

**“STUDY OF SURGICAL MANAGEMENT OF PROXIMAL
TIBIAL FRACTURES USING LOCKING COMPRESSION
PLATE”**

By

Dr. J.PRANEETH KUMAR REDDY



DISSERTATION SUBMITTED TO SRI DEVARAJ URS ACADEMY OF
HIGHER EDUCATION AND RESEARCH CENTER, KOLAR, KARNATAKA

In partial fulfillment of the requirements

for the degree of

MASTER OF SURGERY

IN

ORTHOPAEDICS

Under the Guidance of

Dr. B.SHAIKH NAZEER

Professor



**DEPARTMENT OF ORTHOPAEDICS,
SRI DEVARAJ URS MEDICAL COLLEGE,
TAMAKA, KOLAR - 563101**

2016

**SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND
RESEARCH CENTER, KOLAR, KARNATAKA**

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation/thesis entitled **“STUDY OF SURGICAL MANAGEMENT OF PROXIMAL TIBIAL FRACTURES USING LOCKING COMPRESSION PLATE”** is a bonafide and genuine research work carried out by me under the guidance of **Dr. B. SHAIKH NAZEER**, Professor, Department of Orthopedics, Sri Devaraj Urs Medical College & Research center, Tamaka, Kolar.

Date:

Dr. J.PRANEETH KUMAR REDDY

Place: Kolar

**SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND
RESEARCH CENTER, KOLAR, KARNATAKA**

CERTIFICATE BY THE GUIDE

This is to certify that the dissertation entitled “**STUDY OF SURGICAL
MANAGEMENT OF PROXIMAL TIBIAL FRACTURES USING
LOCKING COMPRESSION PLATE**” is a bonafide research work done by
Dr. J.PRANEETH KUMAR REDDY in partial fulfillment of the
requirement for the degree of MASTER OF SURGERY in **ORTHOPAEDICS**.

Date:

Place: Kolar

Signature of the Guide

Dr. B.SHAIKH NAZEER,

Professor,

Department of Orthopaedics,

Sri Devaraj Urs Medical College &

Research Centre, Tamaka, Kolar.

**SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION
AND RESEARCH CENTER, KOLAR, KARNATAKA**

**ENDORSEMENT BY THE HOD,
PRINCIPAL / HEAD OF THE INSTITUTION**

*This is to certify that the dissertation entitled “**STUDY OF SURGICAL MANAGEMENT OF PROXIMAL TIBIAL FRACTURES USING LOCKING COMPRESSION PLATE**” is a bonafide research work done by **Dr. J.PRANEETH KUMAR REDDY** under the guidance of Dr. **B.SHAIKH NAZEER**, Professor, Department of Orthopedics.*

Dr. ARUN H.S,
Professor & HOD,
Department of Orthopaedics,
Sri Devaraj Urs Medical College
& Research Center, Tamaka, Kolar

Dr. RANGANATH B.G,
Principal,
Sri Devaraj Urs Medical College
& Research Center, Tamaka, Kolar

Date:
Place: Kolar

Date:
Place: Kolar

**SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND
RESEARCH CENTER, TAMAKA, KOLAR, KARNATAKA**

ETHICAL COMMITTEE CERTIFICATE

This is to certify that the Ethical committee of Sri Devaraj Urs Medical College & Research Center, Tamaka, Kolar has unanimously approved

Dr. J.PRANEETH KUMAR REDDY

Post-Graduate student in the subject of

ORTHOPAEDICS at Sri Devaraj Urs Medical College, Kolar

to take up the Dissertation work entitled

***“STUDY OF SURGICAL MANAGEMENT OF PROXIMAL
TIBIAL FRACTURES USING LOCKING COMPRESSION
PLATE”***

to be submitted to the

**SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND
RESEARCH CENTER, KOLAR, KARNATAKA**

Date:

Member Secretary

Place: Kolar

Sri Devaraj Urs Medical College
& Research Center,
Tamaka, Kolar – 563101

**SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND
RESEARCH CENTER, KOLAR, KARNATAKA**

COPY RIGHT

DECLARATION BY THE CANDIDATE

I hereby declare that the Sri Devaraj Urs Academy of Higher Education and Research Centre, Kolar, Karnataka shall have the rights to preserve, use and disseminate this dissertation/thesis in print or electronic format for academic /research purpose.

Date:

Dr. J.PRANEETH KUMAR REDDY

Place: Kolar

© Sri Devaraj Urs Academy of Higher Education and Research Centre,
Kolar, Karnataka.

ACKNOWLEDGEMENT

Ever since I began this dissertation, innumerable people have participated by contributing their time, energy and expertise. To each of them and to others whom I may have omitted through oversight, I owe a debt of gratitude for the help and encouragement.

I am deeply indebted and grateful to my esteemed teacher, mentor and guide **Dr. B.SHAIKH NAZEER**, Professor, Department of Orthopaedics, Sri Devaraj Urs Medical College, Tamaka, Kolar, for his guidance, support and constant encouragement throughout the period of this study. His knowledge and experience has guided, molded and infused in me a sense of confidence to overcome hurdles both personally and academically.

I am highly grateful to **Dr. Ranganath B.G**, Principal, Sri Devaraj Urs Medical College, Tamaka, Kolar, for permitting me to conduct this study.

I also acknowledge my debt to **Dr. Arun H.S**, **Dr. P.V.Manohar** and **Dr. N.S.Gudi**, Department of Orthopaedics, Sri Devaraj Urs Medical College, Tamaka, Kolar, who gave me moral support and guidance by correcting me at every step.

I remain thankful to all my Assistant Professors and Lecturers for their support and encouragement. I acknowledge my sincere thanks to all my co-Post Graduates for their help and support at every step throughout my study.

All the non-medical staff of Department of Orthopedics, Sri Devaraj Urs Medical College, Tamaka, Kolar, have also made a significant contribution to this work, to which I express my humble gratitude.

I am thankful to the Department of Anesthesia, Sri Devaraj Urs Medical College, Tamaka, Kolar, for their valuable co-operation.

Last, but not the least, I thank the Almighty and **my patients** for providing me the opportunity to carry out my study.

Dr. J.PRANEETH KUMAR REDDY

ABSTRACT

BACKGROUND:

Ever since the advent of high velocity transport system, there is an alarming increase in road traffic accident (RTA) with increased orthopaedic related morbidity and mortality.

Proximal tibia being involved in body weight transmission through knee joint and leg, it plays a vital role in knee function and stability. The aim of surgical treatment of proximal tibial fractures is to restore and preserve normal knee function, which can be accomplished by anatomical restoration of articular surfaces, maintaining mechanical axis, restoring ligamentous stability and preserving a functional pain free range of motion of knee.

Treatment of these injuries using minimally invasive percutaneous plate osteosynthesis (MIPPO) techniques may minimize soft tissue injuries and damage to vascular integrity of fracture fragments.

AIM OF THE STUDY:

1. To evaluate the clinical outcome of fracture of proximal tibia treated with locking compression plate.
2. To evaluate the complications of locking compression plate in proximal tibial fractures.

MATERIALS AND METHODS:

This study was a hospital based prospective study centered in department of orthopedics at R.L.Jalappa Hospital and Research Centre attached to Sri Devaraj Urs Medical College, Kolar, from December 2013 to May 2015 in which 30 patients with proximal tibia fractures were treated with locking compression plate (LCP).

RESULTS:

The assessment of clinical outcome was made according to Rasmussen's functional grading system. End results showed excellent outcome in 26 cases and good outcome in 4 cases. On subjective evaluation, 4 patients had superficial wound infection, 1 patient had deep vein thrombosis and 4 patients had extensor lag of 10^0 - 15^0 at the end of final follow-up.

CONCLUSION:

. Surgical management of proximal tibial fractures will give excellent anatomical reduction and rigid fixation to restore articular congruity, help to facilitate early mobilization and reducing post-traumatic osteoarthritis and hence to achieve optimal knee function. LCP remains a good choice in comminuted or more severe patterns of fractures.

KEY WORDS:

Proximal tibia fractures, locking compression plate, minimally invasive percutaneous plate osteosynthesis (MIPPO), Intra-articular fractures.

TABLE OF CONTENTS

NO	PARTICULARS	PAGE NO
1	INTRODUCTION	1
2	OBJECTIVES	3
3	REVIEW OF LITERATURE	4
4	ANATOMY	12
5	PROXIMAL TIBIA FRACTURES	22
6	GENERAL PRINCIPLES OF LCP	49
7	MATERIALS AND METHODS	53
8	RESULTS	69
9	DISCUSSION	78
10	CONCLUSION	84
11	SUMMARY	85
12	BIBLIOGRAPHY	86
13	ANNEXURE I: PROFORMA SHEET	91
14	ANNEXURE II: CONSENT FORM	98
15	ANNEXURE III: MASTER CHART	100

<u>LIST OF TABLES</u>		
NO	TABLE	PAGE NO
1	AGE DISTRIBUTION	69
2	SEXDISTRIBUTION	70
3	MODE OF INJURY	71
4	SIDE OF INVOLVEMENT	72
5	TYPE OF FRACTURE	73
6	CLASSIFICATION OF FRACTURE	74
7	DURATION BETWEEN INJURY AND SURGERY	75
8	FUNCTIONAL RESULTS	77
9	COMPARISON OF AGE DISTRIBUTION	79
10	COMPARISON OF SEX DISTRIBUTION	79
11	COMPARISON OF MODE OF INJURY	80
12	COMPARISION OF SIDE OF INVOLVEMENT	80
13	COMPARISON OF TIME OF UNION	81
14	COMPARISON OF COMPLICATIONS	82

<u>LIST OF GRAPHS</u>		
NO	CHARTS	PAGE NO
1	AGE DISTRIBUTION	69
2	SEX DISTRIBUTION	70
3	MODE OF INJURY	71
4	SIDE OF INVOLVEMENT	72
5	TYPE OF FRACTURE	73
6	CLASSIFICATION OF FRACTURE	74
7	DURATION BETWEEN INJURY AND SURGERY	75
8	RANGE OF MOTION	76
9	FUNCTIONAL RESULTS	77

LIST OF FIGURES

NO	FIGURES	PAGE NO
1	ANATOMY OF PROXIMAL TIBIA	13
2	KNEE JOINT AND ITS LIGAMENTS	14
3	TIBIAL PLATEAU AND ITS STRUCTURES	18
4	MUSCLES IN THE REGION OF KNEE JOINT	21
5	BLOOD VESSELS AND NERVES OF THE POPLITEAL FOSSA	21
6	SCHATZKER'S CLASSIFICATION	25
7	AO/TA CLASSIFICATION	26
8	HOHL AND MOORE CLASSIFICATION	27
9	HOHL AND MOORE CLASSIFICATION OF FRACTURE DISLOCATION	27
10	MECHANISM OF INJURY TIBIA PLATEAU FRACTURE	30
11	BIOMECHANICAL LOAD DIFFERENCE	51
12	LOCKING SCREW DESIGNS	51
13	LCP COMBINATION HOLE	52
14	IMPLANTS AND INSTRUMENTS	60

15	PRE-OPERATIVE X-RAY FILMS	62
16	PATIENT POSITIONING ON RADIOLUCENT OT TABLE AND MIPPO TECHNIQUE	63
17	PATIENT POSITIONING ON RADIOLUCENT TABLE AND ORIF	64
18	POST-OPERATIVE X-RAYS	64
19	6 WEEKS FOLLOW UP X-RAYS	65
20	3 MONTHS FOLLOWUP X-RAYS	65
21	6 MONTHS FOLLOW UP X-RAYS	66
22	FLEXION AND EXTENSION BEFORE SUTURE REMOVAL	66
23	RANGE OF MOTION AT 3 AND 6 MONTHS FOLLOW UP	68

LIST OF ABBREVIATIONS

ACL	-	Anterior Cruciate Ligament
AO	-	Arbeitsgemeinschaft für Osteosynthesefragen Association for Osteosynthesis
AP	-	Anteroposterior
ASIF	-	The Association for the Study of Internal fixation
BG	-	Bone Grafting
CRIF	-	Closed Reduction and Internal Fixation
CS	-	Compartment Syndrome
CT	-	Computed Tomography
F	-	Female
FALL (H)	-	Fall from a Height
FALL (L)	-	Fall from a Level surface
GA	-	General Anesthesia
H & L	-	Hohl and Luck
KS	-	Knee Stiffness
LCP	-	Locking Compression Plate
MIPPO	-	Minimal Invasive Percutaneous Plate Osteosynthesis
M	-	Male
MAL	-	Malunion
MRI	-	Magnetic Resonance Imaging
NS	-	Not Significant
OA	-	Osteoarthritis
ORIF	-	Open Reduction and Internal Fixation

PCL	-	Posterior Cruciate Ligament
POP	-	Plaster of Paris
RTA	-	Road Traffic Accidents

INTRODUCTION

Ever since the advent of high velocity transport system, there is an alarming increase in road traffic accident (RTA) with increased orthopaedic related morbidity and mortality.

Proximal tibia being involved in body weight transmission through knee joint and leg, it plays a vital role in knee function and stability. Fractures of proximal tibia have historically been difficult to treat because of its subcutaneous location of the anteromedial surface of the tibia. Severe bone and soft tissue injuries are not infrequent and there is high incidence of open fracture compared with other long bones.³⁵

The aim of surgical treatment of proximal tibial fractures is to restore and preserve normal knee function, which can be accomplished by anatomical restoration of articular surfaces, maintaining mechanical axis, restoring ligamentous stability and preserving a functional pain free range of motion of knee.³⁵

The incidence of malunion, non-union and infections are relatively high in many reported series, causing significant long term disability. Recently more attention has been paid to the condition of soft tissue envelope. Soft tissue friendly approaches and minimally invasive techniques have improved the outcome. Treatment of these injuries using minimally invasive percutaneous plate osteosynthesis (MIPPO) techniques minimize soft tissue injury and damage to vascular integrity of fracture fragments.

Over the last decade plate fixation has become popular for the treatment of proximal tibial fractures. This coupled with biological advantage of percutaneous insertion has resulted in high union rates.

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

- Better distribution of forces along the axis of bone,
- Can be inserted with minimal soft tissue stripping using minimally invasive percutaneous plate osteosynthesis (MIPPO),
- Substantially reduces failure of fixation in osteoporotic bones,
- Reduces 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,
- Provides stable fixation by creating a fixed angle construct and angular stability and
- Allows early mobilization.

Locking compression plate has added advantage of the ability to manipulate and reduce the small and often osteoporotic fracture fragments directly.

OBJECTIVES

1. To evaluate the clinical outcome of fracture of proximal tibia treated with locking compression plate.
2. To evaluate the complications of locking compression plate in proximal tibial fractures.

REVIEW OF LITERATURE

Sir Astley Cooper first described fractures of the proximal tibia in 1825. He, in A treatise on dislocations and on fracture of the joints, clearly described the fracture as follows: The head of the tibia is sometimes obliquely broken; and if it be fractured into the knee joint, the treatment which it requires is similar to that which is necessary in the oblique fracture of the condyle of the os femoris; that is, first: The straight position of the limb, because the femur preserves the proper adaptation of the fractured tibia by forming a splint to its upper portion, and keeping the articular surfaces in apposition. Secondly, a roller to press one part of the broken surface against the other. Thirdly, a splint of pasteboard to assist in the preservation of that pressure and fourthly, early passive motion to prevent ankylosis.¹

A reviewed study conducted on ninety eight cases of fracture of upper end of tibia treated by operative reduction showed satisfactory percentage of good and excellent short and long term results and concluded that reduction of these fractures can only be done operatively.²

A study conducted on fifteen patients with severe fractures of the tibial plateau concluded that by following the below mentioned principles like a) correction of the deformity by open reduction; b) firm internal fixation of the fracture fragments and c) allowing early knee motion, an unstable fracture can be converted to a stable fracture which contributes to improved functional and anatomical results.³

A study conducted on forty four knee specimens obtained at autopsy and on embalmed specimens by applying single force and combination of forces with stress machine concluded that depending on the type of forces the fractures are classified as

abduction fractures, compression fractures, mixed fractures and explosive fractures which helps in selecting the type of treatment in different groups of fractures.⁴

In a study on sixty eight crush fractures of the articular surface of lateral tibial condyle treated with conservative method by traction or plaster immobilization and surgically by open reduction concluded that the functional results are greatly influenced by the extent of the articular depression. The results suggest that when the articular depression is less than 10 mm, conservative treatment gives good results and when the depression is more severe, good result can only be assured if the articular surface is successfully reconstituted which is sometimes difficult to achieve.⁵

A study conducted on a series of 917 tibial condylar fractures where 164 patients were identified and analyzed with injuries to the medial or lateral collateral ligaments, the cruciate ligaments or combination of these ligaments concluded the relationship of ligament injury to the development of instability, angular deformity and arthritic changes.⁶

A study over two and half year period on twenty nine patients with thirty intraarticular proximal tibial fractures treated with early application of cast brace with follow up for an average period of 9.3 months concluded that with cast brace treatment knee range of motion was excellent. Reduction was maintained well and varus or valgus deformities could be well corrected.⁷

Specific indications for locking compression plating include bicondylar tibial plateau fractures, marked comminution, osteopenia or poor bone quality, and a bone gap secondary to loss of bone along one or both columns of proximal tibia. The primary contraindication is a severely damaged soft-tissue envelope that makes proceeding with surgery a dangerous and high-risk proposal. In many cases, soft-tissue and skin damage will be a temporary contraindication for surgery. Delaying

surgical treatment for a period of a few days to a few weeks, until optimal soft-tissue conditions exist, minimizes complications. Additional contraindications for open reduction and internal fixation (ORIF) include patients with serious medical comorbidities that make them poor surgical candidates.⁸

In 1963, buttress plates were developed by the Arbeitsgemeinschaft fuer Osteosynthesefragen (AO) group. The Swiss Association of the Study of Internal Fixation (A.S.I.F) group deserves great credit for developing exposures, techniques of reduction, internal fixation devices and postoperative case regimens.⁹

An experimental study conducted on rabbits to evaluate the biological effect of continuous passive motion on the healing of full thickness defects in articular cartilage of knee joint concluded the following beneficial effects: Continuous passive motion is well tolerated in the first four weeks postoperatively without disturbing general well-being. It doesn't harm normal living articular cartilage of rabbits' knees. It prevents intraarticular adhesions secondary to postoperative immobilization which complicates the healing process. Continuous passive motion stimulates neochondrogenesis through differentiation of the pluripotential cells of the subchondral tissues to chondrocytes.¹²

A comparative study conducted on two groups of patients where 87 patients with 89 fractures of tibial plateau were treated conservatively with skeletal traction, quadriceps exercises and gradual weight bearing and 73 patients with 73 fractures of tibial plateau were treated surgically with open reduction and internal fixation concluded that there were no significant differences in both the groups. Treatment with traction and early movement gives similar functional results as surgical but is time consuming hence it should be reserved for cases where surgery is not desirable.²⁰

In a study on 159 cases of tibial plateau fractures of all types treated by conservative (46%) and surgical (54%) methods, evaluated by Hohl and Luck method reported excellent to good outcome of 62% of cases treated by conservative methods and 84% treated by surgical methods. Incidence of osteoarthritis correlated with poor results due to malalignment, residual step off and instability.²²

A study on 50 cases of tibial plateau fractures of all types by traction mobilization with an average follow up period of 2 years revealed an overall excellent to good result of 94%. Concept of early mobilization to good results and advantages of absence of surgical risks were stressed.²³

A study conducted on 24 patients with high energy fractures of the tibial plateau fixed with Ilizarov fixator and transfixation wires with an average follow up period of 24 months concluded that Ilizarov circular fixator is an ideal method of treatment for these fractures when extensive dissection and internal fixation are contraindicated due to trauma to the soft tissues, deficiency of bone stock and bony comminution.²⁸

As the use of locked plates has expanded and the numbers of fractures fixed with these plates have increased, clinical failures have been seen. The plates can fail when physiological loads are outside plate-design parameters. The locked screws can disengage from the plate secondary to failure of the screw to seat into the plate properly as a result of cross threading or when insufficient screw torque is used to engage the screw threads into the plate threads. Additionally, like all mechanical devices, the screws can break or disengage from the plate under excessive cyclical loading. Despite an excellent “feel” in the operating theater, locked plates may cease providing fragment fixation as a result of exceedingly poor bone quality. Nonunion and malunion can still occur with the use of locked plates.³⁴

