"A STUDY OF SURGICAL MANAGEMENT OF TIBIAL PLATEAU FRACTURES USING BUTTRESS PLATING"

By

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DISSERTATION SUBMITTED TO THE
SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH,
TAMAKA, KOLAR ,KARNATAKA.

IN PARTIAL FULFILLMENT

OF THE REQUIREMENT FOR THE DEGREE OF

MASTER OF SURGERY

IN

ORTHOPAEDICS

UNDER THE GUIDANCE OF
Prof. Dr.B.SHAIKH NAZEER, M.S.(Orthopaedics)

DEPARTMENT OF ORTHOPAEDICS
SRI DEVARAJ URS MEDICAL COLLEGE
TAMAKA, KOLAR .
2011

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ACKNOWLEDGEMENT

*I thank the **LORD ALMIGHTY** for showering his blessings on me.*

It is indeed a great pleasure to recall the people who have helped me in completion of this dissertation. Naming all the people who have helped me in achieving this goal would be impossible, yet I attempt to thank a select few, who have helped me in diverse ways.

I express my deep sense of gratitude and indebtedness to my teacher and guide **Dr.B.SHAIKH NAZEER, M.S.(Orthopaedics)** *Professor, Department of Orthopaedics, Sri Devaraj Urs Medical College, Tamaka, Kolar for his valuable suggestions, guidance, great care and attention to the detail that he has so willingly shown in the preparation of this dissertation.I am blessed and privileged to be taught by such an eminent teacher.*

*I am grateful and my most sincere thanks to **Prof. Dr. N.S.GUDI,** M.S(orthopaedics), Professor & HOD , Department of Orthopedics , Sri Devaraj Urs Medical College, Tamaka, Kolar for his constant encouragement and kind help and kindly advices and available suggestions support throughout .*

*I thank **Prof. Dr.P.V. Manohar** ,M.S.(orthopaedics), professor, Department of Orthopeadics , for his kindly advice and support during the preparation of this study .*

*I am thankful to **Dr.Arun**, professors, Department of Orthopeadics, for the kind of guidance given to make this study possible.*

*I am thankful to **Dr.Venkatesh reddy,** Associate professor for his valuable support and constant encouragement during this study.*

*My sincere thanks to all my **POST – GRADUATE COLLEAGUES and especially Dr.Nandeesh.S and Dr.Manesh Kumar.CH** for their whole hearted support.*

*My deep felt gratitude to **MY DEAR PARENTS** and **MY BROTHER** without whom I would not be the person I am today. They have given me constant support, wise advise and let me fulfill all my desires. Their prayers and sacrifices have done wonders for me.*

*Finally, I thank **ALL MY PATIENTS** who formed the backbone of this study without whom this study would not have been possible.*

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LIST OF ABBREVATIONS USED

A	Artery
ACL	Anterior cruciate ligament
AO	Arbeitsgemeinschaft fur osteosynthesefragen
AP	Anteroposterior
ASIF	Association of surgeons for internal fixation
BP	Blood pressure
CPM	Continue passive motion
CRIF	Closed reduction and internal fixation
DCP	Dynamic compression plate
Lab	Laboratory
Lat	Lateral
LCP	Locking compression plate
MIPPO	Minimal invasive percutaneous plate osteosynthesis
MRI	Magnetic resonance imaging
N	Nerve
NBM	Nil by mouth
OA	Osteoarthritis
ORIF	Open reduction and internal fixation
PCL	Posterior cruciate ligament
POP	Plaster of paris
RTA	Road traffic accidents
TKR	Total knee replacement
TPR	Temperature, pulse rate, respiratory rate
UMEX	Universal mini external fixator

ABSTRACT

Background and objectives:

Tibial plateau fractures are one of the most common intra-articular fractures that results from indirect coronal or direct axial compressive forces. Advance in mechanization and the acceleration of travel have been associated with increase in the number and severity of fractures. Fractures of the upper part of tibia are no exception to this. Fractures of the upper tibia are difficult to treat, apart from the usual problems of confining patients to bed. Conservative treatment at any age, may be complicated by knee stiffness and malunion. This study is done to analyze the surgical management of tibial plateau fractures using buttress plating.

Methods:

This is a prospective study of 20 cases of fresh tibial plateau fractures admitted to R.L.Jalappa hospital attached to Sri Devraj Urs Medical College, Kolar, between October 2009 to October 2011. Cases were taken according to inclusion and exclusion criteria i.e., patients with tibial plateau fractures above the age of 18yrs, closed and open type I, II and IIIA fractures were included. Open type IIIB, IIIC and pathological fractures were excluded from the study.

Results:

The study shows male predominance with maximum presentation between 31 to 40yrs. Mode of injury was more due to RTA, 19(95%). The laterality of fractures was equal. 25% of patients had associated injury. Schatzker type IV fractures were maximum with 7 cases followed by type II and VI, 5 cases each. Post operative results were found to be excellent in 9(45%), Good in 9(45%), Fair in 1(5%) and Poor in 1(5%).

Conclusion and Interpretation:

This study shows that tibial plateau fractures are common in people with high level of activity, who indulge themselves in travelling. Majority of them are due to RTA, with male preponderance mainly occurring between 31 to 50yrs. The surgical management of tibial plateau fractures is challenging and gives excellent anatomical reduction and rigid fixation to restore articular congruity, facilitate early knee motion by reducing post-traumatic osteoarthritis and thus achieving optimal knee function.

KEY WORDS:

Buttress plate; Tibial plateau fractures/Surgey; Fracture Fixation

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INTRODUCTION

Tibial plateau fractures are one of the commonest intra-articular fractures. It results from indirect coronal or direct axial compressive forces. It comprises of 1% of all fractures. These fractures encompass many and varied fracture configurations that involve medial, lateral or both plateaus with many degrees of articular depressions and displacements. Each fracture type has its own characteristic morphology and response to the treatment. It is essential to determine the force of injury since high-energy trauma is associated with considerable soft tissue and neurovascular damage. Apart from tibial plateau bony injury, meniscal tear and ligament injuries should also be assessed[1].

Advance in mechanization and the acceleration of travel have been associated with increase in the number and severity of fractures. Fractures of the upper part of the tibia are no exception to this.

High velocity injury sustained in automobile disasters and increase in road traffic accidents as a whole is creating an ever- growing problem. Since man has taken to travelling at high speeds in the sitting position with the loading edge composed of flexed hind limbs, when the machine or in which the subject is travelling stops suddenly, most of the impact is taken at first upon the patella, then the tibia and femur in varying proportions and at various positions.

The stationary lower limb may be struck by a moving object, this is the common pedestrian injury, the so called "BUMPER FRACTURE", since the bumper of most vehicles being placed roughly at knee height. The exposed knee joint may be subjected to angulation, rotation or shearing strains and when the subject is upright, his body weight assists in the injury and he falls over.

The twentieth century has seen a lot of changes in medical field, especially in orthopaedic trauma. A better understanding of biomechanics, quality of implants, principles of internal fixation, soft tissue care, antibiotics and asepsis have all contributed to the radical change. Thus we have advanced from the conservative approach to internal fixation in fractures as an acceptable mode of treatment.

Fractures of the upper tibia are difficult to treat, apart from the usual problems of confining patients to bed. Conservative treatment at any age, may be complicated by knee stiffness, malunion and nonunion. Open reduction and internal fixation has been advocated using various implants including Buttress plates, cancellous screws, external fixators etc., to achieve good fracture union and optimal knee function.

OBJECTIVES

1. To restore articular congruity and limb alignment.
2. To hasten early knee motion and ambulation of the patient.

REVIEW OF LITERATURE

HISTORICAL REVIEW

The lack of information about fractures of the proximal articular surfaces of the tibia leads to confusion and an inability to agree on a universally acceptable name for these injuries. A workable classification based on clearly defined clinical, radiological entities to separate plateau fractures dislocation on one hand and knee dislocations on other was made[6].

Apley G[8] showed good results of union, satisfactory knee motion in lateral condyle fractures treated with skeletal traction and early mobilization.

In 1963 buttress plates were developed by the AO group. The Swiss ASIF group deserves great credit for developing exposure, techniques of reduction, internal fixation devices and postoperative management regimes.

Robert JM[13] in 1968 reported 100 cases of tibial condyle fractures treated by conservative and surgical. The results were good in 72% conservative, 80% tractions-mobilization and 81% surgical. He advocated early mobilization, preservation for menisci and repair of torn ligaments for best results.

Porter BB[14] in 1970, reviewed 68 cases, both non-surgical and surgical methods observed excellent-good results in 96% of cases by conservative methods with depression < 10mm, 47% in depression > 10 mm and 80% in surgical methods. He advocated good anatomical reduction for best results.

Rasmussen PS.,et al[15] in 1973, in a study of 260 tibial plateau fractures of all types treated by conservative and surgical methods followed up for an average period of 7.3 years they had acceptable results in 95% by closed methods and 80% by open methods. Concluded that instability in extension of more than 10 degrees as the main

indication for surgical treatment, and also found total lack of correlation between anatomic and functional results. Overall incidence of osteoarthritis was 17 to 21%.

George A, Brown and Sprague[9] in 1976 studied that the fracture of tibial plateau and proximal tibia which extends into the knee joint can produce major disability. At University of Lowa authors began treating tibial plateau and bicondylar proximal tibial fractures with early application of a cast brace. They encouraged early motion, weight bearing to tolerance and unrestricted activities using crutches or other supports only when necessary lead to improved knee function.

Schatzkar J, Mc Broom R and Bruce D[16] in 1979, reported 70 cases of tibial plateau fractures of all types treated by conservative (56%) and surgical (44%) with average follow-up of 28 months. Acceptable results were obtained in 58% of cases of conservative group and 78% by open methods. Fractures treated by ORIF with buttress plate and Bone grafting achieved 88% acceptable results.

Apley GA[17] in 1979, in a study of 60 cases it was reported that conservative treatment of tibial plateau fractures by traction- mobilization method for a period of more than 5 years, showed 80% excellent to good results which did not deteriorate with time and also degenerative changes seen on radiographs did not imply bad function.

Burri G, Bartzke J, Coldewey J and Mugglar E[18] in 1979, in a study of 278 cases of tibial plateau fractures over an average follow up period of 2.5 years all treated by surgical methods. They had 89% acceptable results when surgery was performed by inexperienced surgeons and 97% results when treated by experienced surgeons. They concluded that the prognosis improves with the experience of surgeons, accurate reconstruction of articular surface and rigid internal fixation to

allow early mobilization, they also said that the percentage of post traumatic arthritis was directly proportional to the severity of the displacement.

Augusto S[19] in 1979, in the study of fracture of the proximal end of the tibia, particularly intra-articular ones, are considered to be difficult management problems because of the misalignment, incongruity and instability that frequently result from their surgical or nonsurgical treatment. Cadaveric and clinical studies reproduced the same results. They concluded that loss of articular congruity leads to the degenerative arthritis and is less likely to produce so if joint function is maintained. However, there is no general agreement or clear understanding as to the degree of incongruity, malalignment or residual instability necessary to produce such clinical symptoms.

Moore TM[20], in 1981, in a study of 132 cases of Tibial plateau fracture–dislocation treated by conservative (35%) and surgical (65%) methods. He concluded that Moore's group III. IV and V had unstable knee and also associated neurovascular impairment.

In 1982, Bowes DN and Hohl M[21], in a retrospective study of 110 tibial condyle fractures between 1972-78, reviewed using Hohl's 100 point knee rating system treated by all methods showed overall the results were acceptable in 84% of patients.

Bowes DN and Hohl M[24], in 1982 reviewed 52 cases of tibial plateau fractures all types treated with conservative and surgical methods. They followed Hohl's numerical method of evaluation and had minimal follow up of one year. They had 84% overall excellent to good results. Minimally displaced fractures treated by cast brace gave good functional results whereas surgical treatment of severely comminuted fractures had unsatisfactory results.

Blokker CP.,et al[25], in 1984 reviewed 60 patients with tibial plateau fractures over an average follow up of 3 years of which 38 were treated by open reduction and internal fixation and 22 patients treated conservatively. They said that the single most important factor in predicting the outcome in a patient with tibial plateau fracture was adequacy of reduction. They also concluded that only for comminuted bicondylar fracture was open reduction superior to the conservative methods. The residual step off greater than 5mm on the weight bearing area was universally associated with an unsatisfactory result.

