VOLUME - 11, ISSUE - 11, NOVEMBER - 2022 • PRINT ISSN No. 2277 - 8160 • DOI : 10.36106/gjra

Original Research Paper

Orthopaedics

A STUDY OF MINIMALLY INVASIVE PLATE OSTEOSYNTHESIS(MIPO) IN DISTAL TIBIAL METAPHYSEAL FRACTURE

Dr. Dhruv Sandip Shah

MS Ortho, Dept Of Orthopedics, SSG Hospital, Vadodara.

KEYWORDS :

INTRODUCTION

Among all the fractures in the body, tibia is the single largest bone that is commonly involved in injuries. Owing to increase in vehicular accidents and industrial mishaps, high velocity trauma produces tibial fractures in increasing numbers. Fractures of distal tibia are critical because the tibial bone in lower end is subcutaneous with minimal muscle cover and with precarious blood supply, which makes fracture in this part of the tibia prone for many complications like wound dehiscence, infections, delayed union, malunion and ankle stiffness following surgery or conservative management[1].

The mechanism of injury is axial loading due to talus hitting hard the lower end of the tibia[2]. The axial loading on the distal tibia determines the articular surface injury, metaphyseal communition, joint impaction and associated soft tissue injuries[3]. To preserve normal ankle function, it is must to maintain joint congruity, preserve the normal mechanical axis, ensure joint stability and restore full range of motion especially in Indian culture where squatting and sitting cross legged are must as a routine[4].

Management of distal tibial metaphyseal fractures is still a great challenge. Considering its anatomy, it is difficult to achieve and maintain reduction in these fractures. Reduction is even more difficult when a fibular fracture is found at the same level. This fracture pattern reflects a high-energy mechanism of trauma causing an increased angular and rotational instability, limb shortening and soft tissue injuries[5].

The ideal treatment for unstable distal tibial fractures remains controversial. Conservative management with pop cast application and immobilization leads to ankle stiffness (upto 30% of cases) as well as shortening and angulation at fracture site in significant number of cases[1].

Similarly, external fixation of metaphyseal tibial fractures may also be associated with a high incidence of pin site infection and loosening in up to 50% of the cases and malunion rates of up to 45%[5].

The interest in internal fixation has centered on the use of AO plates which have been well documented by Thunold and Roksendohl in the late part of twentieth century.

Conventional open reduction and internal fixation of such injuries results in extensive soft tissue dissection and periosteal injury, compromising the blood supply, and may be associated with high rates of infection, delayed union, and non-union[5].

Plating in open fractures lead to operative insult to already wounded soft tissue, implant failures and non unions. To achieve functional rehabilitation of the limb, anatomic reduction rigid internal fixation and early joint motion historically were stressed. Although constructs were quite stable biomechanically, healing often was delayed because of the extent of soft tissue dissection and bony devascularisation required, disturbing the biology of the soft tissue important to achieve fracture healing.

In current orthopaedic practice, minimally invasive plating osteosynthesis (MIPO) and interlocking nailing are the preferred techniques for fractures of the distal third tibia. Nail osteosynthesis is the preferred treatment in middle 3rd region shaft fractures, but is not always possible for distal third fractures with small metaphyseal fragment, spiral fractures and comminuted fractures.The intramedullary nail spares the extraosseous blood supply, allows load sharing, and avoids extensive soft tissue dissection. However, proximal and distal shaft fractures can be difficult to control with an intramedullary device, increasing the frequency of malalignment. Concerns regarding difficulties with reduction/loss of reduction, less rotational stability, inappropriate fixation in fractures with articular extension, anterior knee pain and hardware failure have slowed the acceptance of intramedullary nailing as a treatment of fractures of the distal tibia. The recent innovation of nails with tip locking is a testimony that earlier nails were insufficient fixation tools for distal tibia; however tip locking is technically difficult and fractures that require it are essentially difficult to fix with nails[6].

Indirect reduction was introduced in 1988 by Mast et al. and others. It was an attemptto decrease surgical dissection by relying on ligamentotaxis for repositioning of fragments, reduction aids such as the distracter and other methods to maintain soft tissue integrity and preserve bony perfusion. Additionally, plates were redesigned to limit contact with the underlying bone and further preserve bony vascularity. In the 1990s, krettek et al. popularized MINIMALLY INVASIVE PLATES OSTEOSYNTHESIS TECHNIQUES using conventional implant placed through a small incision and submuscular (subcutaneous) tunnels. These techniques aim to reduce surgical trauma and to maintain a more biologically favourable environment for fracture healing[4].

As part of continued development of biologically friendly plating, and to facilitate minimally invasive plating techniques, the use of plates that allow screws to lock into the plate to create fixed angle construct is gaining popularity nowadays. This new advance is represented by the "locked internal external fixators". It consists of plate and screw systems where the screws are locked in the plate at a fixed angle. Screw locking minimizes the plate and bone contact because the plate does not need to be tightly pressed against the bone to stabilise the fracture allowing less periosteal damage.

The system works as a flexible elastic fixation that stimulates callus formation allowing micro motion at fracture site. The anatomical shape prevents primary displacement of the fracture, and allows a better distribution of the angular and axial loading around the plate.

Minimally invasive plate osteosynthesis (MIPO) using anatomically contoured locking plate reduces introgenic soft tissue injury and preserves bone vascularity, and aims to achieve correct limb length and both axial and rotational alignment of the bone fragments with minimal damage at bone fracture site, while preserving fracture haematoma.

Despite with advances in identification, understanding and treatment of soft tissue injury and with the liberal use of CT scan, advances in implant design which includes locking plate technology, still the management of these challenging fracture remains elusive.

In the current study, 18 patients having metaphyseal distal tibial fracture were operated using MINIMALLY INVASIVE PLATE OSTEOSYNTHESIS (MIPO) Technique from March 2019 to October 2020, in department of orthopaedics, SSG hospital, vadodara. All patients were evaluated at 6 weeks, 12 weeks, 18 weeks and 24 weeks post-operatively. The outcome was measured by AOFAS (The American Orthopaedic Foot and Ankle Society) ankle–hindfoot score.

AIM AND OBJECTIVES:

· To evaluate the function outcome of treatment
· To clinically evaluate the radiological outcome i.e Rate of union
· Incidence of complications like non-union, infection.
· To compare the results with literature.

BIOMECHANICS AND IMPLANT DESIGN

Biomechanics of the ankle joint

Motion of the foot and ankle

The key movement of the ankle joint complex are plantar- and dorsiflexion, occurring in the sagittal plane; ab-/adduction occurring in the transverse plane and inversion-eversion, occurring in the frontal plane8 (Figure 1). Combinations of these motions across both the subtalar and tibiotalar joints create three-dimensional motions called supination and pronation. Both terms define the position of the plantar surface of the foot (sole). During supination, a combination of plantar flexion, inversion and adduction causes the sole to face medially. In pronation, dorsiflexion, eversion and abduction act to position the sole facing laterally.

Axis Of Rotation Of The Ankle

Whilst many authors consider the tibiotalar joint to be a simple hinge joint, there has been some suggestion that it is multi-axial, due to the internal rotation that occurs during dorsiflexion, and the external rotation that occurs in plantarflexion. However, there is evidence to suggest the tibiotalar joint is indeed uniaxial, but the simultaneous motion observed occur as a result of its oblique axis.The axis of rotation of the ankle joint complex in the sagittal plane occurs around the line passing through the medial and lateral malleoli (dotted line, Figure 2). The coronal plane axis of rotation occurs around the intersecting point between the malleoli and the long axis of the tibia in the frontal plane (Figure 2). The transverse plane axis of rotation occurs around the long axis of the tibia intersecting the midline of foot (Figure 3). Studies of the talar anatomy have highlighted the difference in radial curvature in the medial and lateral aspects, indicating the axis of rotation of the ankle joint will vary as motion changes. Based on this, a number of authors have proposed multiple axes of motion for the ankle joint during normal activity. Since the 1950s, it has been proposed there are a plantarflexion axis, which points upwards towards the lateral side of the ankle joint, and a dorsiflexion axis which is inclined downwards and laterally (Figure 4).

These are parallel in the transverse plane, but can differ by up to 30^0 in the coronal plane. Motion about these axes cannot occur simultaneously, and the transition between axes during motion is estimated to occur close to the neutral position of the joint. The axis of the subtalar joint is also an oblique axis, running from posterior to anterior forming an angle of approximately 40^0 with the anteroposterior axis in the sagittal plane, and forming an angle of 23^0 with midline of foot in the transverse plane. In a similar way to the tibiotalar joint, the subtalar joint creates multiple motion during plantar and dorsiflexion, resulting in pronation and supination.

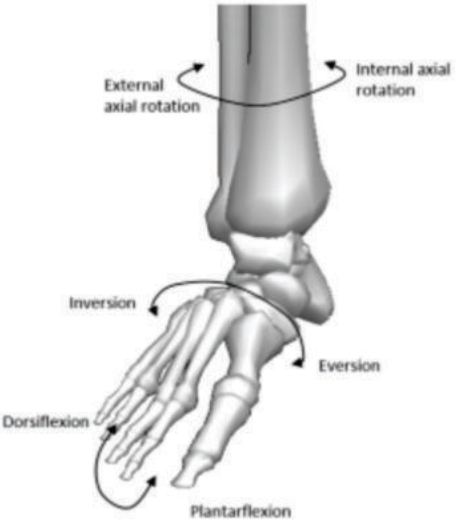


Figure 1 Diagram Illustrating Relative Motions Of The Ankle Joint Complex.