In a study on eighty three bicondylar tibial plateau fractures treated with medial and lateral plates through anterolateral and posteromedial incisions over a period of seventy seven months with a mean duration follow up of fifty-nine months concluded that with two separate incisions and two separate plates accurate articular reduction is possible with a better functional outcome although residual dysfunction is common.³⁶

A multicenter, prospective and randomized clinical study conducted on eighty three displaced bicondylar tibial plateau fractures in eighty two patients where in forty-three fractures were subjected to circular external fixator and forty fractures to open reduction and internal fixation with medial and lateral plates concluded that in case of difficult-to-treat fractures circular external fixator has a better outcome with less intraoperative blood loss, short hospital stay and less severe complications like infections although long term follow up results were not significantly different in both the groups.³⁷

A retrospective study on 36 tibial plateau fractures in 35 patients, from 1999 to 2002 with mean age of 42 years who were treated with less invasive stabilization system (LISS) concluded that LISS technique provokes limited surgical insult to the surrounding soft tissues and to the healing process. Hence LISS system could be considered for the management of tibial plateau fractures.³⁹

A retrospective study on ten patients with posterior tibial plateau fractures resulted from high velocity injuries with a mean follow up period of 26.5 months concluded that articular reduction and functional outcomes of posterior tibial plateau fractures are satisfactory when fixed with posterolateral or posteromedial approach combined with anterior approaches if necessary.⁴⁰

A study was conducted on thirty two tibial specimens in which extra articular proximal tibial fractures were created, divided into groups and fixed with Intramedullary nail (IMN), Dynamic compression plate (DCP), Locking compression plate (LCP) and External fixator (Exfix). After subjecting to axial compression and three point bending tests, it was concluded that IMN has good mechanical properties, but its clinical application for proximal tibial fractures often leads to malalignment deformities. When compared to DCP, LCP was strong enough to fix the proximal tibia fractures and has the additional benefit of minimally invasive surgery.⁴¹

A comparative study conducted between U-grooved locking compression plate (U-LCP) and LISS done over 78 patients with unilateral tibial fractures concluded that U-LCP is an worthwhile alternative treatment of choice with less radiation exposure, shorter operation time and sustainable price compared to LISS for patients with proximal tibial fractures.⁴²

A study conducted on 34 patients with an open proximal tibial fractures treated by minimally invasive percutaneous plate osteosynthesis (MIPPO) concluded this technique as an acceptable method for the treatment of open proximal tibial fracture if soft tissue coverage is adequately performed.⁴³

A study conducted on 20 patients with tibial plateau fractures having a medial component, including five Schatzker IV, five Schatzker V and ten Schatzker VI for whom single lateral anatomically contoured locking compression plate was used with or without additional isolated screws concluded that single lateral locking compression plate ensured good outcomes in patients with proximal articular fractures of the tibia having a medial component.⁴⁴

In a study on 78 patients with complex tibial plateau fractures treated with percutaneous techniques and external fixator concluded minimally invasive technique

as a reasonable alternate treatment in patients with complex tibial plateau fractures as it causes minimal soft tissue stripping and reduces complications like infections.⁴⁵

A three dimensional (3D) tibia bone model study with a medial transverse fracture created by using CT scan images concluded that when this fracture was fixed with a 11 holed locking compression plate then the position of locking screws at 1, 2, 4, 8, 10 and 11 holes had the best biomechanical response to bending and torsion with less chances of screw loosening and risks for bone fracture fixation.⁴⁶

A study on 46 tibial plateau fractures of Schatzker type V and VI with lateral and medial plates through an anterolateral approach and a medial minimal invasive approach over an 8 years period concluded that dual plate fixation of severe bicondylar tibial plateau fractures is an excellent treatment option as it provides rigid fixation and allows early knee mobilization.⁴⁸

In a study on thirty-eight patients with Schatzker I ~ III tibial plateau fractures treated with LCP through minimally invasive technique along with artificial bone transport to the depressed bone who were followed up for 14 to 20 months with a mean duration of 16 months concluded that minimally invasive treatment can reduce postoperative reduction loss with slight surgical wounds and fixed stability.⁵⁰

A study on forty six patients with bicondylar tibial plateau fracture treated with fine-wire circular external fixator combined with limited open reduction and cannulated screw fixation concluded that fine wire external fixator is an effective treatment for high energy tibial plateau fractures with good functional results and minimal serious complications.⁵¹

A comparative study conducted on two groups of patients where twenty patients with tibial plateau fracture were treated with locking plate and twenty one patients were treated with non-locking plate with a mean duration of follow up for

13.4 months concluded that locking plates are superior to non-locking plate with regard to knee score and visual analog scale (VAS) pain score indicating more improvement in knee functional score and minimizing post-operative pain using the locking plate method.⁵²

ANATOMY

The proximal tibia articulates with distal end of femur to make the knee joint.

KNEE JOINT:

It consists of the relationship between 3 articulations

- a) Patellofemoral
- b) Tibiofemoral and
- c) Tibiofibular

This triaxial joint is often exposed to forces in excess of five times the body weight. The normal range of motion can be from 10° of hyperextension to 140° of flexion with 8°-12° of rotation throughout the entire arc. The distal femur articulates with the proximal tibia throughout its range of motion. The addition of medial and lateral menisci converts this non conforming geometry into a joint capable of sustaining significant functional loading.

The tibial plateau is sloped in an anterior to posterior direction from 7°-10° and contains a greater surface area on the medial plateau. The medial and lateral spinous processes prevent translation and protect the interspinous insertion of the anterior cruciate ligament (ACL). The most posterior portion of the interspinous area (inter condylaris tibia) is not covered by articular cartilage. The true axis of rotation is somewhere between the position of the tibial tubercle (10°-15° of external rotation) and the mid portion of the tibia.

MEDIAL TIBIAL CONDYLE:

It is larger than the lateral condyle. Its superior surface articulates with the medial condyle of femur. The articular surface is oval and its long axis is

anteroposterior. The central part of the surface is slightly concave both anteroposteriorly and transversely. The peripheral part is flat and is separated from femoral condyle by the medial meniscus. The posterior surface of the medial condyle is deeply grooved for the semimembranosus insertion.

LATERAL TIBIAL CONDYLE:

It overhangs the shaft of the tibia more than the medial condyle. The articular surface is nearly circular. The central part of the articular surface is concave and the peripheral part is flat. It is separated from the femur by lateral meniscus. The posteroinferior aspect of the lateral condyle articulates with the fibula through the facet for fibula. Fibular facet is flat, circular and directed downwards, backwards and laterally. The anterior aspect of the condyle bears flattened impression.

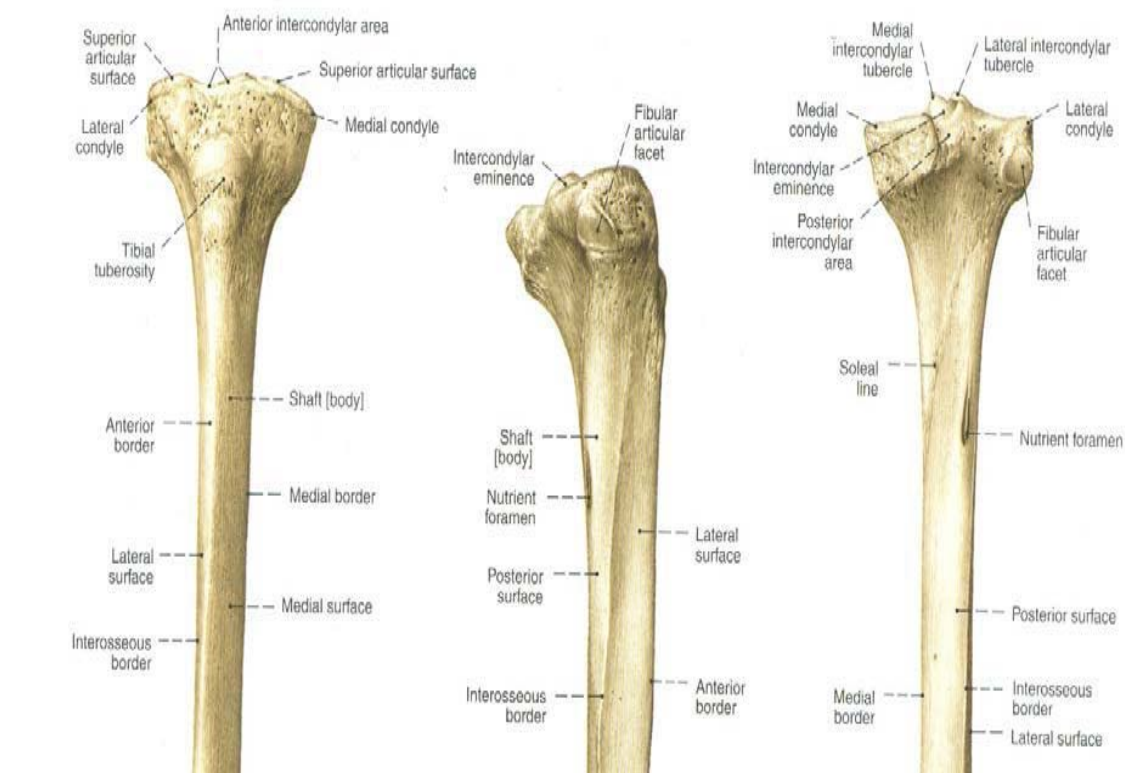


Fig. 1: Anterior, lateral and posterior aspect of the proximal tibia



Roughened area on the superior surface between the articular surfaces of the two condyles. It is narrowest at its middle where it is marked by an elevation termed the “intercondylar eminence”.

1. Anterior horn of the medial meniscus
2. Anterior cruciate ligament
3. Anterior horn of lateral meniscus
4. Posterior horn of lateral meniscus
5. Posterior horn of the medial meniscus
6. Posterior cruciate ligament

The capsule of the knee joint is attached to the circumference of the tibial plateau except in two places. Where the tendon of the popliteus crosses the margin of the tibia the capsule extends down to the head of the fibula. Between the condyles posteriorly the capsule is attached not to the margin of the plateau but to the ridge below the groove for the posterior cruciate ligament. The synovial membrane is attached to the edge of each articular surface, following condylar margins along-side the spine to be draped over the attachment of the anterior cruciate ligament.

The knee is covered by three layers of soft tissues. Layer I includes the deep fascia or crural fascia; layer II is composed of the superficial medial collateral ligament, various structures anterior to this ligament, and the ligaments of the posteromedial corner; and layer III is made up of the capsule of the knee joint and the deep medial collateral ligament.

The two bony prominences in the subcondylar region serve as points of attachment for tendons. The tibial tubercle or tuberosity, located 2.5cm to 3cms below the joint line, provides attachment for the patellar tendon. The tuberosity marks the upper end of the anterior border of the shaft and the anterior limit of the intercondylar area. It is divided into an upper smooth area and a lower rough area. The upper smooth area provides attachment to the ligamentum patellae. The lower rough area of the tuberosity is subcutaneous, but it is separated from the skin by the subcutaneous infrapatellar bursa. The Gerdy's tubercle located on the anterolateral surface of the lateral tibial flare, affords insertion for the iliotibial band.

LIGAMENTS OF THE KNEE JOINTS:

The knee joint is supported by the following structures:

1. FIBROUS CAPSULE:

The capsule is a thin structure and the attachment on the femur is deficient above the level of the patella. The capsule is attached about 1 cm beyond the articular margin of both the femur and the tibia. The capsule has weak attachment to the rims of both the menisci known as the coronary ligaments.

2. TIBIAL (MEDIAL) COLLATERAL LIGAMENT:

It is a flat triangular band attached above to the medial femoral epicondyle just distal to the adductor tubercle and attached below to the upper part of the medial surface of the tibia. It represents the degenerated tendon of the ischial head of the adductor magnus.

3. FIBULAR (LATERAL) COLLATERAL LIGAMENT:

It is attached proximally to the lateral epicondyle, below the attachment of the lateral head of gastrocnemius and above that of the tendon of the popliteus. Its distal attachment is to the head of the fibula overlapped by the tendon of the biceps femoris, a bursa intervening between them. The inferiorlateral genicular vessels and nerves separate it from the capsule.

4. THE OBLIQUE POPLITEAL LIGAMENT:

It is an expansion from the tendon of semimembranosus that blends with the capsule at the back of the joint and ascends laterally to the intercondylar fossa and

lateral femoral condyle. The popliteal artery lies on it and the genicular vessels and nerve penetrate it.

5. THE ARCUATE POPLITEAL LIGAMENT:

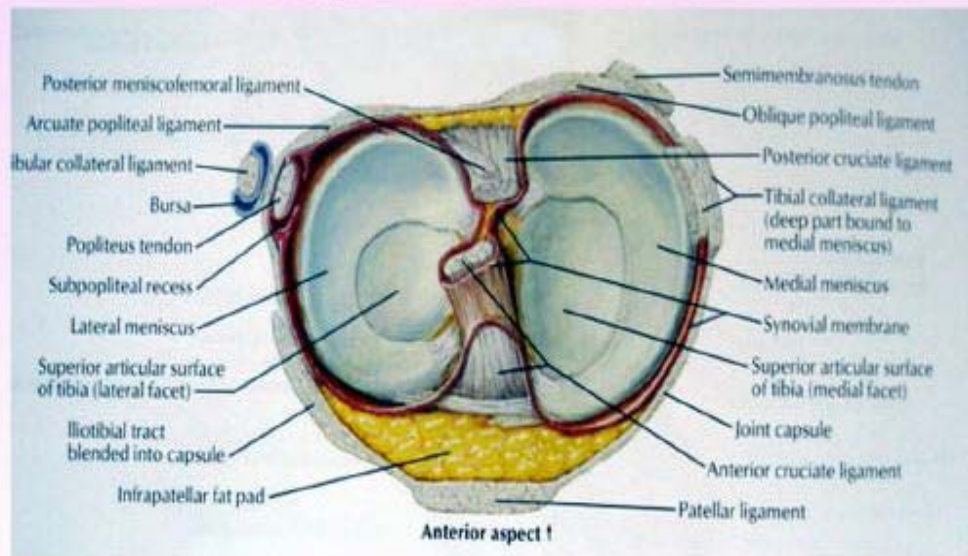
It is a 'Y' shaped thickening of the posterior capsular fibers. It extends from the head of the fibula, arches over the tendon of the popliteus, and is attached to the posterior border of the intercondylar area of tibia.

6. CRUCIATE LIGAMENTS:

These are a pair of very strong ligaments connecting the tibia to the femur. They lie within the capsule of the knee joint, but not within the synovial membrane. It is as though they have been herniated into the synovial membrane from behind so that is covered by synovial membrane on their front and sides but not posteriorly. The anterior cruciate ligament is attached to the anterior part of the tibial plateau between the attachments of the anterior horns of the medial and lateral menisci. The ligament ascends posterolaterally twisting on it and is attached to the posteromedial aspect of the lateral femoral condyle.

The posterior cruciate ligament is stronger, shorter and less oblique. It is attached to a smooth impression on the posterior part of the tibial intercondylar area, which extends to the upper most part of the posterior surface of the tibia. The ligament ascends anteromedially and is attached to the anterolateral aspect of the medial femoral condyle. The cruciate ligaments cross each other like the limbs of the letter X, the anterior ligament lying mainly anterolateral to the posterior ligament.

KNEE JOINT SUPERIOR VIEW



SUPERIOR VIEW: LIGAMENTS AND CARTILAGE REMOVED

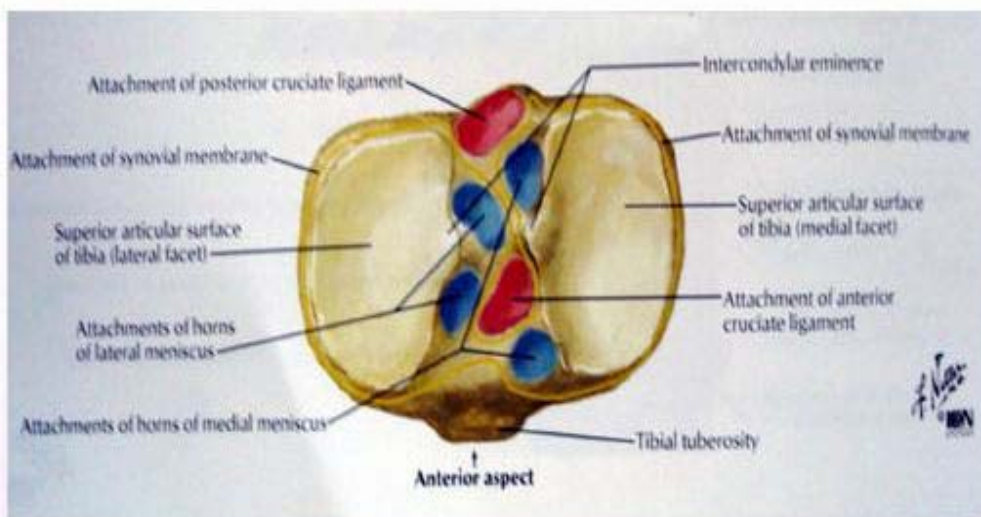


Fig 3: Axial view knee joint showing tibial plateau and its structures

7. THE MENISCI (SEMILUNAR CARTILAGE):

These are crescentic laminae of mainly collagenous fibrous tissue that lie on and are attached to the tibial plateau. The medial meniscus is almost a semicircle and is broad posteriorly. Its anterior horn is attached to the intercondylar area in front of the anterior cruciate ligament, while the posterior horn is similarly attached in front of the posterior cruciate ligament. The lateral meniscus is about four-fifth of a circle and is of uniform width. Its anterior horn is attached in front of the intercondylar eminence of the tibia, behind the anterior cruciate ligament. The posterior horn is attached behind the eminence in front of the posterior horn of the medial meniscus. From the posterior convexity of the lateral meniscus fibrous bands pass upwards and medially to the medial femoral condyle known as anterior and posterior meniscomfemoral ligaments of Humphry and Wrisberg. The lateral meniscus covers much larger surface of the articular surface than does the medial. Meniscotibial ligaments attach the menisci to the periphery of the tibial plateau. These structures are crucial to identify when performing a submeniscal exposure to visualize the articular surface of the tibial plateau. They can be carefully incised in horizontal fashion and must be repaired to avoid producing an iatrogenic peripheral meniscal detachment.

8. TRANSVERSE LIGAMENT:

It is a variable band that connects the anterior convexity of the lateral meniscus to the anterior horn of the medial meniscus.

9. SYNOVIAL MEMBRANE:

It is attached to the articular margins of the femur, tibia, patella and lines the deep aspect of the capsule, but it is separated from the capsule by the popliteus muscle and the cruciate ligaments. Anteriorly the membrane is separated from the patellar ligament by the infrapatellar fat pad.

10. LIGAMENTUM PATELLAE:

This is the central portion of the common tendon of insertion of quadriceps femoris; the remaining portion of the tendon forms medial and lateral patellar retinacula. Ligamentum patella is about 3 inches long and 1 inch broad. It is attached above to the margin and rough posterior surface of the apex of patella and below to the smooth, upper part of tibial tuberosity. The superficial fibers pass in front of the patella. It is related to the superficial and deep infrapatellar bursae, and to the infrapatellar pad of fat.