Lansinger et al[22] in 1986 published a long term result of 102 cases of tibial plateau fractures of all varieties treated by conservative and surgical methods. They evaluated the functional outcome using Rasmussen's criteria and obtained an overall excellent to good result of 90% of the cases and 10% achieved fair or poor results. They advocated treatment of depressed and split depressed fractures by open reduction and bone grafting.

DeCoster TA et al[27]., in 1988, observed the long term outcome of tibial plateau fractures treatment by cast bracing, followed up over a period of 10 years, concluded that cast bracing of minimally displaced fractures gives satisfactory results whereas cast bracing of displaced bicondylar fractures produced variable functional results and 70% of them developed degenerative joint disease.

Duwelius PJ and Connelly JF[28], in 1988, reviewed 100 tibial plateau fractures in 96 patients. 73 tibial plateau fractures treated by closed reduction and early mobilization of the knee using a cast brace. They followed up the cases for an average period of 5 years with excellent to good results in 89%. They found no correlation between functional and radiographic results. They also advocated percutaneous fixation of unstable fractures with instability of more than 10 degree in extension.

Lachiewcz PF and Funcknik T[29], in 1990, in a study of 43 displaced fractures with surgical methods (open reduction and internal fixation by using AO-ASIF principles) and followed up over an average period of 2.7 years. They obtained excellent to good results in 93% of cases. Poor results were due to technical faults or absence of bone grafts. Bicondylar fractures had 110 degree motion, 18 degree less than all other types.

Dennis J et al[23]., in 1990 reviewed 109 tibial plateau fractures, 61 treated by skeletal traction and early knee movement & 48 treated by surgery at an average follow up of 70 months. The functional results were much the same though meniscectomy had been performed in almost half of the surgical patients. Time in bed and duration of hospital stay were clearly shorter after surgery. They concluded that conservative management was a valid alternative to surgery but should probably be reserved to cases where operation is undesirable.

Dalamarter R, Hohl M and Hopp E Jr[30], in 1990 observed that the tibial plateau fractures are associated with soft tissue injuries in 10-30% of cases, need to be evaluated pre-operatively as well as after fixation .The ligament injuries to be treated immediately or after fracture union. The instability can be overcome by adequately treating such injuries is shown by recent studies.

Honkonen SE and Juninen MJ[32], in 1992 reviewed 212 tibial plateau fractures of all types, the residual radio anatomic factors influencing the functional, subjective and clinical outcome of 131 tibial condyle fractures were studied. They concluded that medial condylar fractures with any displacement and all medially tilted bicondylar fractures should be operated. In fracture of lateral condyle, open reduction and internal fixation is indicated when lateral tilt or varus misalignment exceeds 5 degrees, articular step exceeds 3mm or condylar widening exceeds 3mm.

Marwah., et al[26], in 1993,reviewed 50 cases of tibial plateau fractures of all types by conservative methods of traction-mobilization. They followed up the cases for an average period of 2 years with an overall excellent to good result of 94%. They followed up the cases for an average period of 2 years with an overall excellent to good result of 94%. They stressed on the concept of early mobilization to good results and advantages of absence of surgical risks.

Segal D and Arati R.,et al[31],in 1993, in a study of 134 tibial plateau fractures treated by conservative and surgical methods. All lateral tibial plateau fractures with depression of more than 5mm were treated operatively, 95% of patients with Hohl type 1, 2 or 5 had satisfactory results as opposed to 70% of patients with type 3 fractures.

Thomas G, Padanilam and Nabil A[33], in 1995, in an evaluation of 18 Tibial plateau fractures in which extensile meniscal detachment approach was used. They had 72% excellent and 38% good results. They concluded that for patients with significant comminution and depression of lateral tibial plateau, this was a safe and effective method for excellent exposure and accurate reduction.

Duparc and Ficat[12] in 1995, in a study of 159 cases of tibial plateau fractures of all types treated by conservative (46%) and surgical (54%). This short term study reported excellent to good outcome of 62% of cases treated by conservative methods and 84% treated by surgica1 methods. Incidence of osteoarthritis correlated with poor results due to misalignment, residual step off and instability.

Marsh JL, Smith ST and Do TT[34], in 1995, reviewed 21 complex tibial plateau fractures treated with open reduction, interfragmentary screw fixation and application of a unilateral half-pin external fixator. All the fractures united. They concluded that external fixation with limited internal fixation is a satisfactory technique for the

treatment of complex fractures.

Buchko GM and Johnson DH[35], in 1996, concluded that, accurate anatomical reduction could be achieved by arthroscopy. The joint congruity restored to near normal has been well shown using arthroscopy.

Dendrinos GK.,et al[36], in 1996 reviewed 24 patients with high energy fractures of the tibial plateau treated with Ilizarov fixator and transfixion wires. 11 fractures were open, 12 were treated by ligamentotaxis and percutaneous fixation, 7 by limited open reduction and 5 by extensive open reduction. Patients were followed up for an average period of 24 months. Average time of fracture union was 14.4 weeks. They obtained acceptable results in satisfactory percentage of patients. They concluded that llizarov circular fixator as 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.

Duwelius PJ and Rangitsch MR[37], in 1997, published data of evaluation of 76 tibial plateau fractures treated by limited internal fixation. Instability in extension was used as the primary indication for surgery and obtained 87% good results with minimum follow up of 1 year. They concluded that limited internal fixation with early mobilization is a good method except in AO type C-3 factures.

Mikulak SA and Gold SM[38], in 1998, evaluated 24 patients with Schatzkar type III, treated with small wire external fixator with or without limited internal fixation. They had acceptable results at the end of 12 months and concluded that this technique is an alternative to open plate osteosynthesis.

Sirkin MS, Bono CM and Behrens FF[10] in 2000 reported that various methods of percutaneous fixation of tibial plateau fractures are available. Percutaneous fixation offers its best in isolated undisplaced fractures, split unicondylar (lateral) fractures,

elderly osteoporotic and in badly comminuted ones. The advantages are decreased operative time, less blood loss, smaller incision, short hospital stay and early rehabilitation.

Waddell JP[11] in 2000 reported evaluation of doubtful fractures by X-rays taking AP oblique inclined 10^0 caudally. Various approaches are dealt depending on the fracture geometry. It also gives information regarding associated tibial shaft fractures by intramedullary nailing coupled with buttress plate.

Bal G and Chapman.,et al[39], in 2000, in a follow up study of 21 closed and 13 open fractures over an average period of 26 months using anterior T frame external fixation combined with percutaneous internal fixation for treatment of high energy proximal tibial fractures. Fractures united at a mean period of 20 weeks. They obtained a functional evaluation score of 85%. Concluded that the anterior T–frame external fixture with percutaneous external fixation is a simple reliable inexpensive and effective method to stabilize these complex injuries.

Thomas JG.,et al[40], in 2001,reviewed 25 patients who underwent arthroscopic reduction and internal fixation of tibial plateau fractures, average age of patients was 45 years mean follow up was for 24 months. 76% patients rated their results as excellent and 24% good. No episodes of nonunion, failure of fixation wound infection, DVT, compartment syndrome or arthrofibrosis. Authors recommended that arthroscopic reduction and internal fixation provides an accurate assessment of and allows definitive treatment for intra-articular injuries associated with tibial plateau fractures. This technique allows less soft tissue stripping than the traditional arthrotomy better visualization of the articular surface. Early return to physical activities and obviates the need for meniscal detachment and repair.

David GS, Rani B, Michael DM, James PW and Emil HS[43], in 2001, in a retrospective study of 54 patients it was found that ORIF is a satisfactory technique for the treatment of displaced fractures of tibial plateau, particularly patients younger than 40 years.

Mills WJ and Nork SE[41], in 2002 concluded that in high energy tibial Plateau Fractures, although soft injury may make ORIF difficult, in many instances it has certain advantage over external fixation. The goals of both treatments include anatomic reconstruction of articular surface, restoration of limb axis, spanning metaphyseal comminution if present. All these are met by ORIF. Potential advantage of ORIF over other techniques include – the ability to recognize and repair associated menisci and collateral ligament injuries, greater visualization of articular surface, avoidance of prolonged immobilization.

Gosling T, Schandelmaier P, Marti A, Hufner T, Partenheimer A and Krettek C[44], in 2004, in a biomechanical cadaveric study on 8 fresh frozen human tibia with unilateral lock screw plate and double plating, it was seen that both fixation techniques have higher resistance to vertical subsidence even with loads exceeding the average body weight.

David PB, Sean EN, William JM, Henly MB and Stephen KB[45], in 2004, in a study of 83 patients it was found that use of 2 incisions for open reduction and medial and lateral plate fixation and proper soft tissue handling may contribute to a lower wound complications rate than previously reported.

Jong-keun O.,et al[42], in 2005, published a report showing excellent results with key hole incision and using locking compression plate. The results of this study are encouraging because of less infection rate, minimal soft tissue damage and high rate of early fracture union and above all it is a biological fixation.

Thomas FH, Joshua K and Kent NB[46], in 2007, concluded that dual plate fixations allows less subsidence in bicondylar tibial condyle cadaveric model when compared to isolated lock lateral plates.

Jose B.,et al[47], in 2007, in a study of intra articular tibial plateau fracture, it was found that with proper surgical technique and standard protocol, healing may be reliably achieved.

Stefan E.,et al[48], in 2008,reviewed 116 patients it was found that 2 incision technique starting with reduction of posterior medial edge results in accurate fracture reduction with low complications rate and excellent knee function.

Christopher Z.,et al[49], in 2009, in a study of tibial plateau fracture a technique using anterior midline incision with medial parapatellar arthrotomy and medial full thickness skin flap for ORIF of isolated medial tibial plateau fracture found to be simple method and almost good visualization simply reduction and provides a functional scar.

Yan LH.,et al[50], in 2009, reviewed 21 tibial plateau fracture they found that three dimensional CT is more reliable, radiographic modality than 2D CT in evaluation of fracture patients of tibial plateau that can improve the fracture classification system.

Biggi F, Fabio SD, D'Antimo C and Trevisani S[51], in 2010, in a study of 58 patients they concluded that internal fixation with locking plates, following the principles of MIPPO provides satisfactory fracture reduction with good results regarding the midterm clinical outcome.

Cift H.,et al[52], in 2010, in a study of experimental load bearing of bone models it was found that plate-screw fixation system has significant higher stabilization capacity than fixation with screws alone.

Alexander B, Monika H, Benjamin U, Alexander H and Reto B[53], in 2010, in a study of 45 patients CT scanning improved the inter and intra observer reliability of the OTA/AO, the Schatzker and the Hohl classification.

Ching HM.,et al[54], in 2010, in a study of 15 patients with staged external and internal fixation with less invasive stabilization system plating, gross anatomy restoration, soft tissue reconstruction, stable fixation and high union rates achieved and good to excellent range of motion achieved.

Solomon LB.,et al[55], in 2011, in a study using radiostereometric methods for Schatzker type 2 fracture, internal fixation with subchondral screws and a buttress plate provided adequate stability to allow immediate post-operative partial weight bearing, without harmful consequences.

Philipp NS, Donald G, Ambrose W, David PB, William MR and Michael JG[56], in 2011, in a study of 74 patients it was found that considerable sagittal plane deformity exists in the majority of bicondylar tibial plateau fractures i.e. lateral plateau has a higher propensity for saggital angulation and tends to have increased posterior slope and identification of this deformity allows for accurate preoperative planning and specific reduction maneuvers to restore anatomical alignment.

ANATOMY

The proximal tibia lies between the tibial shaft and knee joint.

A thorough understanding of anatomy of structures and biomechanics of knee is very important to plan for reduction, surgical management and post-operative care to determine the possible complications after injury to upper tibial region.

