“A CLINICAL STUDY OF PROXIMAL TIBIAL FRACTURES TREATED WITH LOCKING COMPRESSION PLATE”

By

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Dissertation submitted to

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In partial fulfillment

Of the requirements for the degree of

MASTER OF SURGERY

IN

ORTHOPAEDICS

Under the guidance of

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2015

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DR. SHARATH BABU MUKKA

LIST OF ABBREVIATIONS

DOA	-	Date of admission
M	-	Male
ROM	-	Range of movement
F	-	Female
DOD	-	Date of discharge
R	-	Right
RTA	–	Road traffic accident
L	-	Left
Med	-	Medial
OA	-	Osteoarthritis
Lat	–	Lateral
INF	-	Infection
CR	-	Closed reduction
Ex Fix	-	External Fixator
B/K	-	Below knee
UE	-	Upper end
A/K	-	Above knee
FWB	-	Full weight bearing
ORIF	-	Open reduction and internal fixation
B/L	-	Bilateral
F/U	-	Follow up
WK	-	Weeks
EV	-	Elevation
DOM	–	Domestic

Fig	-	Figure
CCS	-	Cannulated cancellous screw
BG	-	Bone graft
MCL	-	Medial collateral ligament
ACL	-	Anterior cruciate ligament
PCL	-	Posterior cruciate ligament
DCP	-	Dynamic compression plate
LCP	-	Locking compression plate
BP/S	-	Buttress plate and screws

ABSTRACT

INTRODUCTION:

Knee joint is one of the major weight bearing joints in the lower extremity. The proximal tibial fractures are one of the commonest intra-articular fractures. Generally these injuries fall into two broad categories, high energy fractures and low energy fractures. Fractures of the proximal tibia are the results of high-energy injuries, and because of the lack of soft tissue coverage in this region. The majority of tibial plateau fractures are secondary to high speed velocity accidents and fall from height. Fractures result from direct axial compression, usually with a valgus or varus moment and indirect shear forces.

The aim of surgical treatment of proximal tibia fracture is to restore congruent articular surfaces of the tibial condyles maintaining the mechanical axis and restoring ligamentous stability eventually can achieve functional painless and good range of motion in the knee joint.

OBJECTIVE:

- The objective is to study the functional outcome and duration of union in proximal tibial fractures treated with locking compression plate.

METHODS:

The study was conducted between the period of october 2013 to august 2015 in Shri. B.M. Patil medical college, hospital and research centre, VIJAYAPUR. 26 patients with diagnosis of proximal tibial fractures were treated with locking compression plate. All Schatzker's classification type 1 to 6 proximal tibial fractures in adults aged 18 years and above of either sex were included in the study. All patients were followed up. With each follow up, clinical and radiological examinations were performed at 6 weeks, 3months and 6months.

RESULTS:

The study included 26 patients, 25 male and 1 female aged from 21 to 80 years with mean age of 41.03 years. The average time for fracture union in our series was 16.61 weeks. In the present study, knee stiffness was observed in 2 patients. Our study yielded excellent to good results in 80% of the cases.

CONCLUSION:

Displaced tibial plateau fractures are best managed operatively. Optimal knee function is achieved by accurate anatomical reduction and secure fixation followed by early mobilisation to attain functional arc of motion.

For minimally displaced fractures with minimal bone defects percutaneous fixation suffices where as for more comminuted fractures open reduction and internal fixation is mandatory.

Post operative rehabilitation protocol in terms of non-weight bearing and achieving satisfactory range of motion needs to be strictly adhered to, in order to obtain optimal functional results.

In our study we found that proximal tibial locking plate provides complete union and early mobilisation to attain better functional outcome.

KEY WORDS: Proximal tibial fractures, locking compression plate

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INTRODUCTION

The knee joint is one of the major weight bearing joints in the lower extremity. Proximal tibial fractures are one of the commonest intra-articular fractures. Generally these injuries fall into two broad categories, high energy fractures and low energy fractures. Fractures of the proximal tibia are the results of high-energy injuries, and because of the lack of soft tissue coverage in this region, it is vulnerable and open fractures are commonly encountered. In such cases, the treatment of damaged soft tissues is of primary concern.[1]

The majority of tibial plateau fractures are secondary to high speed velocity accidents and fall from height.[2]

Fractures result from direct axial compression, usually with a valgus or varus moment and indirect shear forces.[3]

The aim of surgical treatment of proximal tibia fracture is to restore congruent articular surfaces of the tibial condyles maintaining the mechanical axis and restoring ligamentous stability eventually can achieve functional painless and good range of motion in the knee joint.[4]

The various clinical studies established that bone beneath a rigid conventional plate is thin and atrophic which are prone for secondary displacement due to insufficient buttressing and secondary fractures after removal of plate, fracture site take longer period to osteosynthesis due to interruption of vascular supply to bone due to soft tissue and periosteal stripping. So there was the birth of a new concept of biological fixation using the plates, otherwise called minimally invasive percutaneous plate osteosynthesis (MIPPO).

But this was difficult as conventional plates needed to be accurately contoured to achieve good fixation, osteoporosis also posed the same problem of poor fixation with conventional plates this lead to the development of the internal fixators.[5] Point contact-fix I later Point contact fix-II.

As more and more concepts about biological fixation become clearer the innovation of plates progressed and lead to the development of less invasive stabilizing system. Research to combine these two methods has lead to the development of the anatomically contoured locking compression plate .[6]

This new system is technically mature as it offers numerous fixation possibilities and has proven to worth in complex fracture situations and in osteoporotic bones.

AIMS AND OBJECTIVES OF THE STUDY:

The aim of the present study was

- To study the functional outcome and duration of union in proximal tibial fractures treated with locking compression plate.

REVIEW OF LITERATURE

SURGICAL ANATOMY OF KNEE JOINT [7-9]

Introduction

The field of surgery of the knee has rapidly increased in the scope in the past decade through the basic and clinical research of many individuals. Knee is composed of: Osseous structures Extra-articular structures Intra-articular structures. Stability of the knee joint is ensured by dynamic and static structures. Knee joint was described by Potočnik *et al*,[7] as the largest and most heavily loaded joint of the human body

Knee is a trochoginglymoid joint that derives its physiologic joint play and its typical rolling-gliding mechanism of flexion and extension from its six degrees of freedom - three in translation and three in rotations.

The translations of the knee take place on the anterior-posterior, medial-lateral, and proximal-distal (compression-distraction) axes. Knee is a semi-hinge joint that permits flexion and extension, and limited varus-valgus and internal-external rotations.

The knee bone surfaces of the femur, tibia and patella are covered with a thin layer of articular cartilage which represents the weight bearing surface.

Femur is the largest, longest and strongest bone in the knee. The distal part has two condyles, the lateral and medial condyle. Four knee ligaments attach to this bone at the ‘origo’ attachment site and multiple muscle groups are connected to the femur.

The second biggest bone in the knee is tibia, also known as the shin bone. Tibia forms the connection from the knee to the ankle joint, and consists of a plateau and the tibial tubercle in the proximal part.

Three knee ligaments attach proximally to this bone as an insertion location i.e. anterior cruciate ligament, posterior cruciate ligament and medial collateral ligament

The third long bone in the knee is fibula, which runs along the lateral side of the tibia from the knee to the ankle joint. Fibula and the lateral side of the femur are connected by another knee ligament, which is the lateral collateral ligament

The fourth bone in the knee is the patella, which has a flat and triangular shape. Besides protecting the frontal part of the knee joint, the main function of the patella is to increase the lever arm of the Quadriceps femoris muscle complex.

The distal part of the femur and the proximal part of the tibia are covered with cartilage, providing a smooth layer for joint articulation. The cartilage layers provide damping of the joint contact forces, and play an important role in the lubrication of the joint. The joint is lubricated by synovial fluid, which is contained within the synovial membrane called the joint capsule.

Between the articular cartilages surface of the femur and the tibia, the medial and lateral meniscus are located, which act as shock absorbers and load distributors for the articular cartilage. Furthermore, the menisci have a stabilizing effect of the knee joint. Each meniscus is attached to the tibia through the horns.

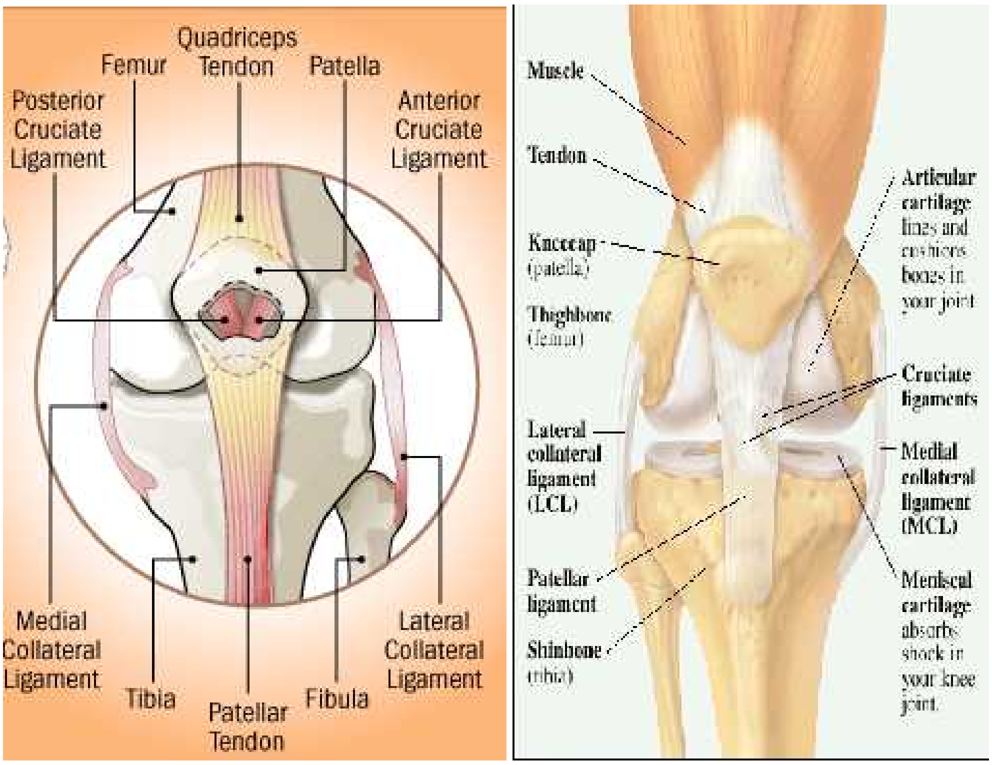


Figure 1: Knee Joint Structures

Arterial Anastomosis around Knee Joint

The genicular anastomosis is a rich and intricate interconnection of several arteries in the vicinity of the knee joint.

This arterial anastomosis supplies the distal femur, proximal tibia, patella, joint capsule, synovium and superficial tissues. Vascular injection techniques have demonstrated that the anastomosis is composed of two interconnected arterial networks: a superficial network located in the superficial tissues, and a deep network situated adjacent to the bone and fibrous capsule of the knee joint. The arteries which make up the genicular anastomosis are:

1. The medial and lateral superior genicular arteries
2. The medial and lateral inferior genicular arteries, the descending genicular artery and its branch the saphenous artery
3. The anterior and posterior tibial recurrent arteries, the circumflex fibular artery and the descending branch of the lateral circumflex femoral artery

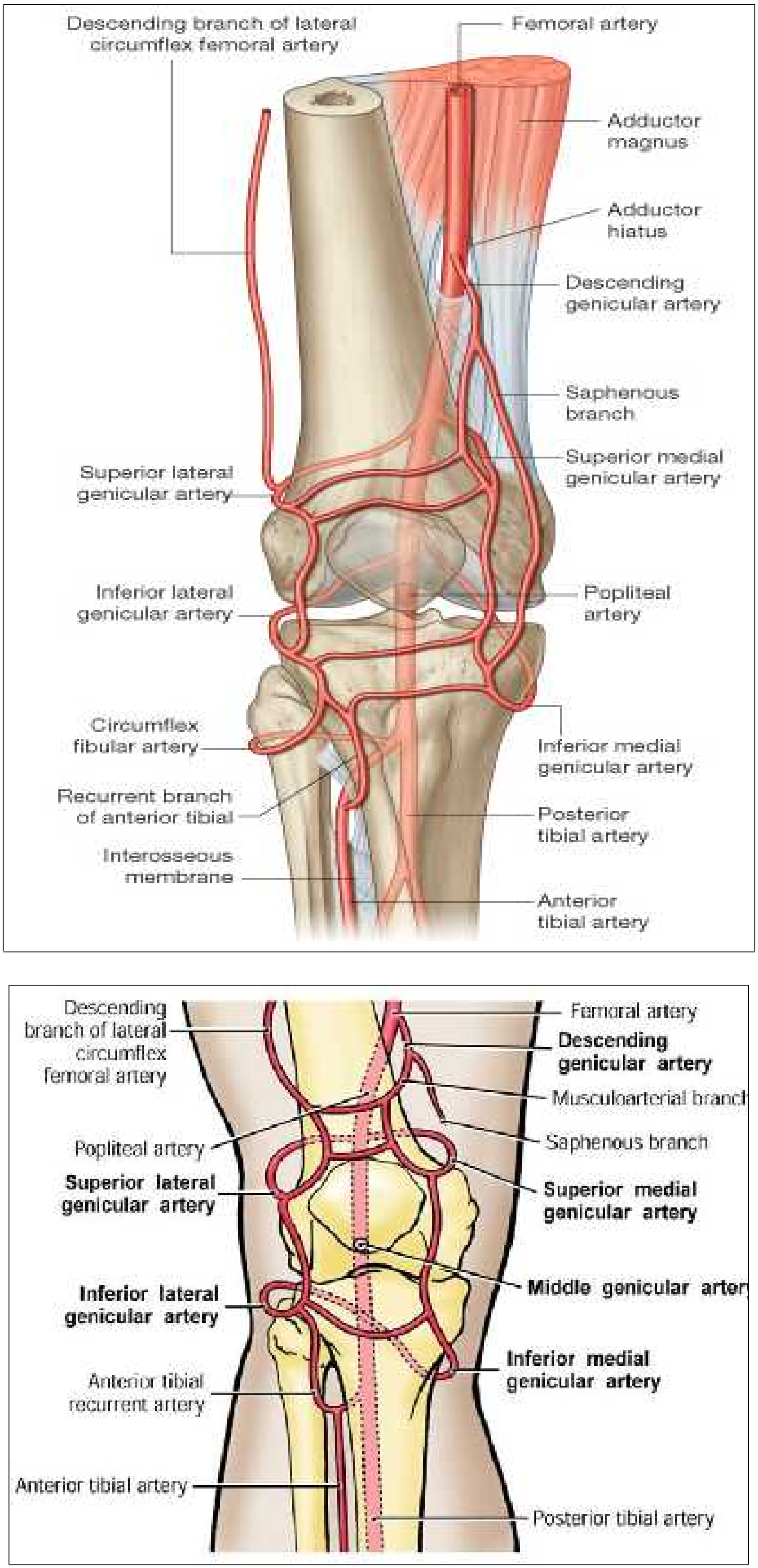


Figure 2: Arterial Anastomosis around Knee Joint [10]

The Anatomy Of Tibia- The Orthopedics View

- **The need to study Anatomy Of tibia for an orthopaedician**

Past few decades have seen enormous advances in the field of science and technology. The marriage of orthopaedics with technology has rapidly made innovations since thought impossible now a reality. In order to understand the recent advances in orthopedic surgery in depth understanding of functional anatomy and biomechanics is very essential.

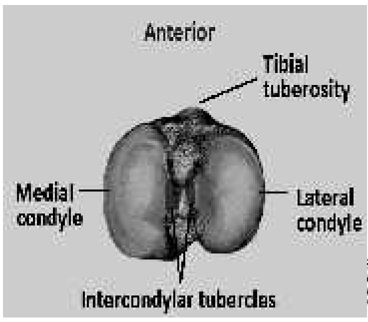
- **The Tibia**
- **Embryology of tibia**
- The tibia is ossified from three centers
- one for the body - center of the body, about the seventh week of fetal life, and gradually extends toward the extremities
- Ossification center for the upper epiphysis appears before or shortly after birth
- Ossification center for the lower epiphysis appears in the second year
- **Gross anatomy**

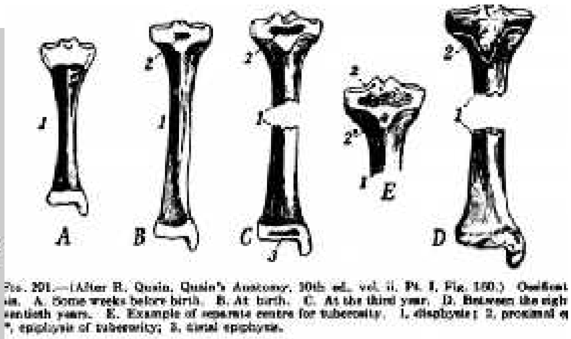
Tibia is also known as the shin bone or the shank bone. The tibia, second largest bone of the skeleton, is located on the anteromedial side of the leg. Tibia supports most of a person's weight. It articulates with the condyles of the femur superiorly and the talus inferiorly. The shaft of the tibia is approximately triangular in the tranverse section, and it has medial, lateral, and posterior surfaces.

Muscles are attached to its lateral surfaces. There are no standard radiological landmarks that separate the metaphysis and the diaphysis. The proximal and distal segments of long bones are defined by a square whose sides are the same length as the widest part of the epiphysis. The diaphyseal segments are contained between the proximal and distal segments.