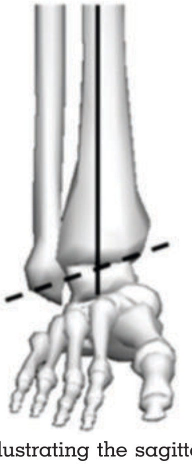


Figure-2 Diagram illustrating the sagittal and frontal plane axis of rotation for the ankle joint complex. Dashed line represents the axis of rotation for the dorsiflexion and plantarflexion. The intersecting point between the bold and dashed line represents the point of rotation for inversion and eversion.

Figure-3 Diagram illustrating the ankle joint complex axis of rotation in the transverse plane. The intersecting point represents the point of rotation for internal and external foot progression (toe in or toe out gait).

Range Of Motion

The ankle range of motion (ROM) has been shown to vary significantly between individuals due to geographical and cultural differences based on their activities of daily living, in addition to the method used for assessing ROM. Motion of the ankle occurs primarily in the sagittal plane, with plantar- and dorsiflexion occurring predominantly at the tibiotalar joint. Several studies have indicated an overall ROM in the sagittal plane of between 65 and 75^0, moving from 10 to 20^0 of dorsiflexion through to 40-55^0 of plantarflexion. The total range of motion in the frontal plane is approximately 35^0 (23 inversion 12 eversion). However, in everyday activities, the ROM required in the sagittal plane is much reduced, with a maximum of 30^0 for walking, and 37^0 and 56^0 for ascending and descending stairs, respectively. Historically there has been a convention where dorsi- and plantarflexion motion was solely attributed to the tibiotalar joint motion, and inversion-eversion was considered to occur only at the subtalar joint. More recently, the complete separation of the motions to each joint has been dismissed; most plantar/dorsiflexion is still considered to occur at the tibiotalar joint but with a few degrees accounted for at the subtalar joint. The distribution of inversion and/or eversion and rotation across the two joints has been an area of greater contention, with some studies indicating eversion to occur at the subtalar joint and rotation/inversion to occur at the tibiotalar, whereas others have shown version to be distributed across both joints. Whilst gait analysis can be used as an objective tool for quantifying motion of lower limb joints and forces that act upon these joints, gait analysis cannot separate the talocalcaneal (subtalar), tibiotalar (talocrural) and transverse-tarsal (talocalcaneonavicular) joint due to the major limitation of accurately measuring talus motion using skin-mounted markers. However, despite this limitation, gait analysis is still a commonly used tool for the quantification of ankle joint complex kinematics and kinetics.

Figure 4 depicts example gait analysis data of the ankle joint complex kinematics, kinetics and powers. During a normal gait cycle, the stance phase can be split into three sub-phases based on the sagittal motion of the ankle; i) the heel rocker; ii) the ankle rocker and iii) the forefoot rocker. The heel rocker phase begins at heel strike, where the ankle is in a slight plantarflexed position pivoting around the calcaneus (the continuation of plantarflexion) until the end of the heel rocker phase when the foot is flat on the ground. During this sub-phase the dorsiflexors are eccentrically contracting to lower the foot to the ground. The ankle rocker phase is where the ankle moves from plantarflexion to dorsiflexion during which the shank (tibia and fibula) rotate forward around the ankle allowing forward progression of the body.

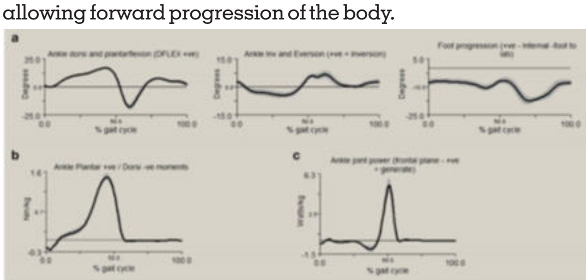


Figure 4- Diagram illustrating typical outputs from gait analysis of five walking trials. a) representing ankle complex rotation in sagittal, frontal and transverse planes (left to right, respectively); b) sagittal plane ankle moments and c) sagittal plane ankle power. The shaded area on all graphs represents +1 standard deviation.

During the forefoot rocker phase, the foot rotates around the forefoot phase, starting when the calcaneus lifts off the ground evident by the ankle beginning to plantarflex and continuing until maximum plantarflexion (approximately 14^0) being achieved at toe-off, where power generation is achieved for the leg to begin the swing phase. During swing phase the ankle dorsiflexes enabling the foot to clear the ground and avoiding stumbling/tripping, before returning to slight plantarflexion at heel strike. This flexion motion is complemented by motion at the sub-talar joint, with approximately 15^0 of eversion/inversion. For the majority of individuals, inversion occurs at heel-strike, and progresses to eversion during mid-stance phase, allowing the heel to rise and push off into swing.

Forces In The Ankle Joint

The ankle joint complex bears a force of approximately five times body weight during stance in normal walking, and up to thirteen times body weight during activities such as running. The ankle moment obtained from gait analysis (see Figure 4b) demonstrates a dorsiflexion moment at heel strike as the dorsiflexors eccentrically contract to control the rotation of the foot onto the ground and prevent the foot from slapping the ground. During the second phase, there is a plantarflexor moment as the ankle dorsiflexors contract eccentrically to allow forward progression of the shank over the foot. During the third phase, the plantar flexion moment continues with the plantar flexors contracting concentrically towards toe-off. As walking speed increases, ankle kinetic patterns remain similar in profile but with greater magnitudes. Ankle joint moments acquired from gait analysis do not commonly report ankle moments in the coronal or transverse planes due to the complex nature of movement of the ankle joint complex and the high variability between individuals.

Ankle power (Figure 4c) varies when the major muscles acting on the ankle joint complex are either absorbing or generating power during gait. The negative values correspond with power absorption from the plantar flexors eccentrically contracting during the heel and ankle rocker phases. The maximum joint power of the ankle joint complex is generated at approximately 50% of gait cycle during the forefoot rocker phase corresponding with the power generation of the plantarflexors required for the lower limb to propel the body forward towards toe-off.

Experimental studies have indicated that approximately 83% of load is transmitted through the tibiotalar joint, with the remaining 17% transmitted through the fibula. The amount of load transferred through the fibula varies, with increased loading occurring during dorsiflexion. Of the load carried across the tibial-talar joint, between 77% and 90% is applied to the talar dome, with the remaining load distributed across the medial and lateral surfaces. This load distribution is a function of both ligamentous forces and positional effects, with the medial facet experiencing highest load during inversion, and the lateral facet exposed to highest load during eversion.

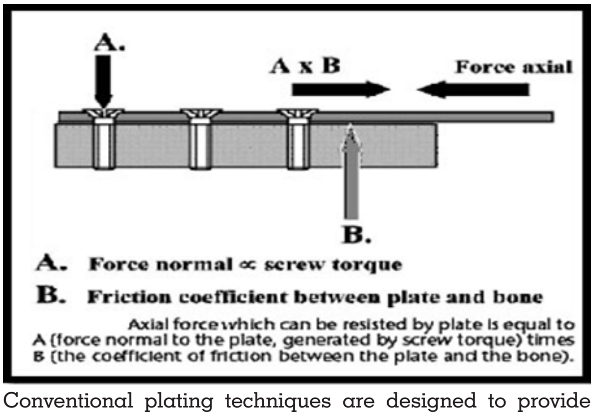
The ankle has a relatively high level of congruency, meaning that despite experiencing high loads during normal activities, the load-bearing area of the ankle is large (11-13 cm^2), and it has been proposed that this should result in lower stress than at the hip or knee.5 The majority of contact analysis within the ankle has been conducted through computational prediction or cadaveric experimentation, which clearly have limitations for assessing in-vivo conditions. A statically applied load of 1.5 kN (approximately twice body weight) in a cadaveric study, with the ankle in a neutral position demonstrated a mean contact pressure of 9.9 MPa, and a contact area of 483 mm^2, significantly less than the area proposed previously. Exploration of the pressures under static loading with the ankle in positions reflecting phases of the gait cycle indicate that contact pressures are generally higher in plantarflexion than ibn dorsiflexion. Weight bearing MRI and fluoroscopy has shown that the largest contact area occurs during the stance phase of gait, with lower contact at both toe-off and

VOLUME - 11, ISSUE - 11, NOVEMBER - 2022 • PRINT ISSN No. 2277 - 8160 • DOI : 10.36106/gjra

heel strike.

CONVENTIONAL PLATE BIOMECHANICS

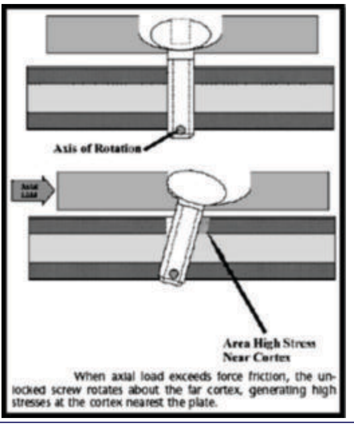
The function of standard plate and screw constructs depends upon the stability requirements of a particular fracture. Plate-screw-bone constructs can act as load-bearing devices depending on fracture reduction and fragment interference. Neutralization plates function as load-shearing devices. These plates are placed across a fracture, already reduced and compressed by lag screws, to neutralize the effect of bending, rotational and axial forces on the fracture site. Buttress plates and antiglide plates are load bearing devices that act to counter shear forces at a fracture site by converting them to compressive axial forces. These plates are place at the apex of the fracture; the plate-screw construct acts as a load –bearing devices. This technique is used to treat many articular fractures.