KNEE JOINT:

It consists of the relationship between (3) articulations

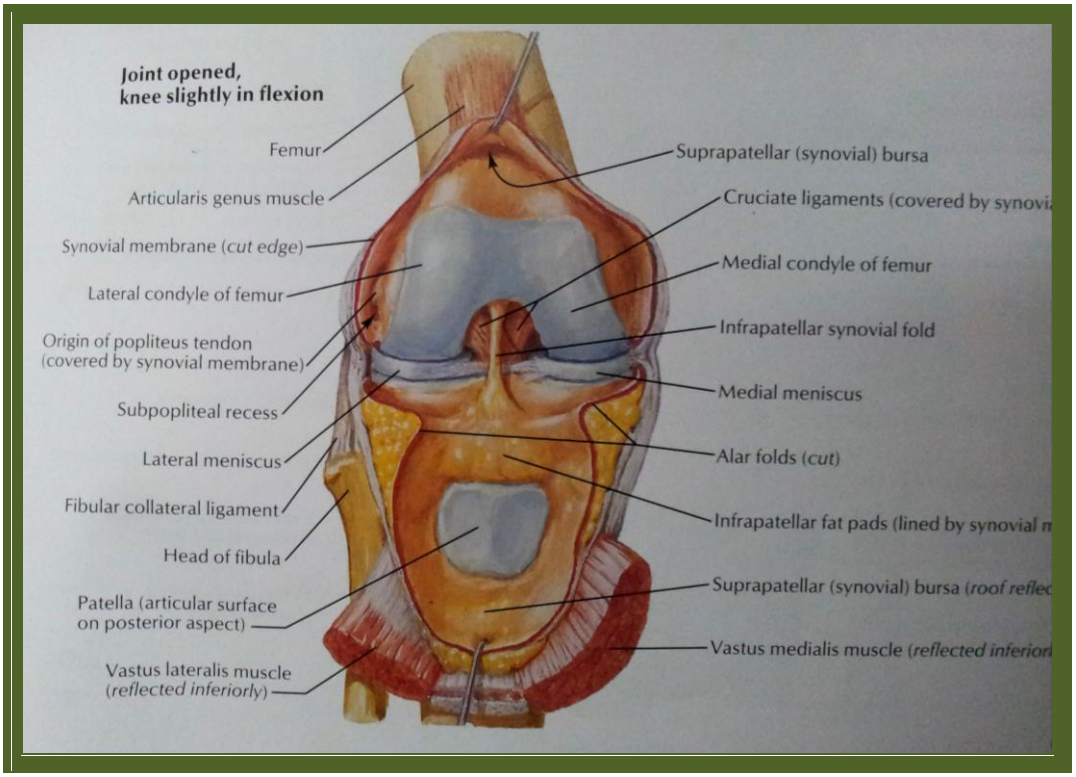
a) Patellofemoral

b) Tibiofemoral and

c) Tibiofibular

This triaxial joint is often exposed to forces in excess of five times the body weight step. 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 confirming 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 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[2]:

- 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.

The peripheral part is flat and is separated from femoral condyle by the medial meniscus. The posterior surface of the medial condyle has a groove.

LATERAL TIBIAL CONDYLE:

It overhangs the shaft of the tibia more than the medial condyle.

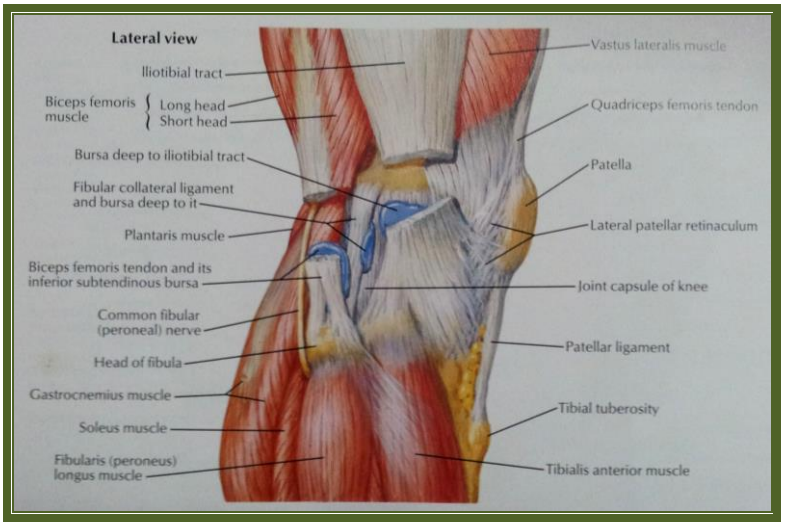
The articular surface is nearly circular. The central part of the articular surface is concave and the peripheral part is flat. It is separated from the femur by lateral meniscus.

The postero-inferior 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.

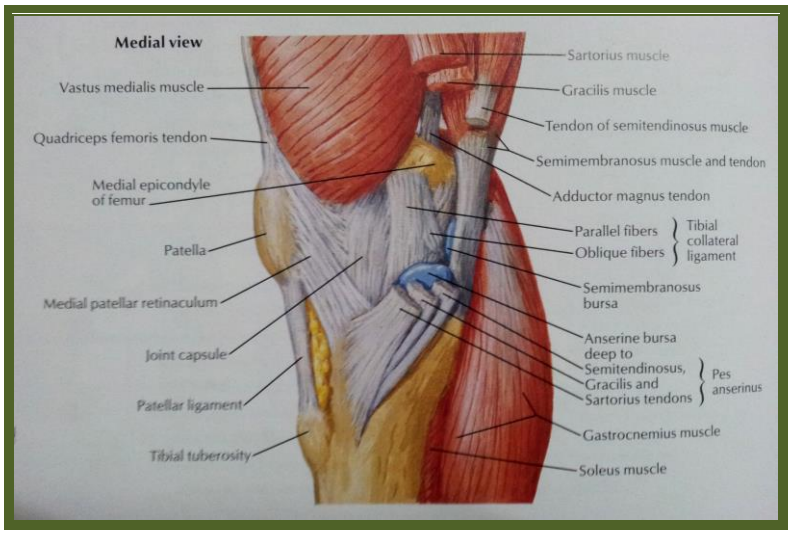
INTERCONDYLAR AREA:

- Roughened area on the superior surface between the articular surfaces of the two condyles.

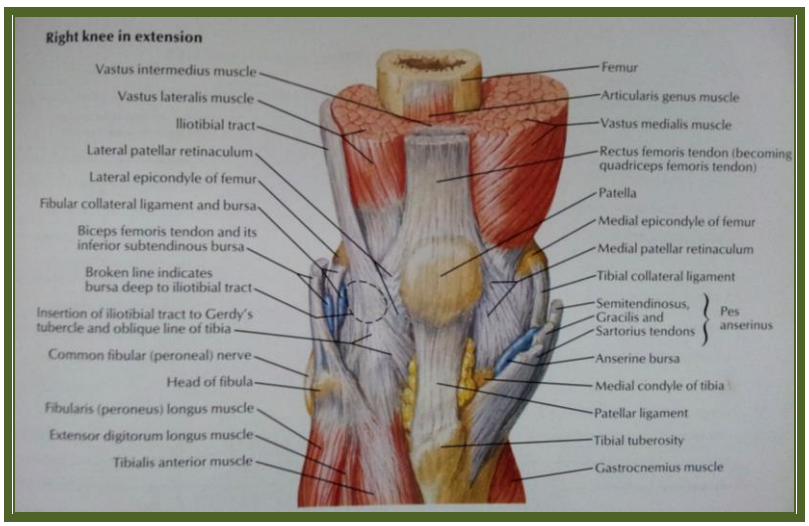
Lateral view



Medial View



Anterior View



It is narrowest at its middle where it is marked by an elevation termed the *"INTERCONDYLAR EMINENCE".*

- The intercondylar area gives attachment to the following structures from before backwards.
    1. Anterior horn of the medial meniscus.
    2. Anterior cruciate ligament (ACL)
    3. Anterior horn of lateral meniscus.
    4. Posterior horn of lateral meniscus
    5. Posterior horn of the medial meniscus
    6. Posterior cruciate ligament (PCL).

TUBEROSITY OF THE TIBIA:

It lies at the upper end of the shaft of the tibia on the anterior border. It is divided into a smooth upper and a rough lower portion by a line or crest which marks the epiphyseal line. The upper smooth portion provides attachment to the ligamentum patellae.

COMPARTMENTS: The compartments of the knee are -

1. Anterior
2. Medial
3. Lateral
4. Posterior

BLOOD SUPPLY TO THE JOINT:

It is the genicular circulation that is responsible for all structures about the knee joint. Five arteries form this genicular anastomosis

1. The superior genicular A
2. The medial genicular A

3. The lateral inferior genicular A
4. The middle genicular A
5. Anterior and posterior tibial recurrent arteries.

This supplies bone, capsule, and synovial membrane. This anastomosis is situated around the patella, the lower end of femur and upper end of tibia.

1. Superficial part : Lies in the superficial fascia around the patella and the ligamentum patellae

2. Deep part: On the femur and tibia. It is formed.

Medially by

1. Descending genicular A
2. Superior medial genicular A
3. Inferior medial genicular A

Laterally by

1. Descending branch of lateral circumflex femoral A
2. Superior lateral genicular A
3. Inferior lateral genicular A
4. Anterior tibial recurrent A
5. Posterior tibial recurrent A
6. Circumflex fibular A

Medial and lateral arteries are connected by long anastomosis which is interconnected by horizontal anastomoses just above and below the patella.

ANASTOMOSES AROUND THE KNEE[3]

- Descending genicular A - branch of femoral A
- Descending branch of lateral circumflex femoral A
- Lateral genicular A- anastomosis connecting the above 2 arteries

- Medial genicular A
- Medial inferior genicular A
- Lateral inferior genicular A
- Anterior tibial recurrent A
- Circumflex fibular branch of posterior tibial A

NERVE SUPPLY: All three nerves supply the knee joint

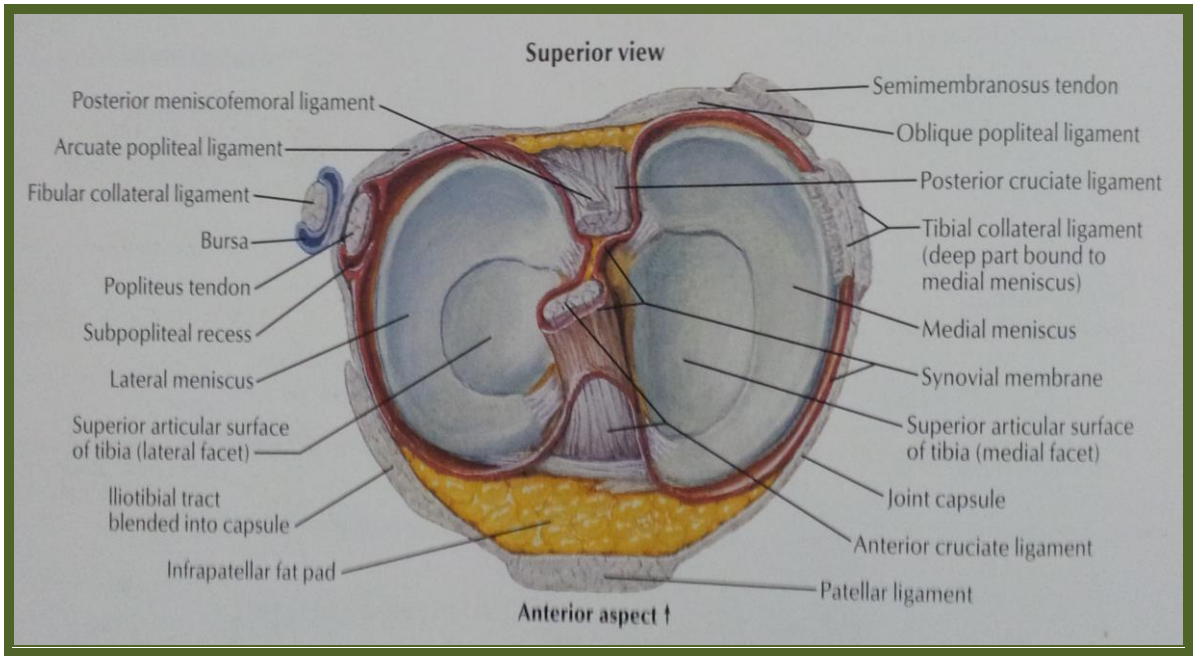
1. Femoral nerve through its branches to vasti especially vastus medialis.
2. Sciatic N through genicular branches of common peroneal N.
3. Obturator N through its posterior division.