Parts of tibia

- It has a body or the corpus tibiae
- Three borders
- Three surfaces
- Anterior crest or border
- The medial border
- The interosseous crest or lateral border
- The Upper /proximal extremity is large
- The medial condyles
- Lateral condyles
- The superior articular surface
- Two smooth articular facets intercondyloid eminence or the spine of tibia
- Lower /distal extremity is smaller
- Five surfaces
- Medial prolongation-medial malleolus





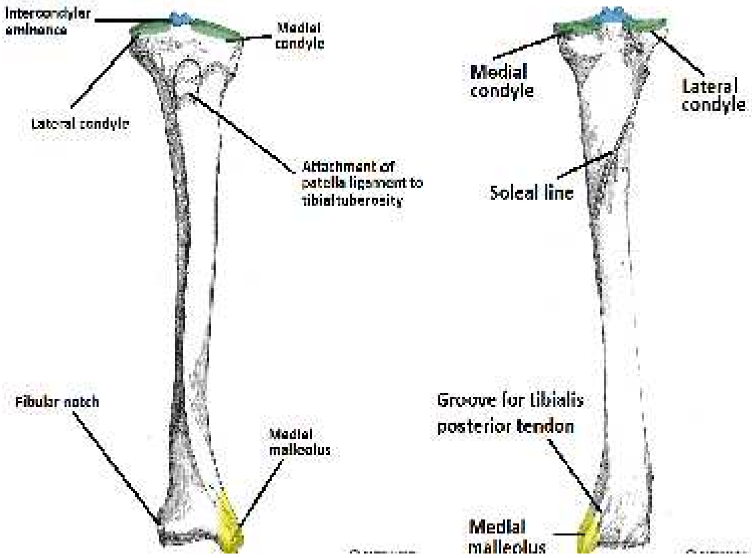


Figure 3 :Embryology And Anatomy Of Tibia

Proximal Tibia

The diaphysis of the tibia is usually divided into proximal, middle, and distal thirds. The proximal tibia is the upper portion of the bone where it widens to help form the knee joint. Proximal tibia is triangular and has a wide metaphyseal region and narrow distally. The shaft of the tibia is the narrowest at the junction of its middle and inferior thirds, which is the most frequent site of fracture.

Because of its location, the tibia is exposed to frequent injury; it is the most commonly fractured long bone. Because one third of the tibial surface is subcutaneous throughout most of its length, open fractures are commoner in the tibia than in any other long bone.[11]

The Intramedullary canal of the tibia is generally triangular. The isthmus of the canal is short, usually extending for approximately 6 cm. The prominent tibial tuberosity is located at the anterior border of its upper section, and the patellar ligament is attached to the upper portion of the tibial tuberosity.

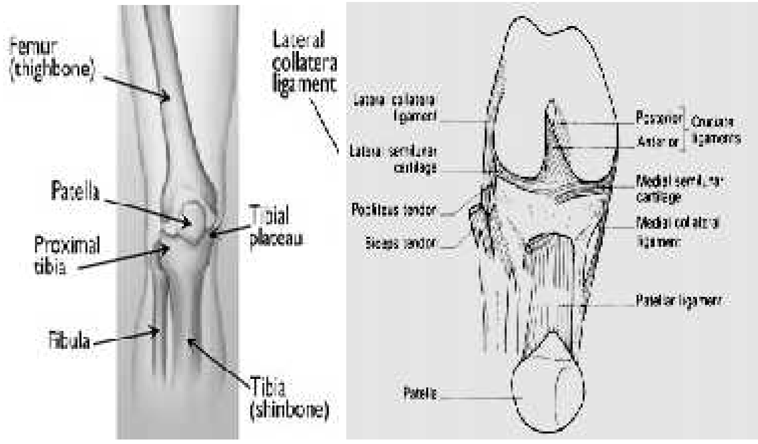


Figure 4: proximal tibia and related structures

Tibial Plateau

The proximal tibia is expanded in the transverse axis, providing an adequate bearing surface for the body weight transmitted through the lower end of femur. It comprises of two prominent masses, the medial and lateral condyles.

Two condyles are separated by an irregularly roughened non-articulating intercondylar area consisting of the medial and lateral tibial spines. Anterior and posterior to the intercondylar eminence are the area that serves as attachment sites for cruciate ligaments and menisci. The condyles project backwards a little so as to overhang the upper part of the posterior surface of the shaft.

Medial condyle is larger and the upper articular surface is oval in outline. The lateral condyle overhangs the shaft especially at its posterolateral part. The articular surface is nearly circular in its outline and is slightly hollowed in its central part.

The articular surfaces on the plateau are not equal, the lateral being wider than the medial. The medial plateau shows no significant concavity in the coronal plane and the lateral plateau showing a slight concavity. In the sagittal plane, the lateral plateau appears convex and the medial plateau appears concave. Thus neither plateau provides much assistance in stabilizing the knee.

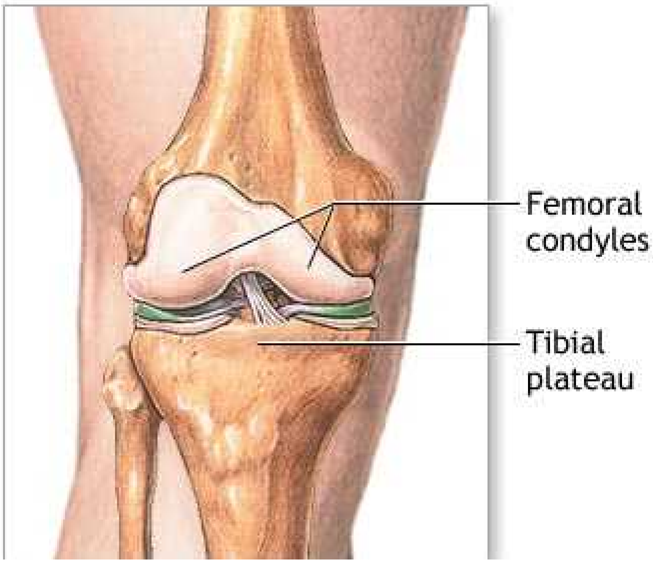


Figure 5: Tibial Plateau

The muscular unit of the knee [12, 13]

The extra articular structures comprises of musculotendinous units and ligamentous units.

Musculotendinous units:

These are made up of:

1) Quadriceps femoris - Anteriorly
2) Gastrocnemius and Popliteus **-** Posteriorly
3) Semimembranosus, Semitendinosus, Gracilis, Sartorius- Medially
4) Biceps femoris, Iliotibial band- Laterally

Figure 6 : Anterior Part Of Knee

The ligaments associated with the knee [12,13]

Capsule –

The capsule completely surrounds the knee joint, the attachments to the femur area as follows.

Anteriorly, the capsule is attached to the anterior surface of the femur. Laterally, capsule is attached to the lines between the epicondyles and the condyles.

Posteriorly the superior edges of the rounded condyles serve as the line of capsular attachment.

Patellar Ligament –

The quadriceps tendon, the patella, and the patellar ligament form the anterior wall of the knee joint. Lateral expansions from the quadriceps tendon (retinaculi) blend with the capsular ligament.

Tibial Collateral Ligament –

This thin band of ½ inch in width extends from the medial epicondyle of the femur to the side of the tibia. It is attached to the medial meniscus.

Fibular Collateral Ligament –

This ligament is cord like and extends from the lateral epicondyle of the femur to the head of the fibula. Unlike the tibial collateral ligament, this is not attached to the lateral meniscus. The intra articular structures are the semilunar cartilages or menisci, transverse, and two cruciate ligaments.

Cruciate Ligaments -

These important ligaments actually hold the femur and tibia together and the name is derived from the fact that they across one another.

The anterior cruciate ligament arises from the anterior intercondylar region of the tibia, and courses posteriorly and laterally to attach to the posterior end of the lateral condyle of the femur on its medial surface. This ligament become tense in extension of the joint, prevents overextension, and is thought to induce the medial rotation needed to lock the knee joint.

The posterior cruciate ligament arises from the posterior part of the intercondylar region of the tibia, courses superiorly in an anterior and medial direction to reach the medial condyle and is attached to its lateral surface. These ligaments becomes tense in flexion of the joint and prevent overflexion, and may be involved in locking the joint.

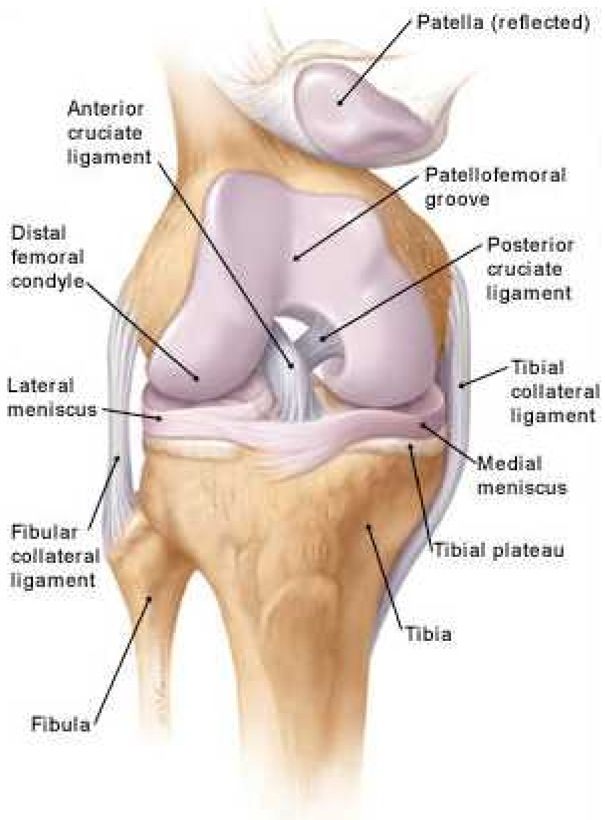


Figure 7 :**The ligaments associated with the knee**

The Role of Tibia In The Mechanics of Knee Joint [14,g]

Functional stability of the knee is provided by both passive and active stabilizers. The passive stabilizers include the ligaments around the knee, osseous congruity and the menisci. The active stabilizers are the muscles that surround the knee.

- **Range of Movement**

ROM of the knee ranges from $+10^0$ of recurvatum extension to 130^0 of flexion. Functional range of movement is from near full extension to about 90^0 of flexion. Rotation varies with position of flexion.

At full extension there is minimal rotation. At 90^0 flexion, 45^0 of external rotation and 30^0 of internal rotation are possible. Abduction and adduction are essentially 0^0

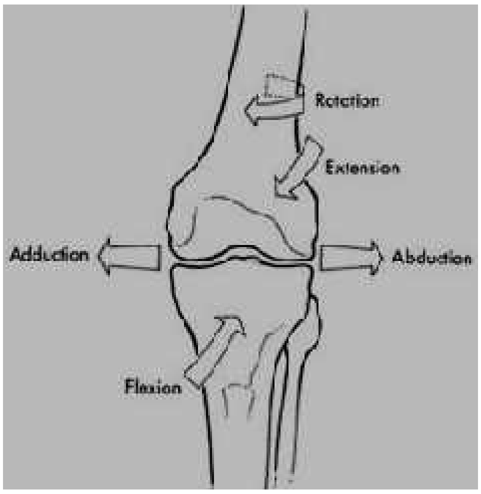


Figure 8: Movements at the knee joint

Joint motion:

The femur internally rotates during last 15^0 of extension. Posterior roll back of the femur on the tibia during knee flexion increases maximum knee flexion.

The axis of rotation of the intact knee passes through medial femoral condyle

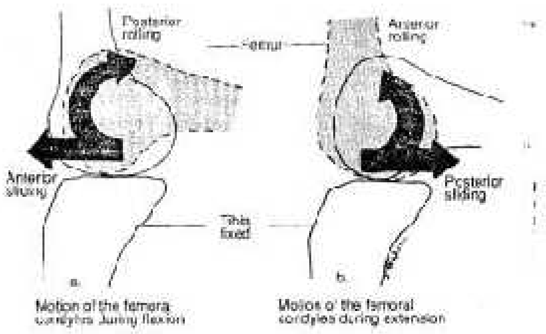


Figure 9: Roll and glide movements of the femoral condyle.

A. Pure rolling motion: femur rolls off the tibial plateau before full flexion is complete.
B. Pure sliding motion: femur impinges the posterior tibial plateau before full flexion is achieved.
C. Combined rolling and gliding of the femoral condyles allows full range of flexion. [14]

Axes of movements at the knee[15, 16]

The mechanical axis:- femoral head to center of ankle

Vertical axis:- from centre of gravity to ground

Anatomic axis:- along the shaft of femur and tibia

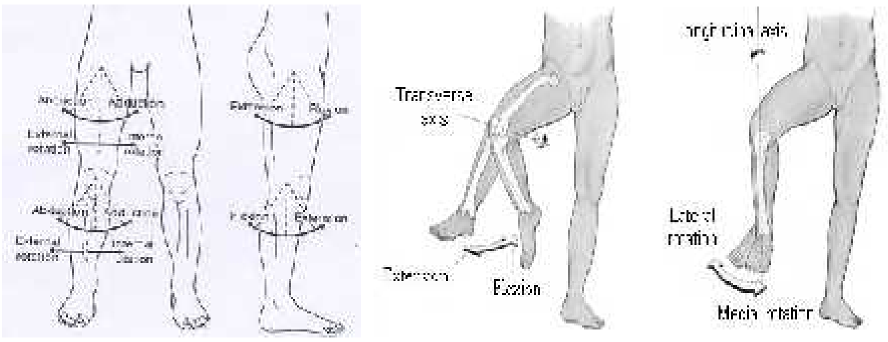


Figure 10: Axes of movements at the knee

★ **Tibial fracture** [17]

Etiology

Tibial fractures are the most common fractures that occur in the human body with the industrialization high-speed lifestyles with motor vehicles, snowmobiles, and motorcycles, as well as growing popularity of extreme sports, contribute to the increasing occurrence of tibial shaft fractures in today's society.

Incidence

- Young people experience these fractures often as a result of a high-energy injury, such as a fall from considerable height, sports-related trauma, and motor vehicle accidents.
- Older persons with poorer quality bone often require only low-energy injury (fall from a standing position to create these fractures).
- Low energy-Result of torsional injury
- Indirect trauma
- High energy-direct trauma proximal tibia- the most common cause of bumper fracture

Epidemiology

Most of the tibial fractures are closed fractures accounting to almost three quarters 76.5% of all tibial fractures [18]

The mechanisms in tibial fracture [19]

Injuries to the tibia occur as a result of:

- Force directed either medially (valgus deformity, the classic bumper fracture) or laterally(varus deformity)
- An axial compressive force
- Both an axial force and a force from the side
- Patellar tendon causes the proximal fragment into extension
- Hamstring tendon causes the distal fragment into flexion
- Anterior compartment musculature causes a valgus deforming force

Depending on the type of force the fracture pattern may be

- Split – valgus or varus force
- Depression if Axial load
- Combined axial and split leads to either or combined fracture

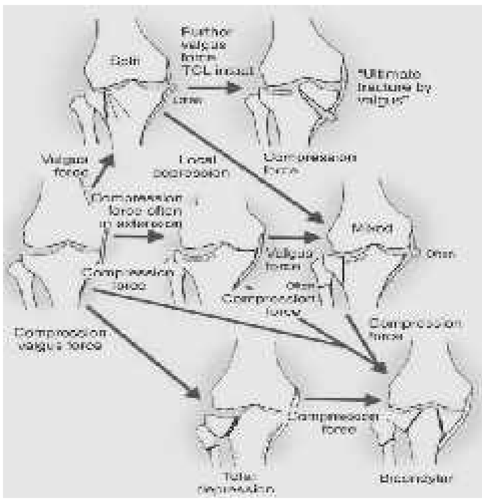


Figure 11: The mechanisms in tibial fracture

Cotton.[20] said in his study when an automobile strikes the leg of the walking street people it results in tibial fractures .

Graham.[21] said that when a straight Knee is subjected to an abduction or valgus strain, the medial ligament may tear or lateral tibial plateau may fracture.

Wilson.[22] suggested that when the abduction force is combined with compression force, fracture of tibial plateau may occur.

Kennedy.[23] showed that necessary to cause a fracture of the tibial condyle are forced abduction and compression.

Hohl.[24] noticed in his study that the location and degree of depression in a fracture depends upon the flexion angle of the knee at the moment of injury.

Classification of tibial fractures

Oestern and Tscherne in 1984 [25] developed a four grade system for classifying closed fractures.

- Grade 0 fractures result from indirect injury to the limb and cause minimal soft-tissue damage, a simple fracture pattern.
- Grade 1 fractures are caused by a low- or moderate-energy mechanism that causes superficial abrasion or contusion, a mild fracture pattern.
- Grade 2 fractures are caused by direct trauma to the limb, and they involve deep abrasion accompanied by skin or muscle contusion, a severe fracture pattern.
- Grade 3 fractures are accompanied by extensive skin contusion or a crush injury, severe damage to underlying muscle, and they may also cause subcutaneous avulsion.

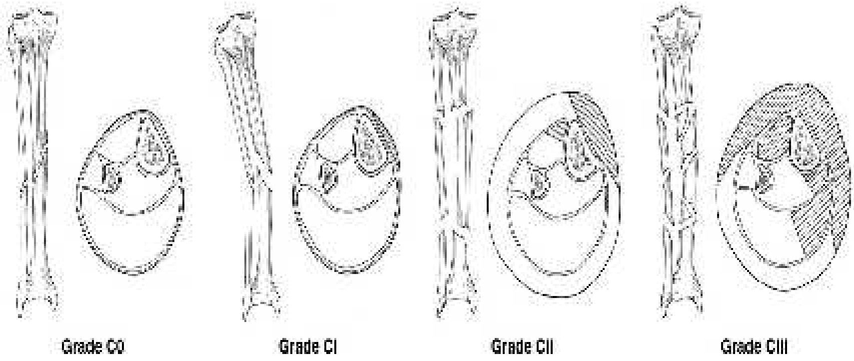


Figure 12: Oestern and Tschern Classification of closed fractures.

