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Plate on Plate Technique of Minimally Invasive Percutaneous Plate Osteosynthesis in Distal Tibial Fractures, an Easy and Inexpensive Method of Fracture Fixation

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Background: Plate on plate technique can lessen operative time and patient morbidity.
Objectives: This study aimed to evaluate the outcomes of minimally invasive percutaneous plate osteosynthesis (MIPPO) using plate on plate technique of locking plate fixation for closed fractures of distal tibia in a prospective study.
Patients and Methods: Twenty-five patients with distal tibial fractures were treated by MIPPO using locking plate by plate on plate technique. Preoperative variables including age of patient, mode of trauma, type of fracture and soft tissue status were recorded for each patient. Perioperative variables included surgical time and radiation exposure. Postoperative variables included wound status, time to union, return to activity and the American orthopaedic foot and ankle score (AOFAS).
Results: All the fractures had united at one year. The average time to union was 16.8 weeks. There were two cases of superficial infection and two cases of deep infection, which required removal of hardware after the fracture was united. The average AO foot and ankle score was 83.6 in our study population.
Conclusions: MIPPO using locking plate by plate on plate technique was a safe, effective, inexpensive and easily reproducible method for the treatment of distal tibial fractures in properly selected patients, which minimized operative time and soft tissue morbidity.

Keywords: Percutaneous; Plate on Plate; Tibia; Bone Fractures

1. Background

Management of fractures of distal end of tibia is a source of controversy and debate (1, 2). Treatment modalities of distal tibia fractures vary from closed reduction and cast application to open reduction and internal fixation and each method of treatment has its own merits and demerits. Certain anatomic and physiologic features of distal tibia like subcutaneous location, precarious blood supply, high incidence of open fractures and presence of neighboring hinge joints allowing for little rotational malalignment (3, 4), make management of distal tibial fractures very controversial. Fracture pattern, soft tissue status, bone quality, age and activity level of patient affect the selection of treatment methods (2). MIPPO minimally invasive percutaneous plate osteosynthesis is a method of fracture fixation gaining wide popularity because it reduces surgical trauma without substantial exposure of fractured zone. Proposed advantages of MIPPO include limited soft tissue dissection, reduced wound related complications, preservation of osteogenic fracture hematoma and improved union rates (1, 4-6).

2. Objectives

Various techniques of screw placement include giving stab incisions and placement of screws by using fluoroscopy and jigs. These methods are time consuming or expensive. Plate on plate technique employs placement of an identical plate to the one already placed percutaneous and fixed provisionally by K wires over the skin using the same K wires already used to temporarily fix the underlying plate to bone and using its holes for the placement of mini skin incisions for accurate placement of screws, thus reducing the amount of surgical trauma, operation time, radiation exposure and cost of treatment without any untoward effects on fracture or implant.

3. Patients and Methods

The present study included 25 cases of distal tibial fractures treated by plate on plate technique of MIPPO using locking plate between November 2010 and October 2012. The study was approved by the ethics committee of our institute and a written informed consent was obtained from all patients before the operation. Patients with

pathological fractures and open fractures were excluded from the study. Distal tibial fractures were either intraarticular or extraarticular corresponding to OTA 43 A, B or C fractures. Preoperative variables including age of patient, mode of trauma, type of fracture and soft tissue status were recorded for each patient. Perioperative variables were surgical time and radiation exposure. Postoperative variables included wound status, time to union, return to activity and the AO foot and ankle score (Table 1).

The operation was performed after the stabilization of soft tissue averaging 9.98 days ranged from 5 to 16 days in our study (1, 7, 8). All patients with distal tibial fracture were initially assessed and stabilized in the emergency department of our hospital. After diagnosis and management of life threatening emergencies, fractured extremity was splinted and elevated to reduce swelling (1). Detailed radiographic evaluation (Figures 1 and 2) was performed in two perpendicular planes of knee and ankle. CT scan was performed in case of complex intraarticular fractures (8, 9). Fractures were classified using the orthopedic trauma association (OTA) classification (10). Surgery was performed on a standard radiographic table under tourniquet control (1, 11). Preoperative prophylactic antibiotics were administered intravenously preoperatively before inflation of tourniquet (1). Fractures were reduced using indirect means of reduction like manual traction, calcaneal pin traction, use of femoral distractor, using K wires as joy sticks or rarely by small incisions and using bone clamps (1, 2, 8, 12, 13) and reduction confirmed under image intensifier fluoroscopy. Associated fibular