LIGAMENTS[4]:

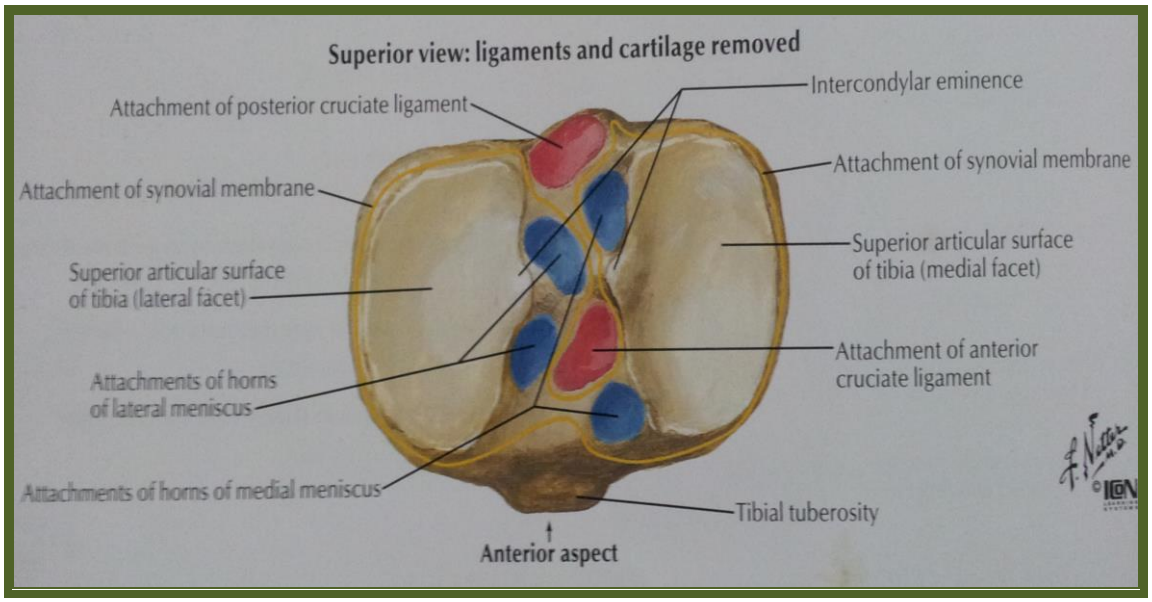
The Ligaments supporting the knee joint are:

1. Fibrous capsule
2. Ligamentum patellae
3. Tibial collateral ligament
4. Fibular collateral ligament
5. Oblique popliteal ligament
6. Arcuate popliteal ligament
7. Anterior cruciate ligament
8. Posterior cruciate ligament
9. Medial meniscus
10. Lateral meniscus
11. Transverse ligament

Knee Joint Superior View



Superior View: Ligaments and cartilage removed



FIBROUS CAPSULE:

The capsule is a thin structure attached to the articular surfaces and surrounds sides and posterior aspect of the joint. In front of the joint attachment on the femur is deficient above the level of the patella permitting the synovial membrane to pouch upward beneath the quadriceps tendon, forming the suprapatellar bursa. The capsule has weak attachment to the rim of both the menisci known as the coronary ligaments.

EXTRACAPSULAR LIGAMENTS:

Tibial collateral (medial) ligaments - The MCL is a broad 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 is firmly attached to the edge of the medial meniscus. It represents the degenerate tendon of the ischial head of the adductor magnus.

FIBULAR COLLATERAL (LATERAL) LIGAMENT:

The LCL is cord like it is attached proximally to the lateral epicondyle, below the attachment of the lateral head of gastronemius and above that of the tendon of popliteus. Its distal attachment is to the head of the fibula overlapped by the tendon of biceps femoris, a bursa intervening between them. The tendon of the popliteus muscle intervenes between the ligament and lateral meniscus.

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.

ARCUATE POPLITEAL LIGAMENTS:

It is a ‘Y’ shaped thickening of the posterior capsular fibres. It extends from the head

of the fibula, arches over the tendons of the popliteus and is attached to the posterior border of the intercondylar area of tibia.

INTRACAPSULAR LIGAMENTS:

The cruciate ligaments are a pair of very strong ligaments connecting the tibia to the femur. They lie within the capsule of knee joint, but not with in the synovial membrane it is as though they have been herniated into the synovial membrane from behind so they are covered by synovial membrane on their front and sides but not posteriorly.

ACL:

The ACL is attached to the anterior part of the tibial plateaus between the anterior horns of the medial and lateral menisci the ligament ascends posterolaterally, twisting on itself, and is attached to the posteromedial aspect of the lateral femoral condyle.

It is slack when the knee is flexed, but taut when the knee is fully extended, ACL prevents anterior displacement of tibia on femur. With the knee joint flexed, the ACL prevents the tibia from being pulled anteriorly.

PCL:

The PCL is stronger shorter and 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 anterior fiber becomes slack when knee is extended but becomes taut in fIexion the posterior fiber taut in extension. PCL prevents posterior displacement of the tibia on the femur with the knee joint flexed the PCL prevents the tibia from being pulled posteriorly.

MENISCI (SEMILUNAR CARTILAGE):

The menisci or semilunar cartilage are C Shaped (crescentric) lamellae of fibro cartilage that lie on and are attached to tibial plateau. Which are triangular in cross section. The peripheral border is thick and convex and attached to capsule and the inner border is thin and concave. The upper surfaces are concave and are in contact with femoral condyle. Their function is to deepen the articular surfaces of the tibial condyles to receive the convex femoral condyles; they also serve as cushions between the 2 bones.

The medial meniscus is nearly semi-circular and is much broader behind than front its outer horn is attached to the inter condylar area in front of the ACL and connected to lateral meniscus by few fibers called the "transverse ligament". Posterior horn is attached to posterior intracondylar area in front of PCL.

The lateral meniscus is nearly circular (4/5 of a circle) and is uniformly wide throughout anterior horn is attached to the anterior intracondylar area immediately in front of intercondylar eminence of the tibia behind ACL. Posterior horn is attached behind the eminence in front of posterior horn of the medial meniscus from the posterior convexity of the lateral meniscus fibrous bands pass upward and medially to the medial femoral condyle known as anterior and posterior meniscofemoral ligaments of Humphrey and Wrisberg.

SYNOVIAL MEMBRANE:

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

LIGAMENTUM PATELLAE:

This is central portion of the common tendon of insertion of quadriceps femoris; the remaining portion of the tendon forms medial and lateral patellar retinacula. Ligamentum patellae is about 3" long and 1" 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 the tibial tuberosity. The superficial fibers pass in front of the patella, it is related to the superficial deep intra patellar bursa and to the inferior patellar pad of fat.

MECHANICS OF KNEE JOINT

The mechanical axis of the femur does not coincide with the anatomical axis since a line traversing the centre of the hip joint and the centre of the knee forms an angle of 6° - 9° with the axis of the shaft of the femur.

Because of the disparity between the lengths of the articular surfaces of the femoral condyles and the tibial condyles, two types of motion during flexion and extension are produced.

1) Ginglymus (hinge)
2) Trochoid (pivot joint) articulation.

The joint permits flexion and extension in the sagittal plane and some degree of internal and external rotation when the knee is flexed.

The complex flexion and extension motion is a combination of rocking and gliding.

The rocking motion is demonstrable in the first 20° of flexion, after which the motion becomes predominantly of the gliding type.

The natural deflection outward of the tibia on the femur, at the knee joint produces greater weight bearing stresses on the lateral femoral condyle than the medial. But because the medial condyle of the femur is prolonged further forwards than the lateral condyle, the vertical axis of rotation falls in a plane near the medial condyle[4].

The ratio of rolling to gliding is not constant. The ratio is 1:2 in early flexion and about 1:4 by the end of flexion.

MECHANICS OF KNEE JOINT

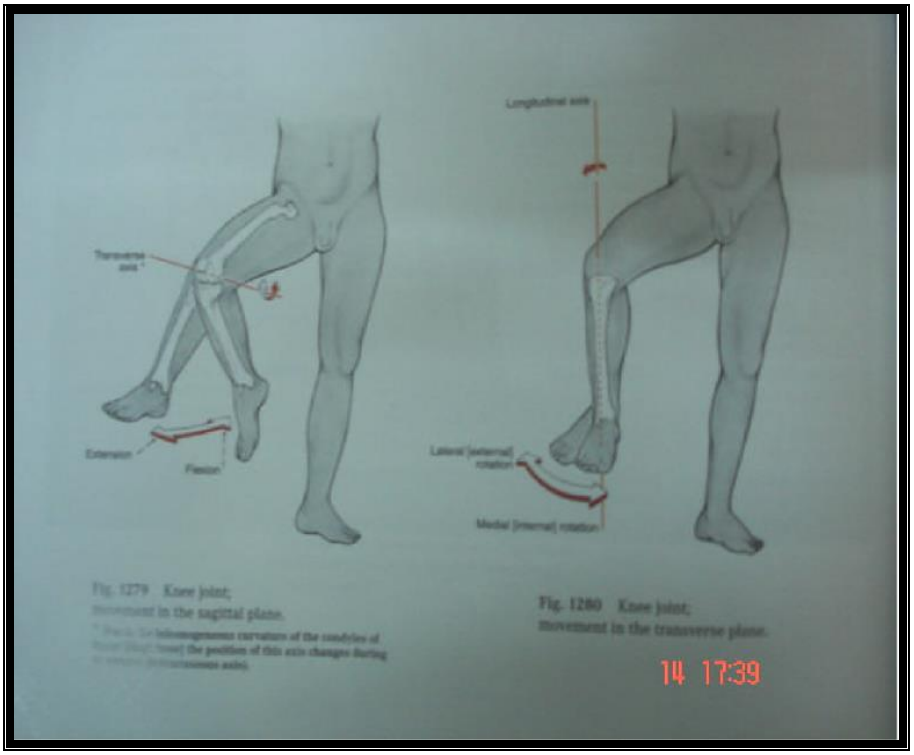
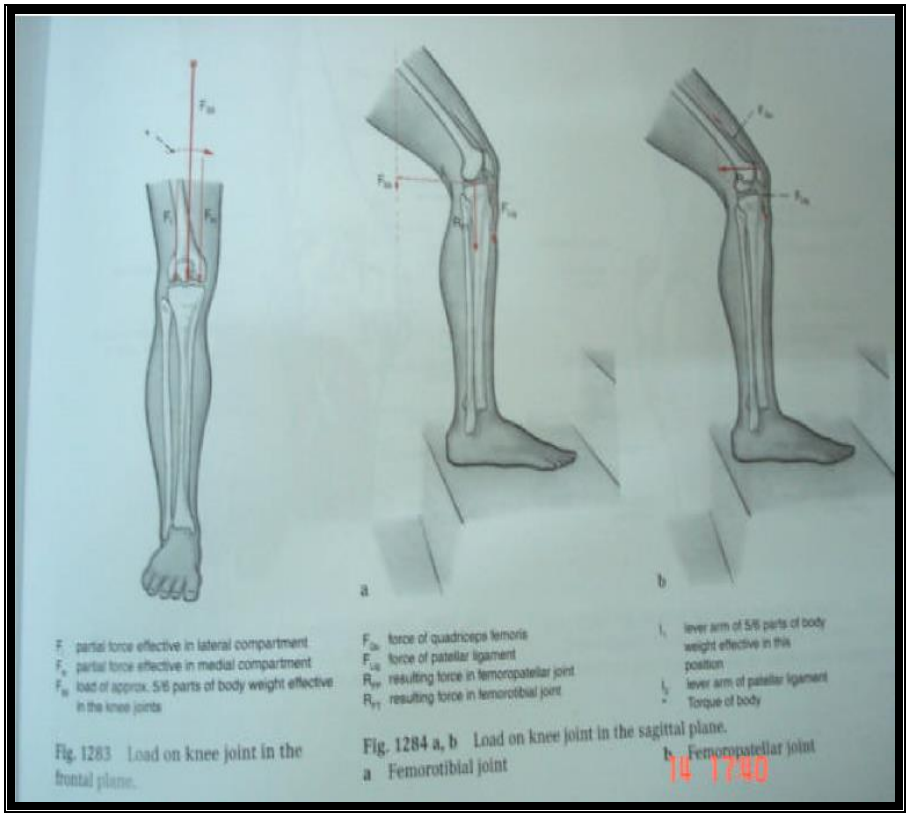


Fig. 1279 Knee joint; movement in the sagittal plane.

Fig. 1280 Knee joint; movement in the transverse plane.



F partial force effective in lateral compartment
F_o partial force effective in medial compartment
F_K load of approx. 5/6 parts of body weight effective in the knee joints

Fig. 1283 Load on knee joint in the frontal plane.