Classification of skeletal injury

Open tibial shaft fractures are generally classified according to the three-graded system published by Gustilo and Anderson [26]

- **Grade 1**- skin opening of 1cm or less, minimal muscle contusion, usually inside out mechanism
- **Grade 2**- skin laceration 1-10cm, extensive soft tissue damage
- **Grade 3a**- extensive soft tissue laceration (10cm) but adequate bone coverage
- **Grade 3b-** extensive soft tissue injury with periosteal stripping requiring flap advancement or free flap
- **Grade 3c**- vascular injury requiring repair

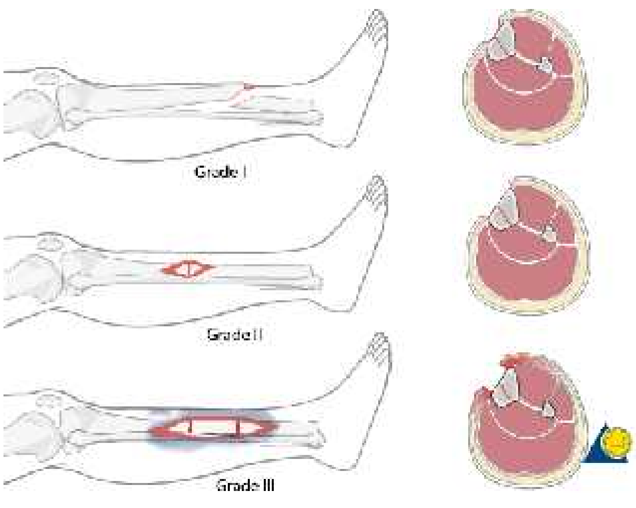


Figure 13: Gustilo and Anderson Classification of closed fractures skeletal injury.[27]

In 1956, Hohl and Luck classification which was later expanded by Hohl, from the terminology point of view.

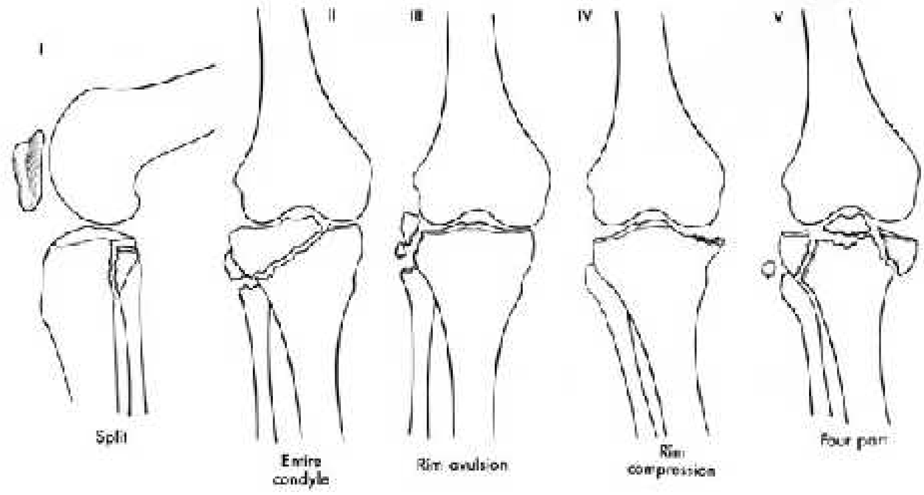


Figure 14: Hohl and Luck classification[28]

Moore put the name fracture –dislocation of the knee. He considered some split fractures from Hohl classification to be true fracture-dislocation because of their instability.

Classification of tibial plateau fractures as described by Hohl and Moore: [29]

Type1, Minimally Displaced

Type 2, Local Compression

Type 3, Split Compression

Type 4, Total Condyle

Type 5, Bicondylar

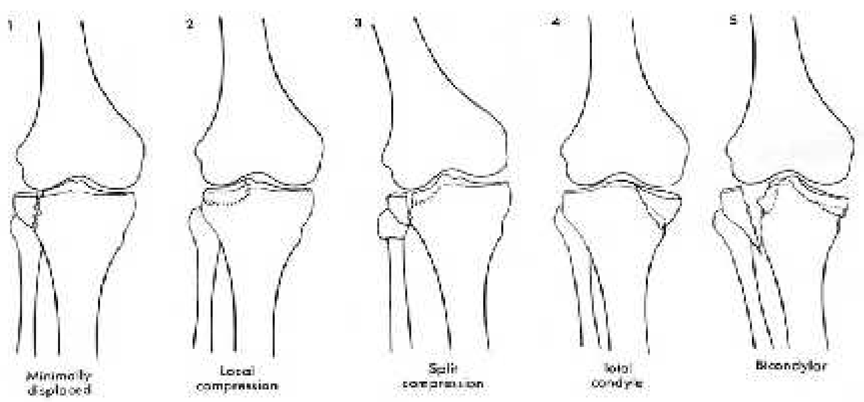


Figure 15: Tibial plateau fractures as described by Hohl and Moore

The A-O classification [30]

Type A- extra articular

Type B -intra articular

Type C- intra articular and metaphyseal

Type A2.1	Lateral oblique
Type A2.1 (II)	Medial oblique
Type A2.2	Anterior oblique
Type A2.3	Transverse
Type A3.1	Intact wedge
Type A3.2	Fragmented wedge
Type A3.3	Complex comminution

Table 1: The A-O classification

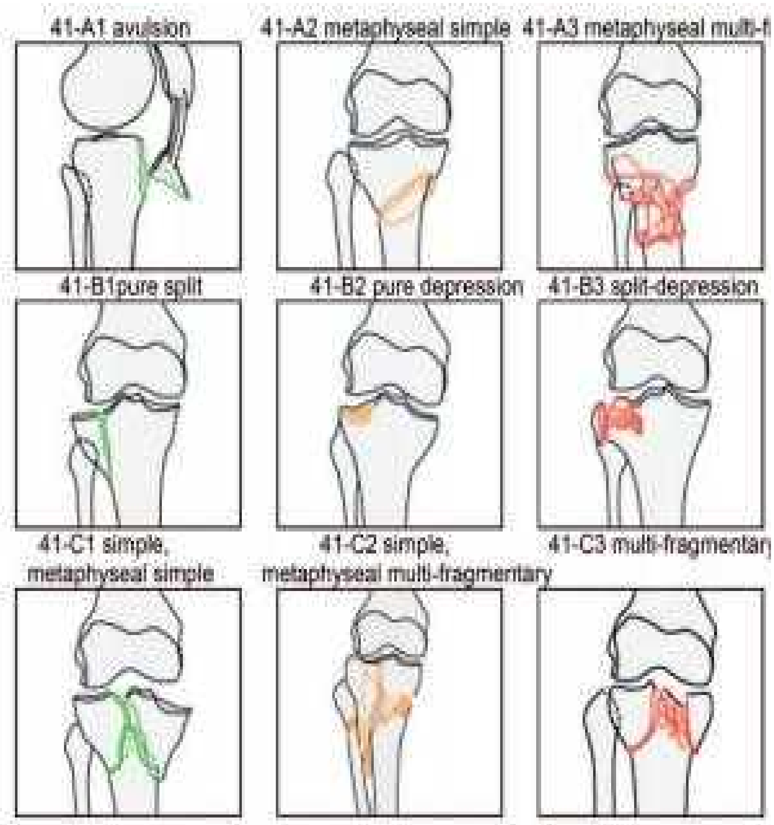


Figure 16 : The A-O classification

- **Associated injuries**

Up to 30% of patients with tibial fractures have multiple injuries

- Ipsilateral femur fracture so called “floating knee”, seen in high energy injuries
- Neuro/vascular injury
- Fracture of the ipsilateral fibula
- Ligamentous injury of knee

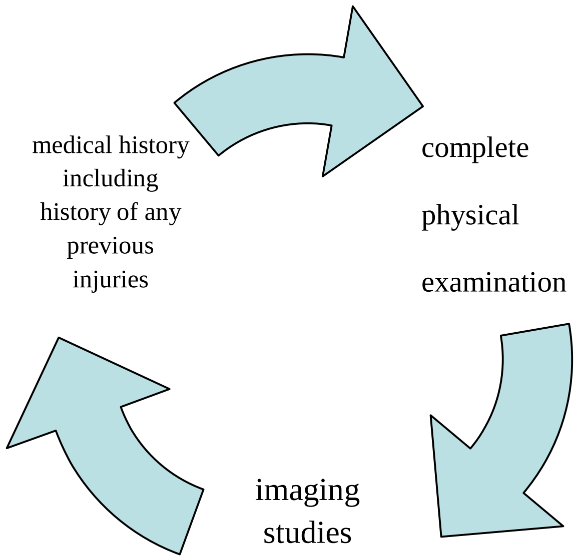
- **Complications of tibial fracture** [31,32,33]

Regardless of treatment technique the reported complications are high in tibial fractures

- Wound breakdown
- Deep infection
- Deep vein thrombosis
- Compartment syndrome
- Myositis ossificans
- Nerve damage peroneal palsies
- Arthrofibrosis
- Knee or ankle pain
- Poor or delayed healing
- Osteomyelitis
- Vascular damage
- Arthritis
- Unequal leg length

The diagnosis [34]

To diagnose a proximal tibia fracture three main pillars include



Symptoms

Pain that is worse when weight is placed on the affected leg Swelling around the knee and limited bending of the joint Deformity —Pale, cool foot —vascularity impaired. Numbness or "pins and needles," around - nerve injury or excessive swelling within the leg.

Investigations

X-rays. provide clear images of bone. X-rays can show whether a bone is intact or broken & type of fracture and where it is located within the tibia.

Schatzker classification.[35] system is one method of classifying tibial plateau fractures and each increasing numeric fracture category indicates increasing severity, reflecting not only increased energy imparted to the bone at the time of injury but also an increasingly worse prognosis . The most common fracture of the tibial plateau, is type II.

Classification

This system divides tibial plateau fractures into six types based on the radiological findings. This classification was first published by Joseph Schazker *et al***,** in 1990.[36]

- **Schatzker I:** wedge-shaped pure cleavage fracture of the lateral tibial plateau, originally defined as having less than 4 mm of depression or displacement
- **Schatzker II:** split and depression of the lateral tibial plateau, type I fracture with a depressed component
- **Schatzker III:** pure depression of the lateral tibial plateau

  divided into two subtypes
- **Schatzker IIIa:** those with lateral depression
- **Schatzker IIIb:** those with central depression
- **Schatzker IV:** pure depression of the medial tibial plateau, without a fracture fragment
- **Schatzker V:** involving both tibial plateau
- **Schatzker VI:** fracture through the metadiaphysis of the tibia

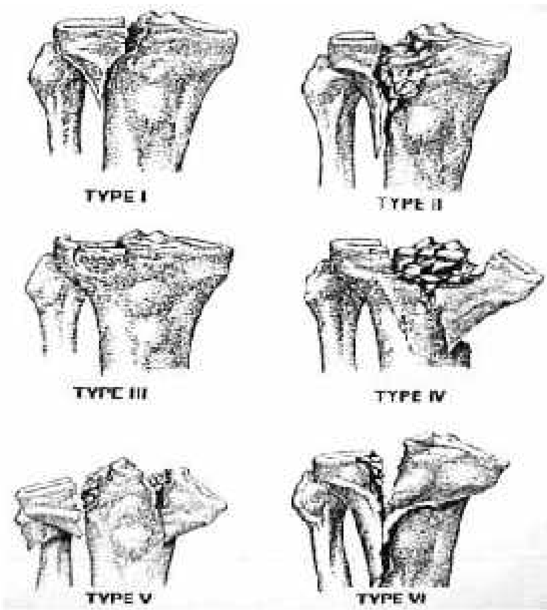


Figure 17: Schatzker classification

Views

- A-P/lateral
- Routine view in suspected tibial fractures to look for fractures
- Oblique view
- Internal rotation view-Shows posterolateral fragment
- Traction view

CT scan.

In case of tibial fractures CT with reconstructions to show the amount of the articular surface involvement in comminuted fractures

Figure 18: CT scan tibial plateau fracture

MRI scan.

MRI is better than CT scan in delineating of soft tissues, and is considered as very important to evaluate soft-tissue pathology.

Kode showed that in assessing the tibial plateau fractures MRI was equivalent to CT scans in terms of fracture assessment but was for soft-tissue injuries.[37]

Figure 19: MRI scan tibial plateau fracture

Angiography should be considered whenever there is an alteration in the distal pulses or when there is serious concern about any arterial lesion

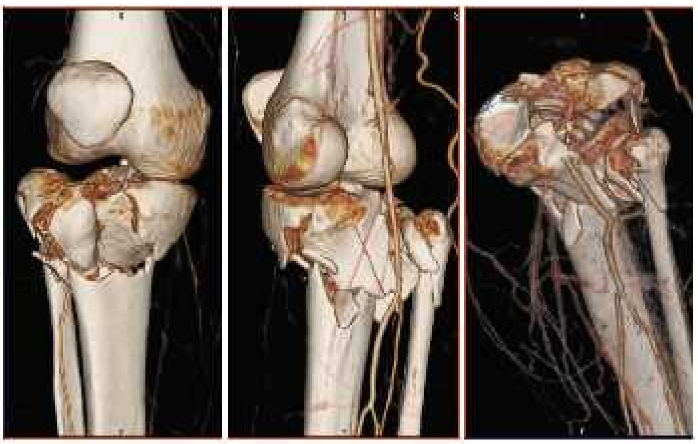


Figure 20 : Angiography tibial plateau fracture

Treatment of intra-articular proximal tibial fractures [38-50]

Complex proximal tibial fractures are the major problems in orthopaedic surgery and associated with high complication rates. Fractures of tibial plateau are serious injuries that result in functional impairment. Emphasis in treating these fractures are anatomical restoration of fracture surface, repair of soft tissue injury, rigid fixation to obtain a stable painless knee with normal range of motion

Most common difficulties faced by the orthopaedician while dealing with intra-articular proximal tibial fractures are:-

- The compromised skin and soft tissue envelope, which invites a high rate of complications following attempted open reduction and internal fixation.

- Poor bone quality and comminuted fracture patterns creating difficulty in achieving stable fixation.

The treatment of all types of intra-articular fractures aim at:-

- Restoration of normal joint function.
- Preservation of late posttraumatic osteoarthritis.
- Permanent or progressive disability in the knee is caused by instability, angular deformity, restricted movement and pain.

Before deciding the line of treatment one must bear in mind the following facts:-

- Extent of damage in tibial plateau fracture is often greater than what is seen on x-ray.
- Malunion is extremely common where as non-union is unknown.
- Painful knee and stiffness are the most serious and common complications of the tibial plateau fracture.

Treatment options include **non-operative treatment** and **operative treatment**

Non-operative treatment

Non-operative treatment of intra-articular proximal tibial fractures includes :

- Closed Manipulation
- Skeletal traction with early mobilization
- Casts or braces
- Hybrid ring

Operative treatment

Different authors used different criteria for the surgical management of these fractures.

Surgical treatment of intra-articular proximal tibial fractures includes:

- Uniplanar external fixation
- Fixed angle implants utilizing percutaneous exposure and reduction
- Dual plating with one or two incision
- Arthroscopically assisted fixation
- Minimal percutaneous pinning, lateral plating and medial fixator
- Minimally invasive techniques

Absolute indications for surgical treatment of intra-articular proximal tibial fractures are:

- An open fracture
- Associated compartment syndrome
- Acute vascular injury
- Irreducible fractures

Arthroscopy guided joint surface reconstruction and percutaneous screw/ external fixator stabilization

The fractures amenable to arthroscopy reduction and internal fixation are type I, II and III plateau fractures. The likely advantages are: Provides direct visualization of the intra-articular fracture more accurate reduction of the fracture Decreased morbidity compared with arthrotomy Facilitates diagnosis and treatment of meniscal and Ligamentous injuries Permits thorough joint lavage to remove loose fragments. The fractures are later stabilized using percutaneous screws or plates and screws.

Joint reconstruction and stabilization with external fixator:

- Ring type
- Tubular type

External fixation using either half pin fixator or ring fixator has been advocated as definitive fixation for type V and type VI condylar fractures. An external fixator placed below the knee can maintain articular surface reduction, axial alignment and also allow early motion. The advantage is its minimal invasiveness: thus reducing the wound complications.

The half pin uniplanar fixators have advantage in open plateau fractures for management until definitive fixation is done. Associated ligamentous and meniscal injuries are treated as and when present either conservatively or by secondary repair depending upon the severity of the injury.

Use of locked plates

Locking plates are indicated in high energy, those with severe comminution and in osteoporotic fractures. It acts like internal splint. Isolated lateral locked plating may offer a more biological approach to bicondylar fracture and may provide viable alternative to dual plating in fractures with tenuous soft tissues.

