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Management of distal tibia fractures with MIPPO

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Abstract
Background and Objective: Our objective was to evaluate clinical results and outcomes of metaphyseal lower third tibia using locking compression plate by minimally invasive percutaneous plate osteosynthesis (MIPPO) technique and open reduction technique.
Minimally invasive medial plating will restore limb alignment and yield successful clinical outcomes for high-energy metaphyseal fractures of the distal tibia. Despite the significant reoperation rate and prolonged time to union, most patients can expect a predictable return of function. Strong consideration should be given to adjunctive measures in at–risk patients, including those with highly comminuted fracture patterns, bone loss, or Type II or III open fractures.
Materials and Methods: Adult patients with fractures of lower third tibia admitted to Belgavi institute of medical sciences (BIMS) will be taken for this study after obtaining their informed, valid written consent. This is a prospective observational study from July 2019 to September 2019.
Results: Twenty-three patients were followed an average of 12 months (range 6-20 months) with mean fracture healing time was 16 weeks (12-60 weeks). One patient had delayed union which took 20 weeks. Two patients developed superficial infection but fractures united completely.
Interpretation/Conclusion: This technique has resulted in effective stabilization of lower third tibial fractures. It does provide adequate stability and allows early motion. Open reduction not only helps in achieving reduction in difficult situation but also in rapid union because it facilitates preservation of blood supply to the fragment and anatomical reduction of fracture with greatest advantage being fracture hematoma is not disturbed. This technique is effective in extra articular fractures occurring within 5cm of joint were intramedullary nails offend don't provide stability.

Keywords: Distal third tibial metaphysis, locking compression plate, minimally invasive percutaneous plate osteosynthesis (MIPPO)

Introduction
The difficulty in treating the fractures of distal tibial end is exemplified by orthopaedists, who in the first half of twentieth century, believed these injuries were so severe and fraught with so many complications, that the fracture was deemed not amenable for surgical reconstruction. Distal tibial fractures represent a significant challenge to most of the surgeons even today. They are only 1-10% of all lower extremity fractures.
Conservative treatment by cast application lead to prolonged immobilization, leading to ankle and knee stiffness affecting quality of life of the patient.
Introduction of the locking compression plate was a revolution in the evolution of management of fractures where prolonged bed rest is avoided and return to work is satisfactorily helpful. For the past decade, plating using fracture reduction has been successful in treating complex fractures of the lower extremity especially distal tibia. The goal of this technique is to apply stable plate fixation while maintaining the fracture biology and minimizing soft tissue problems.
Recently, there has been an increasing trend toward use of a locking plate for treatment of complex fractures of the distal part of the tibia. Compared with a conventional plate, a locking plate imparts a higher degree of stability and provides better protection against primary and secondary losses of reduction and minimization of bone contact.
Locking plates (LPs) have the biomechanical properties of internal and external fixators, with superior holding power because of fixed angular stability through the head of locking screws, independent of friction fit.

Objectives

1. To evaluate the functional outcome following use of locking compression plate for lower third fractures of tibia.
2. To study the advantages and complications of locking compression plate and duration of union in above mentioned fractures.

Locking Compression Plates

The aim of any surgical fracture treatment is to reconstruct the anatomy and restore its function. According to the AO ASIF, internal fixation is distinguished by precise reduction, stable fixation, preservation of blood supply and early, functional mobilization. Plate and screw osteosynthesis has been established and clinically recognized for quite some time. Clinical results have been improved by using internal fixation with angular stability (internal fixators) in metaphyseal fractures and in osteopenic bone. The Synthes Locking Compression Plate (LCP) is part of a stainless steel and titanium plate and screw system that merges locking screw technology with conventional plating techniques.

Anatomic contoured locking compression plate

The Locking Compression Plates (LCP) have the following LC-DCP features:

- 80° of longitudinal screw angulation
- 14° of transverse screw angulation
- Uniform hole spacing
- Load (compression) and neutral screw positions

The Locking Compression Plates have combination locking and compression holes (Combi holes).

The Combi holes allow placement of standard cortex and cancellous bone screws on one side or threaded conical locking screws on the opposite side of each hole.

A. Threaded hole section for locking screws
B. Dynamic Compression Unit (DCU) hole section for standard screws
C. Locking screw in threaded side of plate hole
D. Cortex screw in compression side of plate hole

Locking screws: The screw design has been modified, as compared to standard 3.5 mm cortex screws, to enhance fixation and facilitate the surgical procedure.

New features include

Conical screw head: The conical head facilitates alignment of the locking screw in the threaded plate hole to provide a secure screw/plate construct.