Axial force which can be resisted by plate is equal to A (force normal to the plate, generated by screw torque) times B (the coefficient of friction between the plate and the bone).

Conventional plating techniques are designed to provide absolute stability. When employed properly as compression plates or neutralization plates, conventional plates have the ability to resist axial, torsional and bending loads. This is particularly true when no fracture gap exists and the plate is placed on the tension side of the fracture. Conventional plating techniques are currently reserved for the articular segments of fractures or simple diaphyseal fracture where anatomic healing is crucial.

The necessary normal force between the plate and the bone to prevent plate motion generates compressive forces under the plate that prevent periosteal perfusion. Prevention of periosteal perfusion can lead to a "compartment syndrome" under the plate that can result in periosteum and bone necrosis deep to the plate and adjacent to the fracture site. In turn, this can then lead to localized bone resorption at the screw threads and result in loosening of the plate; although it is noted that studies demonstrated maintenance of compressive forces between the plates and bone in vivo at up to 3 months. Attempts to minimize this problem led to design and manufacture of the limited contact plate (LC-DCP). The LC-DCP reduces contact by 50%but still relies on the plate-bone interface for stability.



When axial load exceeds force friction, the unlocked screw rotates about the far cortex, generating high stresses at the cortex nearest the plate.

BIOMECHANICS OF MIPPO TECHNIQUE

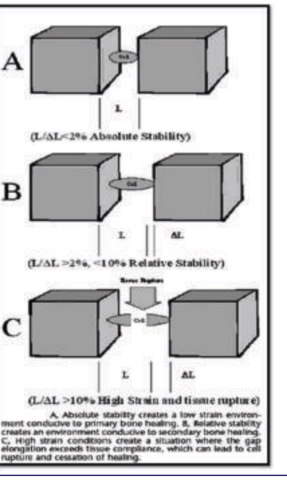
The concept of stability is crucial in fracture surgery. Increasing degree of fracture stability can be provided by splints, casts, intramedullary devices, external fixators, locked plates and compression plates. Stability determines the amount of strain at the fracture site, and strain determines the type of healing at the fracture site. Primary bone healing occurs is kept to less than 2%, Secondary bone healing occurs when strain is kept between 2% to 10%. Bone can not be formed when strain is greater than 10%.

Strain is defined as the relative change in fracture gap divided by the fracture gap (fracture gap strain ΔL/L) (Fig. 1). In a 1979 article, Perren observed that "tissue cannot be produced under strain conditions which exceed the elongation at time of tissue rupture"Elongation at the time of tissue rupture for lamellar bone is 2% and almost 100% for granulation tissue. Fibrous tissue, tendon, and bone have decreasing tolerance for elongation and prepare the fracture site mechanically and biologically for solid bone union, solid bone union having the least tolerance for elongation.

Fracture gap strain determines the type of healing that occurs at the fracture site. Primary bone healing (endosteal healing) occurs when there is absolute stability (rigid fixation) at the fracture site. Its occurrence requires that motion be kept to a minimum and strain must be less than 2%. Compression plating and neutralization plating provides rigid fixation, minimizing strain by decreasing gap motion and prohibiting increase in gap length. By reducing gap lengths (L) to zero, compression and neutralization plating can create very high gap strains if any fracture site motion (ΔL) persists. Accordingly the fixation methods demand that the plates be placed on the tension side of the fracture so that fracture compression is assured and excess gap motion is prevented.

Secondary bone healing (enchondral ossification) occurs when relative stability is provided and strain is kept between 2% and 10%. Splints, casts, locked plates and external fixators and plating with MIPPO technique (spanning the fracture site) provide this relative stability. Secondary bone healing is characterized by callus formation.

The healing cascade that results in callus formation starts with the formation of hematoma. Hematoma is followed by inflammation and the formation of fibrous tissue. Eventually, mesenchymal stem cells differentiate to form new cartilage, which will finally ossify into bone. Tissue differentiation results in tissue that become progressively more rigid and less tolerant to strain until the most rigid material, cortical bone is formed. Each step in the healing cascade decreases the motion at the fracture gap, and therefore the gap strain, ultimately creating an environment conducive to bone formation.



A, Absolute stability creates a low strain environment conducive to primary bone healing. B, Relative stability creates an environment conducive to secondary bone healing. C, High strain conditions create a situation where the gap elongation exceeds tissue compliance, which can lead to cell rupture and cessation of healing.

Gap strain is reduced by parameters that increase the gap length or decrease motion. Gap length can be increased by fracture comminutionand/or imperfect reduction. Bone resorption at the fracture site can decrease strain by increasing gap length. If motion does not increase as a result of this absorption, strain may be reduced. Strain reduction then, in turn, may lead to the return of relative stability.

Relative stability and secondary bone healing are the goals of the newer "BILOGIC FIXATION TECHNIQUES". Bridging fixation provided by splints, casts, external fixators, intramedullary nails, and locked plate constructs, including the plating with MIPPO technique decrease gap strain by minimizing motion while tolerating an increased gap length.

LOCKING COMPRESSION PLATE BIOMECHANICS

The clinical need for the development of locked plates arose from the failure of standard plate and screw constructs to meet the demands of minimally invasive and indirect bridging fixation, as well as a failure of compression plating techniques to provide an environment favorable to secondary bone healing. Implants that heal the fractures by secondary bone healing are favored for diametaphyseal areas and instances where anatomic reduction is not essential for good function. Newer locked plates control the axial orientation of the screw to the plate, thereby enhancing screw-beam construct.

A single beam construct is created when there is no motion between the components of the beam i.e. the plate, screw, and bone. Single-beam constructs are 4 times stronger than load-sharing beam constructs where motion occurs between the individual components of the beam constructs. Locked compression plates are single beam constructs by design.

As a single beam construct, locked screw-plate construct act as fixed-angle devices. Functioning as a fixed-angle device, locked plates can enhance fracture fixation in circumstances where fracture configuration or bone quality do not provide sufficient screw purchase to achieve the plate-bone interfaces; fixation is improved because bone has much higher resistance to compressive stress than shear stress.

Fixation is further improved by the inherent angular and axial stability of locked plates. When implanted, locked plates act as "internal external fixators" (Extremely rigid fixators) because of their close proximity to the bone and fracture site. Fixation rigidity is a function of the pin (screw) material, length, and diameter and the material and dimensions of the fixators bar (plate). Screw length for locked plates are 10 to 15 times shorter than for external fixators, greatly increasing fixation rigidity. Strain at the fracture site is optimized, so that secondary bone healing with callus formation is favored over fibrous nonunion or primary bone healing. Stability across the plate becomes a function of the mechanical properties of plate. Relative stability of the fracture is achieved when the plate is properly sized to the loading situation.

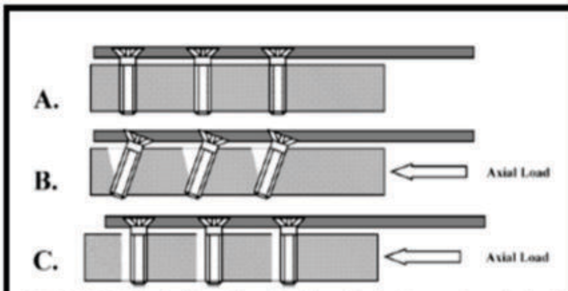


FIGURE 5. Much like other fixed-angle devices, when locked plates fail in bending and axial loading, large areas of bone must fail in compression. The fixed bolts experience the majority of the load perpendicular to their axes.

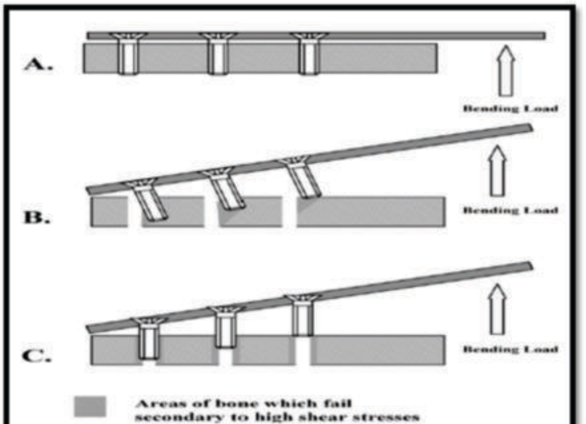


FIGURE 4. A, Bending load applied to plate–screw–bone construct. B, Screws not locked to plate rotate within the plate, orienting parallel to the load applied. Fixation strength is equal to bone shear stress times the area of bone within the screw threads.

Locking plates stabilize bone fragments by means of the attachment of the screw to the plate in a rigid, fixed angle coupling, usually accomplished with threads in the screw head, plate hole, or both. This locking of screw to plate makes the fixation construct more resistant to failure from sequential screw loosening and pullout. Because all the screws in a single bone fragment are locked to the plate at fixed angles, they must fail as a unit rather than individually and sequentially. This feature may be of particular advantage in osteoporotic bone with thinner cortices; in this situation, nonlocking screws cannot generate as much plate to bone compression, so the frictional forces resisting motion are less. In addition, the fixed angle nature of the plate and screw fixation resists cantilever bending stresses and reduces the risk of angular deformity in metaphyseal fractures that are comminuted, missing bone or otherwise mechanically unable to share load. It has been proposed that the reduced plate to bone compression afforded by locking plates serves to protect the viability of the bone by maintaining micro vascular circulation within the cortex and its investing tissues.

