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Minimally invasive plate osteosynthesis with locking compression plate for proximal and distal diametaphyseal tibial fracture

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ABSTRACT

Background: The treatment of proximal and distal diametaphysealtibial fractures remains controversial. This study was performed to evaluate the results of Locking compression plate using MIPO technique in the management of proximal and distal diametaphysealtibial fracture. **Aims and Objective:** To analyse and observe the result of management of metaphyseal fractures of tibia with respect to operative technique, stability of fixation, union of fracture, post-operative range of motion and complication. **Materials and Methods:** The study was prospective study. Forty two patients who sustained fractures of proximal and distal diametaphyseal tibial fractures with or without articular involvement were included in the study and treated by employing the concept of Minimally invasive plate osteosynthesis during period of August 2015 to December 2017 and followed up at regular interval with minimum six months to thirty months. *Intervention:* Surgical reduction and fixation of fracture using proximal and distal anatomical locking compression plate followed by rehabilitation. *Main outcome measure:* Radiological outcome, perioperative and postoperative complication, postoperative alignment, range of motion. **Results:** All fractures got united with the average duration of 22.7 weeks for proximal metadiaphyseal tibia and 19.9 weeks for distal diametaphysealtibia. There were 3 delayed union cases which got united without any surgical intervention. Deep peroneal nerve palsy was seen in 2 cases with proximal tibia fracture treated with longer plate. 2 cases of superficial infection and one deep infection seen with proximal diametaphyseal fracture and 2 superficial infection with one case of wound dehiscence and implant prominent seen with distal diametaphyseal tibia fracture. No malalignment or angulation of more than 10 degree occurred in any plane for both proximal and distal diametaphyseal fractures. **Conclusion:** MIPO provides stable fixation with excellent union rate with minimal complication for both proximal and distal diametadiaphysealtibial fracture.

Key words: Proximal diametaphysealtibial fracture; distal diametaphysealtibial fracture; MIPO; Locking compression plate

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INTRODUCTION

A fracture is the result of mechanical overload with important biological consequences. Proper understanding of mechanical and biological aspects of fracture repair is the key to selection of type of treatment for a particular fracture.

Earlier concept of AO/ASIF to treat comminuted fracture was by anatomical reduction and absolute stability by plating to produce impressive post-operative X-rays, but various studies have shown that this type of management leads to bad and worse results and is associated with complication like delayed union, non-union, wound breakage and deep infection and implant failure.[1,2] A novel concept

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of biological fixation is developed with utmost respect given to soft tissue and vascularity of the bone. Principle of biological fixation involves realignment of fracture fragments by manipulation at a site distal to fracture, leaving comminuted fragments out of the mechanical construct, thus preserving soft tissues with minimal exposure.[3]

The fracture is stabilized by fixing the plate to the proximal and distal major fragments by minimal soft tissue dissection.[4,5] This leads to secondary healing using principle of relative stability by technique called "Minimally Invasive Percutaneous Plate Osteosynthesis".

Fracture of tibia are usually the result of high energy axial compression and rotation forces, and are usually associated with severe soft tissue compromise, complex fracture pattern, intra-articular involvement, severe comminution and displacement.[6,7] The limited soft tissue, subcutaneous location and poor vascularity render the tibial fractures very challenging.

Treatment of proximal and distal metadiaphyseal fracture of tibia with or without articular extension is challenging because of its unique anatomical characteristics of sub-cutaneous location, proximity to the joints, risk of compartment syndrome, damage to neuromuscular structures and limited soft tissue coverage. Several methods of treatment are implemented including non-operative treatment, external fixation, intramedullary nailing, and internal fixation with traditional implants (standard screws and plates). [8]However, each of these treatment options is associated with certain merits and demerits.[9]

The complications associated with conventional osteosynthesis with plates include wound infection, skin breakdown and delayed union or non-union requiring secondary procedures like bone grafting.[10-13] 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.