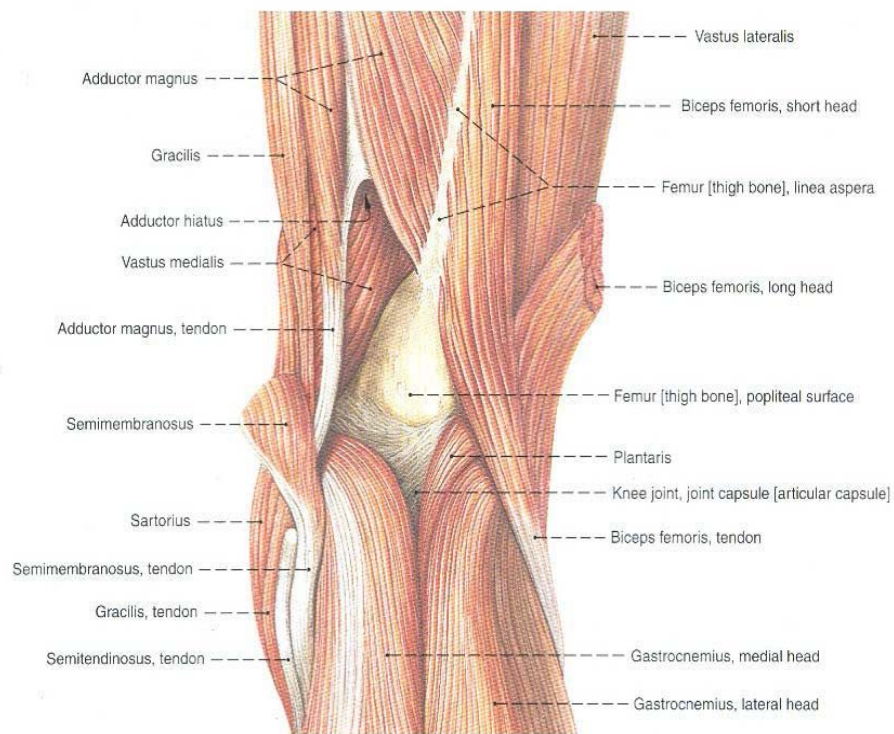


Fig. 4: Muscles in the region of knee joint

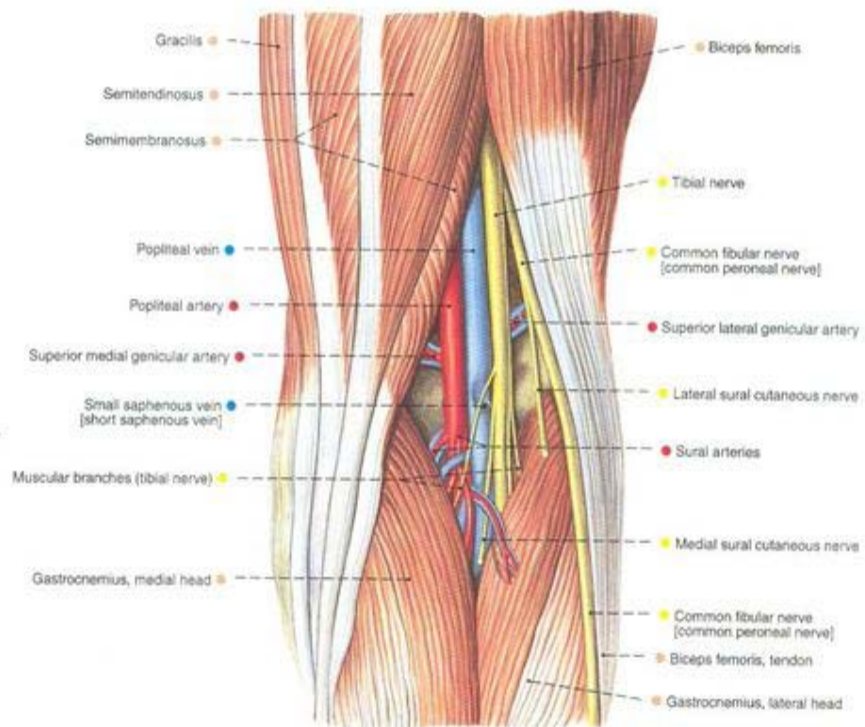


Fig. 5: Blood vessels and nerves of the popliteal fossa

PROXIMAL TIBIA FRACTURES

INCIDENCE:

Fractures of proximal tibia constitute 1% of all fractures and 8% fractures in the elderly. These fractures encompass many and varied fracture configurations that involve the medial condyle (10-23%), lateral condyle (50-70%) or both with metaphyseal extension(11-30%) with differing degrees of articular depression and displacement.³⁵

NATURE OF VIOLENCE:

It can be either direct/ indirect.

DIRECT: Automobile accidents, which is one of most frequently encountered.

1. Road traffic accidents/ automobile accidents.
2. Falling from a height
3. Industrial accidents
4. Athletics
5. Assault.

INDIRECT: Trivial injures like

1. Stumbling
2. Twisting
3. Missing steps, etc

CLASSIFICATION OF THE PROXIMAL TIBIA FRACTURES:

SCHATZKER CLASSIFICATION⁴⁷:

TYPE I - Pure cleavage fracture

TYPE II - Cleavage combined with depression

TYPE III - Pure central depression

TYPE IV - Fractures of medial condyle.

TYPE V - Bicondylar fractures with metaphysis-diaphyseal association

TYPE VI - Plateau fracture with dissociation of metaphysis and diaphysis

HOHL AND MOORE'S CLASSIFICATION OF FRACTURE DISLOCATIONS¹³:

TYPE I - Split

TYPE II - Entire condyle

TYPE III - Rim avulsion

TYPE IV - Rim compression

TYPE V - Four part

HOHL AND MOORE'S CLASSIFICATION OF TIBIAL PLATEAU FRACTURES⁴⁹:

TYPE 1 - Minimally displaced

TYPE 2 - Local compression

TYPE 3 - Split compression

TYPE 4 - Total condyle

TYPE 5 – Bicondylar

THE AO CLASSIFICATION OF PROXIMAL TIBIAL FRACTURES¹⁹:

TYPE A - Metaphyseal fractures that do not involve the joint surface.

A1 - Avulsion

A2 - Metaphyseal simple

A3 - Metaphyseal multifragmentary

TYPE B - Partial articular fractures.

B1 - Partial articular, pure split

B2 - Partial articular fracture, pure depression

B3 - Partial articular fracture, split depression

TYPE C - Complete articular fractures.

C1 - Complete articular fracture, articular simple and metaphyseal simple

C2 - Complete articular fracture, articular simple and metaphyseal multifragmentary

C3 - Complete articular fracture, multifragmentary

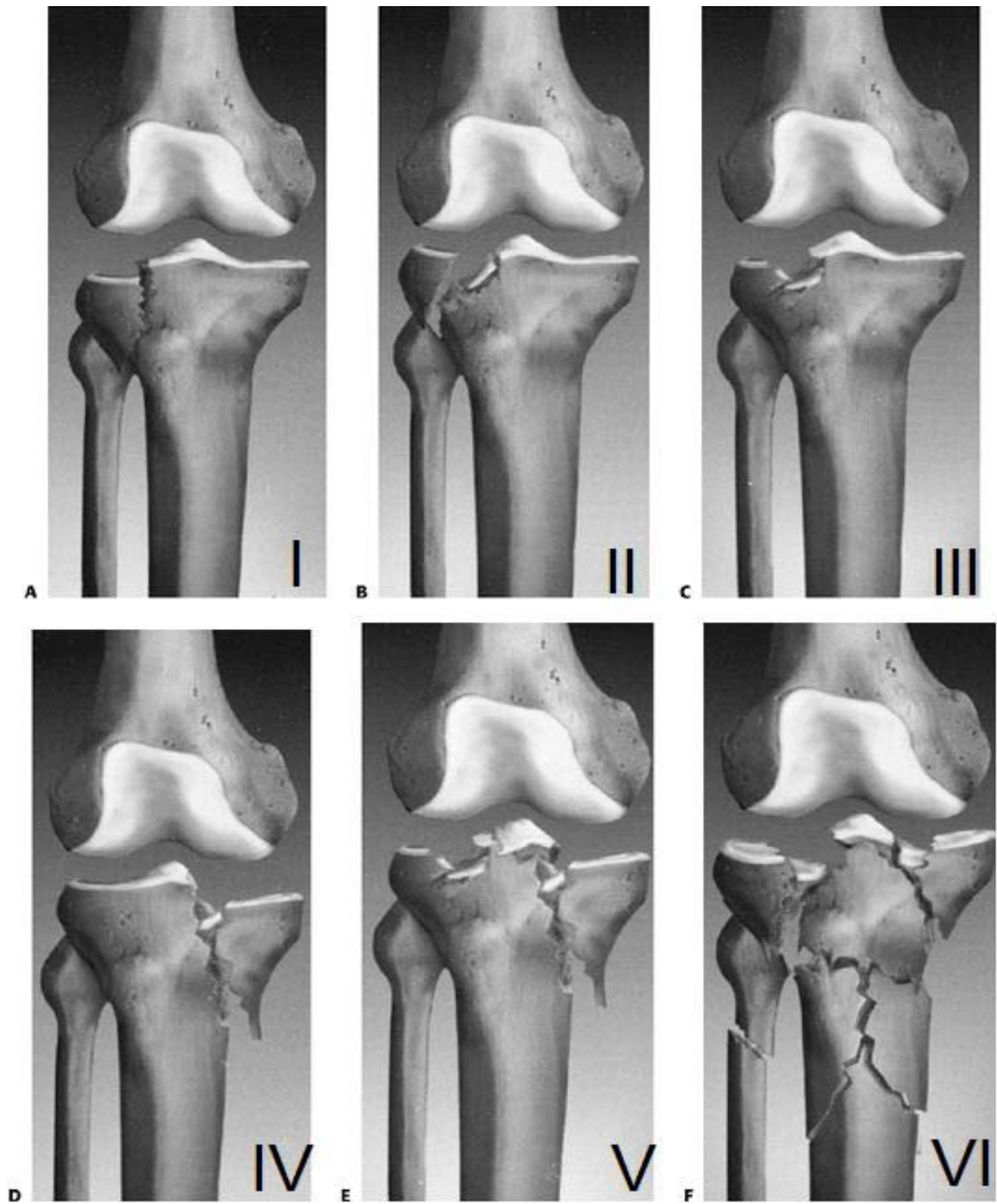


FIG. 6: SCHATZKER'S CLASSIFICATION

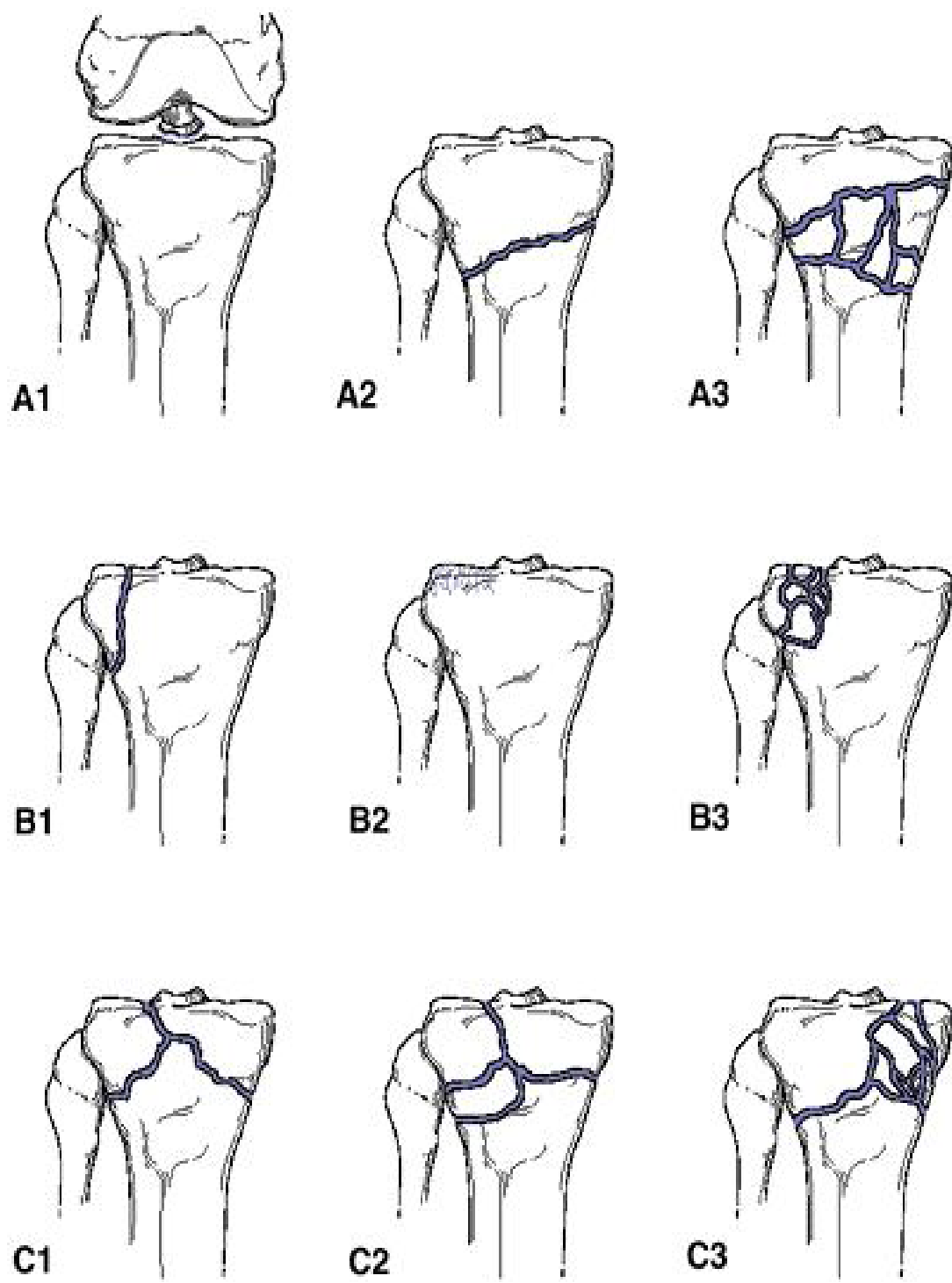


FIG. 7: AO/TA CLASSIFICATION

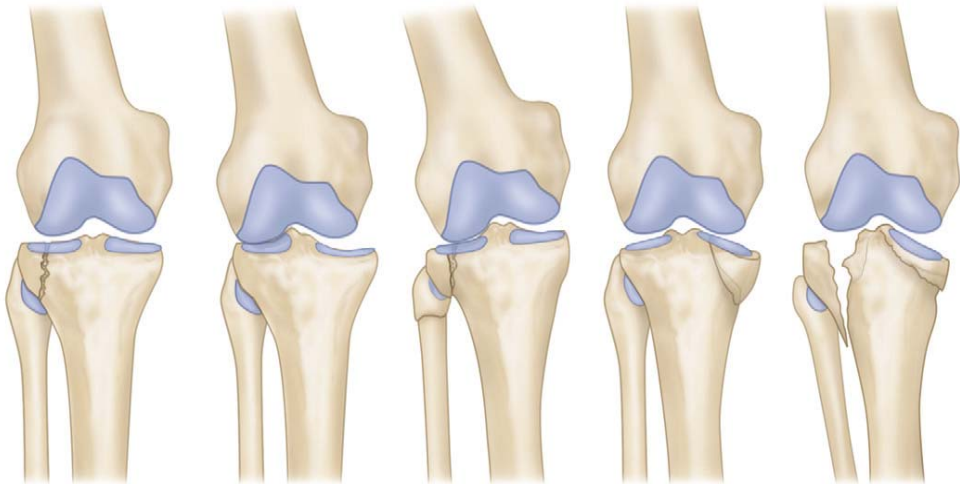


Fig. 8: Classification of tibial plateau fractures by Hohl and Moore

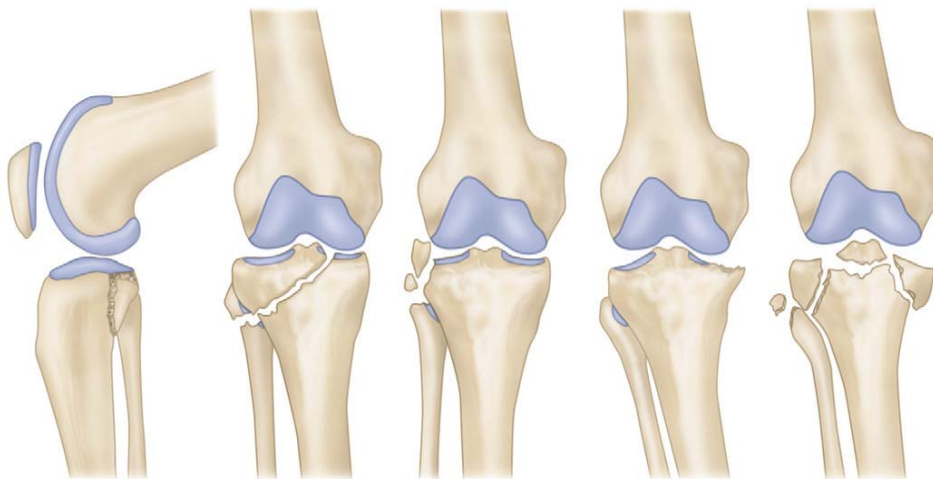


Fig. 9: Hohl and Moore classification of proximal tibial fracture-dislocations.

MECHANISM OF INJURY

BIOMECHANICS:

A basic understanding of the mechanism of fracture production has always aided in the treatment of specific fractures. Proximal tibial fractures are usually caused by high velocity trauma causing valgus or rarely varus force with or without axial loading as in road traffic accidents or fall from a height. Valgus loading in the range of 2250 to 3750 inch pounds produce “mixed” fracture with large variation in the amount and the degree of joint and condylar disruption. The “classic bumper fracture” is the fracture of lateral plateau resulting from a medially directed blow to the lateral aspect of the knee. This creates valgus deforming force with axial loading of the lateral plateau by lateral femoral condyle. The femoral condyle exerts both a compressive and shearing force on to the underlying tibial plateau. This frequently results in a split fracture, a depressed fracture or both. Isolated fractures are usually confined to young adults, with dense cancellous bone that is capable of withstanding the compressive forces on the joint surface with age the strong cancellous bone of the proximal tibia gradually becomes sparser and osteopenic. As a result, split depressed or depressed fractures become more common in patients after their fifth decade of life. These typically result from low energy injuries.

The presence of osteoporosis is also important, not only because it facilitates the crushing or depression of subchondral bone but also explains, with the velocity of injury the production of certain types of fractures.

Kennedy and Baitey studied the mechanism of tibial plateau fractures and classified them based on cadaveric studies as abduction fracture, compression fractures, mixed fractures and explosive fractures. The location of the fracture

depended on the degree of flexion or extension of the knee. With increasing flexion, the fracture would be more posteriorly and would be predominantly of the compression type. However when the axial load exceeded 8000 pounds, “explosive” severely comminuted fractures were produced. This mechanism is thought to occur clinically after a fall from a height on an extended knee or due to high-energy motor vehicle accidents. The magnitude of the force determines not only the degree of comminution but also the degree of displacement. Thus in addition to the fracture there may be associated soft tissue lesions, such as tears of the medial collateral ligament or anterior cruciate ligament with lateral plateau fractures or tears of the lateral collateral ligament or posterior cruciate ligament or lesions of the peroneal nerve or popliteal vessels with medial plateau fractures. It is also important to differentiate split fractures that are result of shearing force from rim avulsion fractures that are associated with knee dislocations and point to a much more unstable injury.⁴

The lateral condyle is fractured more often than the medial condyle, this is because of the physiological valgus of the knee, the weaker trabeculation under the lateral tibial plateau, and increased frequency of valgus injuries, as the knee is protected medially by the contralateral side. The anatomical square shape of the lateral femoral condyle is also important in this respect.