FRACTURE HEALING IN MINIMALLY INVASIVE PERCUTANEOUS PLATE OSTEOSYNTHESIS

The classical stages of bone healing as described by Hunter are:

1. Inflammation
2. Soft callous
3. Hard callous
4. Remodelling

Bringhton aptly said that healing of fractured bone is reparative osteogenesis and added stages of impact and induction to above list of bone healing.

Johncharnley, studied the fracture healing process and differentiated the healing of cancellous bone which unites by contact, without callous formation and required controlled collapse from the healing of cortical bone which heals by callous formation. He has his phase theory of healing of cortical bone.

The healing of bone has been described as:

Fracture Exudate

It's produced by cells migrating to the active site in stage of inflammation. It contains hematoma, platelets, prostaglandin, growth factor and biochemical inducers like TGF (â), PGE2, Interleukin 1, BMP. The BMP is Bone Morphogenic Protein believed to arise from fracture bone from the osteoprogenitor cells, progenitor of osteogenic cell line.

With the advent of anatomical reduction and internal fixation the concept of primary bone healing in "SondreAnlogenr" (Danis and Lane) came into being. Parren et al. redescribed it as direct bone healing and Hunter' stages as indirect bone healing. Direct bone healing takes place in anatomically reduced and in fractures which are stable after fixation.

Histologically, there is development of organelle composed of osteoblasts, osteoclasts and capillaries going across the fracture site.

A variant of this healing is Gap Union in which the gap at fracture site is filled up by bone of different orientation other than lamellar bone.

Vascularity And Stability

The importance of vascularity of fracture site is unopposed as it forms the fracture exudates. Most of the internal fixation started with attempt of rigid fixation in trying to achieve anatomical reduction, violated the vascularity of bone.

Controlled motion of fracture fragments, physiologically induced, is the single most important factor in early bone healing. (A Sarmiento)

Movement between the fracture fragments brings biochemical and biomechanical phenomenon releasing PG E2 and other growth factors. The movement in the longitudinal axes of the bone at the fracture site is not only helpful but crucial for bone healing.

Recently the hypothesis of regeneration torus has been proposed. This says that where fracture is not stable, the body creates organelles of transient stability. This is torus or doughnut shaped. This is induce by injury or mechanical instability from vascular cells or local cell it aids rapid stabilization of site by organization of fibrous tissue which then changes to bony tissue.

Edmonchao has modified the classification of bone healing based on above facts:
I. Non-Osteal bone Union
II. Osteal bone Union

Primary Bone Healing

1. Primary Contact Healing
2. Primary Gap Healing

Secondary Bone Healing

1. Secondary Contact Healing
2. Secondary Gap Healing.

In primary bone healing mechanical integrity of bone is not restored until the end of remodeling and therefore required support for the duration of consolidation phase.

In secondary bone healing stabilization occurs rapidly and is achieved by periosteal callous which provides a sturdy bridge of bone tissue across the fracture gap. This is physiological as it involves a natural feedback mechanism by the tissue in the presence of fracture.

STABILITY AND FRACTURE HEALING

The concept of stability is crucial in fracture surgery. Increasing degree of fracture stability can be provided by splints, casts, intramedullary devices, external fixators, locked plates and compression plates. Stability determines the amount of strain at the fracture site, and strain determines the amount of strain at the fracture site, and strain determines the type of healing that can occur at the fracture site. Primary bone healing occurs is kept to less than 2%, Secondary bone healing occurs when strain is kept between 2% to 10%. Bone cannot be formed when strain is greater than 10%.

Fracture gap strain determines the type of healing that occurs at the fracture site. Primary bone healing (endosteal healing) occurs when there is absolute stability (rigid fixation) at the fracture site. Its occurrence requires that motion be kept to a minimum and strain must be less than 2%.

Secondary bone healing (enchondral ossification) occurs when relative stability is provided and strain is kept between 2% and 10%. Splints, casts, locked plates and external fixators and plating with MIPPO technique (spanning the fracture site) provide this relative stability. Secondary bone healing is characterized by callous formation.

The healing cascade that results in callous formation starts with the formation of hematoma. Hematoma is followed by inflammation and the formation of fibrous tissue. Eventually, mesenchymal stem cells differentiate to form new cartilage, which will finally ossify into bone. Tissue differentiation results in tissue that become progressively more rigid and less tolerant to strain until the most rigid material, cortical bone is formed each step in the healing cascade decreases the motion at the fracture gap, and therefore the gap strain, ultimately creating an environment conducive to bone formation.

IMPLANT DESIGN

Plate

Three types of plate used in our study.
A. Distal tibia metaphyseal locking plate,
B. Clover leaf plate,
C. Anatomical distal tibia locking plate.

Plate Designs

- Anatomically contoured plate, twisted 20 degrees and bent to fit distal tibia.
- Limited contact shaft with screw holes from 5+4 to 5+9.
- 5 holes distally accept 3.5 mm cortical, 3.5 mm cortical locking and 4 mm cancellous screws.
- Distal hole for 1.6 or 2 mm kirschner wire.
- Proximal screw holes accept 4.5 cortical or 5 mm locking cortical screws.
- Locking holes in distal region are parallel to joint.
- Plate is of low profile for minimal prominence on medial malleous.
- MM and 4 mm cancellous screw sit flush with plate to prevent prominence at medial malleous.
- Rounded edges to minimize soft tissue irritation
- Clover leaf plate is desingned for multipurpose orthopaedics uses and lacks properties of newer designs

Distal Tibia Metaphyseal Locking Plate

Distal Tibia Metaphyseal Locking Plate

Anatomical Distal Tibia Locking Plate

Anatomical Distal Tibia Locking Plate

Clover Leaf Plate

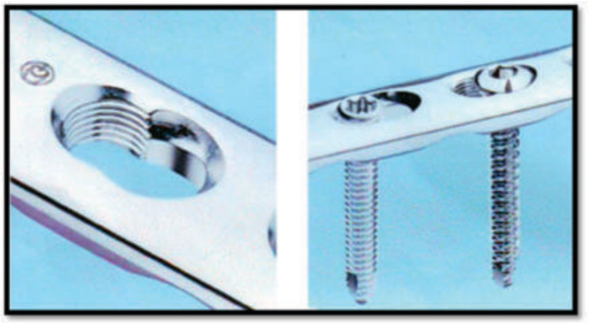
Clover Leaf Plate

COMBI HOLES
It is the combination of locking hole and compression holes.

The LCPcombi holes allows placement of conventional cortex and cancellous bone screw on one side and threaded conical locking screw on the opposite side of the same hole.

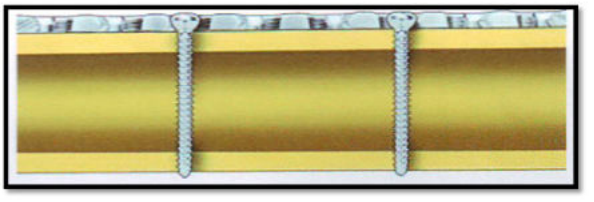
FIXED ANGLE STABILITY
The locking screws mate with the threaded plate holes to form a fixed angle construct.

UNICORTICAL FIXATION OPTION
Unicortical locking screws provide stability and load transfer only at the near cortex due to the threaded connection between the plate and the screw. Because the screw is locked to the plate, fixation doesn't rely solely on the pullout strength of the screw or on the frictional force between the plate and the bone.

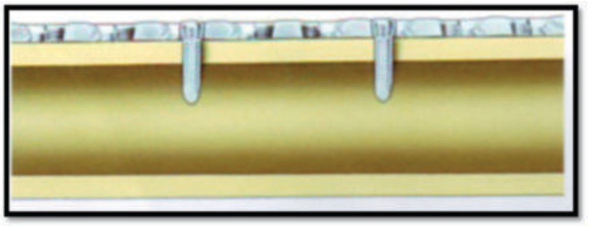


Combi Holelocking Simple

Screw Screw



Bicortical Simple Screws



Unicortical Locking Screws

SCREW DESIGNS
SCREWS
4.5 MM CORTEX SCREW
The 4.5 mm cortex screw is a fully threaded non-self tapping screw. Pretapping of cortical bone is necessary before insertion of the screw. The thread and the polished surface allow easy removal of the screw, even though hard cortical bone has grown between the threads during healing.

The 4.5 mm cortex screw has a smooth tip. It is important for the holding power of the screw that the threads engage the entire far cortex. The tip of the screw and one or two threads should therefore protrude on the opposite side of the bone. In hard cortical bone the 4.5 mm cortex screw has a holding strength of approximately 2500 N (250 kg).

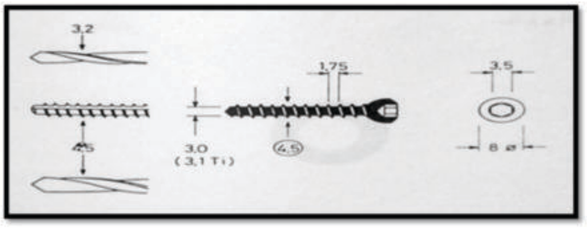
Measurement of the screw length is rounded up rather than down to ensure optimal holding power. The 4.5 mm cortex screws are available in lengths from 14mm to 110 mm in stainless steel and from 14 mm to 140 mm in titanium.