Type of Implant	Relative Indications	Relative Contraindications	Advantages	Disadvantages
Blade Plate	Comminuted Supracondylar fracture Low fracture	Intracondylar comminution	Strong able to maintain varus / valgus and antecurvatum or retrocurvatum alignment Most stable fixation	Technically demanding Can comminute unrecognized intracondylar fractures
Compression Screw	Comminuted supracondylar fractures associated with simple intraconcylar splits	Intracondylar comminution Very low fractures Coronal fractures	Technically easier to use than blade plate Compresses simple intracondylar spilts Able to maintain varus / valgus alignment	More difficult to maintain recurvatum / antecurvatum alignment in low fractures Occupies a large bone volume in the intracondylar region Requires additional screw fixation in disal fragment for stability
Condylar Plate	Simple supracondylar fracture in association with intracondylar comminution	Comminuted supracondylar fracture	Can be contoured to achieve anatomic reduction of a simple fracture Multiple screw insertion can help reduction of intracondylar comminution	Poor resistance to varus / valgus moments, so requires reconstruction of medical cortical continuity
Dual Plate	Supracondylar and intracondylar comminution	Should be reserved for situation in which no other device will work	Allows multiple-screw fixation of intracondylar comminution Dual plates provide strength for suprecondylar comminution	Massive dissection with resultant stiffness Potential for "dead bone sandwich"
Antegrade Nail	Extensive supracondylar comminution, especially proximal	Low fractures Intracondylar extension	Minimal dissection and injury of the soft tissue envelope Strong fixation automatic grafting (reamings)	Can "blow apart" unrecognized intracondylar fractures Can be difficult to achieve anatomic alignment
Retrograde Nail	Osteoporosis Supracondylar periprosthetic fracture	"High-demand" patient Low Fracture	Minimal dissection and injury to soft-tissue envelope Some grafting of the fracture site by reaming	Low strength device Residual fracture instability may necessitate caution when initiating postoperative motion

Table 2: The Operative Implants Available In Tibial Plateau Fracture

Follow-up and Evaluation [51]

The prognosis of tibial plateau fracture treatment is given by

- The degree of displacement
- Type of fracture
- Method of treatment and
- Quality of postoperative care

Quality of postoperative care plays a very important role in the long term outcome in patients treated for tibial plateau fracture

- **Rassmussen's Knee Score**[52]

Parameter	Score	Excellent	Good	Fair	Poor
Depression		6	4	2	0
None	6				
<6 mm	4				
6-10 mm	2				
>10 mm	0				
Condylar widening		6	4	2	0
None	6				
<6 mm	4				
6-10 mm	2				
>10 mm	0				
Angulation (valgus/varus)		6	4	2	0
None	6				
<10°	4				
10-20°	2				
>20°	0				

Table 3: Rasmussen radiological healing score

Clinical features					
Rating	Pain	Walking capacity	ROM	Clinical signs	Stability
Excellent	No	Normal	Normal	No	Normal
Good	Minimal	Walking outdoor for at least 1 h	75% of normal	+	Minimal
Fair	Occasional ache	Walking outdoor for 15 min	>50% of normal	Swelling, ++	Instability in flexion
Poor	Pain at rest	Walking indoor only	50% of normal or less	+++	Instability in flexion as well as in extension

ROM: Range of motion

Table 4: Rasmussen's functional score system

Alho and Ekeland criterias [53]

Alho and Ekeland criterias consists of six aspects:

1) Tibial mal-alignment and shortening
2) Range of knee motion and extensor lag
3) Range of ankle motion
4) Foot Motion
5) Pain in limb
6) Swelling

Per Edwards criteria [54] is commonly used for the functional assessment of the results

a) Resumption of the activities of daily living
b) Resumption of the occupation
c) Pain free movements and walking
d) Squatting and sitting cross legged

Locked plate technology

Introduction

Plating techniques remain the mainstay for managing most periarticular and selected long bone fractures. Recent concepts in plating are based on attempts to

- Minimize soft-tissue stripping
- Decrease the need for bone grafting
- Improve union rates

Locked plate technology

Locked plate technology concept [55]

Locking compression plate was devised by combining the features of a LC-DCP and a PC-Fix.[56] In Locked plate technology the locked plates the “internal external fixators”, does not rely on frictional force between the plate and the bone to achieve compression and provide absolute stability having the advantage that the local blood supply under the plate is preserved allowing a superior bone healing and minimal complications.

The locking plate behaves like an external fixator but without the disadvantages of an external system not only in the transfixion of the soft tissues, but also in terms of its mechanics and the risk for sepsis. It is actually more an “internal fixator”.[57]

Locked plating does not require that the plate be compressed to the bone, as the interface between the plate and screw is secured without this plate-bone compression

Locked plate technology the historical background [58,59]

Plates for internal fixation of fractures have been used for more than 100 years. Plating of fractures began in 1895 when Lane first introduced a metal plate for use in internal fixation.

The earliest ancestor of the locking plate is the monocortical fixator by Carl Hansman in 1886. It rapidly reached its final form in the hands of Paul Reinhold in France in 1931, then fell

After the Litos system then the Zespol the concept progressively cut itself a significant place in the osteosynthesis techniques beginning in 1995. This concept was developed independently and nearly simultaneously by Patrick Sürer system unchanged since its beginning, and by the Arbeitsgemeinschaft für Osteosynthesefragen, Association for the Study of Internal Fixation through many stages.

The Schuli locking nut systems were proposed in 1998 so that a common screw could be locked in a plate

The point contact fixator (PC-fix) followed by the Less Invasive Stabilization System (LISS) and the locking compression plate (LCP) with all its versions.

Today, locking screw technology is reportedly being used in 5–25% of all fractures

Locking mechanisms types [56,60]

There are two broad categories of locking plates: fixed-angle locking plates and variable-angle locking plates. In the latter, the screw can be locked with a certain clearance within a cone with an angle on the order of 1–15°.

Advantages of Locking compression plate [60]

Locking compression plate device offers potential biomechanical advantage over other methods by,

- Better distribution of forces along the axis of bone
- They can be inserted with minimal soft tissue stripping using minimally invasive percutaneous plate osteosynthesis (MIPPO)

- Substantially reducing failure of fixation in osteoporotic bones
- Reducing the risk of a secondary loss of intraoperative reduction by locking with screws to the plate
- Unicortical fixation option
- Better preservation of blood supply to the bone as a locked plating does not rely on plate bone compression
- Provide stable fixation by creating a fixed angle construct and angular stability
- Early mobilisation

Advantages over Conventional plate

- They maintain a certain elasticity to stimulate bone healing
- Less rigid than conventional plates
- The quality of the reduction is less vital, provided that the local soft tissues and therefore vascularization of the fragments are maintained intact
- The callus is a stress callus, secondary, as in nailed osteosynthesis

Locked Plating Disadvantages [60,61]

- Very expensive
- Constructs may be too rigid
- Some percutaneous applications be self-drilling, that must be unicortical or strips near cortex
- No tactile feedback on bone purchase
- They “allow you to stop thinking”
- Reduction must still be achieved, it is not magically achieved by locking implant

Biomechanics of Locked Plate Technology [62]

Strain theory is very important to the understanding and application of locking plates. Perren, in 1979, advanced the original argument that fractures will heal by primary bone healing, secondary bone healing or proceed to non-union. Fracture strain is calculated by fracture gap displacement divided by fracture gap overall length.

Low strain states (< 2%) – as present in absolute stability – will heal primarily – without callus formation.

Medium strain states (2–10%) – seen in relative stability – will heal with secondary bone healing and abundant callus.

High strain states (> 10%) typically proceed to non-union because the elasticity of fibrous tissue is required to accommodate the significant movement at the fracture gap.

Ahmad *et al.*[63] studied on biomechanics of locking compression plate. Consistent results were achieved in LCP constructs in which the plate was applied at or less than 2mm from the bone.

Egol *et al.*[64] conducted a study on Biomechanics of Locked Plates and screws and showed that Locked plates and conventional plates rely on completely different mechanical principles to provide fracture fixation and they provide different biological environments for healing doing so.

Locking plate constructs are often long plates with relatively few screws used for relative stability, or short plates with multiple divergent screws used in juxta-articular fractures.

These plates provided stable fixation but many considered their use demanding and technically challenging requiring precise 3-dimensional alignment and careful preoperative planning. The working length of a plate should be 2–3 times the length of the comminuted segment.

Reducing the area of contact between plate and bone, as achieved by the LC-DCP design, significantly reduced the vascular changes caused by pressure With the locking head screws engaged in the plate, the plate is not pressed onto the bone. This reduces interference to the blood supply to the bone underlying the plate.

Loading forces are transmitted directly from the bone to the screws, then onto the plate, across the fracture and again through the screws into the bone. Friction between plate and bone is not necessary for stability.

The plate and screws provide adequate rigidity and do not depend on the underlying bone when using a locking reconstruction plate

On each side of the fracture, the screws are locked into the plate as well as into the bone. The result is a rigid frame construct with high mechanical stability

The typical torque applied to 3.5 mm screws is between 3 to 5 Nm (Newton meter) that resist axial loads as small as 500 N (125 lbs.). The screw with the greatest amount of force bears the greatest load. As long as the patient load does not exceed the frictional force of the plate to the bone and the axial stiffness of the screw or cortical bone at the fracture site, the construct is stable enough to allow healing

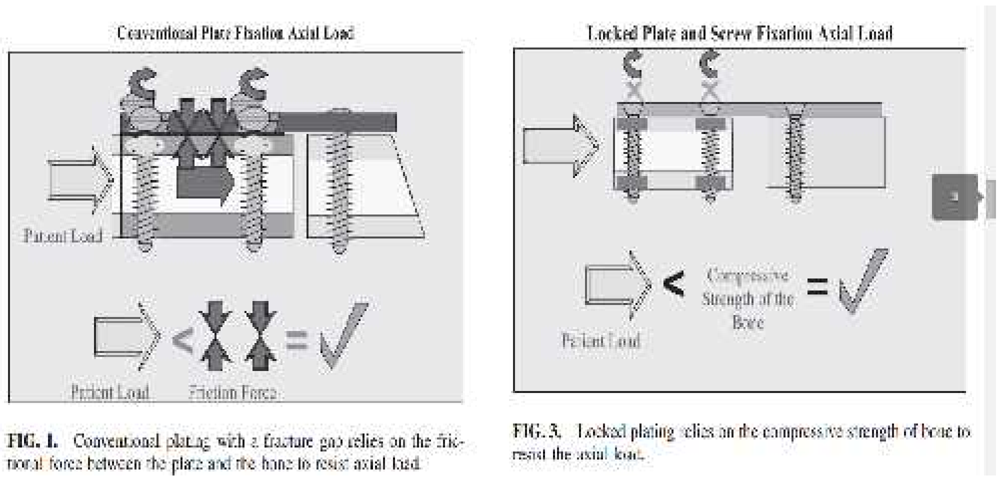


Figure 21 : Axial load distribution in conventional and LCP

- **Bending** [65,66]

Bending tests require a fracture gap greater than zero. In locked plating, because the screws lock into the plate, they must all either fail simultaneously as the plate backs directly out Locking constructs give another “cortex” with the screw locking into the plate thus the failure will only occur if perpendicular forces to the plate overcome the compressive forces of bone surrounding all the screws and the construct moves as one unit, that is, the locking screws fails to neutralize bending loads.

- **Torsion** [66]

The torsional stability of a construct is more dependent on the number of screws rather than whether the screws are locked or conventional.

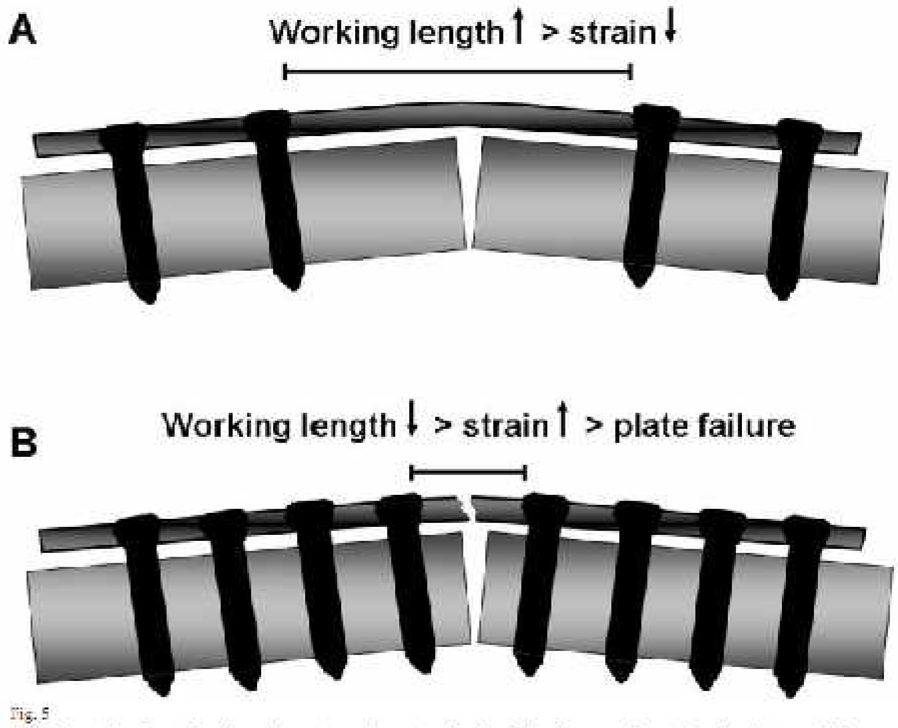


Fig. 5

Relationship of working length and strain at the level of the fracture for the locked internal fixator principle. When a fracture is bridged with a locking plate, three or four plate holes should be left empty at the level of the fracture in order to increase the working length and decrease the strain and stress concentration on the plate (A). In contrast, if a locking construct is made too stiff with too many screws at the level of the fracture (B), the short working length will lead to increased strain and stress concentration with loading and torsional forces, causing the plate to break

Figure 22: Relationship between working length and strain

Locking Screw Design [64-66]

- Threaded on the underside of head
- Larger core diameter which increases strength and dissipates load over larger area of bone
- Smaller thread pitch

Types of Locked Plate

Depending on the plate type the new implants in different plate functions of fixation:

- Neutralization plate (LCP)
- Locking compression plate (LCP)
- Internal fixator or “locked splinting” (LISS, LCP)
- “Antiglide” or buttress—(LCP)
- Bridging plate (LCP, LISS)

Indications for Locked Plate Fixation

- Biological Fixation
- Spanning Comminution
- Percutaneous Techniques in selected indications
- Implant as reduction tool
- Metaphyseal / Bicondylar Articular Fractures
- Short Articular Segment
- Periprosthetic Fractures
- Fractures in osteoporotic or pathologic bone
- Juxta-articular fractures Revision procedures

Indication	Biomechanical Principal	Technique	Bone Quality	Typical Anatomic Location
Comminuted shaft fractures	Bridging	Locked internal fixator	Normal or osteopenic	Femur, tibia, humeral shaft
Comminuted metaphyseal intra-articular fractures	Combination	Combined (Lag screws for articular fixation locking head screws for metaphyseal bridging)	Normal or osteopenic	Distal part of femur, distal part of tibia.
Short segment metaphyseal fractures	Bridging or Combination	Locked internal fixator	Normal or osteopenic	Proximal part of humerus, distal part of humerus , distal part of radius, proximal part of tibia.
Simple fractures in osteoporotic bone	Compression	Dynamic compression with eccentric screw placement or a compression device, locking head screws for shaft ; tension device with locking head screws only.	Osteopenic	Osteoporotic foream
Simple fractures in osteoporotic bone	Neutralization	Conventional lag screw, locking head screws for neutralization plate.	Osteopenic	Osteoporotic ankle.

Table 5: Some of LCP Uses

MATERIALS AND METHODS

This study was a prospective study done on 26 consenting cases of proximal tibial fractures admitted to Shri B.M. Patil Medical College, Hospital And Research Centre, Vijayapur during October 2013 To August 2015 chosen based on the inclusion and exclusion criteria

Patients were informed about the study in all respects and written informed consent will be obtained. The follow up period was 6 weeks, 3months and 6months.

INCLUSION CRITERIA

- All Schatzker's classification type 1 to 6 proximal tibial fractures in adults aged 18 years and above of either sex.
- Patients willing for treatment and giving informed and written consent.

EXCLUSION CRITERIA:

- Age group of less than 18 years.
- Patients not fit for surgery, managed conservatively for other medical reasons.
- All open fractures of proximal tibia.
- Patients with pathological proximal tibial fractures other than osteoporosis.
- Extraarticular fractures of proximal tibia.

SAMPLE SIZE:

With an average incidence rate of proximal tibial fractures 1.75% [0.5 – 3%] at 95% confidence interval and ± 5 margin of error the sample size is n=26.

$$n = \frac{z\alpha^2 \times p \times q}{d^2}$$

Hence 26 cases of proximal tibial fractures were included in the study.

STATISTICAL ANALYSIS:

Data was analyzed using following statistical methods

- Diagrammatic presentation.
- Percentages.
- Mean +/- SD.

INVESTIGATIONS:

- X-ray of knee joint with proximal 2/3rd leg Antero-posterior & Lateral views.
- Complete blood count.
- Bleeding time, Clotting time.
- Urine- Albumin, sugar and Microscopy.
- Random blood sugar, Blood urea and Serum creatinine.
- HIV and HbsAg.
- Blood grouping and Rh- typing.
- ECG.
- Chest X-ray- Postero-anterior view.
- Computed-tomography scan.
- Other specific investigations whichever needed.

OPERATIVE PROCEDURE

Positioning

After induction of anaesthesia, patient should be positioned on the operating table such that at least 110 degrees of knee flexion can be obtained preferably by dropping affected leg at the end of the table. A rolled flannel blanket is placed under the ipsilateral buttock. This serves to place the trans-condylar axis of the distal femur parallel to the floor and assist with rotational alignment during multi-fragmentary tibial fractures. External rotation of the limb is also prevented by using such a roll.