Large core diameter: The large core diameter improves bending and distributes larger area in the bone

Thread profile: The shallow thread profile of the locking screws results from the larger core diameter, but is acceptable because locking screws do not rely solely on the screw threads to create compression between the plate and the bone to maintain stability.

Drive mechanism

The Star Drive recess provides improved torque transmission to the screw while retaining the screw without the use of a holding sleeve.

Unicortical screw fixation

Bicortical screw fixation has long been the traditional method of compressing a plate to the bone where friction between the plate and the bone maintains stability. Screw stability and load transfer are accomplished at two points along the screw: the near and far cortices.

Unicortical locking screws provide stability and load transfer only at the near cortex due to the threaded connection between the plate and the screw.

Screw stability and load transfer are accomplished at two points along the screw: the screw head and near cortex. Because the screw is locked to the plate, fixation does not rely solely on the pullout strength of the screw or on maintaining friction between the plate and the bone.

a) Bicortical screws require two cortices to achieve stability
b) Unicortical screws utilize the locked screw and the near cortex to achieve stability.

Advantages of locking compression plates: It enables fracture treatment using compression plating with conventional cortex or cancellous bone screws.

- An LCP plate can also be used as an internal fixator and permits stable bridging over shattered zones.
- The LCP system permits the combination of conventional and locking screws.
- Unicortical locking screw permits better vascularity. The plate & screws from one stable system & the stability of the fracture depends on the stiffness of the construct.
- Locking the screw into the plate to ensure angular as well as axial stability eliminates the possibility for the screw to toggle, slide or be dislodged & thus strongly reduces the risk of postoperative loss of reduction.
- Multiple angle stable screw fixation in the epiphyseal & metaphyseal region, allows for fixation of many fractures that are not treatable with standard devices.
- Improved stability in multi fragmentary, complex fractures, which have loss of medial/lateral buttress or have bone loss double plating avoided.
- The fixed angle stability avoids subsidence of fixation in metaphyseal areas. This allows for less precise contouring of the plate, as fixation depends on plate-screw construct rather than friction between plate bone interface.
- Improved biology for healing. Fixation provided by the plate does not depend on the compression between the plate & bone but on the fixation of the screw to the plate & anchorage of the screw in the bone, the plate no longer needs to make any contact with the underlying bone. The immediate advantage of this is that there is absolutely no interference with periosteal blood supply. Maintained bone perfusion decreases infection rate, bone resorption, delayed & non-union, & secondary loss of reduction.
- Better fixation in osteoporotic bone.
- No or less need for primary bone graft as more fractures fixed with bridging technique with elastic fixation & also because of angle stable constructs avoiding post operative collapse.
- Advantage in osteopaenic bone or multi fragmentary fractures where traditional screw purchase is compromised.

Disadvantages of locking compression plates

- The surgeon has no tactile feedback as to the quality of screw purchase into the bone as he tightens the screw. As the screw lock in the plate, all screws abruptly stop advancing when the threads are completely seated in the plate regardless of bone quality.
- Current locking plate designs can be used to maintain

fracture reduction but not to obtain it. The fracture must be reduced & limb alignment, length & rotation must be set properly before placement off any locked screws. Inability of the surgeon to alter the angle of the screw within the hole & still achieve a locked screw.
- Any attempt to contour locked plates could potentially distort the screw holes & adversely affect screw purchase.

Indications

1. LCP a conventional plating technique (compression method, principle of absolute stability)

•Simple fractures in the diaphysis & metaphysis (if precise reduction is required for functional outcome).
- Articular fractures
- Delayed or non-union.
- Closed wedge osteotomies.

The operative technique is much same as conventional plating. In case of good bone quality, additional screws can be regular cortical screws, giving stability by increasing fixation between plate & the bone.

Three bi-cortical conventional screws on each side of fracture are effective. In osteoporotic bone stability is increased by using locking head screws.

2. LCP in a MIPO technique (internal fixator method, principle of relative stability)
- Multi fragmentary fractures in diaphysis & metaphysic Simple fractures in metaphysis & diaphysis (if non-precise reduction is enough for functional outcome.
- Open-wedge osteotomies
- Periprosthetic fractures
- Secondary fractures after intramedullary nailing.
- In bones of good quality, the use of unicortical locking head screws is sufficient. However atleast 3 screws must be inserted on either side of fracture in each main fragment.
- In osteoporotic fractures, use of locking screws in strongly recommended with atleast 3 screws in each manifestation, on either side of fracture, of which at least one must be inserted bio-cortically.