Important Dimensions	
Head diameter	8.0 mm
Hexagonal socket width	3.5 mm

Core diameter	3.0 mm (titanium 3.1mm)
Thread diameter	4.5 mm
Pitch	1.75mm
Drill bit for gliding hole	4.5 mm
Drill bit for thread hole	3.2 mm
Tap diameter	4.5 mm

4.5 MM Screw

4.5MM Screw



4.5 MM Screw Dimensions

5.0 MM LOCKING CORTEX SCREW

5 MM Locking Cortex Screw

The 5 mm cortical locking screw is a fully threaded self tapping screw. Pretapping of cortical bone is not necessary. The threaded head locks inside the plate, once screw gets locked inside the hole. The screw head lies flush with plate. The thread and the polished surface allow easy removal of the screw, even though hard cortical bone has grown between the threads during healing.

The 5 mm cortical locking screw has a serrated tip. It is not important for the holding power of the screw that the threads engage the entire far cortex, as only monocortical purchase is equal to bicortical purchase in case of locking screws.

The 5 mm locking head screws are available in 14mm to 110 mm in stainless steel and from 14mm to 140 mm in titanium.

Important Dimensions	
Head diameter	8.0mm
Hexagonal socket width	3.5mm
Core diameter	4.0mm
Thread diameter	5.0mm
Pitch	1.0mm
Drill bit for thread hole	4.5 mm

The simple screws in the simple hole can be angulated a bit but the locking screw can not be angulated and they seat exactly 90 degrees to the plate. The locking screws are 5 mm self tapping screws and are inserted with drill till the locking head gets purchase with the plate.

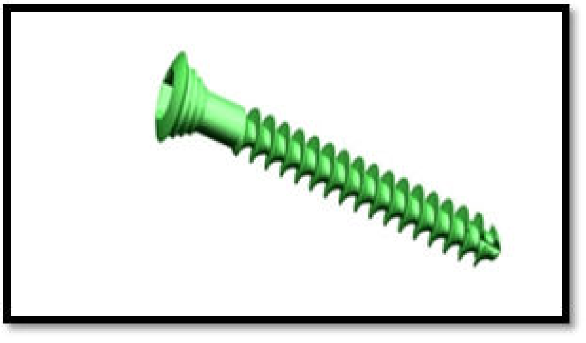
3.5 MM CORTEX SCREW

CORE DIAMETER	2.4 MM
DRILL BIT	2.5 MM
SHAFT DIAMETER	3.5 MM
CORTICAL TAP	3.5 MM
HEAD DIAMETER	6 MM
HEXAGONAL SOCKET	2.5 MM

4 MM CANCELLOUS SCREW

DRILL B IT	**2.7 MM DRILL BIT**
EXTERNAL DIAMETER OF SHAFT	2.6 MM
GUIDE WIRE DIAMETER	1.6 MM
SCREW HEAD DIAMETER	5.1 MM
WITH REVERSE CUTTING FLUTES, CANCELLOUS THREAD PROFILE, SELF DRILLING, SELF TAPING THREADS WITH SPHERICAL UNDERSIDE.	

3.5 MM CORTEX SCREW



NON CANNULATED LOCKING CANCELLOUS SCREW

CANNULATED CANCELLOUS SCREW

MATERIALS AND METHODS

This prospective study was carried out in the selected group of patients treated for DISTAL TIBIA METAPHYSEAL FRACTURES by MIPO Distal Tibia plate from March 2019 to October 2020 in the department of Orthopaedics, medical college and SSG Hospital, Vadodara. Written and informed consent was obtained from all patients.

CRITERIA FOR PATIENT SELECTION

Inclusion Criteria

1. Patients above age of 18years.
2. The fractures of the distal tibia without intra-articular extension (including lower third fractures of tibia)
3. Closed fractures, fractures with Open Grade-I Injury.

Exclusion Criteria

1. Anaesthetically unfit patient.
2. Open Grade II & III injuries patients.

METHOD OF TREATMENT

At casualty

As soon as patient arrived at the casualty, thorough history was taken including personal details, side affected, mode of injury, time of injury, associated with bleeding or not etc. Patient was evaluated physically including vital signs and systemic comorbidites and local part condition to identify whether the fracture is of open or closed variety.

A) Primary Treatment

The patient was examined thoroughly for vital signs, head injury, thoraco-abdominal injury and other associated injuries. The distal circulation was checked and was examined for any neurological deficit. All wounds (if any) were covered by sterile dressing after cleansing with betadine and H_2O_2 and normal saline wash. Full length x-rays in antero-posterior and lateral views were taken of affected leg for diagnosis, extent of comminution and later on to measure likely length of plate. Temporary immobilization was given by above knee posterior plaster splint. Tetanus prophylaxis in form of Tetanus Toxoid and Tetanus immunoglobulin (tetglob) were given. Parenteral antibiotics were started in patients having open grade-I fractures.

Preoperative Radiograph

Ankle Traction In Lower Third Tibia Fractures

B) Pre-Operative Treatment

Affected limb was kept elevated on Bohler Braun splint in straight limb in ward and all routine blood investigations and physician and anaesthetic fitness were carried out as necessary for surgery.

Patients having edematous local site were given anti-edema prophylaxis in form of typsin,bromelain and rutoside tablet along with glycerin –$MgSO_4$ dressing.

C) Timing Of Surgery

The closed fractures were operated as early as possible. If definitive fixation was delayed due to any reason,(i.e patient having significant swelling) external fixator was done primarily.

D) Selection Of Implant

In tibial fractures anatomical distal tibial metaphyseal plate was considered according to the fracture geometry on antero-posterior and lateral view of the affected limb.

E) Pre Operative Measurement Of Implant Size

Pre operatively on antero-posterior view and lateral view, the size of the implant was measured considering the magnification of the x-rays. The size was determined as implant should hold 6-8 cortices on the metaphysis and 6-8 on diaphysis spanning the fracture site.

ANAESTHESIA

Spinal, epidural or general anaesthesia could be given to the patient. But in most of the patients spinal anaesthesia was preferred.

Position

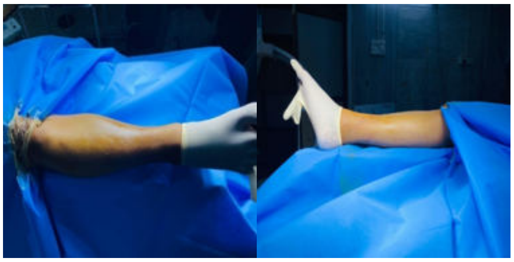
Patient was taken on the plain radiolucent table in supine position. The affected limb was scrubbed and prepared with savlon. Painting and draping was done under asepsis and antiseptic conditions. Draping was done in such a manner that the area from middle of the thigh to whole foot was exposed for proper recognition of anatomical landmarks. The foot was covered with either sterile pad or hand gloves.

Injectable antibiotic in form of injection cefoperazone-sulbactam 2gm was administered intravenously 30 minutes prior to incision.

MIPO DISTAL TIBIA PLATE

- Preliminary Reduction

After patient was prepared, preliminary reduction was done with traction and manipulation under image intensifier using k-wires, Steinmann pin and reduction foreceps.



Instrument Trolly **Draping**

INCISION AND PLATE INSERTION:

Distally:

For minimally invasive plate insertion, small incision of 3-4 cm length was vertically placed distal to the fracture over the medial aspect of tibia to access the medial malleolus with care not to injure saphenous vein. An epiperiosteal, subcutaneous tunnel was created with a periosteal elevator or osteotome or long anatomical distal tibia plate using blunt dissection. Precontoured anatomical locking compression plate for the tibia was then inserted along the tunnel. The plate was slided under IITV image control and position was confirmed in Anteroposterior and Lateral views.

The plate was secured by k-wire hole at any one end unicortically.

Incision at Entry

Provisional Fixation

REDUCTION OF FRACTURE FRAGMENTS AND PROVISIONAL FIXATION

The fracture fragments were reduced and reduction was confirmed using image intensification. They were reduced in form of alignment as well as length by applying manual traction as well as varus –valgus force and rotation. If the fracture geometry was such that it required interfragmentary compression then a standard lag screw was inserted percutaneously. The cortical screw was first inserted to flush the plate to the bone in proximal fragment in oblique fashion to avoid future stress-riser.

SCREW INSERTION DONE BY PERCUTANEOUS METHOD:

The screws were inserted with percutaneous method. Under IITV guidance, with knife small incision was kept over the combi hole either for cortical or locking screw.

1. Insertion of Distal Screws

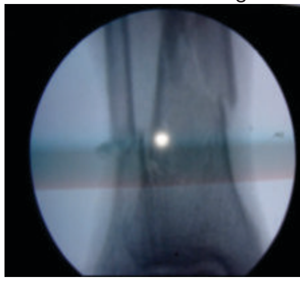
- The plate distally had accepted 4.0 mm locking screw or 4 mm cancellous screws. Thread the 3.5 mm drill guide in the distal locking hole until fully seated.
- After that we removed the drill guide and inserted locking screw under power.
- Once the plate was fixed proximally and distally by one screw in each fragment, k-wires were removed.

2. Insertion of Proximal Screws

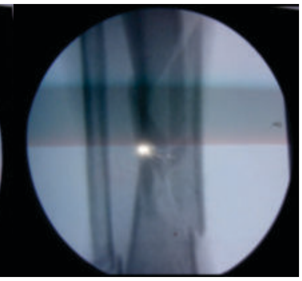
- The plate proximally had accepted 3.5 mm cortex or 4 mm cortex locking screws. For 4 mm locking screw insertion, we had used 3.5mm drill guide. For 3.5 mm cortical screw insertion, we had used 2.8 mm drill guide. The drill guide was inserted until fully seated.