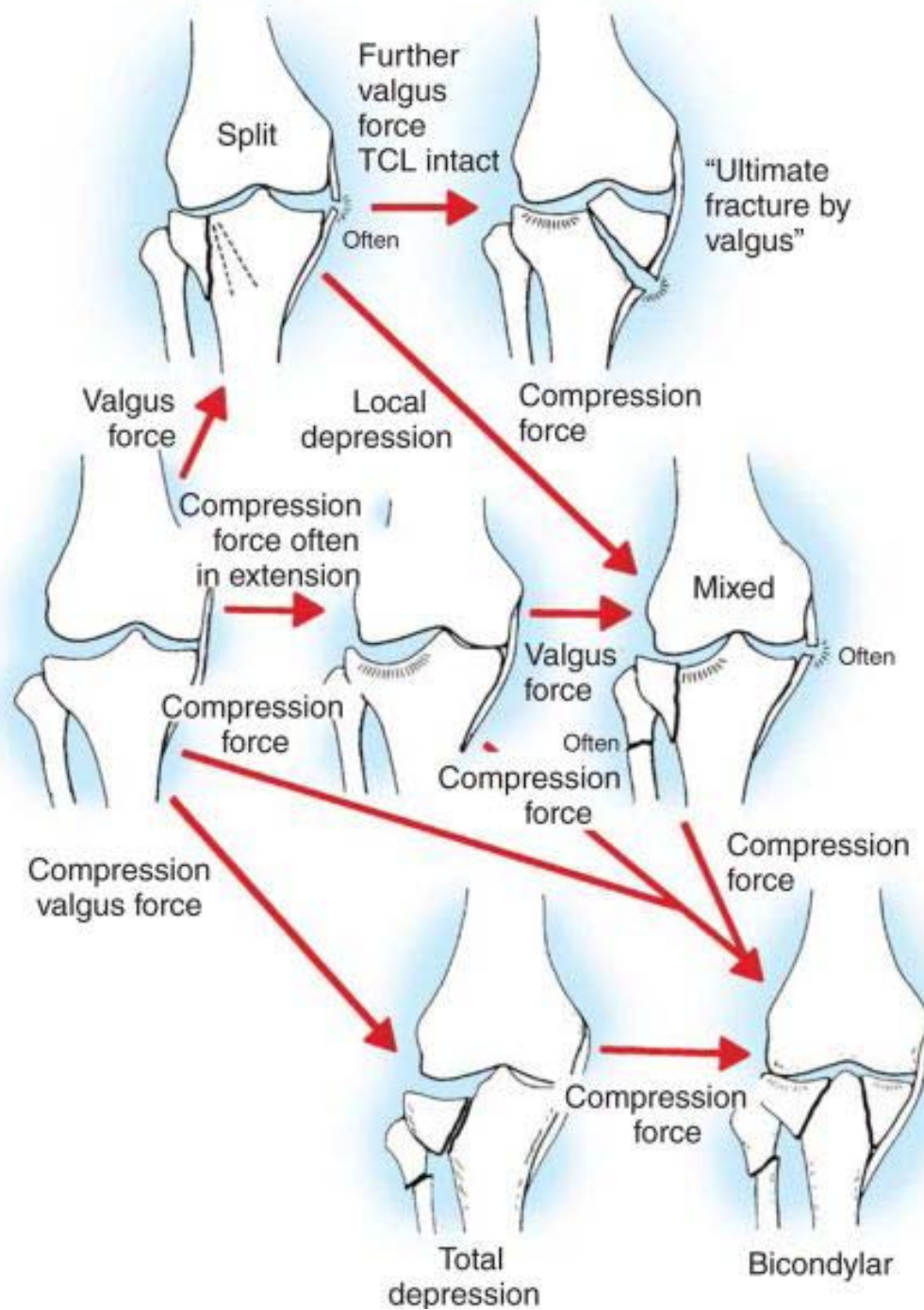


Fig. 10: Mechanism of injury tibial plateau fracture

CLINICAL EVALUATION

The extent of soft tissue and bone injury must be accurately ascertained to formulate an optimal treatment program for each tibial plateau fracture. To obtain this information, a thorough physical examination and imaging study of the injured knee are required. Painful and swollen knee is unable to bear weight on the affected extremity. History of valgus injuries such as bumper injuries to the knee, football or soccer injuries, fall from a height, this allows the surgeon to ascertain whether the injury is a high energy or a low energy forces. Fracture blisters, compartment syndrome, ligamentous disruption, neurovascular injuries seen exclusively in high energy forces. Medial condyle, bicondylar metaphyseal shaft disassociation is all consistent with high energy mechanism.

The knee is inspected for condition of skin with swelling and deformity, abrasions and open wounds are carefully evaluated, because their presence affects the timing and the type of definitive treatment that can be employed. The knee is often diffusely swollen and tender. Areas of tenderness are usually adjacent to the fracture or overlying the site of ligament injury. Knee alignment is compared to the normal side. Valgus deformity is observed most frequently but varus deformity, recurvatum, or procurvatum can occur depending on the fracture configuration.

Arterial circulation to the lower leg and foot must be evaluated at an early stage by palpation of arterial pulses about the ankle and foot. Compartment syndrome is uncommon but occurs sufficiently often than it must be considered, especially in the more comminuted fractures.¹⁸

Similarly peroneal nerve function should be tested and documented prior to treatment by noting the ability of the patient to feel sensation on the dorsum of the

foot and to extend the foot and toes may influence the treatment outcome in these difficult fractures. Deep contusions, hemorrhagic blisters, lack of skin wrinkles, all indicate internal degloving injury, the presence of this precludes the use of extensive incision for emergent formal internal fixation. In such case temporary measures such as spanning external fixation consider allowing soft tissue to recover before internal fixation. If open wounds are present their relation to the fracture site and knee joint must be ascertained.

Knee stability should be assessed in every injured knee, except those with bicondylar fractures or those with tibia or femoral fractures. It is often possible soon after the fracture to test the stability by applying valgus and varus stresses to the knee without using sedation or anesthesia.⁶

The technique is to apply valgus and then varus forces slowly, first in extension and subsequently in a few degrees of flexion, noting the angular deviation and the end point, compared with the normal knee since instability may persist unless it is corrected. The stability tests are repeated intra-operatively after fixation of fracture which is more accurate than before surgery.

INVESTIGATIONS

PLAIN X-RAYS:

X-ray evaluation provides information about the type of fracture, the degree of displacement, and the quality of bone. In many plateau fractures anteroposterior and lateral views provide insufficient information for determination of an optimal treatment plan. If fracture suspected not observed in AP and lateral views, 40° internal oblique view profiles lateral plateau, external oblique view 40° projects

medial plateau. Fracture depression and displacement must be visualized clearly so that fracture can be understood and optimal treatment selected. Oblique projections give information about the location of fracture lines and depressed areas. The amount of plateau depression and displacement is important to determine, although the exact number of millimeters of depression does not necessarily provide an indication for or against operative treatment. The plateau view, taken with a caudal tube angulation of 10^0 to match the normal posterior slope of the plateau, gives more accurate measurements than does a standard anteroposterior view.

Traction films are utmost important to detect the fracture pattern and to classify the fractures.

COMPUTERIZED AXIAL TOMOGRAPHY (CT):

CT scan is capable of providing images of the proximal tibia in several constructed planes. These images graphically demonstrate fracture lines and the direction and degree of fragment displacement. CT scans are valuable in any displaced plateau fracture but are most useful in bicondylar fractures and should be used as a preoperative planning tool. Properly interpreted, CT scans often influence the choice of surgical approach and guide insertion of percutaneous screws or placement of thin wires, when hybrid external fixation is used¹⁶ and CT scan gives limited soft tissue information.

MAGNETIC RESONANCE IMAGING (MRI):

Magnetic resonance imaging (MRI) is becoming more widely used to evaluate the associated soft tissue injuries in tibial plateau fractures. Although exact fracture displacement is not clearly evident in these studies, cruciate, collateral and

meniscal injuries accompanying plateau fractures are well visualized especially in Schatzker type II, IV and VI.

ARTHROGRAPHY:

Arthrography is rarely used with the freshly fractured knee. As noted previously, however, fracture depressions can be visualized using arthrography and, occasionally, torn menisci are diagnosed. Today arthroscopic evaluation of the knee has superceded arthrography.

ARTHROSCOPIC EXAMINATION:

Diagnostic arthroscopy before the definitive treatment of plateau fractures helps to evaluate the intraarticular structures and fragments of the bone and cartilage that are free in the joint can be removed.²⁷

ANGIOGRAPHY:

Angiography should be considered whenever there is an alteration in the distal pulses or when there is serious concern about the possibility of an arterial lesion. Angiography indicated in persistent arterial bleeding, if distal pulse not felt. High energy injuries, fracture dislocation patterns, unexplained compartment syndromes and Schatzker IV, V and VI fractures should lower the surgeon's threshold for obtaining an arteriogram as part of the preoperative evaluation.

METHODS OF TREATMENT

The number and diversity of treatments that have been used in the management of proximal tibial fractures is a tribute to the ingenuity of surgeon who was stimulated by dissatisfaction with earlier methods. In general, the best treatment is the simplest and least risky that gives promise of accurate articular surface reduction, restoration of leg alignment and knee stability while permitting early rehabilitation.

Schatzker²⁴ has formulated the following principles of treatment:

1. Tibial plateau fractures immobilized for more than 4 weeks usually leads to some degree of joint stiffness.
2. Internal fixation of plateau fractures combined with immobilization of the knee leads to even greater degrees of joint stiffness.
3. Regardless of the method or technique of treatment, the knee joint must be mobilized early.^{12, 15.}
4. As long as joint mobility is preserved, secondary reconstructive procedures are possible.
5. Impacted articular fragment cannot be dislodged by traction or manipulation alone, because there are no soft tissue attachments to lever them upward.
6. Depressed articular surface defects do not fill in with hyaline cartilage and remains as permanent defects, therefore, any joint that is, unstable as a result of joint depression or displacement will remain unstable unless it is surgically corrected.
7. Articular fractures that result in joint instability require open reduction and internal fixation.
8. Absolute joint congruency can be restored only by open reduction.

9. Anatomic reduction and stable fixation is necessary for cartilage regeneration.
10. Open reduction and internal fixation if indicated but inadvisable, then skeletal traction and early motion is advisable.

CLOSED MANAGEMENT TECHNIQUES:

Closed management of plateau fractures has always been popular because it is relatively simple, with minimal risk to the patient and gives favorable results in fractures with lesser articular displacements however uncorrected articular offsets or displacements causes significant degradation of long term results.

INDICATIONS:

There are several indications for non-operative treatment, majority of which are limited to low energy lateral tibial plateau injuries.

Relative indications:

- 1) Undisplaced or incomplete fractures.
- 2) Minimally displaced stable lateral plateau fractures.
- 3) Selected unstable lateral plateau fracture in elderly osteoporotic patients.
- 4) Significantly associated medical disease (cardiovascular, metabolic etc.)
- 5) Advanced osteoporosis.
- 6) Spinal cord injury with fracture.
- 7) Severely contaminated open fractures (Type III B)
- 8) Infected fractures.
- 9) Inexperience with surgical techniques.

Goal of non-surgical treatment is not only reduction of the fracture but restoration of axial alignment and knee motion. No more than 7 degrees of

malalignment in frontal (mediolateral) plane accepted. Knee should not exhibit varus or valgus instability greater than 5 or 10 degrees at any point in the arc of motion from full extension to 90 degrees of flexion compared with the opposite side.

METHODS:

1) FUNCTIONAL MANAGEMENT:

Tibial plateau fractures with small displacement and little tendency to redisplace are treated appropriately by functional methods of early knee movement and muscle strengthening, using a brace or soft dressing, until the fracture healing is evident by x-ray. Whenever functional management is used, X-rays should be taken every few days until evidence of bone healing is present and to ensure that reduction is maintained.

2) CAST IMMOBILIZATION:

Cast treatment is mostly used for undisplaced or minimally displaced fracture of various types. The cast is applied from groin to ankle or foot with knee in 10-15° of flexion. The cast is worn for an average of 3-6 weeks after which a period of rehabilitation of at least 2-4 weeks without weight bearing is instituted. Cast immobilization can also be followed with functional cast braces, partial weight bearing is resumed at 9-10 weeks and complete weight bearing at 12-16 weeks depending on clinical and radiological evidence of fracture healing.

3) HINGED CASTS AND BRACES:

The role of bracing or cast bracing, in plateau fracture management is becoming more clearly defined^{7,10,17}. Recent orthotic developments have made

fracture bracing as effective as cast bracing. Either of these bracing methods can be used in certain unstable fractures or when it is necessary to maintain continuing varus or valgus stress to prevent fracture displacement.

4) TRACTION:

Traction is a useful and reliable method of plateau fracture management that permits knee movement while helping to correct and maintain fracture position. The disadvantage of traction is the expense of hospital confinement for 3 to 6 weeks until the fracture becomes sufficiently stable for a brace or other form of support to be used.

Traction is an option when open reduction is contraindicated. Some contraindications for surgery are extraordinary risk because of systemic condition, loss of skin or infection in the area of the knee, or a fracture so comminuted or osteopenic that in the judgement of the surgeon open reduction could not result in rigid fixation or reasonable restoration of the articular surfaces. The traction is best placed in the distal tibia but has been used in the mid tibia and in the calcaneus.

The other disadvantages of skeletal traction may include less than anatomic fracture reduction, loss of normal knee valgus alignment, pin tract infection and expense.

CLOSED REDUCTION:

Its use is reserved for patients in whom open reduction is contraindicated or to obtain reduction prior to the insertion of percutaneous fixation devices. The problem with this method is not so much the difficulty of obtaining adequate reduction but of maintaining reduction once it has been achieved. Plaster casts are

very unlikely to maintain fracture reduction after closed manipulation. Skeletal traction seems to be the only reliable closed method for preventing redisplacement but it must be continued for about 4 weeks before brace or a cast brace can be safely applied.

5) CLOSED REDUCTION AND PERCUTANEOUS FIXATION:

After successful closed reduction utilizing traction and angular forces, screws or pins may be inserted percutaneously to maintain reduction. This technique is especially helpful for fractures with larger fragments and is gaining popularity because of the availability of cannulated screw systems. Another method involves the use of small wires placed through the reduced proximal tibial fracture and fixed to a half ring that is in turn supported by an external fixator into the mid tibial region²⁵. This technique is useful even for open fractures. Perhaps its best use is with larger fragment plateau bicondylar fractures that have an associated subcondylar or proximal tibial shaft fracture.

SURGICAL TREATMENT

A surge of enthusiasm for open reduction developed in the 1960 based on the recognition the new internal fixation devices combined with techniques of reduction did have the ability to fix fractures rigidly and accurately. This meant that external support, such as a cast, would be needed only for a short time if at all.³ Rigid fracture fixation has allowed earlier knee movement after open reduction and consequently, improved functional results.

Absolute indication for surgical treatment includes:

1. An open proximal tibia fracture.

2. A proximal tibia fracture with acute compartment syndrome.
3. A proximal tibia fracture with vascular injury.

Relative indications:

1. Lateral tibial plateau fractures that result in joint instability.
2. Most of the displaced medial tibial plateau fractures.
3. Displaced bicondylar tibial plateau fractures.

TIMING OF SURGERY:

An open proximal tibia fracture in association with a compartment syndrome or vascular injury requires immediate treatment. In many cases with associated other system injury, the knee injury, can be stabilized concurrently or immediately after neurosurgical, thoracic or abdominal procedures. In patients with isolated closed proximal tibia fractures, the timing of surgery is primarily dependent on the status of soft tissues and secondarily dependent on the ability to obtain appropriate imaging studies, as well as the availability of the experienced surgical team and implants. If there is no contraindication, it is advisable to proceed to surgery as soon as possible.

When patients present with compromised soft tissues with relative soft tissue swelling or fracture blisters, surgery should be delayed until swelling has subsided and local skin conditions improve.

POSITIONING OF THE PATIENT:

Surgery is performed with the patient supine on a radiolucent operating table under general or spinal anesthesia. The entire injured limb is prepared and

draped along with the ipsilateral iliac crest. The table should provide the capability to flex the knee to 90°. Alternatively, a large sterile bolster that permits knee flexion to 90° can be used. Knee flexion allows the iliotibial band to slip posteriorly off the lateral condyle of the femur that facilitates both exposure and better visualization of the joint.

SURGICAL APPROACH:

The surgical approach for open reduction of proximal tibia fractures is described. The use of this exposure allows as much exposure of the articular surface and tibial shaft as is required and to reduce a fracture and apply plates and screws to the tibial condyle and shaft. Such surgical wounds tend to heal rapidly and predictably. Because many knees with plateau fractures will eventually develop traumatic arthritis, whenever possible skin incisions that are not likely to interfere with later knee replacement should be planned.

Lateral curvilinear approach:

The landmarks are the patella, the lateral tibiofemoral joint line, the tibial tubercle and the fibular head. The skin incision begins laterally over the femoral condyle distal to the origin of the lateral collateral ligament and passes across the joint line anterodistally near the patellar tendon. At the lateral edge of the patellar tendon the incision curves distally down the tibial shaft, 5 or 6 cm. The skin incision may be readily extended down the tibial shaft if a long plate is required or a bone graft needs to be harvested. The subcutaneous tissue is divided in line with the skin incision. On flexing the knee to 80° the iliotibial band moves posteriorly. The joint is entered by incising the capsule and the meniscotibial ligament from anterior to posterior. Varus

stress of the knee permits visualization of the lateral tibial articular surface. If more exposure of the plateau, especially posterior, is required the lateral collateral ligament is divided obliquely and is later resutured.

The meniscus has to be preserved or repaired whenever possible¹⁴. Because of the value of the menisci in guiding pannus after fracture and its function in weight bearing, it should never be removed for visualization of fracture. Only severe meniscal injuries justify removal.

The joint capsule is closed in the same line as it was opened and. The Gerdy's tubercle if osteotomized is reattached with a screw and washer. The lateral collateral ligament if divided has to be sutured. Suction drainage of the knee decreases postoperative pain and swelling.

POST OPERATIVE CARE:

Cephalosporins administered intravenously for 48 hours after open reduction and internal fixation for closed proximal tibial fracture followed by oral antibiotics till suture removal. In open fractures, Cephalosporins combined with aminoglycosides are used for 5 days followed by oral antibiotics till wound healing and suction drainage for two days or based on amount of collection in the drain. The hallmark of the treatment is early range of motion and delayed weight bearing. If stable fixation is done continuous passive mobilization carried out. In Schatzker type I, II and III no weight bearing for four to eight weeks, partial weight bearing for next four to six weeks and full weight bearing at three months. In high energy proximal tibia fractures continuous passive mobilization is set only to 20 to 30 degree flexion and protected with hinged knee braces, weight bearing delayed for eight to twelve weeks.

COMPLICATIONS:

Complications can be divided into two kinds.

1. Early
2. Late

EARLY COMPLICATIONS:

I) THROMBOPHLEBITIS & EMBOLISM:

Immobilization of a leg or injury to the knee may lead to the development of thrombophlebitis in the calf or thigh. In the presence of thrombophlebitis, treatment options may be quite limited and results significantly affected. Pulmonary embolism is seen in a small proportion of patients. It sometimes occurs silently but usually causes pleuritic pain, an episode of bloody sputum or shortness of breath. The diagnosis is reliably established by available tests.

II) FAT EMBOLISM:

Fat embolism is one of the earliest recorded complications in the history of plateau fracture treatment. The presence of petechial hemorrhages, change in fatty enzymes and decreased PO₂ in arterial blood usually establish the diagnosis. Treatment consists of corticosteroids, oxygen to improve respiratory exchange and supportive methods.

III) COMPARTMENT SYNDROME:

It is manifested clinically by pain, increasing with time most frequently located over the proximal portion of the anterior compartment and is tested by

measuring pressures in all leg compartments. Early and complete release of fascia encompassing the affected compartments is the indicated treatment. As a prophylactic measure to avoid compartment syndrome after open reduction of a proximal tibia fracture, the fascia should not be closed.

IV) ARTERIAL INJURY:

Bicondylar fractures with sharp spicules of bone or any plateau fracture especially those with a subcondylar component, may injure the popliteal artery. Surgical repair of the lacerated artery is carried out as an emergency, reserving fracture fixation until circulation has been reestablished. Internal fixation is accomplished later, but closed management technique may also be used effectively.

V) PERONEAL NERVE PARALYSIS:

The anatomical course of the common peroneal nerve around the neck of the fibula makes it vulnerable to injury by direct trauma against the lateral aspect of the knee or by the same type of stretching that may also damage lateral knee ligaments. Peroneal nerve damage usually occurs at the time of fracture but can also result from direct pressure against a plaster cast or traction sling, or from retraction in surgery. Late neurolysis of the peroneal nerve is rarely required and the prognosis for recovery is favorable. Most injured nerves recover the majority of function within a period of 6 months.

VI) LOSS OF FRACTURE REDUCTION:

Fractures that involve the articular surface of the proximal tibia are affected by strong muscle forces across the knee joint. Because of these forces,

fractures tend to displace owing to pressure of the femoral condyle against the tibial plateau.

VII) WOUND INFECTION:

Wound infection is the most common complication and open reduction of a plateau fracture carries with it the risk of wound infection. Wound healing problems were noted most frequently after operative treatment of bicondylar fractures, probably because of the ill-timed surgical incision through contused skin with extensive exposure, retraction, metallic implants and operating time.