Recently, technique of closed reduction and minimally invasive plate osteosynthesis (MIPO) with locking compression plate (LCP) has emerged as an alternative treatment option for proximal and distal diametaphyseal tibia fracture.LCP used subcutaneously does not endanger periosteal blood supply, respects fracture hematoma and also provides biomechanicaly stable construct.[14,15]

MATERIALS AND METHODS

Among 76 patients who attended for proximal and distal metadiaphyseal tibia fractures between August 2015 to Dec 2017 in Manipal Teaching Hospital, Pokhara,42 patients were selected and treated with anatomical proximal and distal tibial locking plate and prospectively followed. Approval for the study was given by Ethics Committee of our hospital and informed consent was obtained from all patients before operation. All closed fractures and Gustilo Anderson Grade 1, Grade 2 and Grade 3A open fractures of proximal tibia and distal tibia with or without articular involvement mainly the extra-articular fracture and partially articular fracture and fractures up to two weeks old were included in the study. Patient with complex bicondylar fracture proximal tibia and complex pilon fracture were excluded as were those in whom MIPO was converted to ORIF owing to unsatisfactory reduction. Other exclusion criteria include age more than 18, Gustulio-Anderson grade 3B, associated vascular injury or compartment syndrome, pathological fractures, fractures older than two weeks and patient unfit for surgery.

After stabilizing the traumatized patient, routine pre-anesthetic investigations were carried out.Standard AP and Lateral view of affected leg with knee and ankle joint were taken.

Limbs with gross swelling were splinted in a plaster slab and elevated in Bohler-Braun frame till swelling subsides and wrinkle appeared. Skin condition around the fracture site was inspected every day for blister formation. Fracture blisters if present were managed with puncturing with sterile needle and non-adhesive dressing and observed closely for any sign of secondary infection.

X-ray were taken and evaluated for fracture morphology,level and extent of comminution and classified accordingly to AO/OTA system. Demographic data(age,sex,fracture type,AO/OTA type,associated injury),radiological union,complication,follow up period mentioned in [Table 1,2].

RESULTS

In case of proximal tibia fractures mean age of the patients was 44.4 years. In case of distal tibialfractures, mean age of patients was 43.82 years. Majority of patients 42.9% were in the age group of (25-35) in proximal tibia and 39.3% were in age group of (40-50).

There were 13 males and 1 female patient with proximal tibial fractures and 23 males and 5 female patients with distal tibial fracture. The commonest mode of injury was road traffic accident for both proximal and distal tibial fractures. Majority of the fractures operated in our study were extra-articular fracture.

Table 1: Demographic data for proximal diametaphyseal tibia fracture

S.No.	Age (yrs)	Sex	Fracture type	AO/OTA type	Associated injuries	Mode of injury	Primary/staged Mippo	RadiologicalUnion time (weeks)	Follow-up (months)	Complication	secondary procedure
1	48	M	O3A	A2		RTA	Staged	18	5	Superficial infection	
2	45	M	O1	A3	Scalp laceration	RTA		40	18	Delayed union, DPN palsy	
3	35	M	C	A3		Fall		52	24	Delayed union , DPN palsy	
4	63	M	C	B1		Fall		18	20		
5	35	M	C	A2		Fall		18	18		
6	33	M	O1	A2	Facial injuries	RTA		20	12	Deep infection	Debridement
7	75	M	C	A2		Fall		18	16		
8	26	M	C	A2		Fall		19	18		
9	48	M	O2	A1		RTA		22	20		
10	72	F	C	A1	Clavicle Fracture	RTA		20	18		
11	42	M	C	B1		RTA		20			
12	32	M	C	A3		RTA		18		Superficial infection	
13	30	M	C	A2		RTA		18			
14	38	M	O1	B1		Fall		17			

Thirty nine patients were treated by primary MIPO, and the other 1 patient with proximal tibial fracture and 2 patients with distal tibia fracture were treated by staged MIPO. Staged MIPO was done for patients with an open fracture for both proximal and distal tibia. In the staged MIPO, conversion to definitive fixation with a locking plate was performed at 2 weeks from time of injury and primary fixation. One patient with open fracture distal tibia had contralateral closed diaphysealtibial fracture. Ankle bridging external fixation for distal tibia and closed reduction and Intramedullary nailing was done for contralateral diaphyseal tibia in primary setting. Definitive fixation with MIPO was done for distal tibia at 2 week's time.

In cases of proximal tibial fracture, radiological union was seen between 17 to 52 weeks with average time of union being 22.71 weeks. In case of distal tibia fractures, average time for radiological union was 19.9 weeks with a range being from 17 to 36 weeks.

Delayed union was seen in 2 (14%) patients with proximal tibial fracture, 1(3.57%) patient with distal tibia fracture. Nonunion was not seen in our cases. Pre-operative x-ray, follow-up x-ray and x-ray of united fracture of proximal and distal metadiaphyseal tibia is shown in [Fig 1(a),1(b),1(c) and 2(a),2(b),2(c)] respectively.