Triangles, bumps made from sterile gowns, dropping the end of the table, and placing the leg over the side of the table may facilitate this degree of knee flexion. The use of a padded kidney rest at the lateral aspect of the proximal thigh, often at the level of the tourniquet can be used to maintain knee flexion and prevent external rotation of the hip in deep knee flexion. Care must be taken not to place any pressure on the neurovascular bundle in the popliteal fossa. Limb is prepared and draped as per the standard aseptic technique. A thigh tourniquet was routinely applied.

Operative procedure of-Minimally invasive percutaneous plate osteosynthesis of tibial fractures

- Anteroposterior and lateral radiographs had been obtained to establish the fracture pattern, classification and surgical planning.
- Spinal anaesthesia/epidural anaesthesia was administered.
- Tourniquet was used in all cases.
- All operations were done under image intensifier.
- The main fracture fragments were aligned using manual traction and closed reduction manoeuvres.
- A 3–4-cm skin incision was made proximal and distal to the fracture.
- Plate was applied on the anteromedial or anterolateral aspect of the tibia.
- An extraperiosteal, subcutaneous tunnel was created with a periosteal elevator.
- Pre-contoured 4.5 mm proximal or distal anatomic locked plates, which included both locking and compression screw holes, were used and passed along this tunnel

- Once satisfactory plate positioning was achieved, plate was secured by passing 3-mm Kirschner wires through the most proximal and distal holes.
- A second plate of similar size and length was placed using the same holes on the Kirschner wires. This acted as an external guide to localize the screw holes and skin incisions without need of fluoroscopic control
- One proximal and distal screw was inserted. Additional screws were then applied using the same technique.
- In general, locking screws were used in the juxta-articular and diaphyseal segments, while nonlocking screws were selected for reduction in large fragments as lag screws.
- Complications of fixation failure such as plate bending, plate fracture, locking screw failure and skin irritation, infection and secondary surgical procedures were also documented.

Operative procedure by open reduction and internal fixation of tibial fractures by locking compression plate

- Anteroposterior and lateral radiographs had been obtained to establish the fracture pattern, classification and surgical planning.
- Spinal anaesthesia/epidural anaesthesia was administered.
- Tourniquet was used in all cases.
- All operations were done under image intensifier.

Technique

- The anterolateral parapatellar approach was used most frequently because of the frequency of lateral Tibial plateau fractures.

- Incision: With the knee in 30° flexion an s-shaped incision starting 3 to 5 cm proximal to the joint line staying just lateral to the border of patella tendon. Curve the incision anteriorly over gerdy's tubercle and extend it distally, staying about 1 cm lateral to the anterior border of the tibia.
- The lateral tibial condylar fragment was replaced to lock the articular fragments together.
- The lateral margin of the articular surface reduced under the femoral condyle for support. As the fragments were elevated and reduced, temporarily fixed them with multiple small Kirschner wires.
- A contoured T or L Buttressplate lateral tibial BP/LCP was applied for definitive fixation.
- This plate was applied to the anterolateral tibial condyle and contoured precisely to conform to the condyle and proximal metaphysis.
- It was secured to the condyle with appropriate cancellous screws/locking screws of sufficient length to engage the opposite medial cortex. Cortical/locking screws (4.5 mm/5 mm) were used to attach the plate to the shaft of the tibia.
- A small thin periosteal elevator was inserted through the window into the cancellous subchondral bone, and the depressed fragments were elevated to the normal level of the articular surface and supported with autogenous iliac bone grafts if required.
- Using fluoroscopic guidance, fractures were reduced and held with large bone reduction clamps.
- Kirschner wires were used as temporary fixation.

- Then a contoured large fragment BP/LCP was applied to the tibial metaphysis and extended it down the tibial shaft far enough to securely stabilize the fracture.
- Medial BP was applied first; the fracture was assessed for stability. If additional stability was needed, a precontoured BP was placed over the lateral side alternatively a single LCP was applied on the lateral side.
- Large cancellous screws were inserted in the proximal part of the BP, and the distal portion was attached with cortical screws.
- Once the fracture had been adequately stabilized, all temporary fixation devices were removed.
- The capsular incisions were closed with interrupted sutures and the skin, and subcutaneous tissue was closed over a Number 10 or 12 suction drain.
- The limb was kept immobilized in a long knee brace and kept elevated over one or two pillows.

POST-OPERATIVE MANAGEMENT:

- The limbs will be kept elevated with pillows
- Intravenous antibiotics will be continued for first five days and then shifted to oral
- Posterior splint given if protection of fixation was desired
- Suction drainage will be removed after 48 hours depending on the amount of collection
- Check X-RAY on 3rd post-operative day
- Quadriceps exercises and ankle mobilization will be started within 48 hours of surgery

- Knee bending and toe touch walking with a walker on second or third postoperative day if the fixation allowed
- Dressing will be done on 2nd, 5th and 8th post-operative day
- Sutures will be removed on 12th post-operative day
- Progressive weight bearing will be allowed as tolerated by patient
- Full weight bearing was permitted only after clinico-radiological evidence of union

FOLLOW-UP:

- Duration after surgery : 6 weeks/ 3 months/ 6 months
- Radiological evaluation – Check X-RAY knee joint with proximal 2/3rd leg Antero-posterior & lateral view

FUNCTIONAL RESULTS

Classification system for the results of treatment - RASMUSSEN'S SCORING

RASMUSSEN'S SCORING	points	Outcome evaluation			
		satisfactory		Unsatisfactory	
		excellent	good	fair	Poor
Subjective complaints					
Pain No pain Occasional ache, bad weather Stabbing pain in certain positions Noon pain, intense, constant pain around knee after activity Night pain at rest	6 5 4 2 0	5	4	2	1
Walking capacity Normal walking capacity Walking outdoors atleast 1 hr Short walks outdoors 15 min Walking indoors only Wheel chair or bedridden	6 4 2 1 0	6	4	2	1
Clinical signs					
Extension Normal Lack of extension(0-10^0) Lack of extension(>10^0)	6 4 2	6	4	2	1
Total range of motion At least 140^0 At least 120^0 At least 90^0 At least 60^0 At least 30^0 0^0	6 5 4 2 1 0	5	5	2	1
Stability Normal stability in extension and 20^0 flexion Abnormal instability 20^0 of flexion Instability in extension(<10^0) Instability in extension(>10^0)	6 5 4 2	5	4	2	2
Sum (minimum)		*27*	20	10	6

Table 6 : RASMUSSEN'S SCORING

Figure-23: OPERATIVE PHOTOGRAPHS

VARIOUS TYPES OF PROXIMAL TIBIAL LCP PLATES

SOFT TISSUE INSTRUMENTS

POWER DRILL WITH K WIRE

PATELLA CLAMP

LOCKING CANCELLOUS AND CORTICAL SCREWS

DRILL SLEAVE APPLIED TO LOCKING HOLE

MIPPO TECHNIQUE

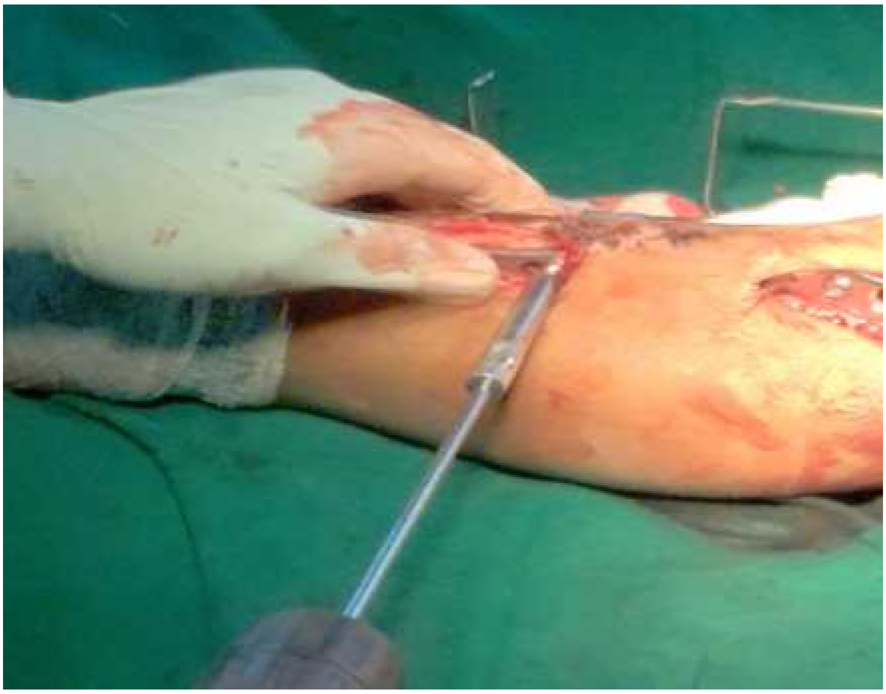
PAINTING AND DRAPING

INCISION

CLOSE REDUCTION OF FRACTURE UNDER C ARM GUIDANCE

PLATE IS INSERTED IN SUBMUSCULAR PLANE

PROPER PLACEMENT IS CONFIRMED WITH C ARM



DRILLING DONE WITH FIXED ANGLE DRILL

SLEAVE APPLIED TO THE LOCKING HOLE

LOCKING SCREW APPLIED

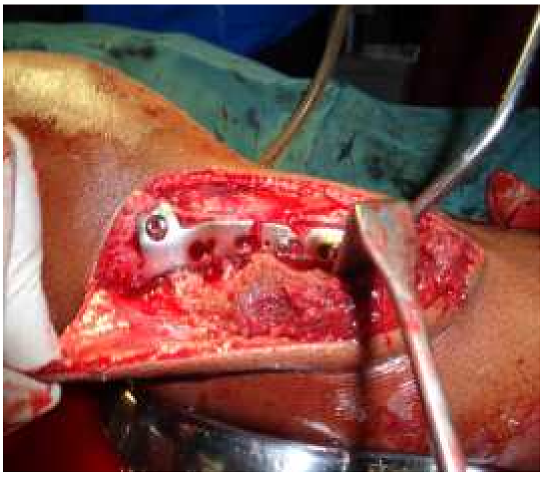
UNDER C ARM GUIDANCE

CLOSURE

ORIF TECHNIQUE

PAINTING AND DRAPING

INCISION



OPEN REDUCTION AND APPLICATION OF PLATE

APPLICATION OF LOCKING SCREWS AFTER FIXED ANGLE DRILLING

CLOSURE

RESULTS AND OBSERVATIONS

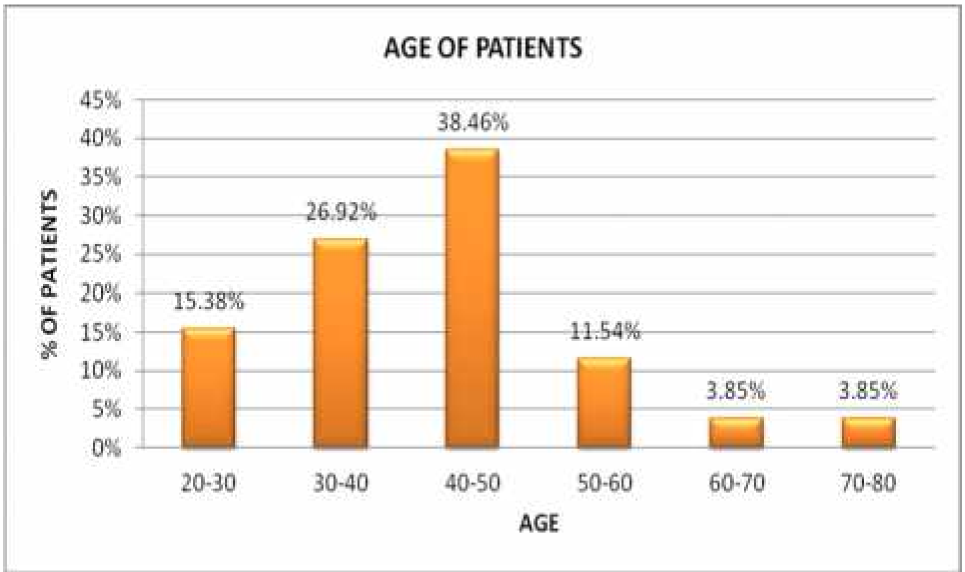
1. DEMOGRAPHIC DATA

AGE DISTRIBUTION

TABLE N0 7 : AGE

AGE	NO. OF PATIENTS	%	MEAN	STDEV
20-30	4	15.38	41.03	12.37
30-40	7	26.92		
40-50	10	38.46		
50-60	3	11.54		
60-70	1	3.85		
70-80	1	3.85		

GRAPH NO 1 : AGE DISTRIBUTION



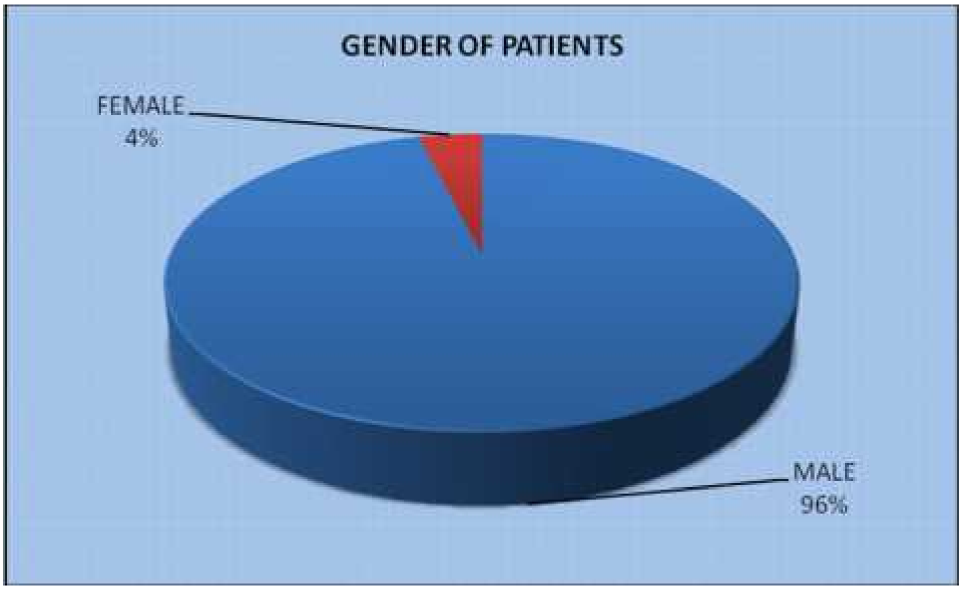
In the present study on evaluation of the age distribution we found that of the 26 cases in the study most patients belonged to the category 40-50 years (10 patients, 38.46%). The mean age was 41.03 years.

GENDER DISTRIBUTION

TABLE NO 8 : GENDER DISTRIBUTION

GENDER	NO. OF PATIENTS	%
MALE	25	96.15
FEMALE	1	3.85

GRAPH NO 2 : GENDER DISTRIBUTION



In the present study on evaluation of the gender distribution we found that of the 26 cases in the study most patients were males (25 patients, 96.15%)

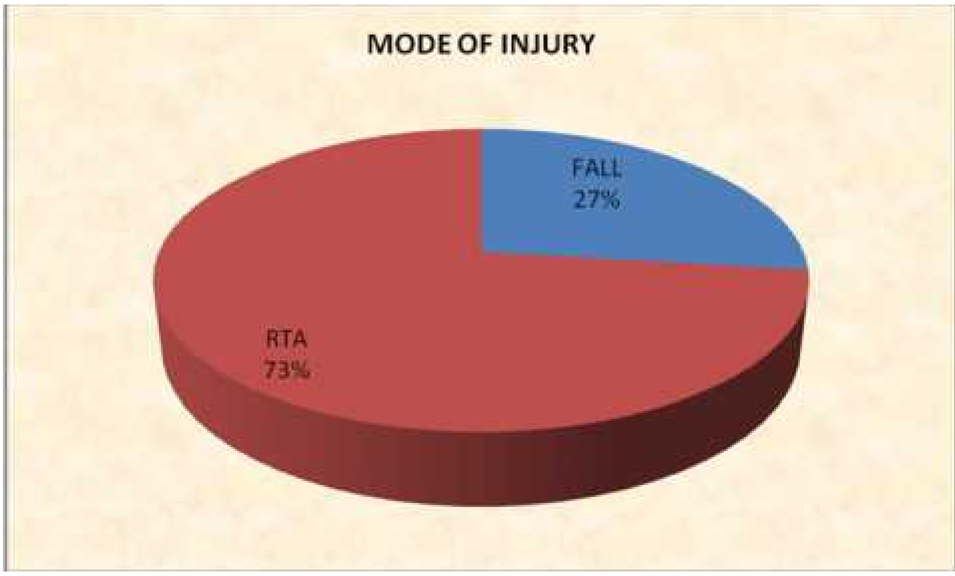
CLINICAL PRESENTATION

MODE OF INJURY

TABLE NO 9 : MODE OF INJURY

MODE OF INJURY	NO. OF PATIENTS	%
FALL	7	26.92
RTA	19	73.08

GRAPH NO 3 : MODE OF INJURY



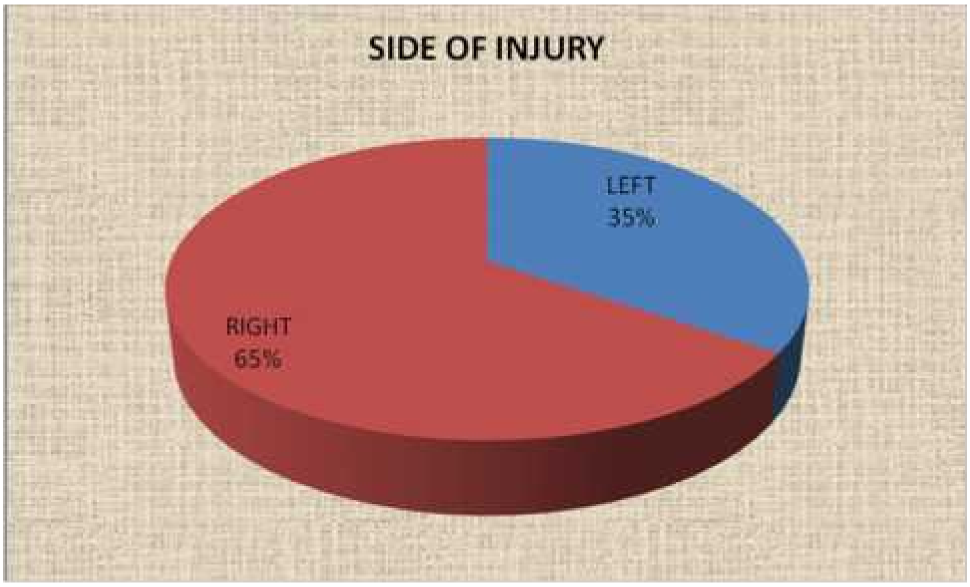
In the present study on evaluation of the mode of injury we found that of the 26 cases in the study most patients were injured by vehicular accident (19 patients, 73%).