F_{Qu} force of quadriceps femoris
F_{Lig} force of patellar ligament
R_{PF} resulting force in femoropatellar joint
R_{FT} resulting force in femorotibial joint

l_1 lever arm of 5/6 parts of body weight effective in this position
l_2 lever arm of patellar ligament
M Torque of body

Fig. 1284 a, b Load on knee joint in the sagittal plane.
a Femorotibial joint
b Femoropatellar joint

- Flexion ranges from 0°- 140°.
- Rotation ranges from 5°-25° with individual variation.
- 5-10° of hyperextension is also possible.
- Medial meniscus is more prone for injury because the anchorage of the medial meniscus permits less mobility.
- SCREW-HOME MOVEMENT: The articular surface of the medial condyle is prolonged anteriorly, and as the knee comes into fully extended position, the femur internally rotates until the remaining articular surface on the medial condyle is in contact. The posterior portion of the lateral condyle rotates forward laterally, thus providing a screwing home movement, locking the knee in the fully extended position.

  When flexion is initiated unscrewing of the joint occurs by external rotation of the femur on the tibia.
- Normal sagittal excursion of tibia on the femur not more than 3-5mm.
- Normal varus and valgus motion at the knee, when extended not more than 6°-8°.

PRINCIPLES

The principles of surgical management of any intra articular fracture fixation are…….

1. Anatomical reduction-to maintain joint congruity and to prevent secondary osteo arthritis.
2. Rigid internal fixation.
3. Enbloc uplifting of depressed articular fragment and bone grafting.
4. Early mobilization of the joint.
5. Defer weight bearing until complete fracture union.

TIBIAL PLATEAU FRACTURES

INCIDENCE:

Fractures of tibial plateau 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 (55-70%) or both (11-30%) with differing degrees of articular depression and displacement.

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. Valgus stress/varus stress
5. Athletics
6. Assault.

INDIRECT: Trivial injures like

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

MECHANISM:

Fractures of the upper tibia occur opposite as a result of strong valgus or varus forces with axial loading.

When a patient sustains varus or valgus force with an axial load, the respective femoral condyle exerts both a shearing and a compressive force on the underlying tibial plateau. This frequently results in a split fracture, a depressed fracture or both.

Isolated split fractures are virtually confined to 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 more sparse and is no longer able to withstand the compressive forces. With impact loading, a depressed or split depressed fracture results[5].

The medial collateral ligament acts like a hinge as valgus forces drive the lateral femoral condyle into the tibial plateau. The lateral collateral ligament acts in a similar way with varus forces and causing medial plateau fractures[1]. With the Magnetic Resonance Imaging (MRI) in patients with upper tibial fractures, ligament injuries have been observed in a higher percentage of patients. Thus in addition to the fracture, there may be an associated medial collateral ligament or anterior cruciate ligaments injury may be present in lateral plateau fracture, conversely, the tears of the lateral collateral ligament or cruciate ligaments may be associated with fractures of the medial tibial plateau.

The location of the fracture depends on the degree of flexion/extension of the knee. However when axial loads exceeds 8000 pounds, explosive severely comminuted fractures were produced. This mechanism is thought to occur clinically in a fall from a height on the extended knee. Also direct injury to the upper part of the tibia, i.e., in the subcondylar (or) subchondral or metaphyseal region may lead to a fracture without involving the articular surface. These types of fractures may be due to road traffic accidents, assaults, etc.

PATHOLOGY OF FRACTURES OF TIBIAL PLATEAU:

Pure split fractures are commoner in young patients.

1. Depressed fractures and split depressed fractures are common in older patients.
2. The degree of flexion of knee combined with valgus/varus strain and axial loading determine the fracture line and the site of depression whether it is anterior, middle or posterior.
3. Collateral ligament integrity and forces determine the type of fracture.
4. Pure axial loading or axial loading combined with varus/valgus stress determines the type of bicondylar fractures.
5. Violent injuries are associated with ligament injures, vascular and nerve injures.
6. Direct injuries to the upper tibia can also lead to subcondylar fractures without involving the articular surface.

Many factors can combine to produce various different types of fractures, their combinations and complications.

FRACTURE CLASSIFICATION

I. SCHATZKERS CLASSIFICATION[5]

TYPE I - PURE CLEAVAGE

A wedge shaped uncomminuted fragment is split off and displaced laterally and downwards. This fracture is common in younger patients without osteoporotic bone.

TYPE II - CLEAVAGE COMBINED WITH DEPRESSION

A lateral wedge is split off, but in addition the articular surface is depressed down into the metaphysis. This tends to occur in older people with osteoporotic bone.

TYPEIII - PURE CENTRAL DEPRESSION

The articular surface is driven into the plateau. The lateral cortex is intact. These tend to occur in osteoporotic bone.

TYPE IV - FRACTURES OF MEDIAL CONDYLE

These may be split off as a wedge or may be comminuted and depressed. The tibial spines are often involved. These fragments tend to angulate into varus.

TYPE V - BICONDYLAR FRACTURES

Both tibial plateaus are split off. The distinguishing feature is that the metaphysis and diaphysis retain continuity.

TYPE VI - PLATEAU FRACTURE WITH DISSOCIATION OF METAPHYSIS AND DIAPHYSIS

A transverse or oblique fracture of the proximal tibia is present in addition to a fracture one or both tibial condyles and articular surfaces.

SCHATZKER'S CLASSIFICATION

II. HOHL AND MOORES CLASSIFICATION:

A. FRACTURE PATTERN

TYPE 1: Split fractures of the lateral condyle

TYPE 2: Lateral compression

TYPE 3: Split with compression fracture

TYPE 4: Total condylar fractures

TYPE 5: Bicondylar fractures

B. *FRACTURE - DISLOCATION PATTERNS*[6]*:*

TYPE 1: Coronal split fracture dislocation

TYPE 2: Entire condylar fracture dislocation

TYPE 3: Rim avulsion fracture dislocation

TYPE 4: Rim compression fracture dislocation

TYPE 5: Four part fracture dislocation.

III A-O CLASSIFICATION OF TIBIAL PLATEAU FRACTURES:

TYPE 1: Wedge fractures

TYPE 2: Depression fractures

TYPE 3: Wedge and depression fractures

TYPE 4: `Y' and `T' fractures/comminuted fractures of both the condyles.

HOHL-MOORE CLASSIFICATION

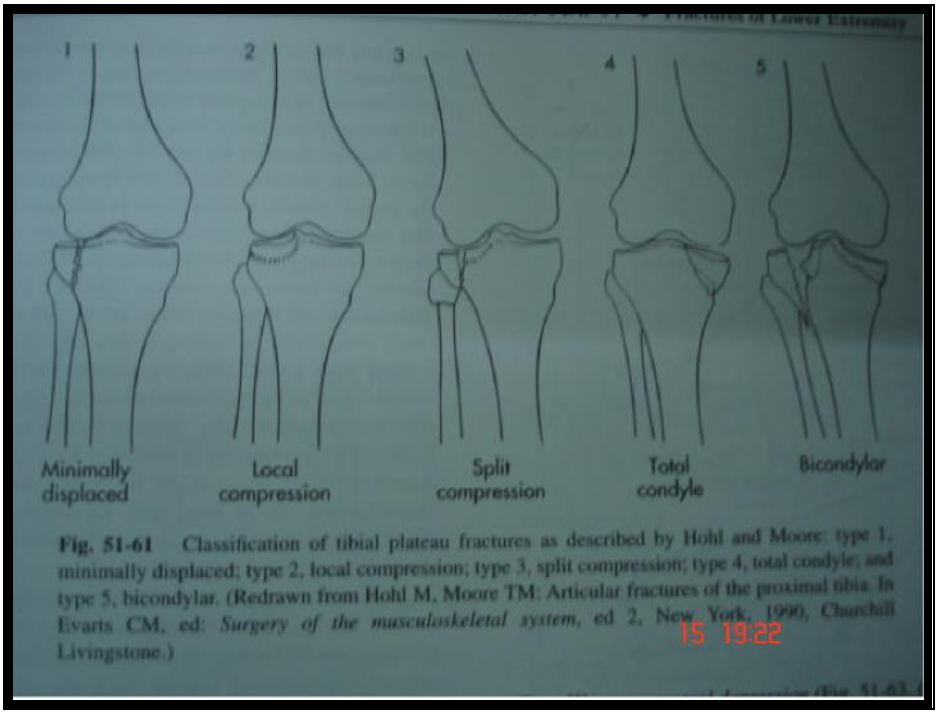


Fig. 51-61 Classification of tibial plateau fractures as described by Hohl and Moore: type 1, minimally displaced; type 2, local compression; type 3, split compression; type 4, total condyle; and type 5, bicondylar. (Redrawn from Hohl M, Moore TM: Articular fractures of the proximal tibia. In Evarts CM, ed: *Surgery of the musculoskeletal system*, ed 2, New York, 1990, Churchill Livingstone.)

FRACTURE PATTERN

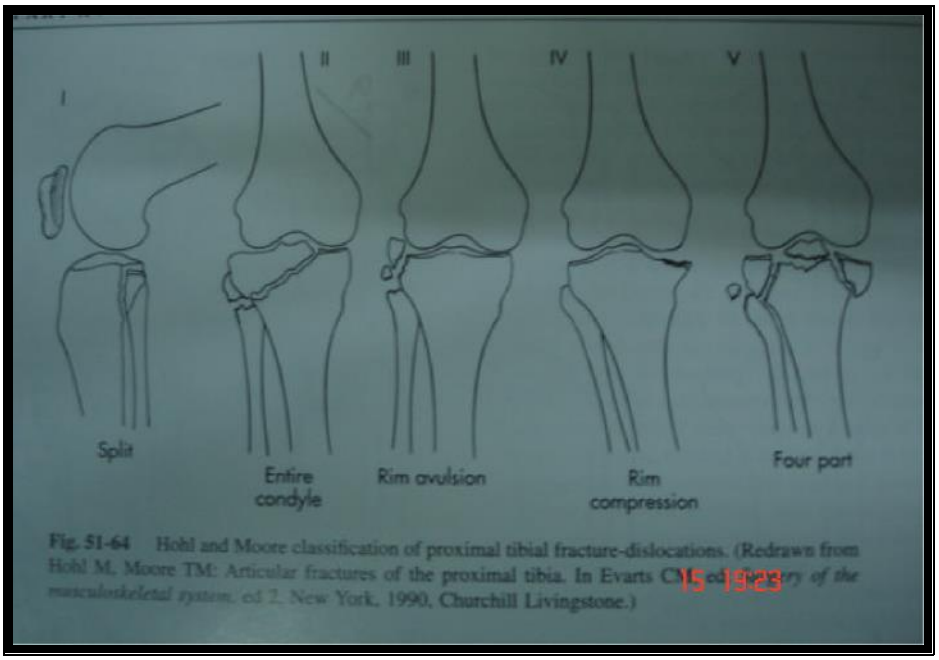
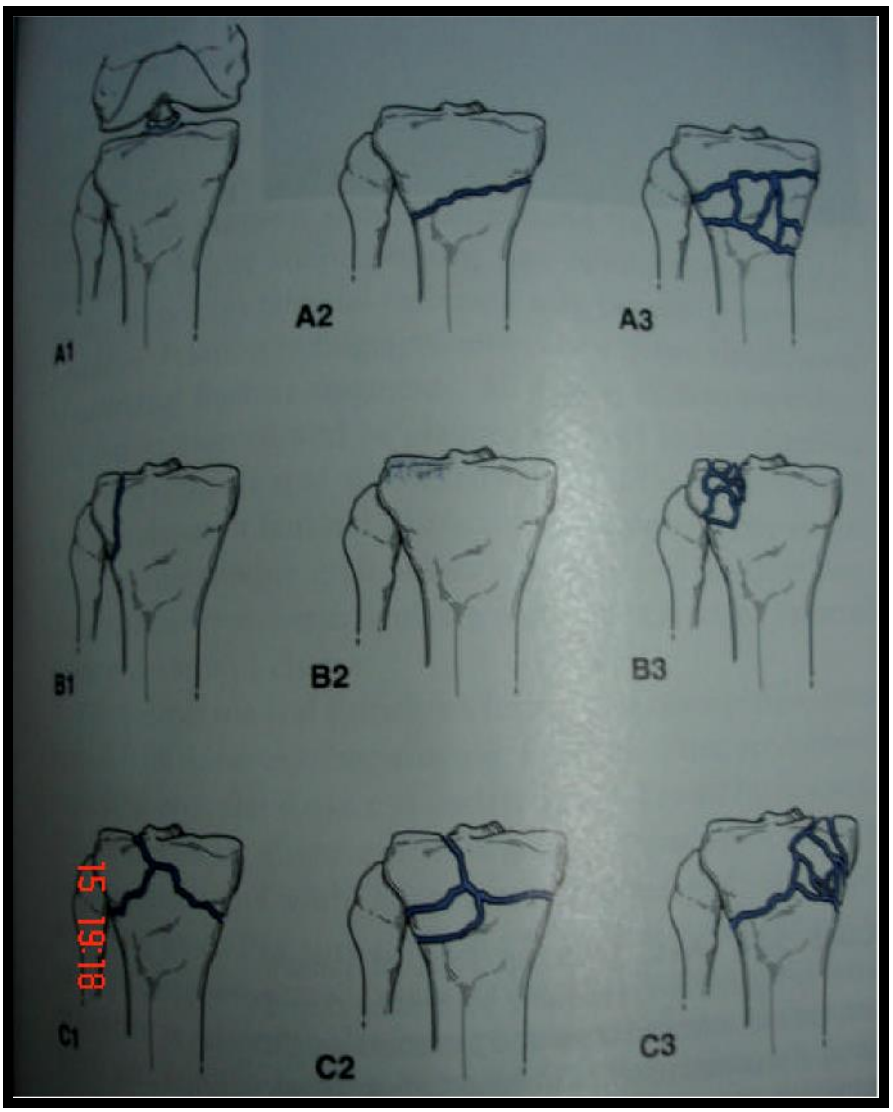


Fig. 51-64 Hohl and Moore classification of proximal tibial fracture-dislocations. (Redrawn from Hohl M, Moore TM: Articular fractures of the proximal tibia. In Evarts CM, ed: *Surgery of the musculoskeletal system*, ed 2, New York, 1990, Churchill Livingstone.)

