superficial infection and delayed union), with range of motion from (0-60°). No cases of implant failure. The complication rate in the study is comparable to that of **Upendra et al.** <sup>(16)</sup> who reported that; 3 cases had delayed union, 2 cases had deep peroneal nerve palsy, 2 cases had superficial infection and 1 case had deep infection. In addition, the study of **Mohammad et al.** <sup>(14)</sup> reported that the complications were; 1 case mal alignments (varus deformity), 1 case of superficial infection and 2 with knee stiffness. The results are in accordance with study of **Girisha et al.** <sup>(1)</sup> who reported that 1 case had knee stiffness, 1 patient had postoperative loss of reduction, 1 case had deep infection and 1 case had knee instability.

## CONCLUSION

Minimally invasive plate osteosynthesis for proximal tibia fractures achieved good radiological and functional outcome. With MIPO technique there was minimal soft tissue damage and minimal disruption of the blood supply to fracture ends. The fractures treated with pure bridge plating and combined principle of compression and bridge plating healed rapidly by secondary fracture union.

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