Closure

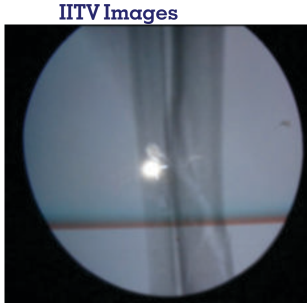
- The stab wounds were closed using ethilon 2-0 suture. Wound was cleaned and sterile dressing was applied.
- Below knee slab was applied and patient was shifted to the ward after vital signs were stable.



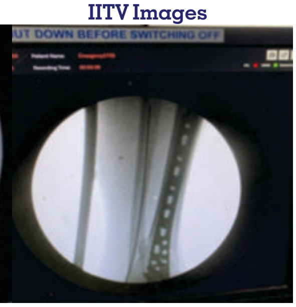
IITV Images



IITV Images

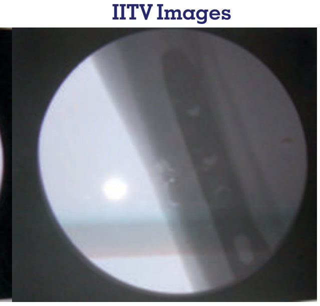


IITV Images

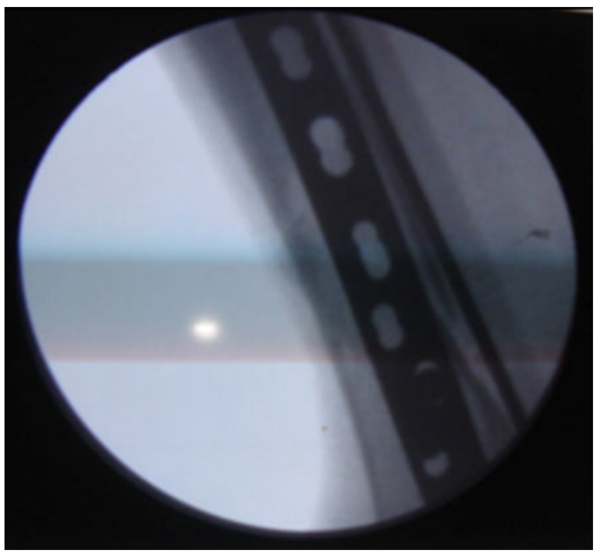


IITV Images

IITV Images



IITV Images



Post-Operative Protocol

The foot end was elevated. The drug protocol was as follows: Intravenous Cefoperazone-sulbactam (2gm) and Amikacin (500mg) injection were given twice a day dosage for first two post- operative days. Patients were shifted to oral antibiotics in form of tablet cefuroxime 500mg in twice a day dosage and tablet levofloxacin 500mg once a day till sutures were removed.

Intravenous injection of Tramadol (100 mg in 100 ml normal saline) twice a day and intravenous paracetamol infusion (1000 mg) four times a day was used for analgesia.

Oral calcium supplementation in form of calcium carbonate (500mg once a day) was started simultaneously. If serum vitamin D_3 deficiency was found in pre-operative blood investigation, it was managed with intramuscular injection of vitamin D_3(6 lac IU) or oral vitamin D_3 supplementation (60000 IU once a week for 10 weeks)

Physiotherapy And Mobilization

After post operative x-ray, quadriceps strengthening exercises and knee mobilization exercises were started, as soon as patients' general condition and pain permitted.

Non weight bearing crutch walking was permitted. After suture removal passive ankle range of motion was started and the patient was discharged with non weight bearing crutch walking for 4 weeks.

FOLLOW UP AND EVALUATION

The patients were followed up in the out patient department. Follow up was conducted regularly at the interval of 4 weeks. Sutures were removed on 10-14th post-operative day. On follow up the patients were evaluated clinically and radio logically according to the proforma. Once the fracture showed signs of union, partial weight bearing was started. Bone union was defined as presence of bridging callus on three of the four cortices on radiograph and the ability to full weight bearing without pain.

At final follow-up i.e. 24 weeks, AOFAS score was calculated. For alignment measurement, anteroposterior and lateral radiographs were made from both legs. Alignment was measured using Johnson's angle. Hereby the angle between the tibia axis and the joint line was measured in A-P plane, which should be between 88^0 and 90^0; a varus or valgus deviation could then be determined easily.

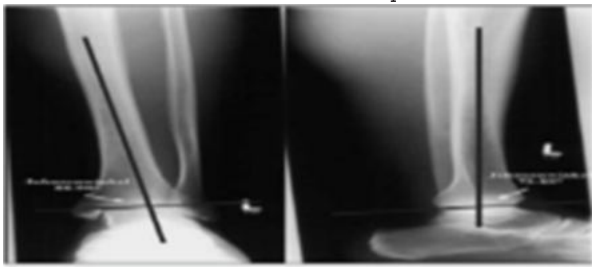


Fig- Johnson angle

These noted findings were then tabulated and series of observations and results pertaining from these observsations were identified.

DISCUSSION AND ANALYSIS

The treatment of distal tibia fractures can be challenging because of the limited soft tissue coverage, the subcutaneous location of the bone and poor vascularity. Though conservative management of these fractures has been described, these methods have been largely superseded by operative techniques for displaced or irreducible fractures. There are various techniques and approaches to surgically treat distal tibia fractures, including intramedullary nailing, external fixator, ORIF and MIPO. Each type of fixation has its own advantages and disadvantages.

IMN(Intra-medullary Nailing) performed in an antegrade fashion for treatment of distal tibia fractures has been associated with a high rate of knee morbidity. Studies have reported chronic anterior knee pain among the more common complications. Fracture malalignment has also been reported with nails. Randomized prospective comparison study of IMN versus plate osteosynthesis was performed by vallier and colleagues. They reported an increased rate of 23% malalignment with the use of IMN to plating.

Metaphyseal fractures of the tibia are often associated with significant soft tissue injury. The key point in management is to recognise the importance of the soft tissue component. Failing to appreciate the soft tissue condition will invariably complicate the injury with infection, wound dehiscene or non-union. The results of operative treatment are dependent on the severity of the initial injury and the quality and stability of reduction. The most important factor is to achieve stable fixation and to allow early range of motion without unnecessary osseous and soft tissue devascularisation. Minimally invasive techniques are based on principles of limited exposure, indirect reduction methods and limited contact between bone and implant. As a result of these principles this technique, as seen in our present study, avoided major soft tissue complications and shortened the hospital stay. Minimally invasive plating techniques reduce iatrogenic soft tissue injury and damage to bone vascularity, as well as preserve the osteogenic fracture hematoma.

The present study is compared with following studies:

1) Paluvadi, S. V., Lal, H., Mittal, D., & Vidyarthi, K. (2014). Management of fractures of the distal third tibia by minimally invasive plate osteosynthesis - A prospective series of 50 patients. Journal of Clinical Orthopaedics and Trauma, 5(3), 129–136. https://doi.org/10.1016/j.jcot.2014.07.010

2) Ronga, M., & Longo, U. G. (2009). Minimally Invasive Locked Plating of Distal Tibia Fractures is Safe and Minimally Invasive Locked Plating of Distal Tibia Fractures is Safe and Effective. May 2014. https://doi.org/10.1007/s11999-009-0991-7

3) Mudgal Ashwani, Daolagupu AK., Agarwala V and Sinha AK.-Management of fractures of the extra articular distal tibia by minimally invasive plate Osteosynthesis—A prospective series of 21 patients.,International Journal of Medical Research & Health Sciences, 2016, 5, 6:276-282

Table-1: Comparison with study of Paluvadi, S. V., Lal, H., Mittal, D., & Vidyarthi, K. (2014). Management of fractures of the distal third tibia by minimally invasive plate osteosynthesis - A prospective series of 50 patients

Parameter	Present study	Paluvadi, S. V., Lal, H., Mittal, D., & Vidyarthi, K. (2014). Management of fractures of the distal third tibia by minimally invasive plate osteosynthesis - A prospective series of 50 patients
No. Of patients	18	50
Mean age (range)	43(21-60)	36(20-56)
Male / female	13/5(2.6)	35/15 (2.33)
Fracture classification (OA/OTA)	43-A: 94% 43-B: 6%	90%-43-A 6%-43-B 4%-43-C
Avg. Duration between trauma and surgery	4 days	4.36 days
Mean operative time	60 minutes	86.233 minutes
Union time	12-18 weeks	16-32 weeks
Complications a. Infection b. Implant failure	 None None	 5 1

c. Malunion d. Implant extraction	None none	1 9
AOFAS score(final follow-up)	98	95.05

Table-2: Comparison with study Mudgal Ashwani, Daolagupu AK., Agarwala V and Sinha AK.-Management of fractures of the extra articular distal tibia by minimally invasive plate Osteosynthesis

Parameter	**Present study**	**Mudgal Ashwani, Daolagupu AK., Agarwala V and Sinha AK.-Management of fractures of the extra articular distal tibia by minimally invasive plate Osteosynthesis- a prospective series of 21 patients**
No. Of patients	18	21
Male/ female	13/5(2.6)	15/6(2.5)
Mean age(years)	43	39.09
Mechanism of injury A.RTA B. falls C. assault D. others	 14 3 1	 14 3 3 1
Fracture classification(OA/OTA) Type 43A1 Type 43A2 type 43A3	 10 4 3	 10 9. 2
Duration of surgery	60	66.67$\pm$ 5.55
Weight bearing (weeks) Partial weight bearing Full weight bearing	 6 10	 6.90$\pm$ 1.33 13.38$\pm$ 1.24
Union time(weeks)	18	21.7
Complications 1. Infection 2. Malalignment 3.Dalyed union 4. Joint stiffness 5. Implant impingement	 None None None 2 none	 4 3 1 5 5
AOFAS Score (final follow up)	98	96.5

Table -3: comparison with the study of Ronga, M., & Longo, U. G. (2009). Minimally Invasive Locked Plating of Distal Tibia Fractures is Safe and Minimally Invasive Locked Plating of Distal Tibia Fractures is Safe and Effective.