FRACTURE – DISLOCATION PATTERN

AO/OTA CLASSIFICATION



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. 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 of Moore, taken with a caudal tube angulation of 10 degree to match the normal posterior slope of the plateau, gives more accurate measurements than does a standard anteroposterior view.

COMPUTERIZED AXIAL TOMOGRAPHY:

CT scan is capable of providing images of the proximal tibia in several reconstructed 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 used.

MAGNETC RESONANCE IMAGING:

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 so clearly evident in these studies, cruciate, collateral and meniscal injuries accompanying plateau fractures are well visualized.

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 superseded arthrography.

ARTHROSCOPIC EXAMINA TION:

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

If an arthroscopic examination is to be done, a midline patellar tendon or a Para patellar portal on the side opposite the fracture is created to avoid the necessity of subsequently performing open reduction in the area of this portal.

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. High energy injuries, fracture dislocation patterns, unexplained compartment syndromes and Schatzker IV, V and VI fractures should increase the surgeon's threshold for obtaining an arteriogram as part of the preoperative evaluation.

MODALITIES OF TREATMENT OF TIBIAL PLATEAU FRACTURES:

I. Conservative[7]:

1. Closed reduction and POP cast application.
2. Skeletal traction and mobilization[8]
3. Functional Brace[9]

II. Surgical:

1. Percutaneous cancellous screw fixation[10].
2. ORIF with cancellous screws and Bone grafting.
3. ORIF with Buttress plate and screws.
4. ORIF with Buttress plate and screws and Bone grafting.
5. External fixator/ Hybrid external fixator/ Ilizarov ring fixator.
6. Arthroscopic assisted internal fixation[5].
7. MIPPO (Minimal Invasive Percutaneous Plate Osteosynthesis)

COMPLICATIONS OF TREATMENT OF

TIBIAL PLATEAU FRACTURES.

The complications occur by virtue of fracture and also after the treatment. Most of the complications are preventable. Preventive care begins with thorough examination of the injured limb. Important aspects to detect are the peripheral neuro vascular injures that may accompany with the upper tibial fractures, prompt treatment of these injuries usually takes precedence over definite fracture treatment and often prevent catastrophic complications.

A) Early Complications:

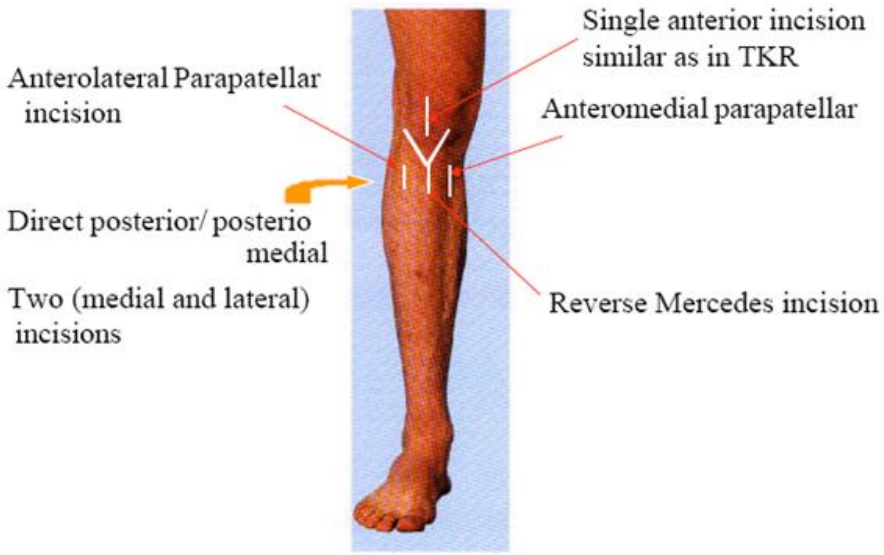
1. Bleeding
2. Wound infection /Dehiscence - Superficial or Deep
3. Sepsis
4. Compartment syndrome
5. Knee stiffness
6. Nerve Injury (Lateral popliteal N)
7. Vascular Injury (Anterior tibial A)
8. Loss of fracture reduction
9. Limb length discrepancy
10. Deep vein thrombosis

B) Late Complications:

1. Wound Infection
2. Knee stiffness
3. Malunion
4. Knee instability – varus/valgus/anterior/posterior
5. Extensor lag

6. Angular deformities
7. Persisting pain/swelling
8. Redepression
9. Refracture
10. Delayed union
11. Non-union

SURGICAL APPROACHES:



APPROACHES[11] :

Three surgical approaches for open reduction of lateral, medial and bicondylar fractures are described. The use of these exposures allows as much exposure of the articular surface and tibial shaft as is required 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.

APPROACH TO LATERAL TIBIAL PLATEAU:

A. 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 patella tendon. At the lateral edge of the patellar tendon the incision curves distally down the tibial shaft, 5 or 6cm. The skin incision may be readily extended down the tibial shaft if a long plate is required or a cortical 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 posteriorly is required the lateral collateral ligament is divided obliquely and is later resutured.

The meniscus has to be preserved or repaired whenever possible. Because of the value of the menisci in guiding pannus after fracture and it 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. The anterior compartment fascia is closed loosely to avoid problems associated with increasing anterior compartment pressure from postoperative swelling. Suction drainage of the knee decreases postoperative pain and swelling.

(b) Lateral Para patellar approach:

The advantage of the lateral parapatellar approach is that it could be incorporated later in a midline skin incision to accommodate late knee replacement. The disadvantage of such an approach is that it is often more difficult to expose the posterior aspect of the joint.

APPROACH TO THE MEDIAL TIBIAL PLATEAU:

(*a) Medial patellar approach:*

The landmarks are the patella, medial femoral condyle, tibial tubercle and tibiofemoral joint line. A skin incision is made beginning over the medial femoral condyle near the adductor tubercle and is extended obliquely anterodistally towards the patellar tendon and distally along the subcutaneous surface of the upper tibia. The knee joint is entered through a vertical Para patellar capsular incision centered on the joint line. To expose the tibial articular surface, the meniscotibial ligament is incised just distal to the meniscus. This is best accomplished with the knee in at least 90º of flexion to shift the tibial collateral ligament posteriorly. Valgus stress on the knee and retraction will then permit visualization of the medial tibial plateau and the medial meniscus.

If the posterior aspect of the medial plateau needs to be exposed, a vertical skin incision is made along the posterior border of the medial collateral ligament. The attachments of the semimembranosus along the upper tibial margin are released, leaving sufficient soft tissue for later resuturing. A vertical incision through the capsule posterior to the medial collateral ligaments is made, and the mensicotibial ligament is incised for articular exposure.

(b) Medial Para patellar approach:

This approach can be used for generous arthrotomy, these are especially useful when cruciate ligament repair or replantation of an avulsed intercondylar eminence is required.

Closure begins with suture of the meniscal margin to the coronary ligament then further closure is affected layer by layer. The capsule is closed and if a part of the semimembranosus has been released, it should be repaired strongly to preserve posteromedial instability.

(c) Approach to both tibial plateaus -THE MIDLINE APPROACH*:*

This approach provides an excellent access to the femoral condyles and tibial plateaus simultaneously. It gives access to plateaus, the intercondylar notch area and the cruciate ligaments.

The midline approach begins with a long vertical skin incision form above the suprapatellar pouch, curving slightly medial or lateral to the patella and then distally just lateral or medial to the tibial tubercle. The skin, subcutaneous and knee joint capsule are incised. For simultaneous and complete exposure of both the plateaus and intercondylar area, it is necessary to reflect the extensor mechanism proximally. If the tibial tubercle is to be osteotomized, it should be outlined by drill holes, and a substantial bone block should be removed with the patellar tendon insertion as suggested by Fernandez. Predrilling of the tubercle and the tibial bed should be accomplished before the fragment is loosened. The tubercle is raised from its bed, separating the patellar tendon from the capsule around the tendon margins to the inferior patellar pole. The infrapatellar fat pad is maintained with the reflected tendon. The menisci are mobilized in the inframeniscal interval. If the menisci are both divided near the anterior attachment, they can be reflected with the femoral condyles.

This approach gives excellent simultaneous exposure of the entire proximal tibial surface.

GENERAL TREATMENT PRINCIPLES OF SPECIFIC FRACTURES (BASED ON SCHATZKER CLASSIFICATION)

TYPE I:

A wedge or split fracture of the lateral plateau if displaced, represents an unstable joint and is an absolute indication for open reduction and internal fixation, preoperative MRI scan or an intraoperative arthroscopic evaluation is usually preferred. That fracture in which the lateral meniscus is intact, reduction is achieved by applying a varus force manually or alternatively by using a laterally based femoral retractor. Reduction is maintained by using percutaneous reduction clamps and fixation is accomplished with 2 or 3, 6.5mm or 7.00 mm cannulated cancellous screws inserted over guide wires perpendicular to the major lateral condylar fracture line with the help of C Arm image intensifier. Washers may be added if desired.

If a preoperative MRI study shows a peripheral meniscal tear or incarceration of the meniscus within the fracture line, or if closed reduction fails to compress the fracture line adequately, open reduction is recommended. If the fragment is unusually large or comminuted at its metaphyseal base, or if significant osteoporosis is present, a laterally based buttress plate should be used instead of solitary lag screw.

TYPE II

The type II injuries involve the combination of a lateral condyle fracture with depression of the lateral articular surface. Therefore, surgical treatment must address the impacted articular fragments when joint instability results. Preoperative evaluation is important to determine the degree and location of articular depression. These

fractures are best approached through a straight midline or lateral parapatellar sub meniscal approach. Elevation of the depressed articular surface can be accomplished through a cortical window or by breaking open the split lateral condyle with or without iliac bone grafting. Fixation of the condyle is then achieved with either lag screws or buttress plate.

TYPE III

The type III fracture is a pure depression fracture of the lateral plateau. The injury usually occurs in the older age group with osteoporotic bone and occurs after valgus stress. If the area of articular depression is small and the joint is stable, treatment is non-operative. However, if the joint is unstable in a physiologically young patient surgical treatment is usually indicated following preoperative CT or MRI scans. Traditional surgical management of type III Injuries includes standard lateral submeniscal approach, a cortical window, elevation of the articular surface and bone grafting. Other less invasive method of treatment is to visualize the articular surface directly with an arthroscope or indirectly using a C Arm intensifier. A small anterolateral incision is used to open a bone window of sufficient size to elevate and bone graft the plateau. Once the fracture is reduced, percutaneously placed 6.5mm or 7.0mm cancellous lag screw can be inserted parallel to the joint surface, immediately below the graft to prevent collapse.