No malalignment or angulation of more than 10 degree occurred in any plane; two patients had a 5 degree varus angulation in sagittal plane in proximal tibia fracture and six patients having valgus angulation of 4 degree in sagittal plane and one patient had external rotation of ten degree in distal tibia fracture. Shortening of more than 10 mm was not noted in proximal and distal tibia fractures However, because the extents were negligible and didn't seem to influence the knee and ankle movement. Twelve (85.7%) patients had achieved 0 to 110 degree of flexion at knee, in 2patients (14.2%) range of movement achieved was 0 to 90 degree. The range of motion at ankle on an average was 16.2 degree of dorsiflexion (range 10-20 degree) and planter flexion averaged 25 degrees (range 15-35 degree)

COMPLICATIONS

Superficial infection was seen in two cases with both proximal tibial fracture and distal tibial fracture. They were treated by a course of oral antibiotics and dressing. Wound dehiscence with exposed implant was seen in one patient treated for distal tibial fracture which responded to wound debridement and re-suturing/secondary suturing and Intravenous antibiotic treatment. One case of deep infection was seen with proximal tibia fracture which responded with wound debridement and IV antibiotics.

Table 2: Demographic data for distal diametaphyseal tibia fracture

S.No.	Age (yrs)	Sex	Fracture type	AO/OTA type	Associated injuries	Mode of injury	Primary/staged Mippo	RadiologicalUnion time (weeks)	Follow-up (months)	Complication	secondary procedure
1	45	M	O1	A1	Ac joint dislocation	RTA		18	24		
2	48	M	O2	A3		RTA		20	18		
3	35	M	C	A2		RTA	Staged	20	20		
4	46	M	C	A1	5 MT head fracture	Fall Injury		18	18		
5	26	M	O1	A2		Fall Injury		22	20		
6	21	M	O3A	A2		RTA		36	20	Delayed union, superficialinfection, hardwareprominence, wound healing difficulty	Wound debridement , Early implant removal
7	70	M	C	A1		RTA		18	18		
8	71	M	C	A1		RTA		18	18		
9	45	M	C	B1		RTA	Staged	17	18		
10	65	F	C	A1		RTA		18	24		
11	52	M	O1	A3	DR fracture	Fall Injury		20	16		
12	48	M	C	A3		RTA		20	18		
13	66	M	C	A1		RTA		20	18		
14	21	M	C	A1		RTA		18	16		
15	27	M	O2	A1		RTA		22	22		
16	50	M	C	A1		Fall Injury		18	18		
17	38	M	C	A2		RTA		18	16		
18	49	F	C	A2		RTA		18	20		
19	46	M	C	A3	Clavicle fracture	RTA		20	18		
20	22	M	C	A3		Fall Injury		18	14		
21	24	M	O2	A2		RTA		20	14		
22	55	M	C	A1		Fall Injury		18	12	Superficial wound infection	
23	42	F	C	A1		RTA		20	-		
24	37	F	C	A3		RTA		24	-		
25	22	M	O1	A1	Head injury+c/l tibia fracture	Fall Injury		18	-		
26	45	M	C	A2		RTA		20	-		
27	45	F	C	A3		RTA		24	-	Hemorraghic blisters	
28	66	M	C	A3		Fall Injury		18	-		

Table: 3(a) Comparison of current study with other studies with proximal metadiaphysealtibial fracture

Study	Total cases	Type of fracture	Study Method	Year	Outcome	Complication
Peter A et al.[22]	87	Closed And Open	Retrospective	2004	Union: not mentioned	2 proximal losses of fixation 2 Non-union 2 deep infection 1 deepperonealnerveinjury
Kim J.et al.[21]	30	Open	Retrospective	2012	Union: 24 (19.4 weeks)	6 nonunion 3 Superficial infection 5 Deep infection
Walia J et al.[19]	50	Closed	Prospective	2013	Union: 50 (14.8 weeks)	3 Superficial infection 1 Malunion
Our Study	14	Closed and open	Prospective	2018	Union: 14 (22.71) weeks	2 superficial infection1 deep infection 2 delayed union 2 deep peroneal nerve palsy

Table :3(b) Comparison of current study with other studies with distalmetadiaphysealtibial fracture