Table 1. Demographic Data [a]

Age, y	Gender	Side	Mode of Trauma	AO Type	Associated Injury	Injury Surgery Interval (Days)	Hospital stay, d	Operation Time, min	Fibula Fracture	Fixed or Not	PWB, wk	FWB, wk	Union, wk	Complications	AO Score	Functional Results as per AO Score	Nicolla Maffulli et al. Bone Results
40	F	R	Fall	43 A 1	nil	14	5	60	yes	no	6	12	14	inf < palp implant	73	good	good
44	F	L	RTA	43 B 1	nil	9	14	55	no	-	6	14	16	AS	80	good	excellent
60	F	L	Fall	43 A 2	nil	14	5	60	yes	no	6	12	16	nil	85	excellent	excellent
25	M	R	FFH	43 C 3	nil	10	15	120	yes	yes	10	18	24	infection, reoperation, ankle stiffness, pain	60	satisfactory	good
25	M	L	Direct impact	43 B 1	patella fracture	16	18	120	yes	yes	6	14	16	nil	97	excellent	excellent
40	F	R	Fall	43 A 3	nil	9	12	60	yes	yes	6	12	18	pain	87	excellent	excellent
50	M	R	RTA	43 A 2	nil	7	10	40	yes	no	6	12	16	superficial infection	85	excellent	good
30	F	L	RTA	43 A 3	nil	10	15	90	yes	yes	6	14	18	nil	87	excellent	excellent
45	M	L	RTA	43 A 1	nil	6	9	60	no	-	6	12	18	nil	87	excellent	excellent
63	M	L	RTA	43 A 1	nil	7	11	90	yes	no	8	14	20	nil	85	excellent	excellent
35	F	L	RTA	43 A 2	nil	5	7	60	yes	no	6	12	12	extrotation.	82	excellent	good
25	F	R	Fall	43 B 1	nil	9	11	120	yes	yes	12	24	30	palpable implant	84	excellent	excellent
22	M	L	FFH	43 A 2	nil	10	12	60	yes	no	6	10	12	nil	97	excellent	excellent
50	F	R	FFH	43 A 3	compression fracture l1	6	8	60	yes	no	8	14	16	nil	85	excellent	excellent
40	M	R	FFH	43B1	shoulder dislocation, head injury, subtrochanteric fracture	10	15	130	yes	no	8	14	18	ankle stiffness	85	excellent	excellent
35	M	R	RTA	43 A 1	nil	10	12	60	no	-	6	10	18	nil	92	excellent	excellent
35	F	L	Fall	43 A 2	nil	9	12	70	yes	no	6	10	18	palpable implant	85	excellent	excellent
40	F	R	Fall	43 A 2	nil	10	13	70	yes	no	6	12	16	mal union (external rotation)	87	excellent	good
45	F	R	Fall	43 A 2	nil	10	5	60	yes	no	6	12	12	nil	85	excellent	excellent
65	F	R	Fall	43 A 3	nil	10	14	90	yes	yes	8	16	20	superficial infection, ankle stiffness, pain	60	satisfactory	good
50	M	R	RTA	43 A 1	nil	10	15	60	yes	yes	6	10	12	nil	87	excellent	excellent
45	M	R	RTA	43 A 1	nil	10	12	90	yes	no	8	14	18	nil	85	excellent	excellent
30	F	L	RTA	43 A 2	nil	10	12	120	yes	yes	6	12	18	nil	87	excellent	excellent
45	M	L	RTA	43 B 2	nil	5	8	40	yes	no	6	12	12	nil	87	excellent	excellent
45	M	R	RTA	43 A 1	nil	10	12	60	yes	no	6	12	12	nil	87	excellent	excellent

[a] Abbreviations: RTA, road traffic accident; FFh, fall from height; PWB, partial weight bearing; FWB, full weight bearing; R, right; L, left; M, male; F, female; MIPPO, minimally invasive percutaneous plate osteosynthesis; AO score, American orthopedic foot and ankle score.