SIDE OF INJURY

TABLE NO 10 : SIDE OF INJURY

SIDE	NO. OF PATIENTS	%
LEFT	9	34.62
RIGHT	17	65.38

GRAPH NO 4 : SIDE OF INJURY



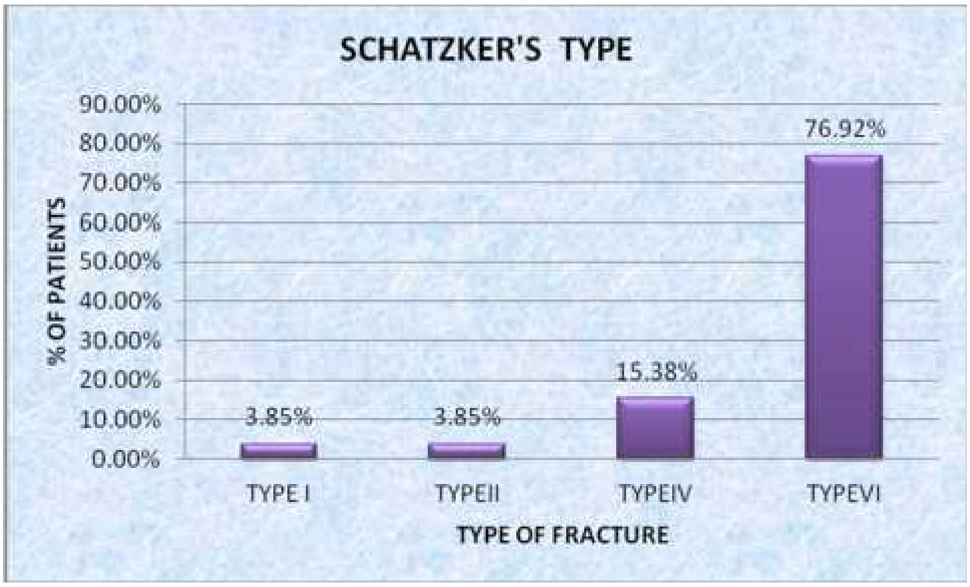
In the present study on evaluation of the side of injury we found that of the 26 cases in the study most patients had a right sided injury (17 patients, 65.38%)

TYPE OF SCHATZKERS FRACTURE

TABLE NO 11 : SCHATZKER'S TYPE

SCHATZKERS TYPE	NO. OF PATIENTS	%
TYPE I	1	3.85
TYPEII	1	3.85
TYPEIV	4	15.38
TYPEVI	20	76.92

GRAPH NO 5 : SCHATZKER'S TYPE



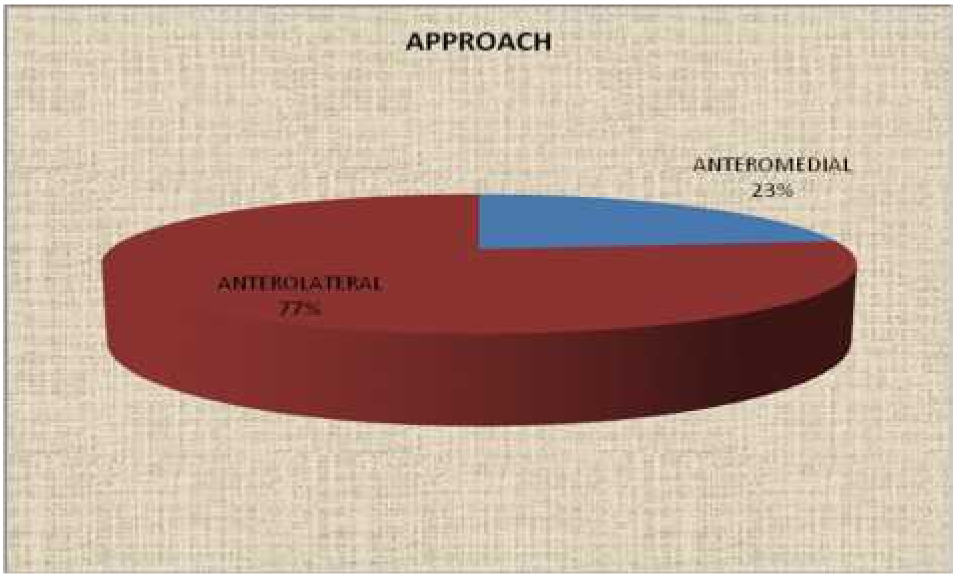
In the present study on evaluation of the type of Schatzker's fracture we found that of the 26 cases in the study most patients had a type VI (20 patients, 76.92%)

TYPE OF APPROACH

TABLE NO 12 : APPROACH CHOSEN FOR SURGERY

APPROACH	NO. OF PATIENTS	%
ANTEROMEDIAL	6	23.08
ANTEROLATERAL	20	76.92

GRAPH NO 6 : APPROACH CHOSEN FOR SURGERY



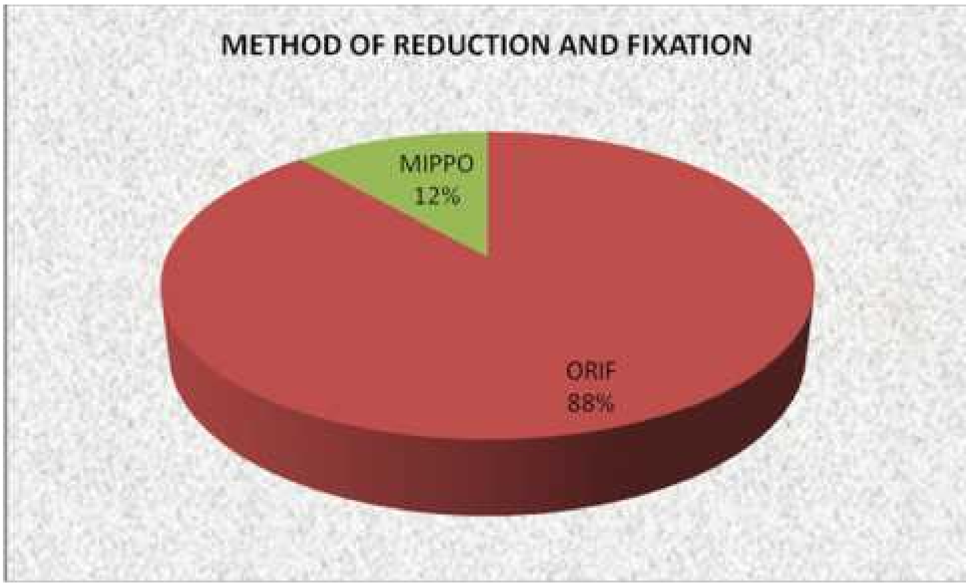
In the present study on evaluation of the type of approach chosen for the treatment of fracture we found that of the 26 cases in the study most patients had anterolateral approach (20 patients, 76.92%).

METHOD OF REDUCTION AND FIXATION

TABLE NO 13 : METHOD OF REDUCTION AND FIXATION

METHOD OF REDUCTION AND FIXATION	NO. OF PATIENTS	%
ORIF	23	88.46
MIPPO	3	11.54

GRAPH NO 7 : METHOD OF REDUCTION AND FIXATION



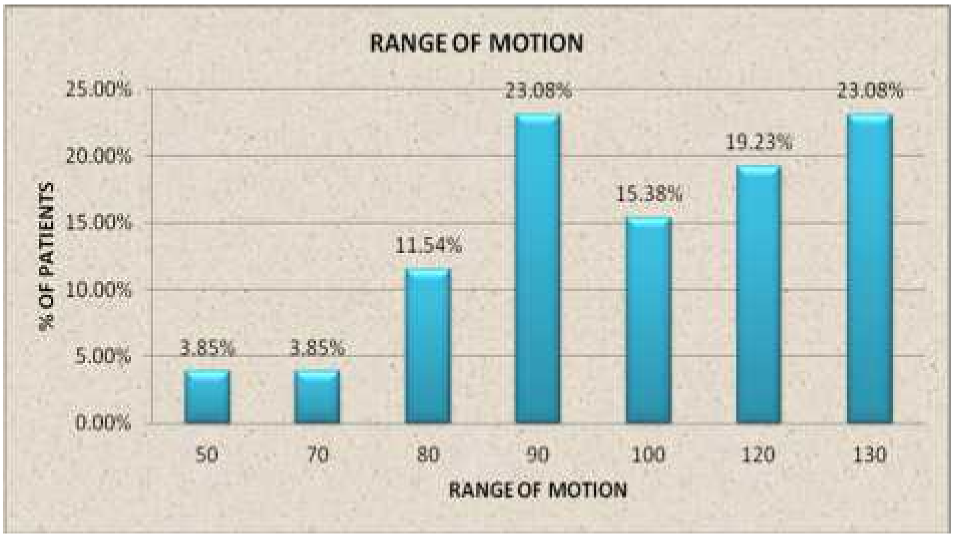
In the present study on evaluation of the method of reduction and fixation we found that of the 26 cases in the study most patients were fixed by orif (23 patients, 88.46%).

RANGE OF MOTION POST OP

TABLE NO 14 : RANGE OF MOTION

RANGE OF MOTION	NO. OF PATIENTS	%	MEAN	STDEV
50	1	3.85	103.07	22.22
70	1	3.85		
80	3	11.54		
90	6	23.08		
100	4	15.38		
120	5	19.23		
130	6	23.08		

GRAPH NO 8 : RANGE OF MOTION



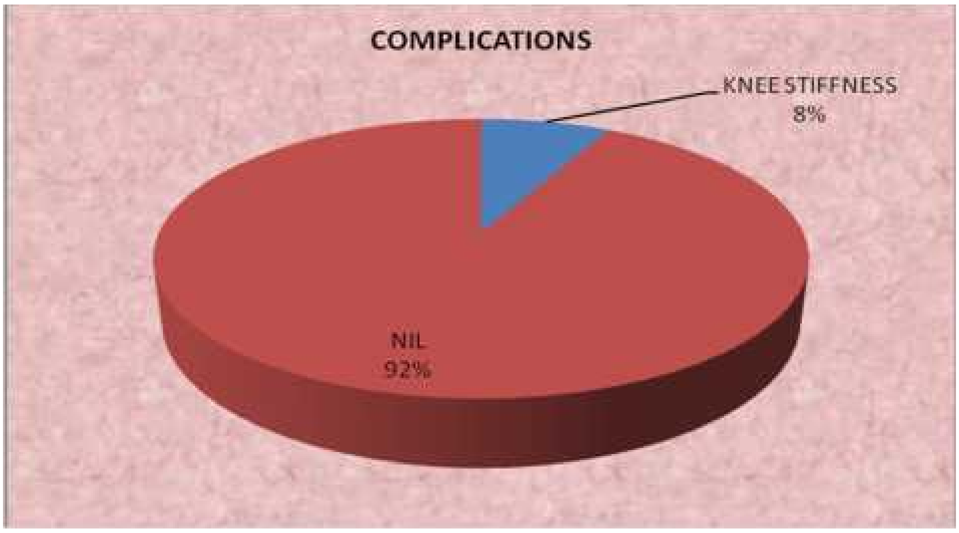
In the present study on evaluation of the range of motion following surgery, most patients had a good range of motion of 130^0 (6 patients, 23.08%).

COMPLICATIONS

TABLE NO 15 : COMPLICATIONS

COMPLICATIONS	NO. OF PATIENTS	%
KNEE STIFFNESS	2	7.69
NIL	24	92.31

GRAPH NO 9 : COMPLICATIONS



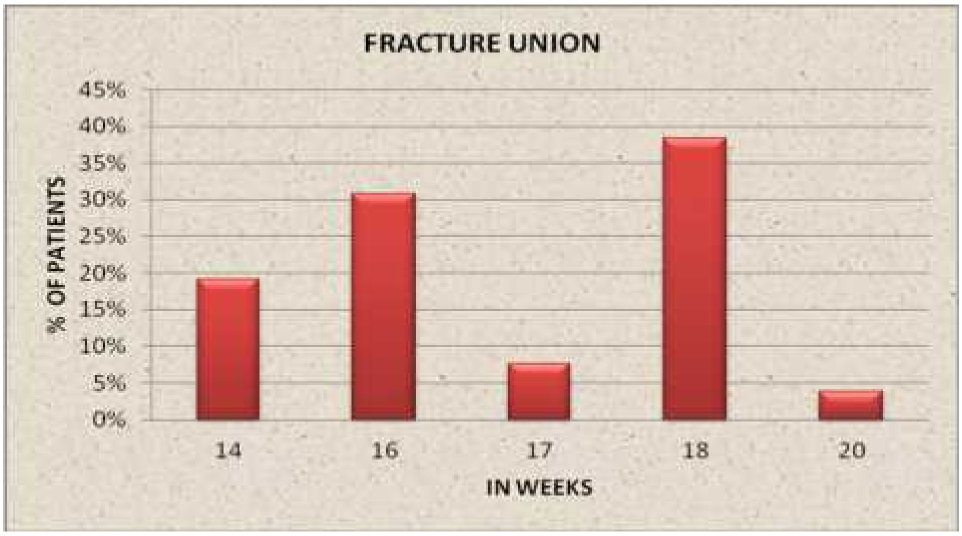
In the present study on evaluation of complications following surgery, most patients had no complications. Only 2 patients had knee stiffness (7.69 %).

DURATION TAKEN FOR THE FRACTURE UNION

TABLE NO 16 : FRACTURE UNION

FRACTURE UNION IN WEEKS	NO. OF PATIENTS	%	MEAN	STDEV
14	5	19.23	16.61	1.65
16	8	30.77		
17	2	7.69		
18	10	38.46		
20	1	3.85		

GRAPH NO 10 : FRACTURE UNION



In the present study on evaluation of the duration taken for the fracture union most patients had fracture union in 18 weeks (10 patients, 38.46%), The mean duration for fracture healing was 16.61 weeks.

THE FINAL OUTCOME

TABLE NO 17 : FINAL OUTCOME

RESULTS	PATIENTS	%
EXCELLENT	11	42.31
GOOD	10	38.46
FAIR	4	15.38
POOR	1	3.85

GRAPH NO 11 : FINAL OUTCOME

In the present study on evaluation of the final outcome of the fracture most patients had excellent results (11 patients, 42.31%), The mean duration for fracture healing was 16.61 weeks.

Proximal tibial fractures treated with LCP can be manipulated under anaesthesia in the event of plate bending due to re-injury. Because LCP provide angular stability and technique of MIPPO retains the fracture biology, manipulation under anaesthesia may be justified in these cases.

The main purpose of the study is to evaluate outcome of the surgery. Hence all the patients included in the study are of the operative group. We have not included any conservatively managed group. Our study shows the effectiveness of the operative treatment as the articular surface was restored anatomically and fixed with suitable implant for early mobilization.

Figure-24: CLINICAL PHOTOS AND RADIOGRAPHS

CASE NO 1

PREOPERATIVE ANTEROPOSTERIOR AND LATERAL VIEW

IMMEDIATE POSTOPERATIVE

6 WEEKS FOLLOW UP

3 MONTHS FOLLOW UP

6 MONTHS FOLLOW UP

COMPLETE EXTENSION

COMPLETE FLEXION

FULL WEIGHT BEARING

CASE NO 2

PREOPERATIVE ANTEROPOSTERIOR AND LATERAL VIEW

IMMEDIATE POSTOPERATIVE

6 WEEKS FOLLOWUP

3 MONTHS FOLLOWUP

6 MONTHS FOLLOWUP

COMPLETE EXTENSION

COMPLETE FLEXION

FULL WEIGHT BEARING

CASE NO 3

PREOPERATIVE ANTEROPOSTERIOR AND LATERAL VIEW

IMMEDIATE POSTOPERATIVE

6 WEEKS FOLLOW UP

3 MONTHS FOLLOW UP

6 MONTHS FOLLOW UP

FLEXION

EXTENSION LAG OF 10 DEGREES

FULL WEIGHT BEARING

Demographic Data

Age Distribution

In the present study on evaluation of the age distribution we found that of the 26 cases in the study most patients belonged to the category 40-50 years (10 patients, 38.46%).

In a study by Tang Xin *et al* (2012).[67] study on evaluation of the age distribution, the mean age was 45 years with a std.dev of 11 years which is similar to our study.

STUDY BY	YEAR	NUMBER OF CASES	RESULT- MEAN AGE
Tang Xin et al	2012	42	20-65 years (mean 40 years)
G Thiruvengita Prasad	2013	40	22 to 61 years (mean 40 years)
Our study	2015	26	20 to 80 years (mean 40 years)

Gender Distribution

In the present study on evaluation of the gender distribution we found that of the 26 cases in the study most patients were males (25 patients, 96.15%).