Study	Total cases	Type of fracture	Study Method	Year	Outcome	Complication
Paluvadi S et al.[23]	50	Closed	Prospective	2014	Union: 50 (21.4 weeks)	Superficial infection: 5 Deep infection: 1 Implant failure: 1 Malunion: 1
Mushtaq A et al.[27]	21	Closed=17 open=4	Prospective	2009	Union: 19 (5.5 months)	Delayed union: 1 Non-union: 1 Wound infection: 2 Secondary procedure: 2
Shrestha D et al.[28]	20	Closed	Prospective	2011	Union: 20 (18.5 wks)	Delayed union: 1 Superficial wound infection: 2 Deep infection: 1 Secondary procedure: 1
Our Study	28	Closed and Open	Prospective	2018	Union: 28 (19.9 weeks)	Superficial infection: 2 Secondary procedure: 1 Delayed union: 1 Wound dehiscence: 1

Deep peroneal nerve involvement with weakness in dorsi-flexion and numbness over lateral aspect of leg and decreased sensation over first web space was seen in two patients with segmental fracture proximal tibia treated with 12 hole proximal tibial locking plate. Patients regained power to dorsi-flexion and improved sensation at around six months. Hemorrhagic fracture blisters were seen in one alcoholic patient with distal tibia fracture who presented to the hospital three days after the injury. He had a fall injury with unsplinted leg for 3 days. One patient was a 21 year old smoker with open fracture 3A distal tibia who had difficulty in wound healing, attributed to his overlying thin subcutaneous tissue and skin layer with prominent hardware. Due to prominence of hardware and wound healing difficulty, early removal of implant was done.

DISCUSSION

Treatment is challenging for proximal and distal dia-metaphyseal tibial fractures. Presence of short segment in proximal tibial and in distal tibial fractures presents an additional challenge with misalignment common in coronal and sagittal plane with higher incidence of malunion and nonunion. None of the treatment options available perfectly fulfil requirements of fracture characteristics of proximal and distal diametaphyseal tibia. Intramedullary interlocking nail is most common method of minimally invasive stabilization of long bone. Presence of wider medullary canal in the metaphyseal area, results in reduced stability due to larger diameter of proximal and distal part of the tibia. So intramedually nail which is designed for interference fit at diaphysis cannot maintain the same stability at proximal and distal tibial fractures.[16] Futhermore Intramedullary nail is contraindicated in intra-articular fractures. Other drawbacks of IMIL nail include malunion (0-29%) and implant failure(5-39%).[17,18]

There is higher incidence of open fracture in proximal and distal tibia fracture attributed to higher energy injures and lack of soft-tissue coverage making the external fixation as treatment option. Although the incidence of infection is less with external fixation than plating, it is

Figure 1:(a) Pre-operative xray of Proximalmetadiaphyseal tibia fracture. (b): Follow-up xray. (c): United fracture of proximal metadiaphyseal tibia

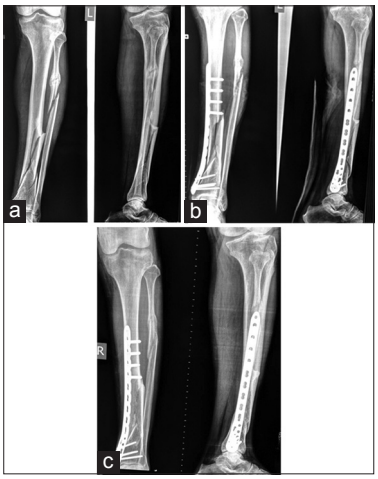

Figure 2: (a) Pre-operative xray of distal metadiaphyseal tibia fracture. (b): Follow up xray. (c):United fracture of distal metadiaphyseal tibi

not easy to reduce and adequately maintain the articular and comminuted proximal and distal tibia fractures. Other potential complications include malunion, joint motion limitation, patient inconvenience and pin tract infection.

Compared to conventional open plating technique, percutaneous plating technique provides mechanically stable construct without significant dissection and surgical trauma to the bone and surrounding soft tissue. As, a consequence, osteogenic fracture hematoma as well as vascular integrity at fracture site is preserved.[19] Unlike conventional plate, Locking compression plate is friction independent, works in principle of single beam construct providing both angular and axial stability and minimizing risk of secondary loss of reduction. [20] Thus, MIPO with LCP has been found to be an effective treatment option for treatment of proximal and distal dia-metaphyseal tibia fractures.

While using MIPO with LCP as internal external fixator, anatomical reduction of fracture by indirect reduction technique before plate application is an important surgical step. In this way, the fracture environment is better preserved, as well as the endosteal and periosteal blood supply to the fracture site is undisturbed which leads to decrease infection rate and better fracture healing. Fixation of distal fibula when the fracture is located within 5 cm from the ankle joint line is important because it restores the original length and rotation of lateral column of the ankle joint and also facilitates fracture reduction for distal tibia.