3. LCP in a combination of both methods (compression method & internal fixator method)

Articular fracture with multi fragmentary fracture extending into the diaphysis: anatomical reduction & inter fragmentary compression of the articular component, bridging of the reconstructed joint block to the diaphysis. Segmental fracture with two different fracture patterns (one simple & one multi fragmentary) conventional method & compression at simple fracture & bridging technique, internal fixator principle for multi fragmentary fracture.

The term 'combination' describes the combination of two biomechanical principles i.e. use of combination of inter fragmentary compression and internal fixator method.

Methodology

This is a prospective observational study from July 2019 to September 2019. 23 Adult patients with fractures of lower third tibia admitted to Belgavi institute of medical sciences (BIMS) will be taken for this study after obtaining their informed, valid written consent.

Inclusion criteria

1. Adults (aged more than 18 years) males and females.
2. Simple fractures unfavorable for interlocking nailing.
3. Complex fractures of the lower third of tibia.

Exclusion criteria: 1. Patients aged below 18 years. 2. Patients not involving with epiphyseal injuries. 3. Patients not willing to undergo surgery. 4. Patients medically unfit for surgery.

On admission of the patient, a careful history was elicited from the patient and/or attenders to reveal the mechanism of injury and the severity of the trauma. The patients were then assessed clinically to evaluate their general condition and the local injury. General condition was assessed with the vital signs and systemic examination. Methodical examination was done to rule out fractures at other sites.

Surgical Technique

Plate selection
- The plates are available in various lengths and configurations similar to the Synthes Small.
- Fragment Set. If necessary, use a bending template to determine plate length and configuration.

Contouring
- Use the bending instruments to contour the Locking Compression Plate to the anatomy.

Reduction and temporary plate placement
- The plate may be temporarily held in place with standard plate holding forceps or the Push-Pull Reduction Device.
- The Push-Pull Reduction device is designed to temporarily hold the plate to the bone through a plate hole. The device is self-drilling and connects with the Synthes quick connection for power insertion. Insert into near cortex only. After power insertion, turn the collect clockwise until it pulls the plate securely to the bone.
- A Threaded Plate Holder can also be used as an aid to position the plate on the bone. The plate holder may also function as an insertion handle for use with minimally invasive plating techniques.

Screw insertion
- Determine whether standard cortex screws, cancellous screws or 3.5 mm locking screws will be used for fixation. A combination of all may be used.

Insertion of a cortex or cancellous bone screw: Use the 3.5 mm Universal Drill Guide for an eccentric (compression) or neutral (buttress) insertion of cortex screws.

Neutral insertion of a standard screw: When pressing the universal drill guide into the DCU portion of the LCP plate, it will center itself and allow neutral pre drilling.

Dynamic compression, eccentric insertion of a cortex screw: To drill a hole for dynamic compression, place the universal drill guide eccentrically at the edge of the DCU portion of the LCP plate hole, without applying pressure. Tightening of the cortex screws will result in dynamic compression corresponding to that of the LC-DCP.

Insertion of 3.5 mm Locking Screws
1. Screw the 2.8 mm Threaded Drill Guide into an LCP plate hole until fully seated.
2. Use the 2.8 mm Drill Bit to drill the desired depth.
3. Remove the drill guide.

4. Use the Depth Gauge to determine screw length.
5. Insert the locking screw under power using a Torque Limiting Attachment and Star Drive Screwdriver Shaft.

Alternative Method of Locking Screw Insertion: Use the Star Drive Screwdriver to manually insert the appropriate length locking screw. Carefully tighten the locking screw, as excessive force is not necessary to produce effective screw-to-plate locking

Screw placement verification: Since the direction of a locking screw is determined by plate design, final screw position may be verified with a K-wire prior to insertion. This becomes especially important when the plate has been contoured or applied in metaphyseal regions around joint surfaces.

1. With the 2.8 mm Threaded Drill Guide in place, insert the 1.6 mm Wire Sleeve into the threaded drill guide.
2. Insert a threaded 1.6 mm Kirschner Wire through the wire sleeve and drill to the desired depth.
3. Verify K-wire placement under image intensification to determine if final screw placement is acceptable.
4. Measurement may be taken by sliding the tapered end of the Direct Measuring Device over the K-wire down to the wire sleeve.

Remove the Direct Measuring Device, K-wire and 1.6 mm wire sleeve, leaving the threaded drill guide intact.
Use the 2.8 mm Drill Bit to drill the near cortex. Remove the threaded drill guide. Insert the appropriate length locking screw.

Results

The present study consists of 23 cases of fracture of the distal metaphysical end of tibia. All the cases were fixed using locking compression plate. The study period was from June 2019 to September 2019.

Age distribution

The age of the patients ranged from 23-62 years with the fracture being most common in the 4th and 6th decade and an average age of 42 years.