Prophylactic antibiotics and newer techniques have fostered the current favorable attitude toward operative fracture management. Careful attentions to skin condition, intra operative antibiotics, surgical approaches requiring little retraction, and rigid fixation have minimized the risk. The duration of antibiotic therapy correlated with clinical appearance of the wound and laboratory assessment of infection and bacteriology reports. Soft tissue closure recommended within five to seven days. If tension free closure cannot be obtained a medial or lateral gastrocnemius flap with subsequent split skin grafting can be done.

VIII) AVASCULAR NECROSIS:

Exposure of fractured tibial plateau by their near complete release from soft tissue attachments may produce avascular changes. Necrosis of elevated fragments in local compression or split compression fractures is seen rarely. Bony fragments need to be exposed to accomplish accurate reduction and rigid fixation. Minimum soft tissue dissection will lessen the risk of avascular changes in the bony fragments.

Percutaneous methods of fixation run no risk of producing avascular changes in the bony fragments.

IX) NONUNION:

Pseudoarthrosis of a proximal tibia fracture is quite uncommon. Cancellous bone in the tibial plateau region is richly supplied with vascularity, which favors rapid bony union. Nonetheless, failure of fracture union happens in about one of 200 plateau fractures. Non-union is commonly seen in Schatzker type VI. Treatment of non-union must be aggressive. In aseptic non-union surgical exposure and grafting is usually successful when combined with rigid internal fixation. In infected non-union antibiotic impregnated beads, rotational free flaps and external fixation are the mainstay of treatment.

X) IMPLANT COMPLICATIONS:

Internal fixation devices can break, slip and cause irritation, when skeletal traction or external fixation pins were used, infection of pin tracts with osteomyelitis occurs rarely, hardware breakage or displacement occurs more often when wires or bolts are used rather than cancellous screws or buttress plates.

XI) CAUSALGIA:

A very rare complication usually following incomplete injury to the infrapatellar branch of the saphenous nerve, such as by stretching at surgery or by local bruising from the initial injury. The treatment is local anesthetic injection of the involved nerve, exploration of the nerve with neurolysis or paravertebral sympathetic blocks.

LATE COMPLICATIONS:

I) LIMITATION OF KNEE MOVEMENTS:

It is well accepted that the process of healing articular injuries utilizes scar tissue that tends to envelop all articular structures. If the knee is immobilized during the period of intense scar formation, dense adhesions arise from the injury to the synovium, encompassing the menisci and fat pad. Late arthrotomy and arthroscopy has confirmed the presence of multiple intra articular adhesions.

The best way to ensure a functional range of knee movement after a proximal tibia fracture is to use a method of treatment that allows early knee motion. If rigid fixation has been obtained, early motion should be encouraged. Arthroscopic lysis of adhesions with gentle manipulation of the knee is ideally done.

II) LACK OF KNEE EXTENSION:

If the knee cannot be extended fully, the gait is altered and walking becomes more difficult. Even a few degrees of flexion contracture cause some gait impairment. The causes of these flexion contractures are prolonged immobilization in flexion, associated subcondylar fracture that has united with anterior angulation, and failure to reduce and maintain the articular fragments in their anatomical position.

III) ANGULAR DEFORMITY:

This is most commonly a valgus deformity due to the predominance of lateral plateau fractures. With loss of articular cartilage and erosion of the articular bony surface, it can be prevented by accurate reduction, and maintenance of the reduction. If the deformity is established, a subcondylar osteotomy is frequently used

to correct the alignment. Unicondylar or total knee replacement may be a better choice than osteotomy for patients in poor health or older than 70 years age.

IV) INSTABILITY:

Three reasons for late instability after plateau fractures are recognized. The first is failure to reduce and maintain reduction of plateau surface. The second is ligament laxity secondary to an unrepaired collateral or cruciate ligament injury. The third is traumatic arthritis with loss of articular cartilage and erosion of the articular cartilage. These are often responsible for development of late knee pain.

V) TRAUMATIC ARTHRITIS:

There is no universal agreement as to what constitutes traumatic arthritis in the knee and the reported incidence following proximal tibia fracture varies greatly from about 10-78%. Squaring of the femoral and tibial condyles are the earliest change seen on x-ray the other changes occur, including spurring on the tibial spines and joint margins, sclerosis of the subchondral bone, joint space narrowing and finally cyst formation in the articular subcortex.

Posttraumatic osteoarthritis leads to articular incongruity and joint instability. Varus malalignment of the tibial plateau is less tolerated than valgus malalignment. If arthritis is limited to medial or lateral compartment with altered mechanical axis corrective osteotomy indicated. If bicompartamental or tricompartmental, an arthrodesis or total knee replacement is necessary.

GENERAL PRINCIPLES OF LCP

The basic principles of an internal fixation procedure using a conventional plate and screw system (compression method) are direct, anatomical reduction and stable internal fixation of the fracture. Wide exposure of the bone is usually necessary to gain access to and provide good visibility of the fracture zone to allow reduction and plate fixation to be performed. This procedure requires pre-contouring of the plate to match the anatomy of the bone. The screws are tightened to fix the plate onto the bone, which then compresses the plate onto the bone. The actual stability results from the friction between the plate and the bone. Anatomical reduction of the fracture was the goal of conventional plating technique, but over time a technique for bridging plate osteosynthesis has been developed for multifragmentary shaft fractures that, thanks to a reduction of vascular damage to the bone, permits healing with callus formation, as seen after locked nailing. Since the damage to the soft tissues and the blood supply is less extensive, more rapid fracture healing can be achieved. The newly developed, so-called locked internal fixators (e.g. PC-Fix and Less Invasive Stabilization System (LISS)), consist of plate and screw systems where the screws are locked in the plate. This locking minimizes the compressive forces exerted by the plate on the bone. This method of screw-plate fixation means that the plate does not need to touch the bone at all, which is of particular advantage in so called Minimal Invasive Percutaneous Plate Osteosynthesis (MIPPO). Precise anatomical contouring of a plate is no longer necessary thanks to these new screws and because the plate does not need to be pressed on to the bone to achieve stability. This prevents primary dislocation of the fracture caused by inexact contouring of a plate. The LISS plates are precontoured to match the average anatomical form of the relevant site and,

therefore, do not have to be further adapted intraoperatively. The development of the locked internal fixator method has been based on scientific insights into bone biology especially with reference to its blood supply. The basic locked internal fixation technique aims at flexible elastic fixation to initiate spontaneous healing, including its induction of callus formation. This technology supports what is currently known as MIPPO. The development of the Locking Compression Plate (LCP) has only been possible based on the experience gained with the PC-Fix and LISS. With reference to the mechanical, biomechanical and clinical results, the new AO LCP with combination holes can be used, depending on the fracture situation, as a compression plate, a locked internal fixator, or as an internal fixation system combining both techniques. The LCP with combination holes can also be used, depending on the fracture situation, in either a conventional technique (compression principle), bridging technique (internal fixator principle), or a combination technique (compression and bridging principles). A combination of both screw types offers the possibility to achieve a synergy of both internal fixation, methods. If the LCP is applied as a compression plate, the operative technique is much the same as conventional technique, in which existing instruments and screws can be used. The internal fixator method can be applied through an open but less invasive or an MIPPO approach. An indirect closed reduction is necessary when using the LCP in the internal fixator method bridging the fracture zone. A combination of both plating techniques is possible and valuable, depending on the indication. It is important to command a knowledge of both techniques and their different features.

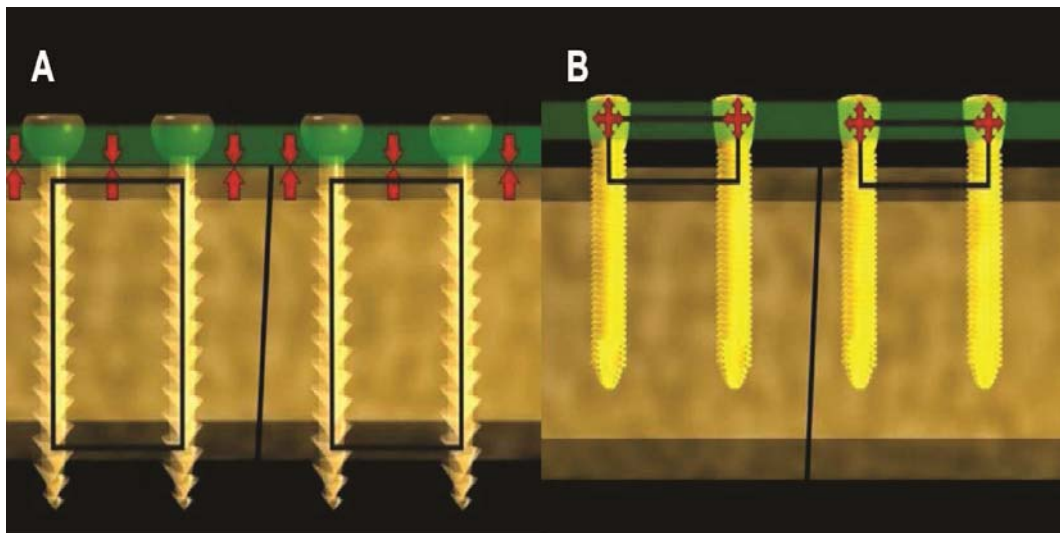


Fig. 11: Differences between distribution of the biomechanical load for standard plates (A) by comparison with LCP (B) and the bone implant interface.



Fig. 12: Locking screw designs and difference between conventional screw and locking screw.

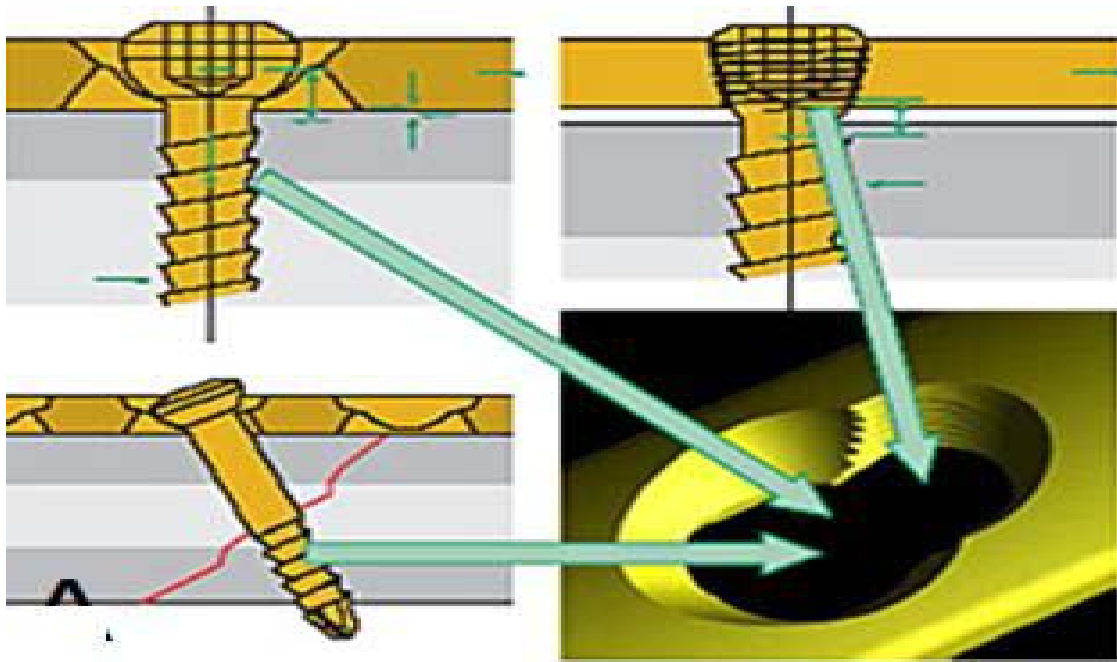


Fig. 13: LCP combination hole combining three proven elements. It mainly consists of two parts: 1) One half of the hole has the design of the standard DC/LC-DCP (dynamic compression unit: DCU) for conventional screws. 2) The other half is conical and threaded to accept the matching thread of locking head screw providing angular stability.

MATERIALS AND METHODS

This is a study of proximal tibial fractures treated with locking compression plate (LCP) which was conducted in the department of orthopedics at R.L.Jalappa Hospital and Research Centre attached to Sri Devaraj Urs Medical College, Kolar from December 2013 to May 2015. Clearance was obtained from hospital ethical committee.

During this period 30 patients were treated for proximal tibial fractures by LCP fixation and all the required data was collected from the patients during their stay in the hospital and during follow up at regular intervals.

The Inclusion Criteria:

1. Age above 18 years.
2. Closed / Open Gustilo-Anderson Type I, II and IIIA.
3. Intraarticular / Extraarticular proximal tibial fractures (AO 41A and 41C).

The Exclusion criteria:

1. Pathological fractures.
2. Patients medically unfit for surgery.

CLASSIFICATION SYSTEM:

The AO classification was used to classify these fractures. The patients were followed up for a minimum period of 6 months.

MANAGEMENT:

The patients were first seen in the casualty/ OPD. The history was taken followed by general and local examination of the patient. Concerned specialists undertook appropriate management of any associated injuries. Intensive care was given to those patients who presented with shock following head injuries and immediate resuscitative measures were taken. Once the patient's general condition was fit, relevant x-rays were taken. Higher investigations such as CT scan were done if indicated.

The patients were taken for surgery at the earliest possible time depending on their medical condition, skin condition and the amount of swelling. If definitive surgery was delayed, fracture was immobilized with an above knee posterior splint. All surgeries were done under C-arm image intensifier control. Fractures were fixed either with MIPPO technique or by open reduction and internal fixation with LCP.

INSTRUMENTS AND IMPLANTS USED:

- Precontoured proximal tibial locking compression plate.
- 4.5mm universal drill guide.
- Drill bits of 3.2mm.
- Power drill.
- Tap of different sizes i.e. 4.5mm and 6.5mm.
- Depth gauge 4.5mm.
- 6.5mm locking screws.
- 4.9mm cortical locking screws.
- 4.5mm cortical screws of varying sizes.
- K-wires.

- Measuring scale.
- 4.5mm Hexagonal screw driver.
- General instrumentation like retractors, periosteal elevators, reduction clamps, bone levers etc.
- Pneumatic tourniquet /rubber tourniquet.

PREOPERATIVE PLANNING:

- Consent of the patient/ patient attenders was taken prior to the surgery.
- Appropriate length of the plate to be used was assessed with the help of radiographs.
- A dose of tetanus and antibiotic was given preoperatively.
- Preparation of the part was done before the day of surgery.
- The injured leg was immobilized in a plaster of paris slab during preoperative period.
- Instruments to be used were checked and sterilized.

POSITION:

- Patient supine on radiolucent operating table.

OPERATIVE PROCEDURE:

- Type of anaesthesia: Spinal anaesthesia.
- Betadine scrub was given to the limb.
- Pneumatic tourniquet was applied after exsanguinations and time noted.

- Painting and draping of the part done.
- Through anterolateral approach, intraarticular fractures were exposed and reduced anatomically, whereas extraarticular fractures were treated through MIPPO technique.
- After achieving reduction, appropriate sized plate was taken and fracture was stabilized using cortical and locking screws. Cortical screws were put before putting locking screws.
- The average time taken for surgery in case of MIPPO technique was 50 minutes (range, 40-60 minutes) and 75 minutes (range, 60-90 minutes) in case of open reduction and internal fixation.
- The major intra-operative problems encountered were in case of comminuted fractures that were tried to reduce by MIPPO technique and later converted to open reduction after unsuccessful attempts.
- Tourniquet was released and haemostasis secured.
- Wound closed leaving suction drain.

POSTOPERATIVE:

Postoperatively after obtaining rigid internal fixation, the patients were mobilized after removal of drains, for 2-5 days the range of motion allowed was 0-20⁰, from the 5th day the range of motion was gradually allowed to be increased to 90⁰ or more. After suture removal on 12-14th day if no complications, full range of movement was allowed. An immediate postoperative x-ray was also done. Intravenous antibiotics were given for 48 hours in case of closed fractures and more as required in case of open fractures. Analgesics were given till adequate pain relief was obtained. The patients were advised quadriceps exercises, early active knee

mobilization and non-weight bearing crutch walking, on discharge. In case of comminuted fractures with unstable fixation, external support was given in the form of slab and mobilization was started after confirming the healing process clinically and radiologically.

FOLLOW UP:

After suture removal, follow up was done at 6 weeks during which patient was clinically evaluated and an x-ray was taken to look for signs of fracture union and loss of reduction if any. The second follow up was done at 3 months during which one more x-ray was done and a clinical evaluation of union done. Based on the clinical and radiological signs of union patients were allowed partial weight bearing and gradually progressed to full weight bearing. Partial weight bearing was delayed until 6 – 8 weeks and full weight bearing allowed after 12-16 weeks if fracture union seen. The patients were then followed up at 6 months during which time the anatomic and functional evaluation was done using the Rasmussen's functional grading system.

CRITERIA FOR EVALUATION OF PROXIMAL TIBIA

FRACTURE RESULTS:

RASMUSSEN'S FUNCTIONAL GRADING SYSTEM:

1. Pain:

- ☐ No pain – 6
- ☐ Occasional pain – 5
- ☐ Stabbing pain in certain position, moderate pain – 4
- ☐ Severe pain, constant pain around knee joint after activity – 2

- ☐ Night pain, at rest - 0

2. Walking capacity:

- ☐ Normal walking capacity in relation to age – 6
- ☐ Walking capacity outdoors for atleast one hour – 4
- ☐ Walking capacity outdoors > 15 minutes – 2
- ☐ Walking capacity - walking indoors only – 1
- ☐ Wheel chair bound/bed ridden - 0

3. Extension of leg (Extensor Lag):

- ☐ Normal extension – 6
- ☐ Lack of extension ($0-10^0$) – 4
- ☐ Lack of extension ($> 10^0$) – 2

4. Range of motion:

- ☐ At least 135^0 – 6
- ☐ At least 120^0 – 5
- ☐ At least 90^0 – 4
- ☐ At least 60^0 – 2
- ☐ At least 30^0 – 1
- ☐ 0^0 – 0

5. Stability:

- ☐ Normal in extension & 20^0 flexion – 6
- ☐ Abnormal in 20^0 flexion – 5

- ☐ Instability in extension ($<10^0$) – 4
- ☐ Instability in extension ($>10^0$) – 2

☐ **At the end of 6 months:**

Points

1. Pain
2. Walking capacity
3. Extension of leg
4. Range of motion
5. Stability

Total Score: _____

- ☐ Excellent results – Total minimum of 27 points.
- ☐ Good results – Total minimum of 20 points.
- ☐ Fair results – Total minimum of 10 points.
- ☐ Poor results – Total minimum of 06 points.