fractures if deemed necessary for fixation were fixed first (11, 14). After checking for reduction under C arm, especially in case of intraarticular fractures (which were provisionally fixed with K wires), a small approximately 3 cm incision was made over the medial malleolus for passing the locking plate (1, 15). A subcutaneous extraperiosteal tunnel was created using the Cobb elevator or blunt end of the plate (1, 16). The plate was temporarily fixed to the bone using K wires by passing them through the holes meant for them and were left projecting from the skin. Then, an identical plate of the same side having the same number of holes was put over the skin by passing it through the same K wires used for plate fixation, thus creating a plate on plate construct with superimposition of holes of one plate over the holes of another one. The holes of the plate over skin were used for giving small incisions and passing screws; thus, reducing the amount of surgical trauma, operation time and radiation exposure (Figures 3 and 4). The plate was fixed to the bone using locking or non-locking screws proximally via stab incisions and distally via previous oblique incision made for passage of plate (Figure 5). Wound was closed and limb was elevated postoperatively in a removable splint. Intravenous antibiotics were administered for 24 hours after the operation (1, 17). Postoperatively toe touch weight-bearing was started with the help of crutches as soon as pain and swelling subsided. Partial weight bearing was allowed at 4-6 weeks and full weight bearing at 10-12 weeks based on clinical and radiographic assessment of fracture healing. Using postoperative bracing was decided based on patient and fracture related factors like comminution and articular involvement as well as rigidity of fixation assessed intraoperatively (1, 2, 8, 12, 18). Delayed wound healing and superficial infection were defined as persistent drainage from the wound for at least two days or separation of wound edges to a width > 1 cm and a length > 1 cm (15, 19). The patients were followed up clinically and radiographically at two weekly intervals initially and then monthly till the fracture united (Figures 6 and 7), then every six months and final follow-up was performed at one-year postoperative. The patients were assessed objectively by physical and radiographic examination. Development of any complication was carefully observed and documented at each follow-up visit. The outcome was assessed at one-year follow-up using the American Orthopedic foot and ankle score (12, 20).

4. Results

All the 25 patients operated by plate on plate technique of MIPPO using locking plate were reviewed at one-year follow-up. All the fractures united at an average duration of 16.8 weeks ranging from 12 to 30 weeks. There were two cases of superficial wound infection and two cases of deep infection. Superficial infection was treated with wound care and antibiotic administration. Deep infections were of delayed onset occurring after two months which required removal of hardware but fractures were united by the time hardware was removed with further uneventful course. There were four cases of ankle stiffness and three with painless palpable implant and one with delayed union. One patient had to be reoperated because of inadequate reduction after first attempt because it was a complex intraarticular fracture. The average AO foot and ankle score in our patients was 83.6 with more than 92% of patients having ankle score greater than 60.