Sex distribution

Out of 23 patients, 17 (70%) patients were males and 6 (30%) of patients were females showing male preponderance because of traveling and working in fields and factories.

Side affected

There were 16 (70%) patients with right distal ribia fractures 7(30%) patients with left distal fractures.

Mode of injury

In our study, 16(70%) of patients sustained injury following road traffic accidents in 7(30%) patient sustained injury following fall.

Fracture Characteristics

Clinical

Out of the 23 case, 19(82%) cases were closed fractures and 4(18%) cases were open fractures.

Open Fracture

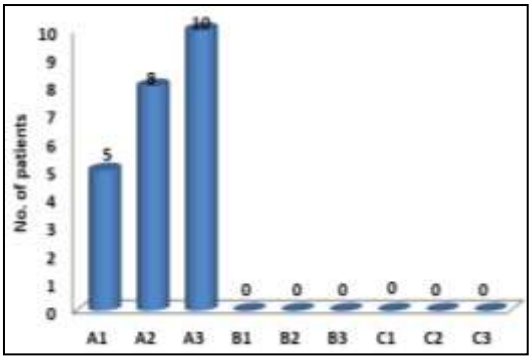
Classification of the 4 cases of open fractures classified based on Gustillo Anderson classification of open fractures, 2(50%) was type 1 compound 2(50%) were of type II compound.

Fracture Pattern

The fracture pattern was classified based on Rudie & Allgower classification for fracture of distal tibia of the 23 case studied, 5(22%) cases were A1, 8(35%) were A2, 10(43%) were A3.

Table 1: Showing fracture pattern

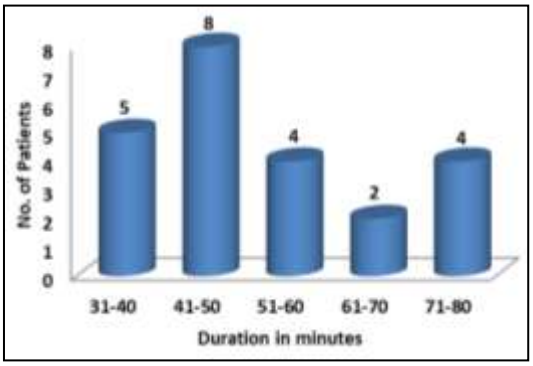
Type	No. of patients	Percentage
A1	5	22
A2	8	35
A3	10	43
B1	-	0
B2	-	0
B3	-	0
C1	-	0
C2	-	0
C3	-	0



Graph 1: Fracture pattern

Duration of surgery

Of the 23 case treated with locking compression plates 5(22%) cases took 31-40 minutes, 8(35%) took 41-50 minute, 4(17%) took 51-60 minutes 2(9%) took 61-70 minutes, 4(17%) took71-80 minutes.
The surgical time averaged 52 minutes.



Graph: Duration of surgery

Duration of fracture union:

All the fractures united with an average of 16weks. There was 1 delayed union with 20 weeks signs of radiological callus formation.

Table 2: Showing of duration of fracture union

Duration (in weeks)	No. of Patients	Percentage
14	10	43
16	6	26
18	6	26
20	1	5
Total	23	100

Fracture of 10 (43%) patients united in 14 weeks, 6(26%) patients united in 16 weeks, 6(26%) fractures united in 18 weeks and in 1 (5%) patients the fractured united in 20 weeks.

Fig 1: Pre-Operative X-ray

Fig 2: Immediate Post-Operative X-ray

Fig 3: 6-month Post-Operative X-ray

Conclusion

According to th*e* study, 23 patients with fractures of the distal tibial had undergone open reduction and closed reduction through MIPPO techniques of application of the locking compression plates. This technique has resulted in the effective stabilization of these fractures. It does provide adequate stability and allows early motion. The open reduction not only helps in achieving reduction in difficult situations, but also in rapid union, because it facilitates preservation of the blood supply to the fragment and anatomical reduction of the fracture. Its greatest advantage in open reduction and internal fixation with locking compression plates is anatomical reduction is achieved and fracture heamatoma is not disturbed much. It is also effective in extra articular fractures occurring within 5cm of the joint because, Intramedullary nails often do not provide enough stability and external fixators usually applied for primary stabilization and until soft tissue edema get subsided and delays the return to work with fixators.

It is a simple, has a rapid and straight forward application and has a reduced surgical time in more extra articular fractures and intra articular fractures due to newer anatomically contoured locking compression plates for the distal end tibia fractures. Although, a larger sample of patients and longer follow up are required to fully evaluate this method of treatment, we strongly encourage its consideration in the treatment of such complex fractures.

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