Fig. 15: Pre-op X-ray films



Fig. 16: Patient positioning on radiolucent OT table and MIPPO technique

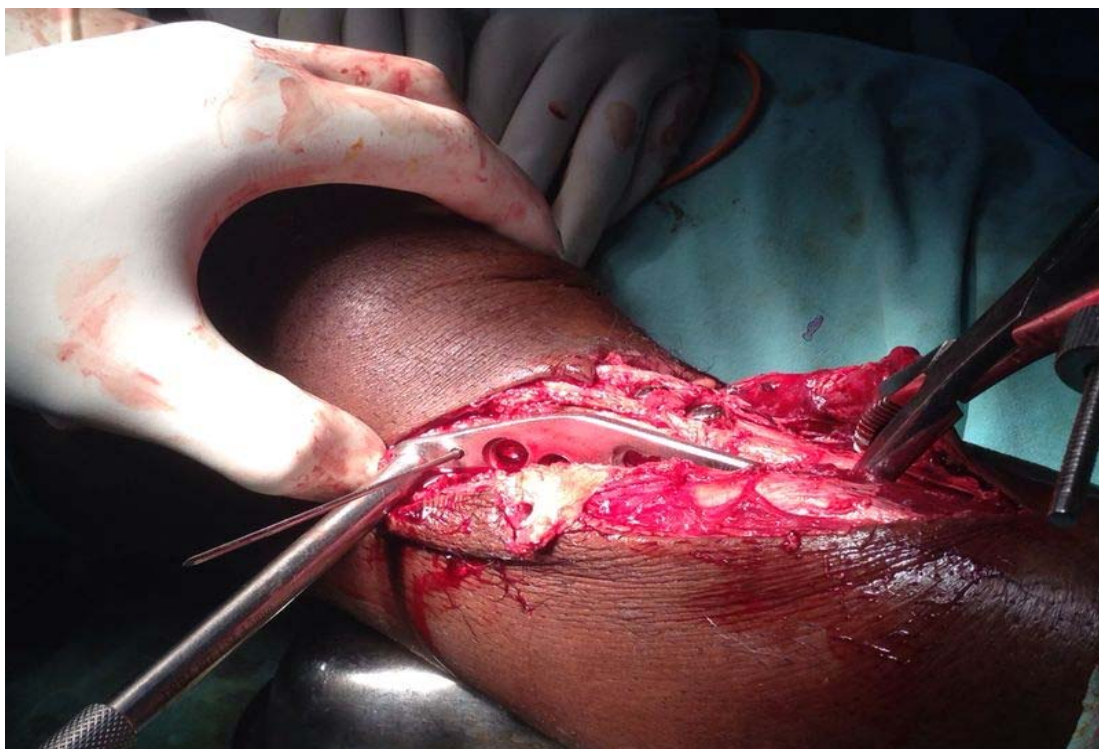


Fig. 17: Patient positioning on radiolucent table and ORIF



Fig. 18: Post op X-rays



Fig. 19: 6 weeks follow up X-rays

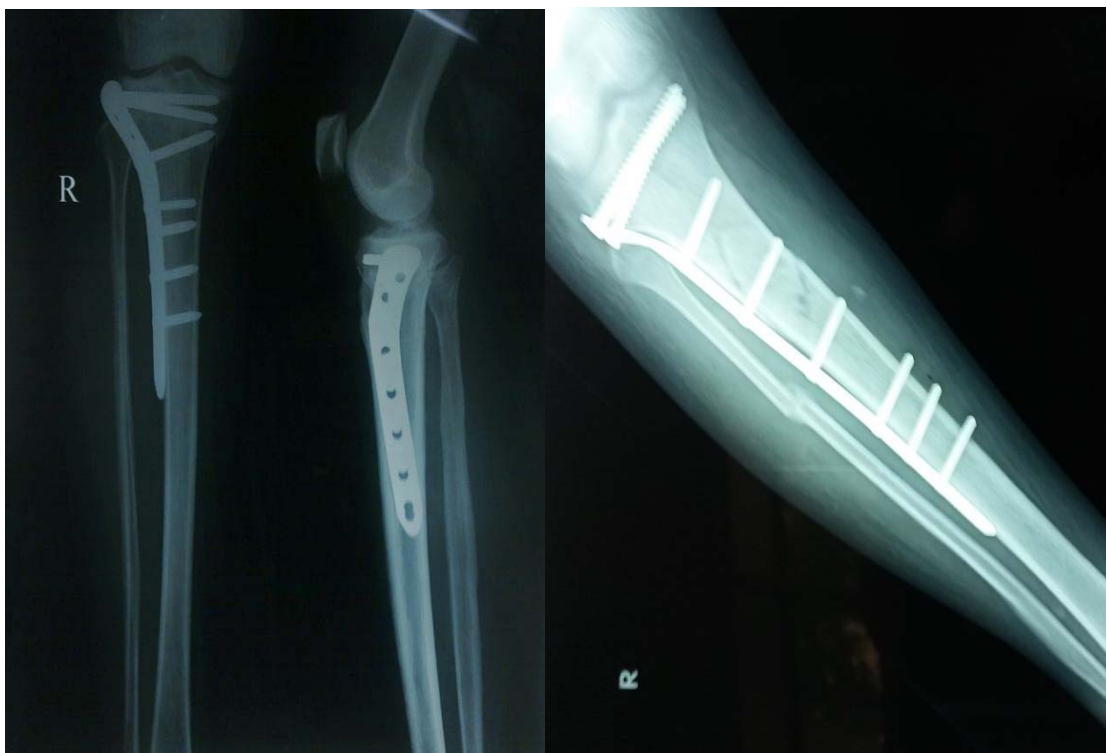


Fig. 20: 3 months followup X-rays

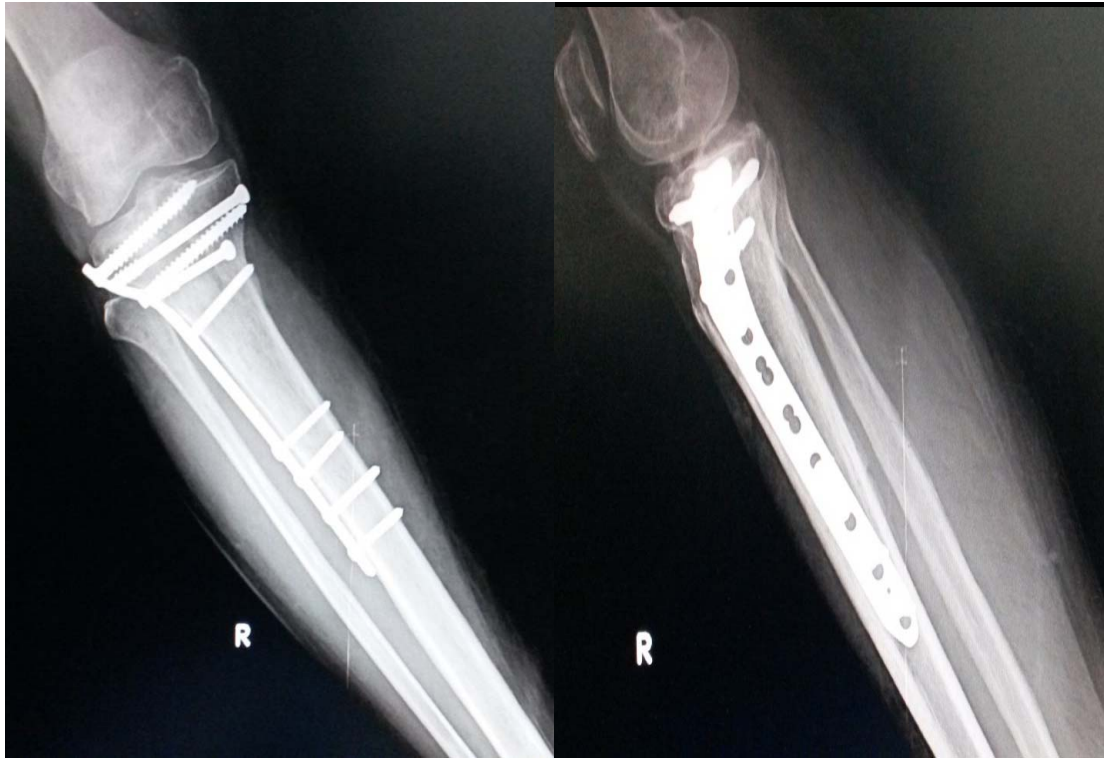


Fig. 21: 6 months follow up X-rays



Fig. 22: Flexion and Extension before suture removal.





Fig. 23: Range of motion at 3 and 6 months follow up

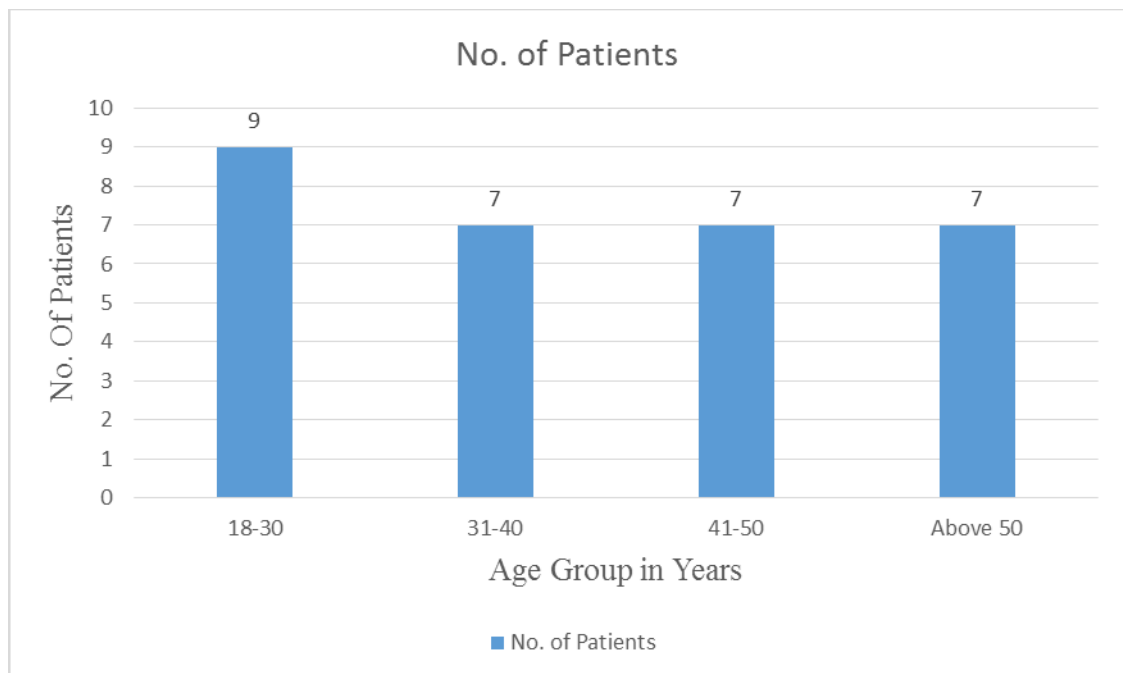
RESULTS

AGE DISTRIBUTION:

The youngest patient in this study was 21 years and the oldest was 60 years. The average age was 41 years. The majority of patients, 30% were in 18- 30 years age group, 23.3% in 31-40, 41-50 and above 50 years age groups.

Table 1: Age distribution:

AGE GROUP (years)	NO OF CASES	PERCENTAGE
18 – 30	9	30%
31 – 40	7	23.3%
41 – 50	7	23.3%
ABOVE 50	7	23.3%



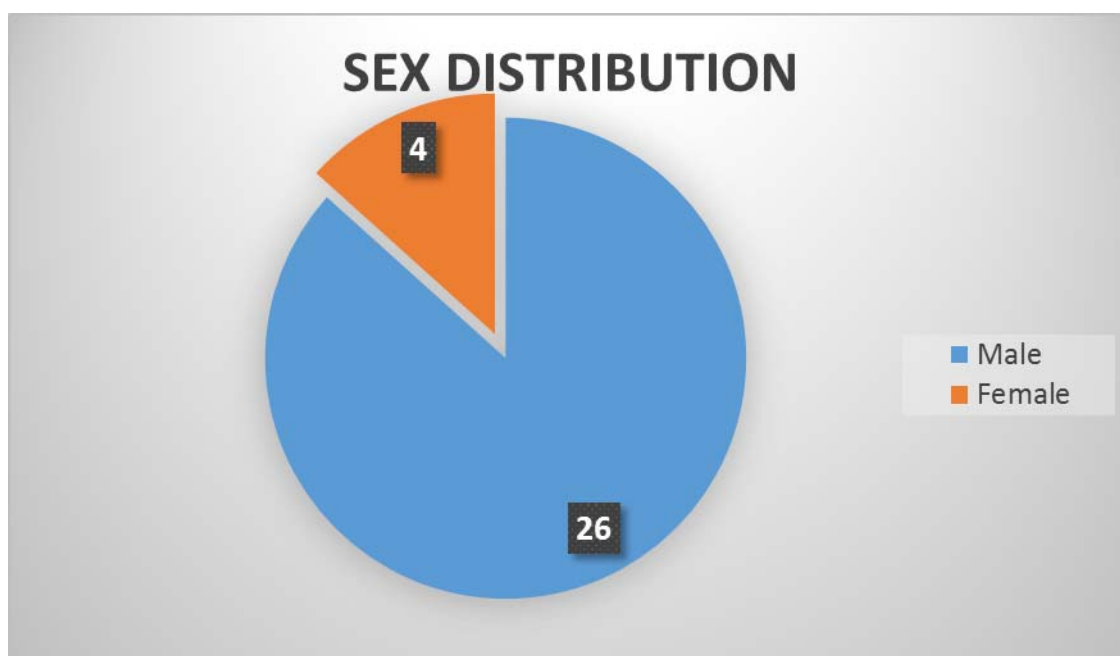
Graph 1: Age distribution

SEX DISTRIBUTION:

In this study 86.7% patients were male and 13.3% were females.

Table 2: Sex distribution:

SEX	NO OF CASES	PERCENTAGE
MALE	26	86.7%
FEMALE	4	13.3%



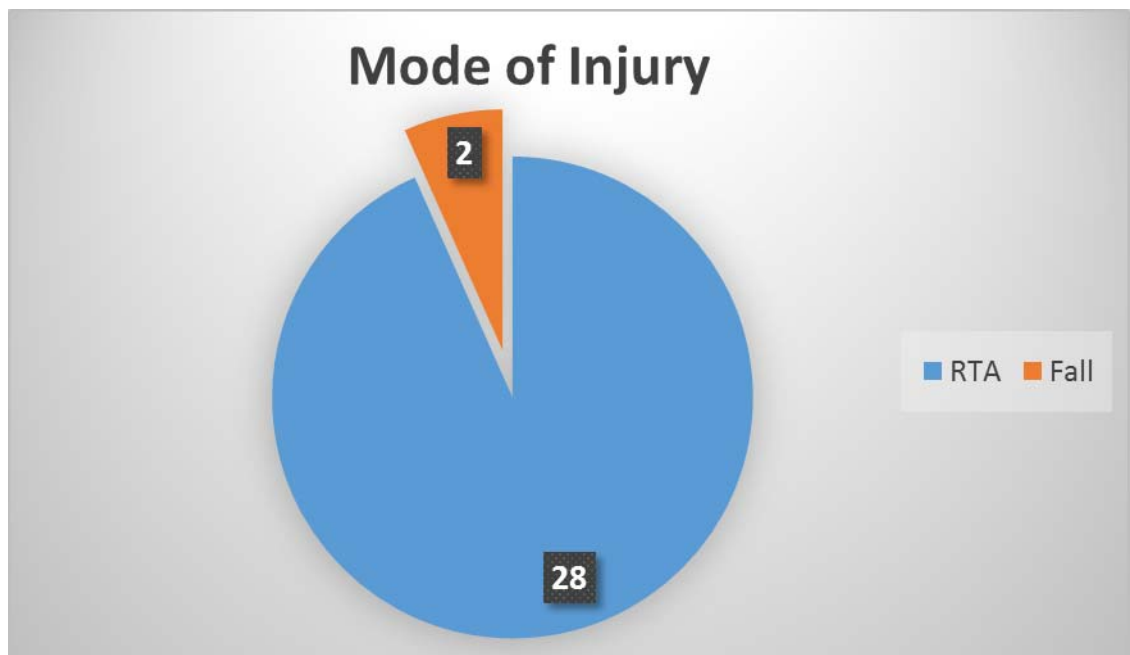
Graph 2: Sex distribution

MODE OF INJURY:

The mechanism of injury was grouped into 2 categories. Road traffic accidents and fall from a height. 93.3% of the patients sustained injury secondary to RTA and the rest 6.7% due to fall from a height.

Table 3: Mode of injury:

MODE	NO OF CASES	PERCENTAGE
RTA	28	93.3%
FALL (HEIGHT)	2	6.7%



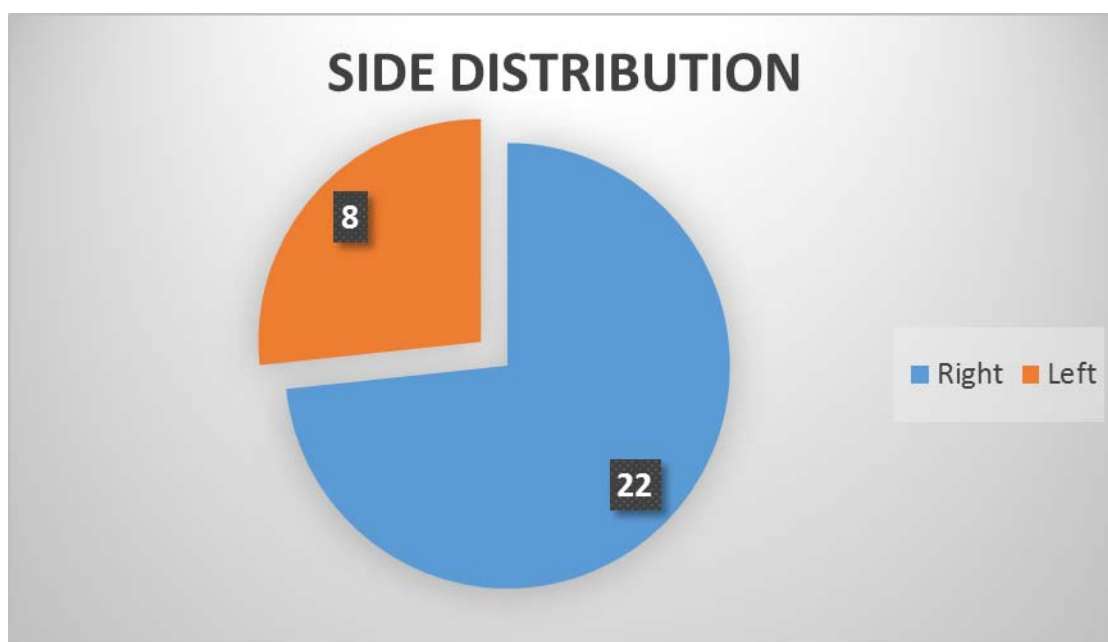
Graph 3: Mode of injury

SIDE OF INVOLVEMENT:

In this study 73.3% of the patients sustained injury on the right side and 26.7% on the left side.

Table 4: Side of Involvement:

SIDE	NO OF CASES	PERCENTAGE
RIGHT	22	73.3%
LEFT	8	26.7%



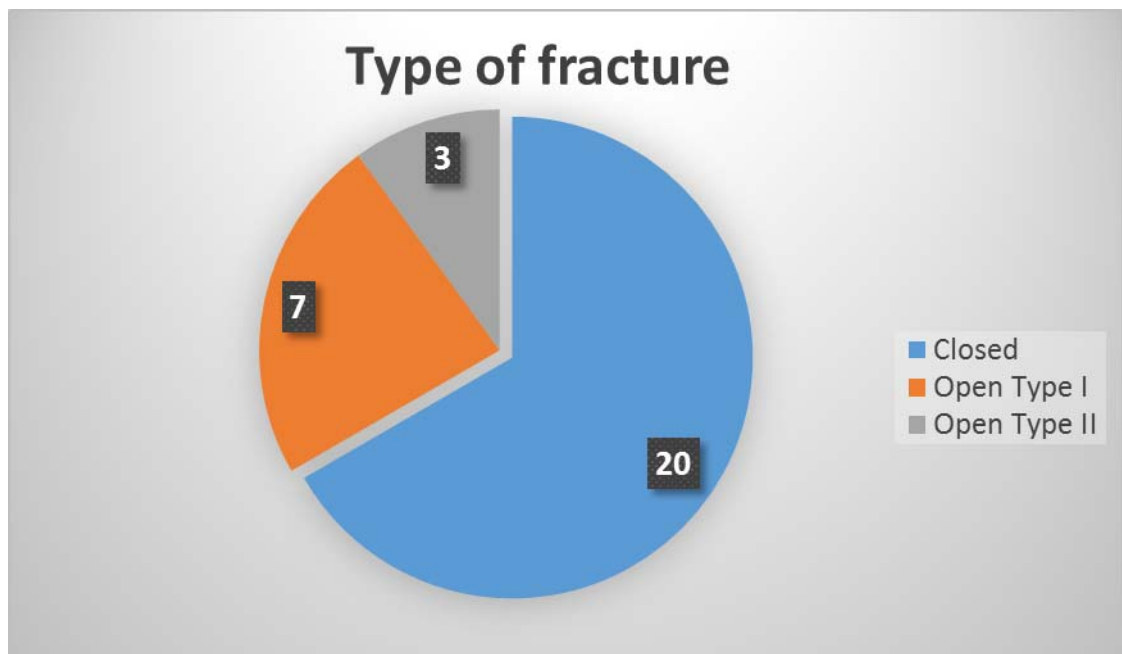
Graph 4: Side of Involvement

TYPE OF FRACTURE:

66.7% of the patients sustained closed fractures, 23.3% sustained open type I fractures and 10% of the patients sustained open type II fractures.