Parameter	**Present study**	**Ronga, M., & Longo, U. G. (2009). Minimally Invasive Locked Plating of Distal Tibia Fractures is Safe and Minimally Invasive Locked Plating of Distal Tibia Fractures is Safe and Effective**
No. Of patients	18	21
Male/ female	13/5	12/9
Mean age (years)	43	43
Time b/w trauma and surgery(days)	4	6.5
Fracture classification(OA/OTA) Type 43A Type 43B	 17 1	 12 5
Type 43C	0	4
Hospital stay	7 days	11 days
Union	18^{th} week	24^{th} week
Deformity	none	1- valgus deformity 3- varus deformity
Restricted ankle range of motion($>20^{0}$)	none	5
Complications 1.Superficial infection 2.Deep infection 3.Others	 1 None None	 6 3 1-Complex regional pain syndrome 4-Deep vein thrombosis

- In present study, we have addressed 18 patients having distal tibial metaphyseal fracture.
- In our study we did single- staged fixation of all distal tibial fractures except in one patient (no. 14) in whom external fixator was done primarily.
- We used medial anatomical distal tibial locking plate for all cases. The plate was low profile plate of 3.5mm system. The thread holes in the plate were locked to the screw head and that minimised plate –bone interface and maintained the vascularity at the fracture site.
- In our study, the mean age was 43 years which was comparable to the studies by Mario ronga et al. and other studies. The age of the patient had no bearing on the time of union in our study.
- In our study more number of male patients were involved than female, i.e. 72% compared to the study conducted by Mario ronga et.al in which it was 60% ,and mudgal ashwani et. al in which it was 72%.
- In our study, majority of the patients (78%) were having injury due to road traffic accident. Among them, 2 patients were having head injury. RTA remained the single largest cause of trauma which was comparable to other studies also.
- In our study, fractures were operated within a week of the injury. Mario ronga et al. and sidhdhartha VP et al. have also reported the same. As the time interval between surgery and injury increased, it became difficult to indirectly reduce the fracture fragments.
- In present study, 1 patient had post- operative superficial wound infection. However, it healed after treatment with appropriate antibiotics and aseptic dressing and infection didn't appear to have any long term effect on fracture healing or the rehabilitation. The study conducted by Mario ronga et al was having 6 cases of superficial wound infection, 3 cases of deep infection, 1 case of complex regional pain syndrome and 4 cases of deep vein thrombosis. In the study of sidhdharth VP et. al there were 4 case of infection.
- In our study, the avg. Union time was 18.7 weeks whereas in study of Mario ronga et. al it was 24 weeks. In study of sidhdhartha VP et. al it was 16-23 weeks and in study of mudgal ashwini et. al ,it was 21.70 weeks.
- In our study, there were no cases of malunion or malalignment. In the study conducted by Siddhartha VP et.al, there was a case of malunion and also a case of implant failure. In the same study 9 patients required implant extraction either because of hardware impingement or infection. The study of Mario ronga et. al, had one case of valgus deformity and 3 cases of varus deformity.
- In present study,one patient was having $<10^{0}$ restricted ankle dorsiflexion and another one in which there was 10-20^{0} restricted ankle dorsiflexion, whereas in the study of Mario ronga et. al, $>20^{0}$ reduction in ankle dorsiflexion was found in 5 patients.
- In present study, clinical results were evaluated according to the AOFAS score chronologically. The avg. AOFAS score at final follow up was 98. The study conducted by Siddhartha VP et. al had reported mean score of 95.05.

The mean score in the study conducted by mudgal ashwani et.al was 96.5.

SUMMARY AND CONCLUSION

This study was conducted in Department of Orthopaedics, S.S.G Hospital and Medical College Baroda and included 18 patients having Distal Tibial Metaphyseal Fracture fixed using Minimally Invasive Plate osteosythesis(MIPO) Technique between March 2019 to October 2020.

- Most of the patients in our study were in the middle age group 21-60 years. The mean age was 43 years.
- Male to female ratio was 2.6:1
- In our study labourers (manual and farm) were 88%
- Road traffic accident was the single largest cause for fracture comprising 78%.
- Patients having close fracture were 89% whereas open grade-1 fracture were 11%.
- According to OA/OTA classification, 17 out of 18 patients were having 43A type of fracture. 1 patient was having 43B type of fracture
- There were two patients who had head injury, one patient was having ipsilateral metatarsal injury and another one was having ipsilateral proximal humerus fracture.
- All the patients were operated within a week of the trauma.
- All the fractures were fixed using anatomical distal tibial locking plate with the commonest being 5*7 hole plate.
- Patients were discharged within 2 days after surgery.
- Average time for union was 18.7 weeks.
- One patient was having superficial wound infection and another two were having ankle joint stiffness.
- 90% of the patients didn't have any pain. In two patients, there was complaint of pain on walking on uneven surfaces.
- None of the patient had limb length inequality.
- All the patients were able to walk without support , only one patient had limp while walking.
- The mean AOFAS score at final follow up was 98.

To conclude, The MIPO technique is a reliable fixation approach to fractures of the distal third tibia as it preserves most of the osseous vascularity and fracture haematoma and thus provides more biological repair. 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 tibial fractures with small distal metaphyseal fragments, vertical split and markedly comminuted fractures.

The present study shows that metaphyseal fractures of tibia without intra-articular extension managed well with minimally invasive plating. It involves minimal surgical trauma. It provides the advantages of early ambulation, lower rates of infection and early union. Overall Minimally invasive plating allows early functional restoration and best radiological outcome.

ANNEXURE

PROFORMA

A STUDY OF MINIMALLY INVASIVE PLATE OSTEOSYNTHESIS (MIPPO) IN DISTAL TIBIA METAPHYSEAL FRACTURE

P.G.TEACHER:-
Dr. Hemant H. Mathur (M.S. Ortho)
Professor & Head
Department of Orthopedics
Medical College &
SSG Hospital, Baroda

STUDENT:-
Dr. Dhruv Sandip Shah
(M.B.B.S)

PROFORMA

1. Bio Data

Name:
Age: Sex:
Profession:
Address:
Reg.No:
Date of Injury: Date of Admission:
Date of Operation: Date of Discharge:

2. HISTORY
- Side Affected :
- Mode of Trauma :
  a) Vehicular Accident :
  b) Fall of Weight :
  c) Assault :
  d) Fall form Height
- Injury-admission interval :
- Injury surgery interval :
- H/o preexisting disease, systemic / local :

3. Clinical Examination
- Type of injury – Close / Open
- Neurovascular deficit
- Associated Injuries

4. Classification
- AO classfication
- Gustilo`s classification.

5. Treatment
- Preoperative Radiography:

(a) Pre-op X-ray
o Type of fracture
-Comminuted -Transverse
-Spiral -Oblique
o Intra-articular or not
o Osteoporosis

(b) Size of implant
Operative details
I. Anaesthesia – SA, GA, Epidural, Regional
IV. Incision – length in centimeters – proximal, distal.
V. Number of screws inserted – proximal, distal, Inter fragmental
VI. Operative time
VII. Number of blood transfusions.(if any)
VIII. Bridged area.
(a) No. of screws left out
(b) In centimeters bridged skin

6. Post – Operative evaluation :
o Immediate post operative
(a) Fixation
o Stable
o Unstable

(b) Alignment
I. Acceptable.
II. Unacceptable(>5 degree of valgus/varus; >10 degree of procurvatam/ recurvatum)
¨ Condition of surgical wound post op.
¨ Condition of Open wound post op.
¨ Mobilization
- Period of non – weight bearing mobilization (weeks)
- Partial weight bearing allowed at (weeks)
- Full weight bearing allowed at (weeks)
¨ Time of suture removal
¨ TotalHospital Stay.

7. Complications
- Early

(a) Compartment syndrome
(b) Infection
I. Superficial
II. Deep.

- Late

(a) Non union
(b) Delayed union
(c) Implant failure
(d) Osteomyelitis.
(e) Fracture at plate end

FOLLOW – UP

In six weekly follow-up we have assessed patient radiologically and clinically according to our Performa.