TYPE IV

The type IV fractures are fractures of the medial plateau. These are usually caused by high energy trauma. Although injury to the bone may not appear to be severe, there is often significant soft tissue injury, leading to greater degree of knee instability. The fracture often includes the tibial eminence or tibial spine. It is often associated with knee dislocation and neurovascular injuries. MRI or arteriography

may be warranted based on the clinical examination. Non operative management of these injuries are associated with a high incidence of varus malunion. In patient with good bone stock or with little or no communication of fracture, closed reduction with valgus force and percutaneous cannulated cancellous screw fixation can be done. For unstable fracture with comminution, a medial Para patellar exposure is carried out and direct reduction of the fragment is achieved. Because of the large forces placed on the medial plateau, simple lag screw is insufficient and the injuries require a buttress plate. In cases in which the fragment is predominantly posterior, a second posteromedial incision may be necessary to achieve anatomical reduction if the intercondylar eminence with the attached cruciate ligament is avulsed, it should be reduced and fixed with a lag screw or loop of wire or suture and secured through drill holes in the anterior cortex.

TYPE V & VI

These are usually high velocity injuries caused by axial loading on an extended knee resulting in bicondylar fractures. These are often associated with ligament injuries or compartment syndrome. What differentiates the Type V from type VI fracture is that the type V fracture does not have metaphysio-diaphyseal dissociation. Because fractures involving both tibial plateaus are frequently comminuted and depressed, the true extent of displacement is best demonstrated on traction X-ray, CT scans or MRI images. Nonoperative management is seldom used as primary treatment because traction and casting do not consistently provide adequate support, and loss of reduction is common. However open reduction and internal fixation of bicondylar tibial plateau fractures through an extensive approach can be frustrating and humbling experience taught with many complications such as wound dehiscence and infection.

One of the most helpful methods is the use of indirect reduction techniques using one or two femoral distracters. Depending on the location of the joint depression or fracture comminution, the proximal tibia can be approached through a limited midline lateral or medial Para patellar incision. The articular surface is elevated from below using a cortical window and supported with a bone graft. After articular reconstruction and fixation with multiple cannulated screws, the condyle must be secured to the upper tibial metaphysis or shaft.

In patients with extensive comminution of the metaphyseal junction restoration of the correct mechanical axis can be difficult. In patients with good bone stock a lateral buttress plate with a small plate placed extra periosteally on the posteromedial tibial surface gives good results. As the severity of the soft tissue injury increases, even a lateral exposure and plating allay is ill advised. The approach for the management of these difficult injuries is hybrid external fixation with limited internal fixation, stable fixation can usually be achieved with the use of small tension wires proximally and half pins distally. A hybrid fixator can maintain length and alignment while spanning a hone of communication. The devices allow secondary correction of angular or rotational deformities. Finally the hybrid also allows early partial weight bearing and range of motion of the knee.

METHODOLOGY

The cases studied for this dissertation, THE SURGICAL MANAGEMENT OF TIBIAL PLATEAU FRACTURES USING BUTTRESS PLATING, were included from inpatients of SRI DEVARAJ URS MEDICAL COLLEGE, TAMAKA, KOLAR. The total number of cases studied was 20. With the youngest patient 26 years and oldest patient 60 years of age.

The intention of this dissertation was to study the surgical management of intraarticular fractures of proximal tibia to obtain a stable, pain free, mobile joint, to prevent the development of osteoarthritis and to correlate the radiological findings with the type of fracture and the functional end result.

Period of study – October 2009 to October 2011.

Inclusion Criteria:

a) Age: Patients above 18 years of either sex.

b) Closed and open tibia type I, II and IIIA fractures.

Exclusion Criteria:

a) Open type IIIB, IIIC fractures.

b) Pathological fractures.

As soon as the operation was planned, certain routine procedures were regularly followed.

1. Use of antibiotics pre-operatively and continued for a minimum of 3 days post-operatively.
2. Preparing the part for surgery.
3. Selection of proper size of buttress plate, condylar screws and cortical screws.
4. Assessment of the joint instability under anaesthesia.

5. To check for any associated fractures.
6. To verify if any other associated procedures might be required like bone grafting.
7. In our series, we have used image intensifier for all of the patients.

Out of 20 patients treated surgically, 7 patients were treated with buttress plate and screws, 9 patients were treated with bone grafting and buttress plate with screws, and 4 patients treated with MIPPO with buttress plate.

Whenever rigid internal fixation was achieved, the patient was mobilized after 48 hours after removal of the drains, for 2-5 days the range of motion allowed was 0-20°, from the 5th day the range of motion was gradually allowed to be increased to 90° or more. After suture removal, full range of movement was allowed.

Whenever there was doubt about the rigidity of fixation, external splinting in the form of plaster of paris slab was given for support. Range of motion exercises (CPM) were done daily under careful supervision and splint reapplied. All the patients were taught and advised to do static quadriceps exercises and dynamic exercises with a quadriceps board as much as possible and throughout the day.

Partial weight bearing was delayed until 6 – 8 weeks and full weight bearing allowed after 12-16 weeks. The best time for open reduction and internal fixation was within 4 hours of injury or 1 week after the injury, when the swelling and the inflammatory reactions have subsided.

Instruments and implants used in proximal tibial fractures:

The various instruments required are

1. Reduction clamps (pointed) for reducing the fracture site.
2. Periosteum elevator : for elevation of periosteum
3. Screw drivers for 4.5mm cortical screws 4mm and 6.5mm cancellous screws

(hexagonal drivers preferred).

4. Hand drill, power drill.
5. Drill bit of 3.2mm for drilling the bone
6. Tap of different sizes i.e., 4.5mm and 6.5mm tap.
7. Depth gauge for measuring the appropriate size of screws.
8. Bone grafting set with (mallet, osteotomes)
9. Bone impaction set

IMPLANTS:

CANCELLOUS BONE SCREWS:

1. 6.5 mm cancellous bone screw with 8mm spherical head and 3.5 mm hexagonal recess, thread length 16mm and 32mm in the partially threaded screws, with 4.5mm shaft, 3mm core, 3.2 mm drill bit and 6.5 mm tap.
2. 4.5 mm cortical bone screw, with 4.5mm shaft, 3mm core, 3.2mm drill bit and 4.5mm tap.
3. 4mm cancellous bone screw, with 6mm head, 2.5 mm hexagonal recess, core diameter 1.9mm, 1.7mm pitch, 2.5mm drill bit and 4mm tap.
4. K-wires

BUTTRESS PLATES:

T plate

L buttress plate with right and left offset.

OPERATIVE PROCEDURE

OPEN REDUCTION AND FIXATION OF TIBIAL PLATEAU FRACTURE

- Apply a tourniquet except in patients with severe soft-tissue injury.
- For fractures of the lateral condyle, make an anterolateral incision, starting 3 cm

above the patella proximally and extending distally below the inferior margin of the fracture site. This incision provides good exposure, while avoiding skin complications.

- Make the fascial incision parallel to the anterior border of the iliotibial tract. The plane of dissection over the anterior patella should be below the fascia, which supplies blood to the prepatellar skin. Do not undermine soft-tissue flaps more than necessary. If necessary for exposure, reflect a portion or all of the iliotibial band from its insertion on the Gerdy tubercle. Gain intraarticular exposure by incising the coronary or inframeniscotibial ligament, and retract the meniscus superiorly.
- Repair any meniscal tears to preserve as much of the menisci as possible.
- To expose the longitudinal fracture of the lateral condyle, strip the origin of the extensor muscles from the anterolateral aspect of the condyle through an incision shaped like an inverted L. Extend the horizontal limb of the incision laterally from the tibial tuberosity, and pass the vertical limb distally just lateral to the crest of the tibia as dictated by the shaft extension of the fracture. Reflect the muscle origin laterally until the fracture line is exposed.
- Retract the lateral fragment to gain access to the central part of the tibial condyle. This lateral fragment often hinges open like a book, exposing the depressed articular surface and cancellous bone of the central depression.
- Alternatively, make a cortical window below the area of depression to allow reduction of this fragment. This approach generally requires less soft-tissue dissection than hinging open the lateral condylar fragment.

- Insert a periosteal elevator well beneath the depressed articular fragments, and by slow and meticulous pressure elevate the articular fragments and compressed cancellous bone in one large mass (Fig. 51-65). This produces a large cavity in the metaphysis that must be filled with bone. Unless this is done, redisplacement and settling can occur. Various types of grafts have been proposed, from transverse cortical supports to full-thickness iliac grafts. We prefer packing cancellous bone into the defect because this much more nearly conforms to the defect cavity. Bone can be obtained from either the iliac crest or the lateral femoral condyle. We have found that cancellous grafts from the bone bank and hydroxyapatite bone graft substitute also are satisfactory.
- If the lateral femoral condyle is used, split it longitudinally, and elevate the synovium and periosteum over the lateral aspect of the condyle. Create a lateral cortical window, and with a curette remove an adequate amount of cancellous bone to fill the defect. Replace the lateral window, and close the synovium. After the cavity in the tibia beneath the elevated fragments has been filled with cancellous bone, pack the bone snugly using an inlay impactor. Replace the lateral tibial condylar fragment snugly to lock the articular fragments together. The lateral margin of the articular surface must be reduced under the femoral condyle for support.
- The standard lateral approach gives only a limited view of the posterolateral plateau and provides no access to the posterior wall of the lateral tibial plateau. Certain fractures located in the posterolateral plateau require a more extensile approach. In this situation, the fascial incision follows the insertion of the extensor muscles and continues over the subcapital fibula. The entire layer is

stripped distally as required. Expose the peroneal nerve, and cut the fibular neck with an oscillating saw. This allows retraction of the upper segment to the back or rotation of the fibular head upward, exposing the posterolateral plateau and the lateral and posterior flare of the proximal tibia.

- As the fragments are elevated and reduced, temporarily fix them with multiple small Kirschner wires.
- Apply a contoured T-buttress or L-buttress plate or hockey stick–shaped AO lateral tibial buttress plate for definitive fixation. This plate is applied to the anterolateral tibial condyle and contoured precisely to conform to the condyle and proximal metaphysis. When properly contoured, it is secured to the condyle with appropriate cancellous screws of sufficient length to engage the opposite medial cortex. Cortical screws (4.5-mm) are used to attach the plate to the shaft of the tibia.
- If the fracture consists of only one or two large fragments with little or no comminution and little central depression, use cancellous screws for fixation. If the lateral cortical bone is fragile and osteoporotic, place a washer to prevent the head of the screw from losing fixation. If a cancellous screw is used, it must be long enough to engage the cortex of the opposite condyle securely. Insert the pin or screw from the lateral side of the lateral fragment directly transverse to the longitudinal axis of the tibia and in a posterior and medial direction, catching the medial tibial cortex.
- If the meniscus has been detached peripherally, carefully suture it back to its coronary ligament attachment. If the iliotibial band has been reflected from its insertion at the Gerdy tubercle, reattach it.

- If displacement of the peripheral rim is slight, and central depression of the condyle is the main deformity, remove an anterior cortical window with its proximal edge about 1.3 cm distal to the articular surface.
- Insert a small thin osteotome or periosteal elevator through the window into the cancellous subchondral bone, and elevate to normal level the depressed fragments of the articular surface. Fill the defect with cancellous bone as just described.

PREOPERATIVE INSTRUCTIONS:

1. Consent of the patient for anaesthesia and surgery
2. NBM 8 hours prior to surgery
3. Injection TT 0.5cc IM stat
4. Preoperative antibiotic
5. Preparation of the parts for surgery

POST OPERATIVE INSTRUCTIONS:

1. BP and TPR hourly
2. Postoperative analgesia
3. To watch out for bleeding
4. Postoperative antibiotics for 7-10 days
5. Foot end elevation (as the surgeries are performed under spinal anaesthesia)
6. Postoperative X-ray preferably the next day.

GRADING OF RESULTS:

Criteria for evaluation of results:

A) Clinically - *Symptoms* - Pain/swelling

Stiffness

Disfigurement

Walking capacity

Signs – Tenderness

Deformity

Range of motion

Shortening

Stability

Radiological signs - Presence / Absence of callus

Alignment of Fracture angulation

CRITERIA FOR EVALUATION OF RESULTS OF POINTS[23]:

1. Pain :
    1) No pain - 6
    2) Occasional pain - 5
    3) Stabbing pain in certain position, Moderate pain-4
    4) Severe pain, constant pain around knee joint after activity - 2
    5) Night pain, at rest - 0
2. Walking capacity :
    1) Normal walking capacity in relation to age -6
    2) Walking capacity out doors for at least one hour-4
    3) Walking capacity outdoors > 15 minutes - 2
    4) Walking capacity - walking indoors only - 1
    5) Wheel chair bound / Bed ridden - 0

3. Extension of Leg (Extensor lag) :

    1) Normal extension – 6
    2) Lack of extension (0-10°) – 4
    3) Lack of extension (> 10°) – 2

4. Range of Motion:

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

5. Stability:

    1) Normal in extension & 20° flexion - 6
    2) Abnormal in 20° flexion - 5
    3) Unstable in Extension (> 10°) - 4
    4) Unstable in extension (> 10°) – 2

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

INSTRUMENTS

ORIF with BUTTRESS PLATE and SCREWS

Skin incision

Fracture Reduction and Contoured plate positioned

Fixed with screws in-situ

Wound closure

ORIF with BUTTRESS PLATE and BONE GRAFT

Skin incision

K-wire passed by hand drill

Bone graft from Ilium

Fixed with plate and screws

RESULTS

AGE DISTRIBUTION:

This study was done to find out the age incidence in our Indian set up and to know the type of fracture incidence and outcome as different age groups present and different response to fracture healing.