Table 5: Type of Fracture:

TYPE	NO OF CASES	PERCENTAGE
CLOSED	20	66.7%
OPEN TYPE I	7	23.3%
OPEN TYPE II	3	10%



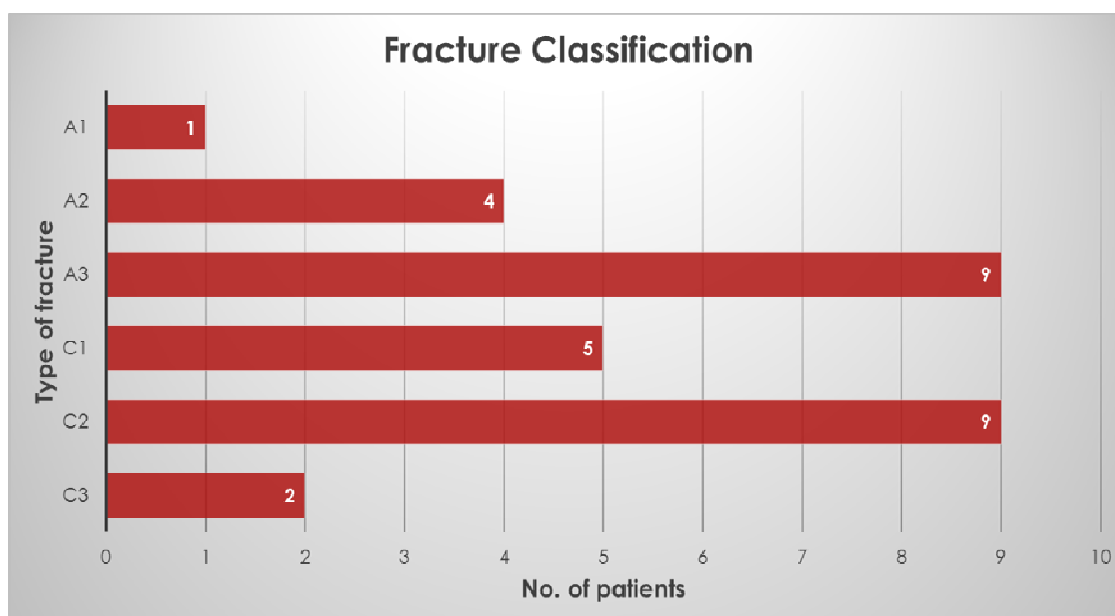
Graph 5: Type of Fracture

CLASSIFICATION OF FRACTURE:

All the fractures in this study are classified according to AO classification system. In this study, 3.3% of the patients were type A1, 13.3% type A2, 30% type A3, 16.7% type C1, 30% type C2 and 6.7% type C3.

Table 6: Classification of fracture:

AO TYPE	NO OF CASES	PERCENTAGE
Type A1	1	3.3%
Type A2	4	13.3%
Type A3	9	30%
Type C1	5	16.7%
Type C2	9	30%
Type C3	2	6.7%



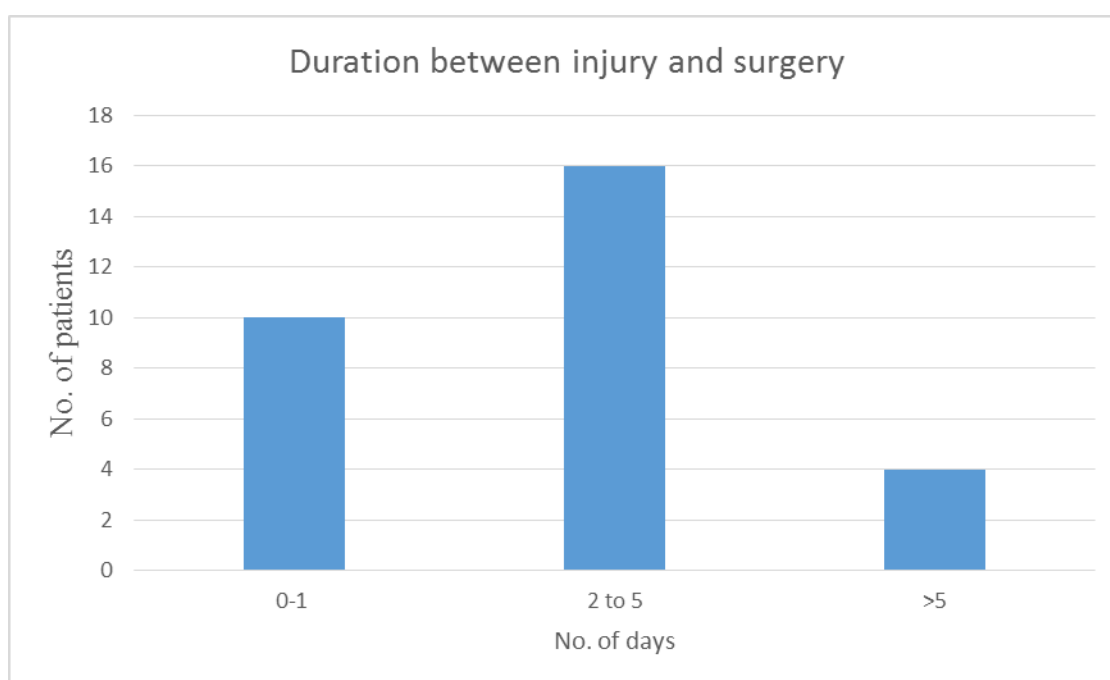
Graph 6: Classification of fracture

DURATION BETWEEN INJURY AND SURGERY:

The average duration between injury and surgery was 2.8 days. 33.3% of the cases were operated within 1 day, 53.3% of the cases were operated within 2-5 days and 13.4% of the cases were operated in more than 5 days.

Table 7: Duration between injury and surgery:

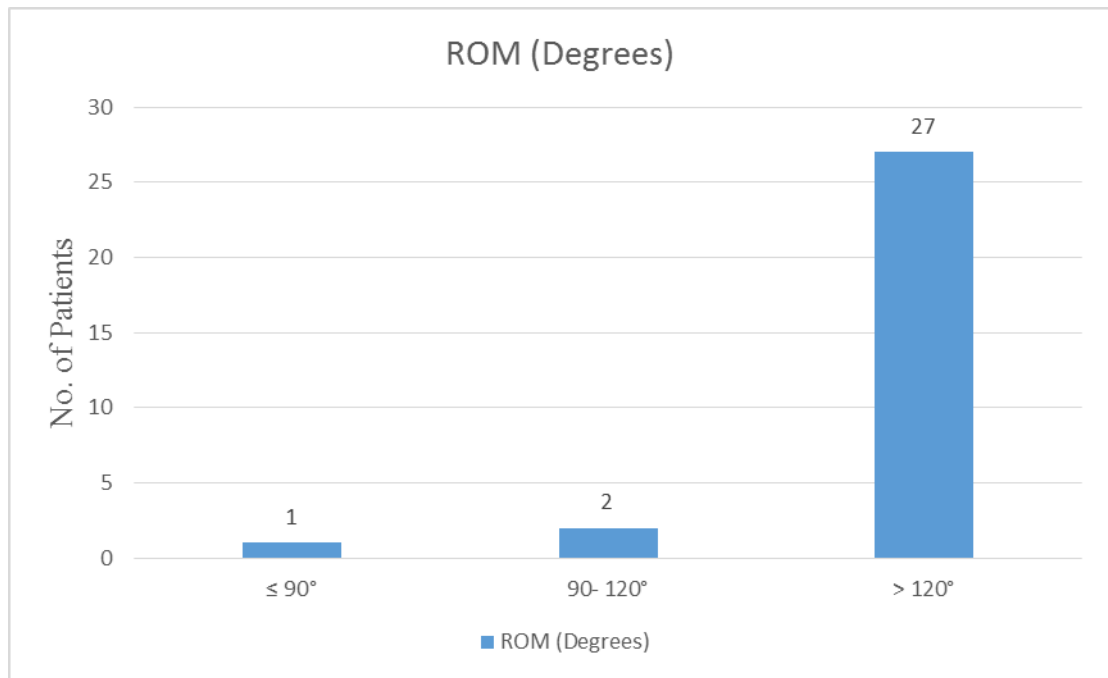
DURATION (Days)	NO OF CASES	PERCENTAGE
0-1	10	33.3%
2-5	16	53.3%
Above 5	4	13.4%



Graph 7: Duration between injury and surgery

RANGE OF MOTION:

The average range of motion was 114 degrees. Only 1 patient (3.3%) had final knee flexion of 90 degrees.



Graph 8: Range of motion (in degrees)

DURATION OF FRACTURE UNION:

Most of the proximal tibia fractures were united by 12-15 weeks ranging from 12-20 weeks with an average union time of 13.75 weeks.

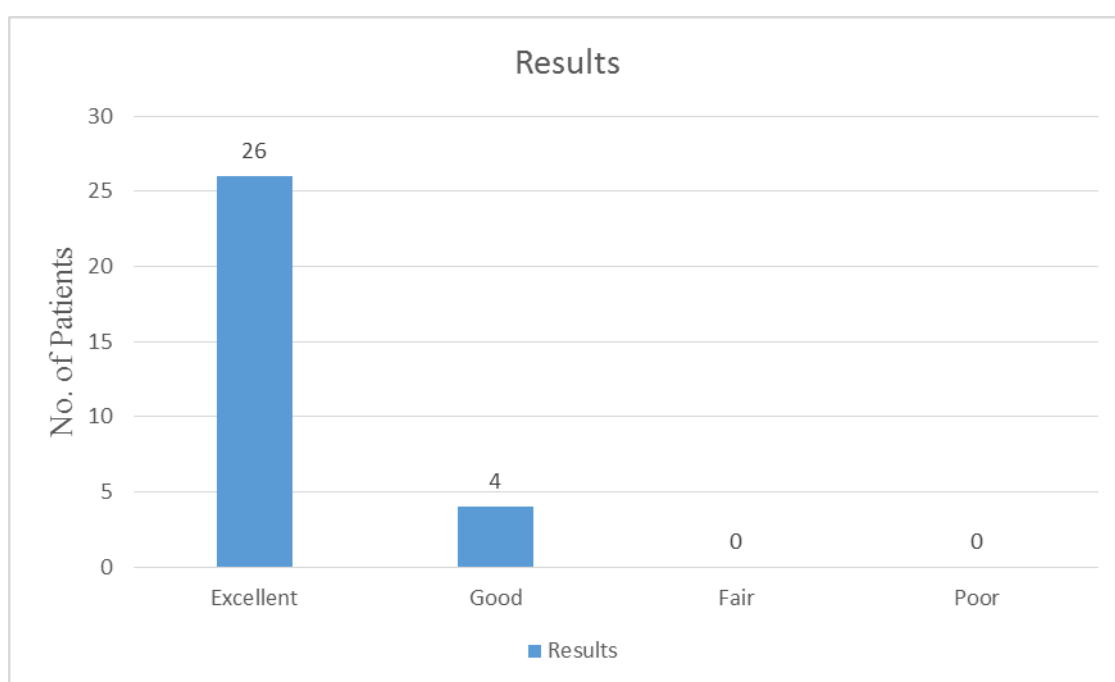
RESULTS BASED ON RASMUSSEN'S FUNCTIONAL GRADING

SYSTEM:

Results were assessed as per Rasmussen's functional grading system for functional results at the end of 6 months of follow up.

Table 8: Functional results:

RESULT	NO OF CASES	PERCENTAGE
Excellent	26	86.7%
Good	4	13.3%
Fair	0	0%
Poor	0	0%



Graph 9: Functional Results

COMPLICATIONS:

EARLY: Infection - 4 cases (13.3%)

Deep vein thrombosis – 1 case (3.3%)

LATE: Extensor lag - 4 cases (13.3%)

DISCUSSION

Proximal tibia fractures present a spectrum of soft tissue and bony injuries that can produce permanent disabilities. Their treatment is challenged by fracture comminution, instability, displacement and extensive soft tissue injuries. The goals of treatment are restoration of joint congruity, normal limb alignment, knee stability and a functional range knee motion. The major limitations of non-operative treatment include inadequate reduction of articular surface and ineffective limb alignment control. Furthermore the extended period of hospitalization and recumbence are not cost-effective in today's health care environment.

AGE DISTRIBUTION:

This study group comprises of 30 patients who were treated by internal fixation with proximal tibia locking compression plate (LCP). The majority of fractures occur between the age of 18 and 30 years (30%) with average age of 41 years. Our findings are comparable to the studies made by Porter⁵, Dendrinos et al²⁸, Lee et al³⁹, Mankar et al⁴⁵ and Patil et al⁵⁴. The table shows the average age in various series:

Table 9: Comparison of age distribution:

SERIES	AVERAGE (yrs)
Porter ⁵	47
Dendrinios et al ²⁸	39
Lee et al ³⁹	42
Mankar et al ⁴⁵	42
Patil et al ⁵⁴	43.4
Present study	41

SEX DISTRIBUTION:

This study had male preponderance with 86.7% and female patients with 13.3% which can be comparable to previous studies done by Delamarter and Hohl¹⁷, Dendrinios et al²³, Barei et al³⁶, Mankar et al⁴⁵ and Prasad et al⁴⁸.

Table 10: Comparison of sex distribution:

SERIES	MALE	FEMALE
Delamarter and Hohl ¹⁷	75.9%	24.1%
Dendrinios et al ²⁸	75%	25%
Barei et al ³⁶	62.7%	37.3%
Mankar et al ⁴⁵	78.7%	21.3%
Prasad et al ⁴⁸	82.5%	17.5%
Present study	86.7%	13.3%

MODE OF INJURY:

In our study the commonest mode of injury being road traffic accident (93.3%) followed by fall from height (6.7%). Our findings are comparable to the studies made by Dendrinios et al²⁸, Barei et al³⁶, Yin et al⁴², Kim et al⁴³ and Patil et al⁵⁴.

Table 11: Comparison of mode of injury:

SERIES	RTA	FALL FROM HEIGHT	OTHERS
Dendrinios et al ²⁸	79.2%	16.7%	4.1%
Barei et al ³⁶	51.9%	30.1%	18%
Yin et al ⁴²	59%	41%	0%
Kim et al ⁴³	80%	16.7%	3.3%
Patil et al ⁵⁴	63.4%	23.3%	13.3%
Present study	93.3%	6.7%	0%

SIDE OF INVOLVEMENT:

In our study 73.3% of the cases were of right side with involvement of left side in 26.7% cases. Our findings are comparable to the studies made by Wang et al⁴⁰ and Patil et al⁵⁴.

Table 12: Comparison of side of involvement:

SERIES	RIGHT	LEFT
Wang et al ⁴⁰	60%	40%
Patil et al ⁵⁴	63.4%	36.6%
Present study	73.3%	26.7%

CLASSIFICATION OF FRACTURE:

In this study, 30% of the fractures are of type A3 and C2 each, 16.7% of the fractures are of type C1, 13.3% are of type A2, 6.7% are of type C3 and 3.3% are of type A1.

TIME OF UNION:

In our series of proximal tibia fractures we had an average union time of 13.75 weeks with range of 12 to 20 weeks. Our findings are comparable to the studies made by Lee et al³⁹, Wang et al⁴⁰, Yin et al⁴², Ehlinger et al⁴⁴ and Prasad et al⁴⁸.

Table 13: Comparison of time of union:

SERIES	MEAN UNION TIME (WEEKS)	RANGE (WEEKS)
Lee et al ³⁹	18	12-28
Wang et al ⁴⁰	15	12-22
Yin et al ⁴²	11.9	9-16
Ehlinger et al ⁴⁴	10	6-16
Prasad et al ⁴⁸	14	8-22
Present study	13.75	12-20

COMPLICATIONS:

The rate of infection was 13.3%. Infections were treated with prolonged continuation of antibiotics and healed over time. All these patients had a final fair outcome. None of the implants had to be removed due to infection. One case developed deep vein thrombosis (3.3%) which was treated conservatively. Four cases

had extensor lag of 10⁰-15⁰ (13.3%) at the final follow-up. Our findings are comparable to the studies made by Barei et al³⁶, Lee et al³⁹, Yin et al⁴² and Patil et al⁵⁴.

Table 14: Comparison of complications:

SERIES	INFECTION	DVT	OTHERS
Barei et al ³⁶	12%	20%	0%
Lee et al ³⁹	8%	0%	4%
Yin et al ⁴²	12.9%	0%	0%
Patil et al ⁵⁴	7%	0%	17%
Present study	13.3%	3.3%	13.3%

FUNCTIONAL RESULTS:

The results of functional evaluation showed 86.7% excellent results and 13.3% good results. Rambold³ in 1960 reported that internal fixation of tibial plateau fractures and early mobilization contributes to good anatomical and functional results. Dennis Jensen²⁰ in 1990 got good results by surgical treatment of proximal tibia fractures. Chaix et al²⁶ reported 86% good to excellent results by surgical means of treatment. Lee et al³⁹ reported good to excellent results by surgical means of less invasive stabilization system treatment. Feng et al⁴¹ reported good results when fixed with LCP in comparison with dynamic compression plate (DCP) with an additional benefit of minimally invasive surgery. Kim et al⁴³ reported good results with MIPPO technique in treatment of open proximal tibial fractures with adequate soft tissue coverage.

The period of immobilization was again individualized depending on the security of rigid fixation and other circumstances demand. The benefits of early knee

motion include - reduce knee stiffness and improved cartilage healing (regeneration). However, these benefits are to be cautiously balanced by risks, including loss of fracture reduction, failure of internal fixation and compromised ligament and soft tissue healing. Several studies stated that the prognosis is given by the degree of displacement, type of fracture, method of treatment and quality of postoperative care.

CONCLUSIONS

At the end of our study, following conclusions were drawn from the surgical management of proximal tibial fractures.

- Road traffic accidents or high velocity injuries are the most common cause of these fractures (93.3%). These high velocity injuries are associated with more severe or comminuted fracture patterns.
- Most of these injuries occur in younger and active age groups (53.3% in 18-40 years age groups).
- These fractures have a predominance of male sex (86.7%) and right side (73.3%).
- The main aim of surgical treatment includes precise reconstruction of the articular surface with elevation of the depressed bone fragment in case of intraarticular fracture, bone grafting in case of bone loss and stable fragment fixation allowing early range of movement.
- Preoperative soft tissue status and their repair at right time, significantly changes the outcome.
- All fracture united well in time (before 6 months). No non-union.
- Infection plays a vital role in influencing the result of the surgical outcome.
- Period of joint immobilization plays a major role in the end result.
- ORIF with LCP seems to be good implant choice in proximal tibia fractures including difficult fracture situations.

SUMMARY

This is a study of surgical management of proximal tibial fractures treated with locking compression plates involving 30 patients operated over a period of 24 months. Patients were followed up for a minimum period of 6 months. Functional evaluation of the knee was done, based on the Rasmussen's functional grading system. In our study:

1. The age of the patients ranged from 21 to 60 years.
2. 26 were men and 4 were women.
3. The mechanism of injury was motor vehicle accident in 28 cases and history of fall from height in 2 patients.
4. The right side was injured in 22 cases and the left side in 8 cases.
5. According to the AO classification, 1 fracture was type A1 (3.3%), 4 were type A2 (13.3%), 9 were type A3 (30%), 5 were type C1 (16.7%), 9 were type C2 (30%) and 2 were type C3 (6.7%).
6. 23 patients with high velocity type injuries had additional fractures.
7. Duration of follow-up was 6 months.
8. Excellent results were obtained in 86.7% of the cases and good results in 13.3% of the cases.
9. 4 patients had infection (13.3%) which healed with appropriate antibiotics, 1 patient had deep vein thrombosis (3.3%) which was treated conservatively and 4 patients had extensor lag of 10⁰-15⁰ (13.3%) at the end of final follow up.