Clinically	6Wk	12Wk	18 Wk	24wk
• Status of Surgical Wound				
• Status of Open Wound				
• Pain				
• Physio protocol(AnkleRange of movement)				
• Persistence of non healing				
• Infection if any				
• Varus / Valgus angulation				
• Partial weight bearing				
• Full weight bearing				
Follow up X –Rays.				
• Alignment				
• Time of Union				
• Signs of infection if any				
Complications at follow-up				
• malunion.				
• Nonunion				
• Loosening of plate				
• Breakage of Screws				
• Prominent hardward				

Final Follow up(PROFORMA-B)

AOFASAnkle-HindfootScale

PatientName:__________
PatientMRN:__________
Date:__________

I. Pain(40points)

None	+40
Mild,occasional	+30
Moderate,daily	+20
Severe,almostalwayspresent	+0

II. Function(50points)

Activitylimitations,supportrequirements

Nolimitations,nosupport	+10
Nolimitationofdailyactivities, limitationsofrecreationalactivities, nosupport	+7
Limiteddailyandrecreational activities,cane	+4
Severelimitationofdailyand recreationalactivities,walker, crutches,wheelchair,brace	+0

Maximumwalkingdistance,blocks

Greaterthansix	+5
Four -six	+4
One-three	+2
Lessthanone	+0

Walkingsurfaces

Nodifficultyonanysurface	+5
Somedifficultyonuneventerrain, stairs,inclines,ladders	+3
Severedifficultyonuneventerrain, stairs,inclines,ladders	+0

Gaitabnormality

None,slight	+8
Obvious	+4
Marked	+0

Sagittalmotion(flexionplusextension)

Normalormildrestriction(30 °or more)	+8
Moderaterestriction(15 °-29 °)	+4
Severerestriction(lessthan15 °)	+0

Hindfootmotion(inversionpluseversion)

Normalormildrestriction(75% - 100%normal)	+6
Moderaterestriction(25% -74% normal)	+3
Markedrestriction(lessthan25%of normal)	+0

Ankle-hindfootstability(anteroposterior, varus-valgus)

Stable	+8
Definitelyunstable	+0

III. Alignment(10points)

Good,plantigradefoot, ankle -hindfoot wellaligned	+10
Fair,plantigradefoot, somedegreeof ankle-hindfootmalalignment observednosymptoms	+5
Poor,nonplantigradefoot,severe malalignment,symptoms	+0

IV. TotalScore(100points) :

_____PainPoints+
_____Function Points +
_____Alignment Points =

_____Total Points/100points

REFERENCES

1. G R, Kumar N R. Study of Complications and Functional Outcome of Fixation of Distal Tibial Fractures With Anatomical Locking Plate Using Mipo Technique. J Evol Med Dent Sci. 2017;6(31):2489-2492. doi:10.14260/jemds/2017/539
2. Blauth M, Bastian L, Krettek C, Knop C, Evans S. Surgical options for the treatment of severe tibial pilon fractures: A study of three techniques. J Orthop Trauma. 2001;15(3):153-160. doi:10.1097/00005131-200103000-00002
3. Egol KA, Kubiak EN, Fulkerson E, Kummer FJ, Koval KJ. Biomechanics of locked plates and screws. J Orthop Trauma. 2004;18(8):488-493. doi:10.1097/00005131-200409000-00003
4. Parikh M, Mukherjee S, Patel N, Dhond A, Khedekar R. Minimally Invasive Plating of High Energy Metaphyseal Proximal Tibial Fractures: Our Experience. J Evol Med Dent Sci. 2015;04(20):3433-3442. doi:10.14260/jemds/2015/496
5. Sanjay M. Minimally invasive plate osteosynthesis of peri- articular fractures of distal tibia□: A clinical study. 2018;2(2):1-3.
6. Paluvadi SV, Lal H, Mittal D, Vidyarthi K. Management of fractures of the distal third tibia by minimally invasive plate osteosynthesis - A prospective series of 50 patients. J Clin Orthop Trauma. 2014;5(3):129-136. doi:10.1016/j.jcot.2014.07.010
7. Brockett CL. Biomechanics of the ankle. Orthop Trauma.:1-7. doi:10.1016/j.mporth.2016.04.015
8. S.M. Perren, Evolution of the internal fixation of long bone fractures. The scientific basis of biological internal fixation: choosing a new balance between stability and biology. J Bone Joint Surg Br, 84-8 (2002), pp. 1093–1110.
9. E. Hasenboehler, D. Rikli, R. Babst, Locking Compression Plate with Minimally Invasive Plate Osteosynthesis in diaphyseal and distal tibial fracture: A retrospective study of 32 patients, Injury, Volume 38, Issue 3, March 2007, Pages 365-370
10. D.J Redfern, S.U Syed, S.J.M Davies, Fractures of the distal tibia: minimally invasive plate osteosynthesis, Injury, Volume 35, Issue 6, June 2004, Pages 615-620
11. Lau TW, Leung F, Chan CF, Chow SP. Wound complication of minimally invasive plate osteosynthesis in distal tibia fractures. Int Orthop. 2008 October; 32 : 697 – 703.
12. Leung FK, Law TW. Application of minimally invasive locking compression plate in treatment of distal tibia fractures. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2009 Nov;23(11):1323-5
13. Mario Ronga, Umile Giuseppe Longo and Nicola Maffulli. Minimally Invasive Locked Plating of Distal Tibia Fractures is Safe and Effective. Clinical Orthopaedics and related Research. Volume 468, Number 4, 975-982
14. Mudgal Ashwani, Daolagupu AK., Agarwala V and Sinha AK.- Management of fractures of the extra articular distal tibia by minimally invasive plate Osteosynthesis—A prospective series of 21 patients., International Journal of Medical Research & Health Sciences, 2016, 5, 6:276-282
15. Gray's text book of anatomy, 38th edition, pages 690-697.
16. Principles of fracture management by ajit j. ThakurR. Texhammar c. Colton,' ao/asif instruments and implants – a technical guide.'A biomechanics of locked plates and screws', journal of orthopaedics trauma, vol 18 no. 8 sept 2004.
17. Vidoviæ D, Matejèiæ A, Ivica M, Jurišiæ D, Elabjer E, Bakota B. Minimally-invasive plate osteosynthesis in distal tibial fractures: Results and complications. Injury. 2015 Nov;46 Suppl 6:S96-9. doi: 10.1016/j.injury.2015.10.067. Epub 2015 Nov 14. PMID: 26584733.
18. Lai TC, Fleming JJ. Minimally Invasive Plate Osteosynthesis for Distal Tibia Fractures. Clin Podiatr Med Surg. 2018 Apr;35(2):223-232. doi: 10.1016/j.cpm.2017.12.005. Epub 2018 Feb 1. PMID: 29482791.
19. Puloski S, Romano C, Buckley R, Powell J. Rotational malalignment of the tibia following reamed intramedullary nail fixation. J Orthop Trauma. 2004 Aug;18(7):397-402. doi: 10.1097/00005131-200408000-00001. PMID: 15289683.
20. Baumgaertel F, Buhl M, Rahn BA. Fracture healing in biological plate osteosynthesis. Injury. 1998;29 Suppl 3:C3-6. doi: 10.1016/s0020-1383(98)95002-1. PMID: 10341891.
21. Luhr HG. Entwicklung der modernen Osteosynthese [The development of modern osteosynthesis]. Mund Kiefer Gesichtschir. 2000 May;4 Suppl 1:S84-90. German. doi: 10.1007/PL00022964. PMID: 10938647.
22. Rüedi TP, Allgöwer M. The operative treatment of intra-articular fractures of the lower end of the tibia. Clin Orthop Relat Res. 1979 Jan-Feb;(138):105-10. PMID: 376196.
23. Aksekili MA, Celik I, Arslan AK, Kalkan T, Uðurlu M. The results of minimally invasive percutaneous plate osteosynthesis (MIPPO) in distal and diaphyseal tibial fractures. Acta Orthop Traumatol Turc. 2012;46(3):161-7. doi: 10.3944/aott.2012.2597. PMID: 22659631.
24. Guo JJ, Tang N, Yang HL, Tang TS. A prospective, randomised trial comparing closed intramedullary nailing with percutaneous plating in the treatment of distal metaphyseal fractures of the tibia. J Bone Joint Surg Br. 2010 Jul;92(7):984-8. doi: 10.1302/0301-620X.92B7.22959. Erratum in: J Bone Joint Surg Br. 2010 Dec;92(12):1717. PMID: 20595119.
25. Shabbir G, Hussain S, Nasir ZA, Shafi K, Khan JA. ORIGINAL ARTICLE MINIMAL INVASIVE PLATE OSTEOSYNTHESIS OF CLOSE FRACTURES OF DISTAL TIBIA Ghulam Shabbir , Shujaat Hussain , Zulfiqar Ahmad Nasir , Kamran Shafi ,. 2011;23(2):121-124.
26. Bahari S, Lenehan B, Khan H, McElwain JP. Minimally invasive percutaneous plate fixation of distal tibia fractures. Acta Orthop Belg. 2007 Oct;73(5):635-40. PMID: 18019921.
27. Francois J, Vandeputte G, Verheyden F, Nelen G. Percutaneous plate fixation of fractures of the distal tibia. Acta Orthop Belg. 2004 Apr;70(2):148-54. PMID: 15165017.
28. Borens O, Kloen P, Richmond J, Roederer G, Levine DS, Helfet DL. Minimally invasive treatment of pilon fractures with a low profile plate: preliminary results in 17 cases. Arch Orthop Trauma Surg. 2009 May;129(5):649-59. doi: 10.1007/s00402-006-0219-1. Epub 2006 Sep 2. PMID: 16951937.
29. Ovadia DN, Beals RK. Fractures of the tibial plafond. J Bone Joint Surg Am. 1986 Apr;68(4):543-51. PMID: 3957978.
30. Rhinelander FW. Tibial blood supply in relation to fracture healing. Clin Orthop Relat Res. 1974 Nov-Dec;(105):34-81. PMID: 4609655.
31. Zelle BA, Bhandari M, Espiritu M, Koval KJ, Zlowodzki M; Evidence-Based Orthopaedic Trauma Working Group. Treatment of distal tibia fractures without articular involvement: a systematic review of 1125 fractures. J Orthop Trauma. 2006 Jan;20(1):76-9. doi: 10.1097/01.bot.0000202997.45274.a1. PMID: 16424818.