Figure 1. Preoperation X Ray, AP View

Figure 2. Preoperation X Ray, Lateral View

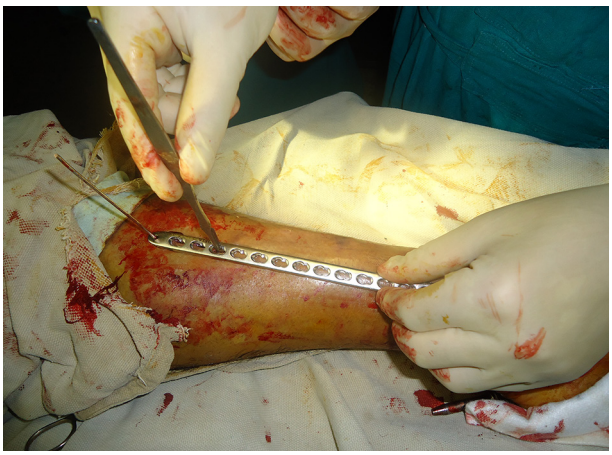

Figure 3. Stab Being Given in Skin Over Plate

Figure 4. Last Screw Hole Placement With Locking Sleeve in Place

Figure 5. Final View of Operated Limb After Completion of MIPPO

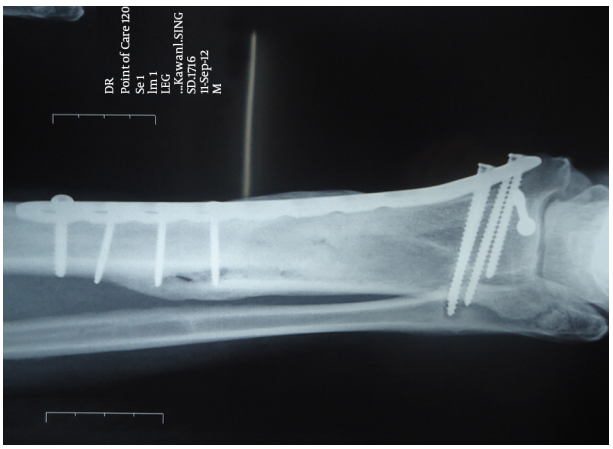

Figure 6. Final Follow-up X Ray, AP View at One-Year

Figure 7. Final Follow-up X Ray, Lateral View at One-Year

5. Discussion

Management of distal tibial fractures remains controversial because of limited soft tissue cover, subcutaneous location and poor vascularity (2, 8, 21). Treatment modalities for distal tibial fractures include closed reduction and cast application (22, 23), external fixation (7, 24), open reduction and internal fixation using plates, staged open reduction (8, 25-27), Intramedullary nailing (19, 28) and minimally invasive percutaneous plate osteosynthesis using a locking plate. MIPPO technique balances the amount of soft tissue dissection with anatomic reduction and preserves periosteal blood supply, osteogenic fracture hematoma and soft tissue cover. Initial clinical series using this method of treatment demonstrates favorable results with low rates of infection and nonunion but complications like palpable implant, ankle stiffness and hardware failure have been reported (2, 4, 7, 8, 25, 29-31). MIPPO is reported to increase radiation exposure, operation time and sometimes difficulty in achieving fracture reduction (32). Using jigs has reduced the operation time and radiation exposure, but it makes the operation more expensive and jigs may not be available at every center. Using plate on plate technique is an easy, inexpensive and easily reproducible alternative to jigs to decrease the operation time and radiation exposure without increasing cost of surgery. Moreover, it is an easy to master technique and can be practiced very easily without any untoward effect on fracture reduction or fixation. We studied clinical results, union rate, complications and return to preinjury daily and sports activities in a selected group of patients with closed fractures of distal tibia using plate on plate technique of MIPPO. The main limitation of our study was its relatively small sample size and lack of control group. We used precontoured distal tibial locking compression plate having nine distal holes. Borg et al. reported the limitation of conventional low contact plates as the number of screws placed in a short distal fragment (15). The union rate, incidence of delayed and nonunion and other complications and the AO foot and ankle score are comparable to other studies included only closed distal tibial fractures with decreased operation time, intraoperative radiation exposure and cost of surgery with plate on plate technique of MIPPO. The average time to union in our study was slightly less compared to other studies likes Mario Ronga et al. and Redfern et al., because we included only closed fractures and also there was only one case of OTA type C fracture (1, 2). Our union rate was comparable to 18.1 weeks of Hazarika et al. who only included closed fractures (11, 18). We fixed the fractures on an average of 9.98 days after injury as recommended by Helfet et al. giving time for swelling to subside and minimize soft tissue related complications associated with distal tibia fractures (9). Using plate on plate technique of MIPPO greatly facilitates the surgical procedure, reduces the operative time and radiation exposure, does not require expensive jig system or other costly instrumentation required for passing screws and is an easily reproducible method with consistently good results. Two cases of our study developed an external rotation deformity, but had no functional limitation or required any further surgical procedure. Malunion was seen in 20% of the cases as reported by Helfet et al. (9). Deep infection was seen in 8% of our cases requiring removal of hardware; whereas, deep infection was seen in nearly 14% of cases of Mario Ronga et al. study (2). The average AO foot and ankle score in our study was 83.6 and 90 in Bahari et al. (8). Redfern et al. did not advocate routine fixation of fibula except for reconstruction of length of tibia in case of extensive comminution (1). Helfet et al. recommended routine fixation of fibular fractures in case of distal tibial fractures (9). We recommend to perform fixation of fibula to reconstruct the length and alignment of fractured tibia in case of severe comminution of tibia and syndesmotic involvement. Most of the patients were mobilized on the first postoperative day and need for postoperative brace or cast was judged individually based on fracture

pattern and comminution as well as patient-related factors. Redfern et al. did not recommend routine postoperative bracing or casting allowing early postoperative range of motion exercises of ankle (1).

Minimally invasive percutaneous plate osteosynthesis using the plate on plate technique offers a useful and reproducible method of treatment of distal tibial fractures with or without articular extension in properly selected patients. This method reduces the cost, operation time and radiation exposure, but further long-term studies including a large number of patients are required before any definitive conclusion.

Authors' Contributions

Nasir Muzaffar wrote the manuscript, Rafiq Bhat collected data and references and Mohammad Yasin helped in drafting and editing.

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