In a study by Tang Xin *et al* (2012).[67] study on evaluation of the gender distribution we found that of the 42 cases in the study most patients were males (30 patients) and females accounted for 12 cases of the total number. This gender distribution is similar to our study

STUDY BY	YEAR	NUMBER OF CASES	RESULT- SEX DISTRIBUTION
Tang Xin et al	2012	42	30 males and 12 females
G Thiruvengita Prasad et al	2013	40	33 males and7 females
Our study	2015	26	25 males and 1 female

Clinical Data

Mode of Injury

In the present study on evaluation of the mode of injury we found that of the 26 cases in the study most patients were injured by vehicular accident (19 patients, 73%).

In a study by Tang Xin *et al* (2012).[67] study on evaluation of the mode of injury most patients were injured due to RTA.

STUDY BY	YEAR	NUMBER OF CASES	RESULT- MOST COMMON MODE OF INJURY
Tang Xin et al	2012	42	RTA.
G Thiruvengita Prasad et al	2013	40	RTA.
Our study	2015	26	RTA.

Type of the Fracture

STUDY BY	YEAR	NUMBER OF CASES	RESULT- MOST COMMON MODE OF INJURY
Tang Xin et al	2012	42	11 Schatzker type IV,19 Schatzker type V fractures,12 Schatzker type VI fractures.
G Thiruvengita Prasad et al	2013	40	20 Schatzker type V fractures, 20 Schatzker type VI fractures.
Our study	2015	26	1 Schatzker type I 1 Schatzker type II 4 Schatzker type IV 20 Schatzker type VI

Range of motion

In the present study on evaluation of the range of motion following surgery, most patients had a good range of motion of 130^0 (6 patients, 23.08%).

In a study by Prasad *et al*.[68] most patients had 120° and above knee flexion which is a finding similar to our study

STUDY BY	YEAR	NUMBER OF CASES	RESULT- MOST COMMON RANGE OF MOTION
G Thiruvengita Prasad et al	2013	40	120°
Our study	2015	26	130^0

Time for fracture union

In the present study on evaluation of the duration taken for the fracture union most patients (10 patients) had fracture union in 18 weeks (38.46%). The mean duration for fracture healing was 16.61 weeks

In a study by Prasad *et al***.**[68] all patients had had union in 8-22 weeks (average 14 weeks).

STUDY BY	YEAR	NUMBER OF CASES	RESULT- TIME FOR FRACTURE UNION
G Thiruvengita Prasad et al	2013	40	8 -22 weeks (average 14 weeks).
Tang Xin et al	2012	42	average 18 weeks
Our study	2015	26	14 -20 weeks (average 18 weeks).

Final Outcome of the Fracture

In the present study on evaluation of the final outcome of the fracture most patients had excellent results 11 patients (42.31%)

In a study by Tang Xin *et al* (2012).[67] study on evaluation of the final outcome of the fracture most patients with surgical approach had excellent results

In a study by Prasad *et al***.**[68] study on evaluation of the final outcome of the fracture most patients with surgical approach had excellent results.

STUDY BY	YEAR	NUMBER OF CASES	RESULT- FINAL OUTCOME OF THE FRACTURE IN MOST CASES
G Thiruvengita Prasad et al	2013	40	Excellent(30 patients)
Tang Xin et al	2012	42	Excellent
Our study	2015	26	Excellent(10 patients)

DISCUSSION

In our study the following were the details of the observations made

- Type I fractures 1 in number, male patient, due to fall is operated using anterolateral approach with ORIF. 130^0 ROM without any deformity and no complications, excellent result.
- Type II fractures 1 in number, male patient, due to fall is operated using anterolateral approach with ORIF. 130^0 ROM without any deformity and no complications, excellent result.
- In our study no Type III fractures were seen

Type IV fractures 4 in number, 3 male patients with RTA and 1 due to fall, all cases were operated with ORIF with an average 90^0 ROM knee stiffness in one case.

- In our study no Type V fractures were seen

Type VI fractures 20 in number, 19 male patients with 11 right sided injury 16 due to RTA and 4 due to fall one female with left sided injury due to fall, 17 cases were operated using anterolateral approach with ORIF with an average 100^0 ROM with knee stiffness in one case . 3 cases antero-medial approach with ORIF and MIPPO in 3 cases with an average 110^0 ROM.

Clinical Studies with Locked Plate Fixation

Tibial plateau fractures can benefit from locked plating in fractures with instability, metaphyseal comminution, and osteoporosis

Gosling *et al*.[69] in a multicentre study, reported 23% postoperative malalignment and 14% loss of alignment when high-energy bicondylar proximal tibial fractures were treated with laterally placed LISS plate only.

Phisitkul *et al*.[70] reported immediate postoperative and delayed loss of alignment in 22% and 8% of cases, respectively, when lateral LISS plate was used in proximal tibial fractures.

Marsh *et al*.[71] presented a series of 21 complex tibial plateau fractures treated with monolateral external fixation and limited internal fixation and reported a 14% rate of malalignment

Weigel and Marsh.[72] presented a 5-year follow-up after treatment of 24 high-energy tibial plateau fractures with limited internal fixation and a monolateral external fixator.

In a study by Shiva Naik *et al.*[73] they showed that locking compression plate is an important armamentarium in treatment of fractures around knee especially when fracture is severely comminuted and in situations of osteoporosis.

Jain *et al.*[74] showed that applied with proper understanding of biomechanics, LCP is one of the best available options for management of challenging peri- and intra-articular fractures especially of proximal tibia

In another study Comparing the fixation of proximal tibial fractures by nonlocking buttress versus locking compression plate by Patil *et al.*[75] and co workers had almost same results in both groups and concluded that Considering its high cost, LP should only be used, where it is more advantageous than conventional plate.

In a study by Peter A. Cole.[76] Internal fixation using the LISS was performed at an average of 7.1 days (range: 0-29 days) after the injury. Twenty-two fractures were operated (within the first 24 hours. The implants used for the fractures in this series included 6 5-hole, 43 and 28 13-hole fixators. The mean number of locking screws used in the proximal articular segment was 4.9 (range: 3-7 screws), and the mean number of screws used in the distal segment was 4.8 (range: 2-6 screws). In 53patients, adjunctive implants were used for periarticular fixation, which included 6 plates (small fragment plates), 1 K-wire, and articular lag screws in 49 fractures.

Allograft bone grafting was performed in 9 cases of tibial plateau fractures, where voids from depressed plateau fracture fragments had to be filled and buttressed.

CONCLUSION

Displaced tibial plateau fractures are best managed operatively. Optimal knee function is achieved by accurate anatomical reduction and secure fixation followed by early mobilisation to attain functional arc of motion.

For minimally displaced fractures with minimal bone defects percutaneous fixation suffices where as for more comminuted fractures open reduction and internal fixation is mandatory.

Post operative rehabilitation protocol in terms of non-weight bearing and achieving satisfactory range of motion needs to be strictly adhered to, in order to obtain optimal functional results.

In our study we found that proximal tibial locking plate provides complete union and early mobilisation to attain better functional outcome.

SUMMARY

The study was a prospective study conducted on 26 consenting patients who presented with proximal tibial fractures admitted to Shri B.M. Patil Medical College, Hospital and Research Centre, Vijayapur during the period October 2013 to August 2015. The main purpose of the study was to evaluate outcome of the surgery of the study group; hence all the patients that included in the study are of the operative group. We have not included any conservatively managed group.

- The age distribution we found that of the 26 cases in the study most patients belonged to category 40-50 years (10 patients, 38.46%)
- The gender distribution we found that of the 26 cases in the study most patients were males (25 patients, 96.15%)
- The mode of injury we found that of the 26 cases in the study most patients were injured by vehicular accident (19 patients, 73.08%)
- The side of injury we found that of the 26 cases in the study most patients had a right sided injury (17 patients, 65.38%)
- The type of schatzker's fracture we found that of the 26 cases in the study most patients had a type vi (20 patients, 76.92%)
- The type of approach we found that of the 26 cases in the study most patients had anterolateral (20 patients, 76.92%)
- The method of reduction and fixation we found that of the 26 cases in the study most patients had ORIF (23 patients, 88.46%)
- The range of motion following surgery, most patients had a good range of motion of 130^0 (6 patients, 23.08%)
- Complications following surgery, most patients had no complications. 2 patients had knee stiffness (7.69%)

- The duration taken for the fracture union most patients had fracture union in 18 weeks (10 patients, 38.46%) . The mean duration for fracture healing was 16.61 weeks
- The final outcome of the fracture most patients had excellent results (11 patients, 42.31%). The mean duration for fracture healing was 16.61 weeks.

REFERENCES:

1. Kim JW, Oh CW, Jung JW, Kim JS. Minimally Invasive Plate Osteosynthesis for Open Fractures of the Proximal Tibia. Clinics in Orthopedic Surgery 2012;4: 313-320.
2. Schulak DJ, Gunn DR. Fracture of the tibial plateaus. Clin Orthop 1975;109: 166-177.
3. Koval KJ, Hulfut DL. Tibial plateau fracture: evaluation and treatment. J Am Acad Orthop Surg 1995;3: 86-94.
4. Wagner M. General principles for the clinical use of the LCP. Injury 2003;34: B31-42.
5. Sommer C, Gautier E, Muller M, Helfet DL, Wagner M. For clinical application of the LCP. Injury 2003;34: B43-54.
6. Stoffel K, Dietar U, Stachowiak G, Gächter A, Kuster MS. Biomechanical testing of the LCP how can stability in locked internal fixator be controlled. Injury 2003;34: B11-19.
7. Potocnik B, Zazula D, Cigale B, Heric D, Cibula E, Tomazic T. A Patient-specific Knee Joint Computer Model Using MRI Data and 'in vivo' Compressive Load from the Optical Force Measuring System. Journal of Computing and Information Technology 2008;16: 209-222.
8. Hunziker EB, Stäubli HU, Jakob RP. Surgical anatomy of the knee joint. In: Jakob RP, Stäubli HU editors. The Knee and the Cruciate Ligaments, 1st edn. Springer: Berlin Heidelberg;1992.p.- 31-47.
9. Beasley LS, Weiland DE, Vidal AF, Chhabra A, Herzka AS, Feng MT *et al.*. Anterior Cruciate Ligament Reconstruction: A Literature Review of the Anatomy, Biomechanics, Surgical Considerations, and Clinical Outcomes.

Operative Techniques in Orthopaedics 2005;15: 5-19.

10. Keith M, Anne A, Arthur D. Essential Clinical Anatomy. clinical anatomy 2014;27: 356–357.

11. Caudle RJ, Stern PJ. Severe open fractures of the tibia. The Journal of Bone Joint Surgery 1987;69: 801-807.

12. Blackburn TA, Craig E. Knee Anatomy A Brief Review. Physical therapy 1980;60: 1556-1560.

13. Watanabe Y, Moriya H, Takahashi K, Yamagata M, Sonoda M, Shimada Y *et al.*. Functional anatomy of the posterolateral structures of the knee. Arthroscopy: The Journal of Arthroscopic Related Surgery 1993;9: 57-62.

14. Müller W. Anatomy. In: Müller W editor. The knee: form, function and ligament reconstruction, 1st edn. New York: Springer Verlag;1983.p.-145–50.

15. Cobb JP, Dixon H, Dandachli W, Iranpour F. The anatomical tibial axis reliable rotational orientation in knee replacement. Journal of Bone Joint Surgery, British Volume 2008;90: 1032-1038.

16. Yoshioka Y, Siu DW, Scudamore RA, Cooke TDV. Tibia1 anatomy and functional axes. J Orthop Res 1989;7: 132-137.

17. Tile M. Fractures of the tibia. In: Schatzker J, Tile M editors. The rationale of operative fracture care, 3rd edn. Springer: New York;2005.p.- 471-518.

18. Court-Brown CM, McBirnie J. The epidemiology of tibial fractures. J Bone Joint Surg Br 1995;77: 417-421.

19. Crimaldi S, Calderazzi F, Becherucci L, Faldini A. Case report: Upper tibial physeal fracture Proposed mechanism of injury and classification. Acta Orthopaedica 2003;74: 765-765.

20. Cotton FJ, Berg R. Fender fracture of the tibia at the knee. New England

Journal of Medicine 1929;201: 989-995.

21. Apley AG. Fractures of the lateral tibial condyle treated by skeletal traction and early mobilisation 1956;38: 699-708.

22. Wilson DR, Feikes JD, Zavatsky AB, O'connor JJ. The components of passive knee movement are coupled to flexion angle. Journal of Biomechanics 2000;33: 465-473.

23. Kennedy JC, Bailey WH. Experimental tibial-plateau fractures. The Journal of Bone Joint Surgery 1968;50: 1522-1534.

24. Delamarter RB, Hohl M, Hopp EJ. Ligament injuries associated with tibial plateau fractures. Clin Orthop 1990;250: 226–233.

25. Oestern HJ, Tscherne H. Pathophysiology and classification of soft tissue injuries associated with fractures. In: Tscherne H, Gotzen L editors. Fractures with soft tissue injuries, 1 st edn. Springer: Berlin Heidelberg;1984. p.- 1-9.

26. Gustilo RB, Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: retrospective and prospective analysis. J Bone Joint Surg 1976;58: 453-458.

27. Gustilo RB, Mendoza RM, Williams DN. Problems in the management of type III (severe) open fractures: a new classification of type III open fractures. J Trauma 1984;24: 742-746.

28. Hohl M, Luck JV. Fractures of the tibial condyle. The Journal of Bone Joint Surgery 1956;38: 1001-1018.

29. Hohl M, Moore TM. Articular fractures of the proximal tibia. In Ewarts CM (ed.): Surgery of the musculoskeletal system 2nd edn. New York: Churchill Livingstone; 1990.

30. Martin JS, Marsh JL, Bonar SK, Decoster TA, Found EM, Brandser EM.

Assessment of the AO/ASIF fracture classification for the distal tibia. Journal of orthopaedic trauma 1997;11: 477-483.

31. Elmrini A, Elibrahimi A, Agoumi O, Boutayeb F, Mahfoud M, Elbardouni A *et al*.. Ipsilateral fractures of tibia and femur or floating knee. International orthopaedics 2006;30: 325-328.
32. Manidakis N, Dosani A, Dimitriou R, Stengel D, Matthews S, Giannoudis P. Tibial plateau fractures: functional outcome and incidence of osteoarthritis in 125 cases. International orthopaedics 2010;34: 565-570.
33. Mehta S, Levin LS. Orthopaedic trauma, fractures, and dislocations. In: Peitzman AB, Fabian TC, Rhodes M, Yealy DM, Schwab CW editors. The trauma manual: trauma and acute care surgery, 4th edn. Lippincott Williams: Philadelphia;2013.p.-404-426.
34. Honkonen SE. Degenerative arthritis after tibial plateau fractures. Journal of orthopaedic trauma 1995;9: 273-277.
35. Schatzker J. Fractures of the tibial plateau. In: Schatzker J, Tile M editors. The rationale of operative fracture care, 3rd edn. Springer: New York;2005.p.-447-469.
36. Markhardt BK, Gross JM, Monu J. Schatzker Classification of Tibial Plateau Fractures: Use of CT and MR Imaging Improves Assessment. Radiographics 2009;29: 585-597.
37. Kode L, Lieberman JM, Motta AO, Wilber JH, Vasen A, Yagan R. Evaluation of Tibial Plateau Fractures: Efficacy of MR Imaging Compared with CT. A.J.R 1994;163: 141-147
38. Decoster TA, Nepola JV, El-khoury GY. Cast Brace Treatment of Proximal Tibia Fractures: A Ten-Year Follow-up Study. Clinical orthopaedics and

related research 1988;231: 196-204.

39. Duwelius PJ, Connolly JF. A Comparison of Functional and Roentgenographic End Results. Clinical orthopaedics and related research 1988;230: 116-126.

40. Perry CR, Evans LG, Rice S, Fogarty J, Burdge RE. A new surgical approach to fractures of the lateral tibial plateau. The Journal of Bone Joint Surgery 1984;66: 1236-1240.

41. Gausewitz S, Hohl M. The significance of early motion in the treatment of tibial plateau fractures. Clinical orthopaedics and related research 1986;202: 135-138.

42. Lansinger O, Bergman B, Körner L, Andersson GB. Tibial condylar fractures. A twenty-year follow-up. The Journal of Bone Joint Surgery 1986;68: 13-19.

43. Joseph S, Mcbroom R, Bruce D. The Tibial Plateau Fracture: The Toronto Experience 1968-1975. Clinical orthopaedics and related research 1977;138: 94-104.

44. Burdin G. Arthroscopic management of tibial plateau fractures: surgical technique. Orthopaedics Traumatology: Surgery Research 2013;99: S208-S218.

45. Tscherne H, Lobenhoffer P. Tibial Plateau Fractures: Management and Expected Results. Clinical orthopaedics and related research 1993;292: 87-100.

46. Young MJ, Barrack RL. Complications of internal fixation of tibial plateau fractures. Orthopaedic review 1994;23: 149-154.

47. Waddell JP, Johnston DWC, Neidre A. Fractures of the tibial plateau: a review of ninety-five patients and comparison of treatment methods. Journal of

Trauma and Acute Care Surgery 1981;21: 376-381.

48. Burri C, Bartzke G, Coldewey J, Muggler E. Fractures of the tibial plateau. Clinical orthopaedics and related research 1979;138: 84-93.