In our study, preferred technique for proximal metadiaphyseal tibia fracture was anterolateral single incision with the lateral placed proximal tibial locking plate subjected to open wound usually located on the medial side because the tibia externally rotates while walking making its medial side more vulnerable due to lack of soft tissue envelope.

The rigidity of laterally placed locking plate in proximal tibia and medial placed locking plate in distal tibia with absence of secondary displacement of metaphyseal segment and of worsening of articular step-offs establishes the effectiveness of LCP in such fractures.

Post-operative infection occurred in 3(21.4%) cases; superficial infection in 2(14.2%) and deep infection in 1 (7.14%) for proximal tibial fractures. For distal tibia, post-operative infection occurred in 2(7.14%) cases; superficial infection in 2 (7.14) cases.

Study done by Kim JW et al[21] and Peter et al[22] found the infection rate to be (26.6%) and (3.89%) for proximal tibia fracture respectively. Reported rate of infection for distal tibia varies between 2.6% to 14.6% depending upon whether the open fractures are included or not. Our study showed infection rate of 21.4% for proximal tibia and 7.14% for distal tibia. All cases healed after treatment and infection did not appear to have any long term effect in fracture healing and rehabilitation of patients. The average time for fracture union was 22.71 weeks with range of 17 to 52 weeks for proximal tibia fractures and average time for fracture union for distal tibia was 19.9 weeks with range from 17 to 36 weeks. Majority of fractures (78.5%) healed within 20 weeks of time period.

Kim et al[21] reported the mean time for primary bone union at 19.4 weeks in 24 of 30 patients with 6 cases of non-union requiring bone grafting. Sidd et al. [23] reported the mean time for radiological union of fracture for distal tibia fracture by MIPO as 21.4 weeks,which ranged from (16-32) weeks.

2 cases of delayed union of proximal tibia fractures and 1 case of delayed union for distal tibia fractures were

seen which united in subsequent follow-up without any intervention. Secondary procedures like iliac crest bone grafting or bone marrow injection for delayed union or nonunion has been reported 3.8% to as high as up to 35%.[24] Comparisons of current study with the other studies in relation to type of study design,radiological union time and complication is mentioned in [Table 3(a) and 3(b)].

Study done by Hasenboehlar et al. found MIPPO with LCP through reliable for metadiaphyseal fractures can prolong union time in simple fracture pattern when it was used only as a bridging plate. [25] Hence, use of LCP in compression mode by using non-locking screw on one side of the fracture or use of percutaneous inter fragmentary screw independent to plate and LCP in a neutralization mode is recommended to avoid delayed union of fracture. In our study, two cases had comminuted segmental fracture involving the proximal metadiaphysis and long segment of diaphysis, so longer plates were chosen in those cases to achieve a mechanically sound fixation. Use of longer plates in such type of fracture lead to involvement of deep peroneal nerve with decrease power of dorsi-flexion, decreased sensation over 1st web space and numbness over lateral aspect of foot in 1 case and only numbness and tingling sensation over lateral aspect of foot in other patient. Cadaveric study by W. Pichler et al. suggested that the risk of iatrogenic injury to deep peroneal nerve is greatest when using a 13 hole LISS plate. At level of 11 th hole, DPN and the artery and the accompanying vein of tibialis anterior are invariably in very close relation to the plate putting them in great danger of iatrogenic injury. So, open incision while placing distal screw while using plates longer than 10 holes is recommended.[26]

Assessment of articular extension in proximal and distal metaphyseal fracture is important because a screw of the LCP does not provide compression of articular surface. So, reduction and fixation for the articular injury should be performed initially followed by LCP application which connects articular block with the diaphysis. Tibia fracture cases are usually result of high velocity injury with multisystem involvement with considerable number of people in our study presenting as polytrauma, So MIPO is used in such cases to prevent blood loss, reduce operative time and less morbidity.

This study was not meant to study the functional outcome but rather than to assess the utility and safety of the MIPO technique, to assess certain clinical outcome parameters and ability of LCP plate to maintain reduction and fixation in the face of compromised soft tissue envelop. Despite having many advantages over nails, external fixators, conventional plating technique, MIPO with LCP have potential disadvantages which include surgeon unfamiliarity with closed reduction technique and fixation leading to coronal and sagittal plane malalignment and possible neuro-vascular injury.

CONCLUSION

MIPO with LCP have been found to be effective for treatment of proximal and distal diametaphyseal tibia fractures with substantial metadiaphyseal comminution, periarticular fractures and in polytrauma cases with excellent clinical and radiological outcome and minimal complication.

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