BIBLIOGRAPHY

1. A treatise on dislocations and on fracture of the joints, Sir Astley Cooper, 1825.
2. Palmer I. Fractures of the upper end of the tibia. JBJS 1957; 33: 160.
3. Rambold C. Depressed fractures of the tibial plateau. JBJS 1960; 42A: 783-797.
4. Kennedy JC, Baitey WH. Experimental tibial plateau fractures: studies of the mechanism and the classification. JBJS Am 1968; 50: 1522.
5. Porter BB. Crush Fractures of the lateral tibial table. Factors influencing the prognosis. JBJS 1970; 52 B: 676-687.
6. Hohl M, Hopp E. Ligament injuries in tibial condylar fractures. JBJS 1976; 58a: 279.
7. Brown GA, Sprague BL. Cast brace treatment of plateau and condylar fractures of the proximal tibia. ClinOrthop 1976; 119: 184-193.
8. James P. Stannard, Proximal Tibia Fractures: Locked plating, Master techniques in orthopaedic surgery: fractures, 2nd edition, Lippincott Williams & Wilkins.
9. Muller ME, Ailgower M, Schneider, Rand Unlilnegger. H manual of Internal Fixation. New York, Springer-vexlag, 1979.
10. Daniel D, Rice T. Valgus-varus stability in the hinged cast use for controlled mobilization of the knee. JBJS 1979; 61A: 135-136.
11. Gossling HR, Peterson CA. A new surgical approach in the treatment of depressed lateral condylar fractures of the tibia. ClinOrthop 1979; 140: 96-102.
12. Salter RB, Simmons DF, Malcolm BW. The biological effects of continuous passive motion on the healing of full thickness defects in articular cartilage; an experimental investigation in the rabbit. JBJS Am 1980; 62: 1232-1251.
13. Moore TM. Fracture dislocation of the knee. ClinOrthop. 1981; 156: 128.
14. Wirth CR. Menicus repair. ClinOrthop 1981; 157: 153.

15. Gausewitz S, Hohl M. The significance of early motion in the treatment of tibial plateau fractures. ClinOrthop 1986; 202: 135-138.
16. Dias JJ, Strung AM, Finaly DB. Computerized Axial Tomography for tibial plateau fractures. J Bone Joint Surg 1987; 69(b): 84-88.
17. Delamarter R, Hohl M. The cast brace and tibial plateau fractures. ClinOrthop 1989; 242: 26-31.
18. Grahan B, Loomer RL. Anterior compartment syndrome in a patient with fracture of the tibial plateau, treated by continuous passive motion and anticoagulants. ClinOrthop 1989; 195: 197-199.
19. Muller ME, Nazarian S, Koch P. The comprehensive classification of fracture of long bones; New York, Spreinger: 1990.
20. Dennis Jensen. Tibial plateau fractures. JBJS (Br) 1990; 72-b: 49-52.
21. Stokel EA, Sadasivan KK. Tibial plateau fractures: standardized evaluation of operative results. Orthopaedics 1991; 14: 263-270.
22. Duparac, Ficat. Volume 2; Fracture of the tibial plateau in Insall: Surgery of the knee: Second edition, New York, Churchill Livingstone, 1993; 1047.
23. Marwah., vol2; Fracture of the tibial plateau in Insall: surgery of the knee, second edition, New York, Churchill Living stone, 1993; 1073.
24. Schatzker J. Tibial Plateau fractures. In Browner, Jupiter, Levine and Trafton skeletal trauma. Philadelphia, WB Saunders 1993; 1745.
25. Blake RB, Morandi M, Watson JT. Treatment of complex tibial plateau fractures with circular external fixators. J Orthop Trauma 1993; 17: 167-168.
26. Chaix. Fractures of the tibial plateau, Insall JN, Winsdor RE, Scottw. Surgery of the knee, 2nd Ed, New York, Churchill Livingstone, 1993; 1038.

27. Vangsness CT, Ghaderi B, Hohl M, Moore T.M. Arthroscopic evaluation of meniscal injuries with tibial plateau fractures. *J Bone Joint Surg* 1994; 76B: 488-490.
28. Dendrinis GK, Kontos S, Katsenis D, Dalas K. Treatment of high-energy tibial plateau fracture by the Ilizarov circular external tibial plateau fixator. *JBJS* 1996; 78(B): 710-717.
29. Duwelius PJ, Rangitsh MR. Treatment of tibial plateau fractures by limited internal fixation. *ClinOrthop* 1997; 339: 47-57.
30. Mikulak SA, Gold SM. Small wire external fixation of high-energy tibial plateau fractures. *ClinOrthop* 1998; 356: 230-238.
31. Bal G, Kuo RS, Chapman JR. The anterior T-frame external fixator for high energy proximal tibial fractures. *ClinOrthop* 2000; 380: 234-240.
32. Sirkin MS, Bono CM, Reilly MC. Percutaneous methods of tibial plateau fixation. *ClinOrthop* 2000; 375: 60-66.
33. Mills WJ, Nork SE. Open reduction and internal fixation of high-energy tibial plateau fractures. *OrthopClin North Am.* 2002; 33: 177.
34. Erik N. Kubiak, Eric Fulkerson, Eric Strauss and Kenneth A. Egol, The evolution of locked plates, *J. Bone joint Surg Am.* 2006; 88: 189-200.
35. Kenneth A. Egol and Kenneth J Koval, In: *Fractures of proximal tibia: chapter 50*, Rockwood and Green's "Fractures in Adults", Vol. 2, 6th edition, Lippincott Williams and Wilkins 2006.
36. Barei DP, Nork SE, Mills WJ, Coles CP, Henley MB, Benirschke SK. Functional Outcomes of Severe Bicondylar Tibial Plateau Fractures Treated with Dual Incisions and Medial and Lateral Plates. *JBJS* 2006; 88(A): 1713-1721.

37. McKee MD, Pirani SP. Open Reduction and Internal Fixation Compared with Circular Fixator Application for Bicondylar Tibial Plateau Fractures. *JBJS* 2006; 88(A): 2613-2623.
38. Wade R. Smith, Bruce H. Ziran, Jeff O. Anglen and Philip F. Stahel, Locking plates: Tips and Tricks, *J. Bone Joint Surg Am.* 2007; 89: 2298-307.
39. Lee JA, Papadakis SA, Moon C, Zalavras CG. Tibial plateau fractures treated with the less invasive stabilisation system. *Int Orthop* 2007; 31: 415-418.
40. Wang SQ, Gao YS, Wang JQ, Zhang CQ, Mei J, Rao ZT. Surgical approach for high-energy posterior tibial plateau fractures. *Indian J Orthop* 2011; 45: 2.
41. Feng W, Fu L, Liu J, Qi X, Li D, Yang C. Biomechanical evaluation of various fixation methods for proximal extra-articular tibial fractures. *J Surg Res* 2012; 178: 722-727.
42. Yin B, Chen W, Zhang Q, Wang J, Su Y, Xu G, Zhang Y. Tibial fracture treated by Minimally invasive plating using a novel low-cost, high technique system. *Int Orthop* 2012; 36: 1687-1693.
43. Kim JW, Oh CW, Jung WJ, Kim JS. Minimally invasive plate osteosynthesis for open fractures of the proximal tibia. *Clin Orthop Surg* 2012; 4: 313-320.
44. Ehlinger M, Rahme M, Moor BK, Marco AD, Brinkert D, Adam P, Bonnomet F. Reliability of locked plating in tibial plateau fractures with a medial component. *Orthop Traumatol Surg Res* 2012; 98: 173-179.
45. Mankar SH, Golhar AV, Shukla M, Badwaik PS, Faizan M, Kalkotwar S. Outcome of complex tibial plateau fractures treated with external fixator. *Indian J Orthop* 2012; 46: 570-574.

46. Taheri E, Sepehri B, Ganji R, Nasirai C. Effect of Screws Placement on Locking Compression Plate for Fixating Medial Transverse Fracture of Tibia. *Biomed Eng Res* 2012; 1: 13-18.
47. Moore TM. Volume 3: Fractures of lower extremity in Campbell operative orthopedics: twelfth edition; Mosby 2013; 2669.
48. 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 J Orthop* 2013; 47: 188-94.
49. Moore TM. Volume 3: Fractures of lower extremity in Campbell operative orthopedics: twelfth edition; Mosby 2013; 2670.
50. Guohui Z. Application of Minimally Invasive Treatment of Locking Compression Plate in Schatzker I ~ III Tibial Plateau Fracture. *J Int Trans Med* 2014; 2(2): 331-335.
51. Ferreira N, Marais L.C. Bicondylar tibial plateau fractures treated with fine-wire circular external fixation. *Strat Traum Limb Recon* 2014; 9: 25-32.
52. Tahririan M.A, Mousavitadi S.H, Derakhshan M. Comparison of Functional Outcomes of Tibial Plateau Fractures Treated with Nonlocking and Locking Plate Fixations: A Nonrandomized Clinical Trial. *ISRN Orthopedics*; 2014: 1-6.
53. Kojima K, Gueorguiev B, Seva G, Stoffel K, et al. Biomechanical Evaluation of Interfragmentary Compression At Tibia Plateau Fractures In Vitro Using Different Fixation Techniques. *Med* 2015; 94: 1.
54. 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 J Sports Med* 2015; 15: 142-147.

ANNEXURE – I

PROFORMA

Name	HP No.
Age	D.O.A
Sex	D.O.S
Occupation	D.O.D
Address	

History:

1. Road traffic accident
2. Fall from height
3. Sports related injury
4. Others

Time and date of injury:

Past history:

Examination:

General physical examination:

Pallor

Pulse

Blood pressure

Respiratory rate

Glasgow Coma Scale

Others

Systemic examination:

Cardiovascular system:

Respiratory system:

Per abdomen:

Central nervous system:

Local examination:

1. Inspection:

☐ Side:

☐ Type of fracture: Closed

Open type I

Open type II

Open type IIIA

☐ Description of wound if any:

- Attitude:

- Swelling:

- Deformity:

- Shortening:

2. Palpation:

- Tenderness
- Abnormal mobility
- Crepitus
- Limb length discrepancy
- Peripheral neurovascular examination.

3. Haemarthrosis:

4. Associated injuries:

Investigations:

Haemogram:

Blood grouping and typing:

ESR:

BT:

CT:

RBS:

Blood urea:

Serum creatinine:

Sodium:

Potassium:

HIV:

HbsAg:

Urine R/E:

Imaging:

X-ray findings



Bicondylar/ Intercondylar

Intraarticular/ Extraarticular

Uncomminuted/ Comminuted

Undisplaced/ Displaced

Fibula - Intact/ Fractured.

Type of fracture:

(Based on AO classification)

Treatment given:

Surgical

Time of surgery – Immediate / Delayed

Anesthesia - Spinal / General

Post-Operative check X-ray

Post-Operative mobilization

Post-Operative complications

Time of partial weight bearing

Time of full weight bearing

Condition on discharge:

Wound status

Range of movement

Follow up:

At Six weeks.

Clinical assessment:

- i. Pain: Absent/ Present
- ii. Wound: Absent/ Present
- iii. Swelling: Absent/ Present
- iv. Tenderness: Absent/ Present
- v. Effusion: Absent/ Present
- vi. Deformities
- vii. Movements:
 - Flexion
 - Extension
 - Extensor lag
- viii. Shortening
- ix. Muscle wasting
- x. Knee joint stability test
- xi. Walking capacity
- xii. X-ray findings

Similar follow up at 3 months:

Similar follow up at 6 months:

☐ Criteria for evaluation of results (Rasmussen's Functional Grading System):

1. Pain:

- ☐ No pain – 6

- ☐ Occasional pain – 5
- ☐ Stabbing pain in certain position, Moderate pain – 4
- ☐ Severe pain, Constant pain around knee joint after activity – 2
- ☐ Night pain, at rest - 0

2. Walking capacity:

- ☐ Normal walking capacity in relation to age – 6
- ☐ Walking capacity outdoors for atleast one hour – 4
- ☐ Walking capacity outdoors > 15 minutes – 2
- ☐ Walking capacity -walking indoors only – 1
- ☐ Wheel chair bound/bed ridden - 0

3. Extension of leg (Extensor lag):

- ☐ Normal extension – 6
- ☐ Lack of extension ($0-10^0$) – 4
- ☐ Lack of extension ($> 10^0$) – 2

4. Range of motion:

- ☐ At least 135^0 – 6
- ☐ At least 120^0 – 5
- ☐ At least 90^0 – 4
- ☐ At least 60^0 – 2
- ☐ At least 30^0 – 1
- ☐ 0^0 – 0

5. Stability:

- ☐ Normal in extension & 20^0 flexion – 6
- ☐ Abnormal in 20^0 flexion – 5
- ☐ Instability in extension ($<10^0$) – 4

☐ Instability in extension ($>10^0$) – 2

☐ At the end of 6 months:

Points

1. Pain
2. Walking capacity
3. Extension of leg
4. Range of motion
5. Stability

Total score: _____

- ☐ Excellent results – Total minimum of 27 points.
- ☐ Good results – Total minimum of 20 points.
- ☐ Fair results – Total minimum of 10 points.
- ☐ Poor results – Total minimum of 06 points.

ANNEXURE – II

CONSENT FORM FOR ANAESTHESIA/SURGERY

I, _____ Son/Daughter/Wife of _____, in my full senses hereby give my whole-hearted consent for surgery which to be performed on me/ my son/ my daughter/ my wife named _____, aged _____ under any type of anesthesia deemed fit for the procedure. The nature of the surgery and the risk involved in the procedure has been explained to me in my own understandable vernacular language to my satisfaction. I understand that for academic and scientific purpose, the procedure may be photographed or video recorded, or used for statistical measurements and I give my consent for the above.

Date:

Signature

Thumb Impression of the Patient

Guardian

Name:

Designation:

Guardian

Relationship

Full Address

KEY TO MASTER CHART

M	-	Male
F	-	Female
RTA	-	Road traffic accident
Fall (L)	-	Fall at level surface
Fall (H)	-	Fall from height
EL	-	Extension lag
ROM	-	Range of motion
OP	-	Out patient
IP	-	In patient
AO	-	Arbeitsgemeinschaft fur osteosynthesefragen Association for Osteosynthesis
DVT	-	Deep vein thrombosis
Wt	-	Weight

ANNEXURE III

MASTER CHART

S.no	Name	OP/IP No	Age	Sex	Side	Mode of injury	Duration of injury	Diagnosis	Complications	Follow-up knee ROM (degrees)			Ambulation/wt. bearing			Outcome
										6 WEEKS	3 MONTHS	6 MONTHS	6 WEEKS	3 MONTHS	6 MONTHS	
1)	VISHWANATHA	960113	23	M	RIGHT	RTA	4 DAYS	CLOSED AO TYPE C 1		10-105	120	135	Partial wt	Full wt	Full wt	Excellent
2)	SHANKAR	962710	35	M	LEFT	RTA	0 DAYS	OPEN TYPE II AO TYPE C 2	Infection	10-45	10-70	10-90	Non wt	Partial wt	Full wt	Good
3)	YERRAPPA	965025	40	M	LEFT	RTA	2 DAYS	OPEN TYPE I AO TYPE C 3	Infection	135	135	135	Partial wt	Full wt	Full wt	Excellent
4)	MUNIVENKATAPP	970817	55	M	LEFT	RTA	2 DAYS	OPEN TYPE I AO TYPE A 3		135	135	135	Partial wt	Full wt	Full wt	Excellent
5)	ANAND KUMAR	980017	30	M	RIGHT	RTA	2 DAYS	OPEN TYPE I AO TYPE C 2		135	135	135	Non wt	Partial wt	Full wt	Excellent
6)	GANESH	982406	24	M	LEFT	RTA	8 DAYS	CLOSED AO TYPE C 1		10-110	120	130	Non wt	Partial wt	Full wt	Excellent
7)	SHIVAPPA	985312	40	M	RIGHT	Fall	0 DAYS	OPEN TYPE I AO TYPE C 2	Infection	15-120	15-135	15-135	Non wt	Partial wt	Full wt	Good
8)	SHIVANNA	985428	40	M	RIGHT	RTA	5 DAYS	OPEN TYPE I AO TYPE C 2		15-90	120	135	Non wt	Partial wt	Full wt	Excellent
9)	MANJUNATH	991214	32	M	RIGHT	RTA	2 DAYS	CLOSED AO TYPE C 2		10-70	10-100	10-120	Non wt	Partial wt	Full wt	Good
10)	IBRAHIM	992752	60	M	RIGHT	RTA	8 DAYS	CLOSED AO TYPE A 2		135	135	135	Non wt	Partial wt	Full wt	Excellent
11)	DEEPA	994049	27	F	RIGHT	RTA	4 DAYS	CLOSED AO TYPE C 2		10-100	130	135	Non wt	Partial wt	Full wt	Excellent
12)	VENKATESHAPPA	993709	40	M	RIGHT	RTA	4 DAYS	CLOSED AO TYPE A 2		10-100	125	135	Non wt	Partial wt	Full wt	Excellent
13)	MANGAMMA	996344	60	F	RIGHT	RTA	1 DAY	CLOSED AO TYPE C 2	Infection	10-100	130	135	Non wt	Partial wt	Full wt	Excellent
14)	NAGAPPA	1006915	50	M	RIGHT	RTA	2 DAYS	CLOSED AO TYPE A 3		120	130	135	Non wt	Partial wt	Full wt	Excellent
15)	MANJUNATH	1008990	25	M	RIGHT	RTA	3 DAYS	CLOSED AO TYPE A 3		125	135	135	Partial wt	Full wt	Full wt	Excellent
16)	MANJUNATH RED	1262	29	M	RIGHT	RTA	0 DAYS	CLOSED AO TYPE A 3	DVT	15-75	110	125	Partial wt	Partial wt	Full wt	Excellent
17)	RAMA REDDY	2027	49	M	LEFT	RTA	0 DAYS	OPEN TYPE II AO TYPE C 2		10-100	120	135	Non wt	Non wt	Partial wt	Excellent
18)	VIJAY KUMAR B.S	1945	47	M	LEFT	Fall	1 DAY	CLOSED AO TYPE A 3		135	135	135	Non wt	Partial wt	Full wt	Excellent
19)	LAKSHMAMMA	5955	55	F	RIGHT	RTA	2 DAYS	CLOSED AO TYPE A 2		125	135	135	Non wt	Partial wt	Full wt	Excellent
20)	VASUDEVA RAO	29078	42	M	RIGHT	RTA	1 DAY	CLOSED AO TYPE C 3		10-110	130	135	Non wt	Partial wt	Full wt	Excellent
21)	ANJINAPPA	38770	50	M	RIGHT	RTA	3 DAYS	OPEN TYPE II AO TYPE A2		135	135	135	Non wt	Partial wt	Full wt	Excellent
22)	SUBBAMMA	38883	59	F	RIGHT	RTA	11 DAYS	CLOSED AO TYPE C2		15-45	10-100	10-120	Non wt	Partial wt	Full wt	Good
23)	MANJUNATHA.B.	41361	21	M	RIGHT	RTA	1 DAY	CLOSED AO TYPE A3		135	135	135	Non wt	Partial wt	Full wt	Excellent
24)	VISHWANATH.K	50578	55	M	RIGHT	RTA	1 DAY	CLOSED AO TYPE C1		15-90	10-110	130	Non wt	Partial wt	Full wt	Excellent
25)	CHALAPATHI	53868	60	M	RIGHT	RTA	3 DAYS	CLOSED AO TYPE C1		10-100	10-120	135	Non wt	Partial wt	Full wt	Excellent
26)	DEVA	92707	26	M	LEFT	RTA	3 DAYS	CLOSED AO TYPE C2		10-130	135	135	Non wt	Partial wt	Full wt	Excellent
27)	MAHESH	107169	21	M	RIGHT	RTA	0 DAYS	OPEN TYPE I AO TYPE A3		135	135	135	Non wt	Partial wt	Full wt	Excellent
28)	NARAYANASWAM	93609	50	M	RIGHT	RTA	6 DAYS	CLOSED AO TYPE C1		135	135	135	Non wt	Partial wt	Full wt	Excellent
29)	MURALI	148660	35	M	RIGHT	RTA	2 DAYS	CLOSED AO TYPE A3		130	135	135	Non wt	Partial wt	Full wt	Excellent
30)	SHAME GOWDA	155164	50	M	LEFT	RTA	2 DAYS	CLOSED AO TYPE A1		10-125	135	135	Non wt	Partial wt	Full wt	Excellent