49. Delamarter RB, Hohl M, Hopp E. Ligament injuries associated with tibial plateau fractures. Clinical orthopaedics and related research 1990;250: 226-233.

50. Fowble CD, Zimmer JW, Schepsis AA. The role of arthroscopy in the assessment and treatment of tibial plateau fractures. Arthroscopy: The Journal of Arthroscopic Related Surgery 1993;9: 584-590.

51. Havitcioglu H, Capkin S, Hapa O, Guler S, Erduran M, Gunal I. What is correlated with functional outcomes of surgically treated tibial plateau fractures? 2013;2: 85-90.

52. Rasmussen PS. Tibial condylar fractures: impairment of knee joint stability as an indication for surgical treatment. J Bone Joint Surg Am 1973;55: 1331-1350.

53. Alho A, Benterud JG, Hogevold HE. Comparison of functional bracing and locked intramedullary nailing in the treatment of displaced tibial shaft fractures. Clin Orthop Relat Res 1992;277: 243–250.

54. Edwards P, Nilsson BE. The time of disability following fracture shaft of tibia. Acta. Orthop Scan 1969;40: 501-506.

55. Jayachandra Reddy B, Abhishek L, Kathyayini R. Comparative Study of Forearm Fractures Treated with Locking Compression Plate Limited Contact Dynamic Compression Plate. Journal of Evolution of Medical and Dental Sciences 2015;4: 1981-1991.

56. Cronier P, Pietu G, Dujardin C, Bigorre N, Ducellier F, Gerard R. The concept

of locking plates. Orthopaedics traumatology: surgery research 2010;96: S17-S36.

57. Saikia K, Bhuyan S, Bhattacharya T, Borgohain M, Jitesh P, Ahmed F. Internal fixation of fractures of both bones forearm: Comparison of locked compression and limited contact dynamic compression plate. Indian Journal of Orthopaedics 2011;45: 417-421.
58. Kubiak EN, Fulkerson E, Strauss E, Egol KA. The evolution of locked plates. The Journal of Bone Joint Surgery 2006;88: 189-200.
59. Strauss EJ, Schwarzkopf R, Kummer F, Egol KA. The current status of locked plating: the good, the bad, and the ugly. Journal of orthopaedic trauma 2008;22: 479-486.
60. Miller DL, Goswami T. A review of locking compression plate biomechanics and their advantages as internal fixators in fracture healing. Clinical biomechanics 2007;22: 1049-1062.
61. Smith WR, Ziran BH, Anglen JO, Stahel PF. Locking plates: tips and tricks. The Journal of Bone Joint Surgery 2007;89: 2298-2307.
62. Hunt SB, Buckley RE. Locking plates: a current concepts review of technique and indications for use. Acta chirurgiae orthopaedicae et traumatologiae Cechoslovaca 2013;80: 185-191.
63. Ahmad M, Nanda R, Bajwa AS, Candal-Couto J, Green S, Hui AC. biomechanical testing of locking compression plates is distance between bone and implant significant? JBJS 2007;38: 358-364.
64. Egol KA, Kubiak EN, Fulkerson E, Kummer FJ, Koval KJ. Biomechanics of Locked Plates and screws J Orthop Trauma 2004;18: 488–493.
65. Cornell CN, Omri A. Evidence for Success with Locking Plates for Fragility

Fractures. HSS Journal 2011;7: 164–169.

66. Dickson KF, Munz JW. Locked plating: Biomechanics and biology. Techniques in Orthopaedics 2007;22: E1-E6.

67. Tang X, Liu L, Tu CQ, Yang TF, Wang GL, Fang Y *et al.*. Timing of internal fixation and effect on Schatzker IV-VI. Chinese Journal of Traumatology 2012;15: 81-85.

68. Prasad GT, Kumar TS, Kumar RK, Murthy GK, Sundaram N. Functional outcome of Schatzker type V and VI tibial plateau fractures treated with dual plates. Indian Journal of Orthopaedics 2013;47: 188-194.

69. Gosling T, Schandelmaier P, Muller M, Hankemeier S, Wagner M, Krettek C. Single lateral locked screw plating of bicondylar tibial plateau fractures. Clin Orthop Relat Res 2005;439: 207–214.

70. Phisitkul P, McKinley TO, Nepola JV, Marsh JL. Complications of locking plate fixation in complex proximal tibia injuries. J Orthop Trauma 2007;21: 83–91.

71. Marsh JL, Smith ST, Do TT. External fixation and limited internal fixation for complex fractures of the tibial plateau. J Bone Joint Surg Am 1995;77: 661–673

72. Weigel DP, Marsh JL. High-energy fractures of the tibial plateau. Knee function after longer follow-up. J Bone Joint Surg Am 2002;84: 1541-1551.

73. Shiva NR, Ganesh P, Subbaiah, Kumar P. Surgical management of closed fractures of distal end of femur or proximal end of tibia using locking compression plate: A prospective study. Journal of Evolution of Medical and Dental Sciences 2015;4: 4479-4490.

74. Jain JK, Asif N, Ahmad S, Qureshi O, Siddiqui YS, Rana A. Locked

compression plating for peri- and intra-articular fractures around the knee. Orthop Surg 2013;5: 255-260.

75. Patil DG, Ghosh S, Chaudhuri A, Datta S, De C, Sanyal P. Comparative study of fixation of proximal tibial fractures by nonlocking buttress versus locking compression plate. Saudi Journal of Sports Medicine 2015;15: 142-147.

76. Cole PA, Zlowodzki M, Kregor PJ. Treatment of proximal tibia fractures using the less invasive stabilization system: surgical Experience and Early clinical results in 77 fractures. Journal of orthopaedic trauma 2004;18: 528-535.

ANNEXURE I

B.L.D.E. UNIVERSITY'S

SHRI.B.M.PATIL MEDICAL COLLEGE, BIJAPUR-586 103

INSTITUTIONAL ETHICAL COMMITTEE

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Ethical Committee of this college met on 13-11-2013 *at* 3-30pm *to scrutinize the Synopsis of Postgraduate Students of this college from Ethical Clearance point of view. After scrutiny the following original/corrected & revised version synopsis of the Thesis has been accorded Ethical Clearance.*

Title "A clinical study of proximal tibial fractures treated with locking compression plate" —x—x—

Name of P.G. student Dr. Sharath Babu Mukka. Department of Orthopaedics.

Name of Guide/Co-investigator Dr Santosh. S. Nandi Assoc. Prof of Orthopaedics

DR.TEJASWINI VALLABHA
CHAIRMAN
INSTITUTIONAL ETHICAL COMMITTEE
BLDEU'S, SHRI.B.M.PATIL
MEDICAL COLLEGE, BIJAPUR.

Following documents were placed before E.C. for Scrutinization
1) Copy of Synopsis/Research project
2) Copy of informed consent form
3) Any other relevant documents.

ANNEXURE II

INFORMED CONSENT FORM

SYNOPSIS

BLDEU'S SHRI B. M. PATIL

MEDICAL COLLEGE HOSPITAL AND RESEARCH CENTRE,

VIJAYAPUR-586 103

TITLE OF RESEARCH: A CLINICAL STUDY OF PROXIMAL TIBIAL FRACTURES TREATED WITH LOCKING COMPRESSION PLATE.

Principle Investigator	:	DR.SHARATH BABU MUKKA
P.G. Guide Name	:	DR. SANTOSH S NANDI M.S (ORTHO)

All aspects of this consent form are explained to the patient in the language understood by him/her.

I. INFORMED PART

1. Purpose of study

I have been informed that this study will test the effectiveness of LOCKING COMPRESSION PLATE IN PROXIMAL TIBIA FRACTURE. This method requires hospitalization.

2. Procedure

I will be selected for the treatment after the clinical study of my age, type of fracture, condition of bone seen in radiograph and after study of fitness for anaesthesia and surgery. I will be admitted electively. I will have to attend follow-up to OPD regularly. I will be assessed in physiotherapy department also.

3. Risk and Discomfort

I understand that I may experience some pain and discomfort during the post operative period. This condition is usually expected. These are associated with the usual course of treatment

4. Benefits

I understand that my participation in this study will have no direct benefit to me other than the potential benefit of treatment which is planned to relieve my pain in the shortest possible period and restore my function.

5. Alternatives

I understand that, the various alternative modes of treatment available to me for this condition with their merits and demerits have been explained to me.

6. Confidentiality

I have been assured that all information furnished to the doctor by me regarding my medical condition will be kept confidential at all times and all circumstances except legal matters.

7. Requires for more information

It has been made clear to me that I am free at all time under any circumstances to touch based with doctor by directly approaching or otherwise to satisfy any querry, doubt regarding any aspect of research concerns.

8. Refusal or withdrawal of participation

It has been made clear to me that participation in this medical research is solely the matter of my will and also that right to withdraw from participation in due course research at any time.

II. CONSENT BY PATIENT

I undersigned, have been explained by Dr. Santosh S Nandi in the language understood by me. The purpose of research, the details or procedure that will be implemented on me. The possible risks and discomforts of surgery and anaesthesia have been understood by me. I have also been explained that participation in this medical research is solely the matter of my will and also that I have the right to withdraw from this participation at any time in due course of the medical research.

Signature of participant/patient date: time:

Signature of witness: date: time:

ANNEXURE – III

SHRI B.M. PATIL MEDICAL COLLEGE, HOSPITAL AND RESEARCH CENTRE, VIJAYAPUR - 586103

PROFORMA

CASE NO. :

NAME :

AGE/SEX :

I P NO :

DATE OF ADMISSION :

DATE OF SURGERY :

DATE OF DISCHARGE :

OCCUPATION :

RESIDENCE :

Presenting complaints with duration :

History of presenting complaints :

Family History :

Personal History :

Past History :

General Physical Examination

Pallor:	present/absent
Icterus:	present/absent
Clubbing:	present/absent
Generalized lymphadenopathy:	present/absent
Built:	poor/moderate/well
Nourishment:	poor/moderate/well

Vitals

PR: RR:

BP: TEMP:

Other Systemic Examination:

Local examination:

Right/ Left Leg

Gait:

Inspection:

a) Attitude/ deformity

b) Abnormal swelling

- Site
- Size
- Shape
- Extent

c) Shortening

d) Skin

e) Popliteal fossa

f) Compound injury if any

Palpation:

a) Local tenderness

b) Bony irregularity

c) Abnormal movement

d) Crepitus

e) Pain elicited by manipulation

f) Transmitted movements

g) Swelling

h) Valgus/Varus deformity

i) Instability

j) Ligament injury

Movements: Active Passive

Knee: Flexion

Extension

Measurements: shortening Apparent:

Real:

MANAGENT :

INVESTIGATIONS:

- X-ray of knee joint with proximal 2/3rd leg Antero-posterior & Lateral views.
- Complete blood count.
- Bleeding time, Clotting time.
- Urine- Albumin, sugar and Microscopy.
- Random blood sugar, Blood urea and Serum creatinine.
- HIV and Hbs Ag.
- Blood grouping and Rh- typing.
- ECG.
- Chest X-ray- Postero-anterior view.
- Computed-tomography scan.
- Other specific investigations whichever needed.
- Final Diagnosis:

TREATMENT:

- Preliminary treatment on admission- Above knee slab, analgesics
- Anaesthesia used – SA/GA
- Approach used
- Type of table – Normal/ fracture table
- Size of plate and screws used
- Intra-operative complications
- Final inspection of the plate, screws and fracture reduction under 'C'-ARM image intensifier

POST-OPERATIVE MANAGEMENT:

- The limbs will be kept elevated with pillows
- Intravenous antibiotics will be continued for first five days and then shifted to oral
- Posterior splint given if protection of fixation was desired
- Suction drainage will be removed after 48 hours depending on the amount of collection
- Check X-RAY on 3rd post-operative day
- Quadriceps exercises and ankle mobilization will be started within 48 hours of surgery
- Knee bending and toe touch walking with a walker on second or third postoperative day if the fixation allowed
- Dressing will be done on 2nd, 5th and 8th post-operative day
- Sutures will be removed on 12th post-operative day
- Progressive weight bearing will be allowed as tolerated by patient

- Full weight bearing was permitted only after clinico-radiological evidence of union
- Functional outcome following Locking compression plate in proximal tibial fracture will be evaluated based on Rasmussen's criteria

FOLLOW-UP:

Duration after surgery: 6 weeks/ 3 months/ 6 months

Radiological evaluation – Check X-RAY knee joint with proximal 2/3rd leg Antero-posterior & lateral view

Complaints:

- Deformity
- Shortening
- Range of motion of knee – flexion and extension
- Pain
- Swelling

RESULTS	EXCELLENT	GOOD	FAIR	POOR

MASTER CHART

S No	Name	Age	Sex	IP No	MOI	SIDE	SCHATZKERS TYPE	DOS	APPROACH	MATHOD OF REDUCTION AND FIXATION	ROM	COMP	FRACTURE UNION WEEKS	RESULTS
1	SHASHIKALA	42	F	1099	FALL	LEFT	TYPE VI	22-11-13	ANTEROLATERAL	ORIF	90	NIL	18	GOOD
2	KUMAR LAXMAN	58	M	829	FALL	RIGHT	TYPE VI	26-11-13	ANTEROMEDIAL	ORIF	80	NIL	16	FAIR
3	IRASANGAPPA	80	M	4180	FALL	RIGHT	TYPE II	18-12-13	ANTEROLATERAL	ORIF	130	NIL	18	EXCELLENT
4	RAKESH	34	M	42608	RTA	RIGHT	TYPE IV	24-12-13	ANTEROMEDIAL	ORIF	70	KNEE STIFFNESS	14	FAIR
5	NAGARAJ	25	M	2140	RTA	RIGHT	TYPE IV	24-01-14	ANTEROLATERAL	ORIF	100	NIL	14	GOOD
6	SHARANAPPA	40	M	1993	RTA	RIGHT	TYPE IV	27-01-14	ANTEROMEDIAL	ORIF	90	NIL	20	GOOD
7	JAGANNATH	50	M	3803	FALL	RIGHT	TYPE I	11-02-14	ANTEROLATERAL	ORIF	130	NIL	18	EXCELLENT
8	VITTAL	28	M	11538	RTA	LEFT	TYPE VI	24-04-14	ANTEROLATERAL	MIPPO	120	NIL	18	EXCELLENT
9	SHANTAYYA	45	M	13128	FALL	RIGHT	TYPE IV	07-05-14	ANTEROMEDIAL	ORIF	120	NIL	18	EXCELLENT
10	RAJEEV	35	M	18072	RTA	LEFT	TYPE VI	27-06-14	ANTEROLATERAL	ORIF	50	KNEE STIFFNESS	17	POOR
11	HUSSAIN	29	M	19583	RTA	LEFT	TYPE VI	08-07-14	ANTEROLATERAL	MIPPO	90	NIL	18	GOOD
12	SAGAR	45	M	21535	RTA	LEFT	TYPE VI	25-07-14	ANTEROLATERAL	ORIF	100	NIL	16	GOOD
13	SHIVANNA	45	M	24729	RTA	LEFT	TYPE VI	22-08-14	ANTEROLATERAL	ORIF	130	NIL	16	EXCELLENT
14	SHRINIVAS	34	M	29823	RTA	RIGHT	TYPE VI	07-10-14	ANTEROLATERAL	ORIF	80	NIL	14	FAIR
15	SANTOSH	36	M	31409	RTA	RIGHT	TYPE VI	21-10-14	ANTEROLATERAL	ORIF	120	NIL	18	EXCELLENT
16	RAMCHANDRA	50	M	33887	RTA	LEFT	TYPE VI	17-11-14	ANTEROMEDIAL	ORIF	130	NIL	18	EXCELLENT
17	IRAPPA	42	M	35368	FALL	RIGHT	TYPE VI	25-11-14	ANTEROLATERAL	ORIF	90	NIL	16	GOOD
18	DASTAGIR	20	M	38541	RTA	RIGHT	TYPE VI	23-12-14	ANTEROLATERAL	ORIF	100	NIL	17	GOOD
19	DEVAPPA	30	M	38921	RTA	RIGHT	TYPE VI	26-12-14	ANTEROLATERAL	ORIF	130	NIL	14	EXCELLENT
20	MALAKARI	42	M	266	FALL	RIGHT	TYPE VI	06-01-15	ANTEROLATERAL	ORIF	90	NIL	16	GOOD

21	SIDHRAM	36	M	1433	RTA	RIGHT	TYPE VI	16-01-15	ANTEROLATERAL	ORIF	120	NIL	16	EXCELLENT
22	RAVINDRA	41	M	1450	RTA	LEFT	TYPE VI	16-01-15	ANTEROLATERAL	ORIF	90	NIL	18	GOOD
23	SURESH	32	M	3009	RTA	RIGHT	TYPE VI	30-01-15	ANTEROLATERAL	ORIF	80	NIL	14	FAIR
24	KONAPPA	40	M	5330	RTA	LEFT	TYPE VI	20-02-15	ANTEROLATERAL	ORIF	130	NIL	18	EXCELLENT
25	MALLAPPA MASALI	60	M	5737	RTA	RIGHT	TYPE VI	24-02-15	ANTEROLATERAL	MIPPO	120	NIL	16	EXCELLENT
26	MALLAPPA MOGILI	48	M	6115	RTA	RIGHT	TYPE VI	27-02-15	ANTEROMEDIAL	ORIF	100	NIL	16	GOOD

KEY TO MASTER CHART

Ip No	:	Inpatient number
MOI	:	Mode of injury
M	:	Male
F	:	Female
RTA	:	Road traffic accident
DOS	:	Date of surgery
ROM	:	Range of motion
ORIF	:	Open reduction internal fixation
MIPPO	:	Minimally invasive percutaneous plate osteosynthesis
COMP	:	Complications