The tibial plateau fractures are commonly seen in the active and productive age group in our setup as they engage in more activities and travels. The type of fracture and fracture pattern depends on many factors like amount of force, age, degree of knee flexion, rate of loading of force, valgus/varus stresses, etc. The graph shows patient age groups versus number of cases.

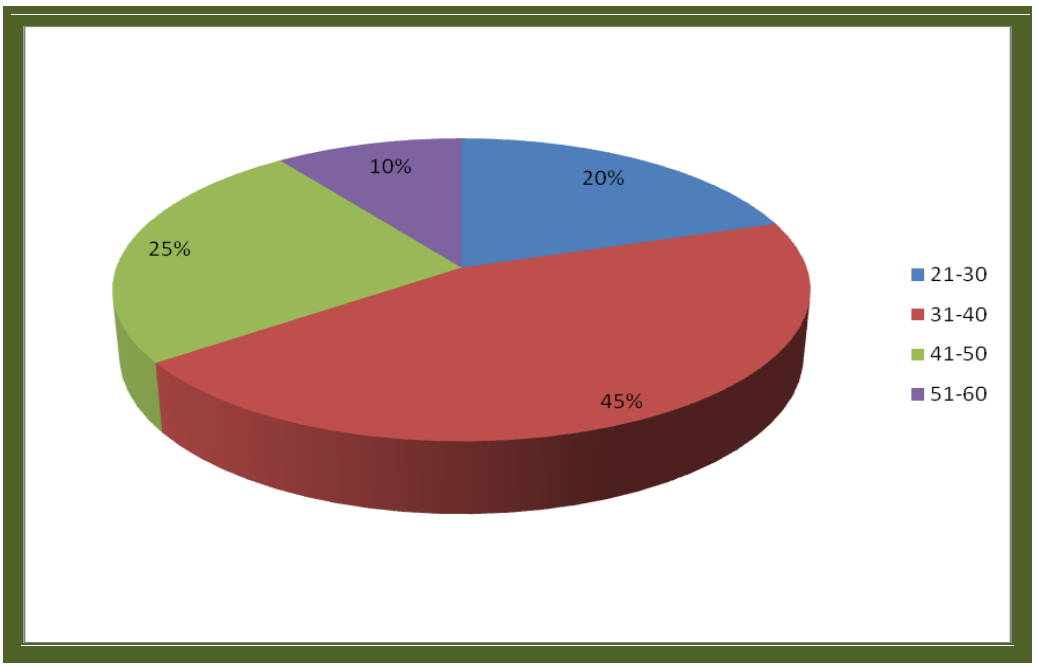
AGE DISTRIBUTION

TABLE – 1

Age in years	No. of cases	Percentage
21-30	4	20
31-40	9	45
41-50	5	25
51-60	2	10
Total	**20**	**100**

In our series, the majority of the patients are found to be between the age group of 31-40 years (9) and 41-50 years (5).

The least number of cases are found in the age group between 51-60.

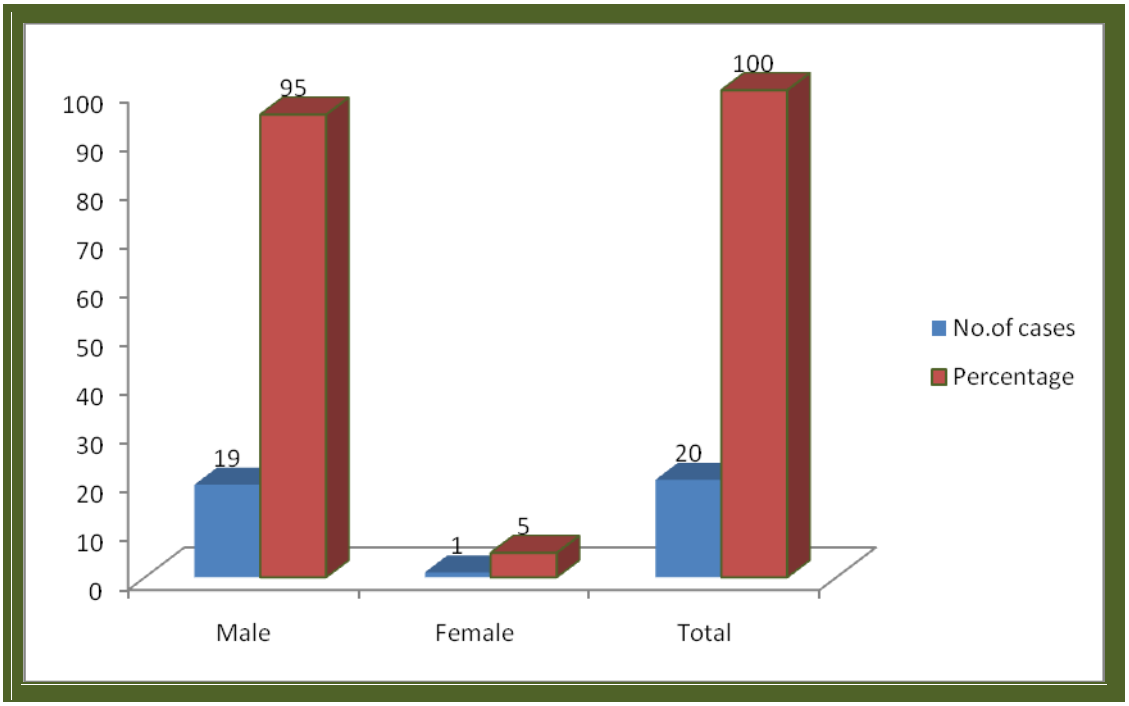


SEX INCIDENCE:

TABLE – 2

Sex	No. of cases	Percentage
Male	19	95
Female	1	5
Total	**20**	**100**

This incidence of sex in patients with upper tibial fractures can be attributed to an overwhelming large proportion of male patients, because in our Indian setup, the female population largely working indoors or in the agricultural fields and do not indulge themselves in travelling or out door activities.



OCCUPATION:

The relationship of fractures to different occupations is shown below.

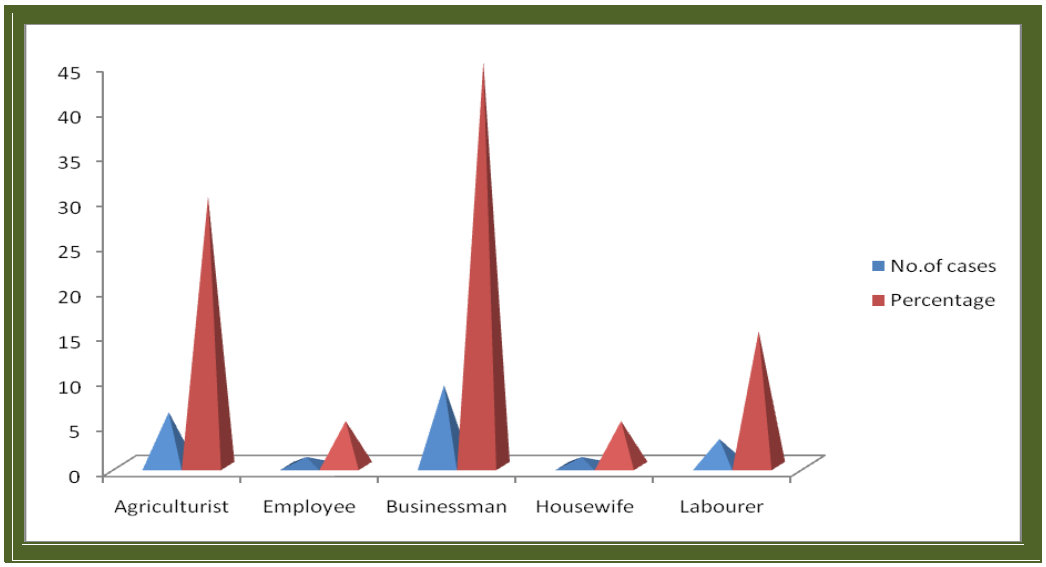
TABLE – 3

Occupation	No. of cases	Percentage
Agriculturist	6	30
Employee	1	5
Businessman	9	45
Housewife	1	5
Labourer	3	15
Total	**20**	**100**

The tabular column clearly shows that the major preponderance of upper tibial fracture is seen in people with a high level of activity, who indulge themselves in travelling like businessmen, because majority of the morbidity is due to R.T.A.

The groups like farmers, house wives and retired people have a comparatively lesser fracture rate as they do not travel very frequently, but if the farmer group were to sustain a fracture, it is mainly due to agricultural accidents and automobile accidents.

Workers and labourers tend to have violent injuries commonly due to industrial accidents, automobile accidents, housewives sustaining fractures through fall from height, when they climb up ladder or stool to pickup objects from the shelves.

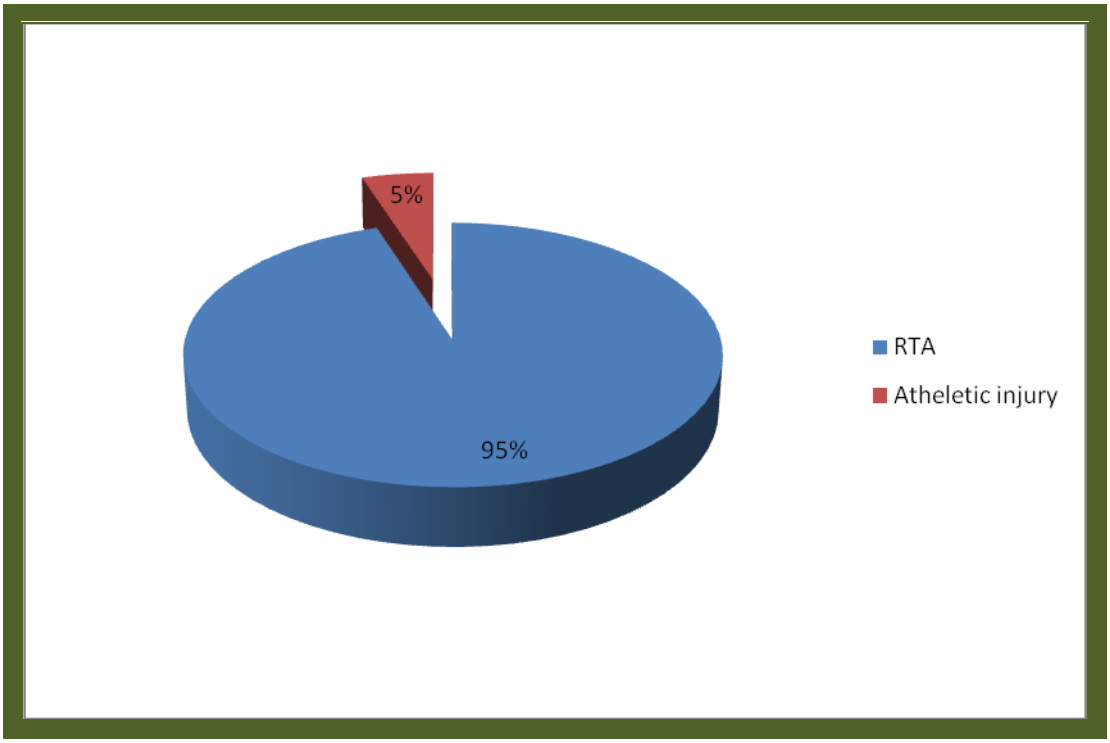


MODE OF VIOLENCE:

In this series, the majority of the patients treated are due to road traffic accidents or automobile accidents. Upto the extent of 75%.

TABLE – 4

Mode of violence	No.of cases	Percentage
RTA	19	95
Athletic injury	1	5
Total	**20**	**100**

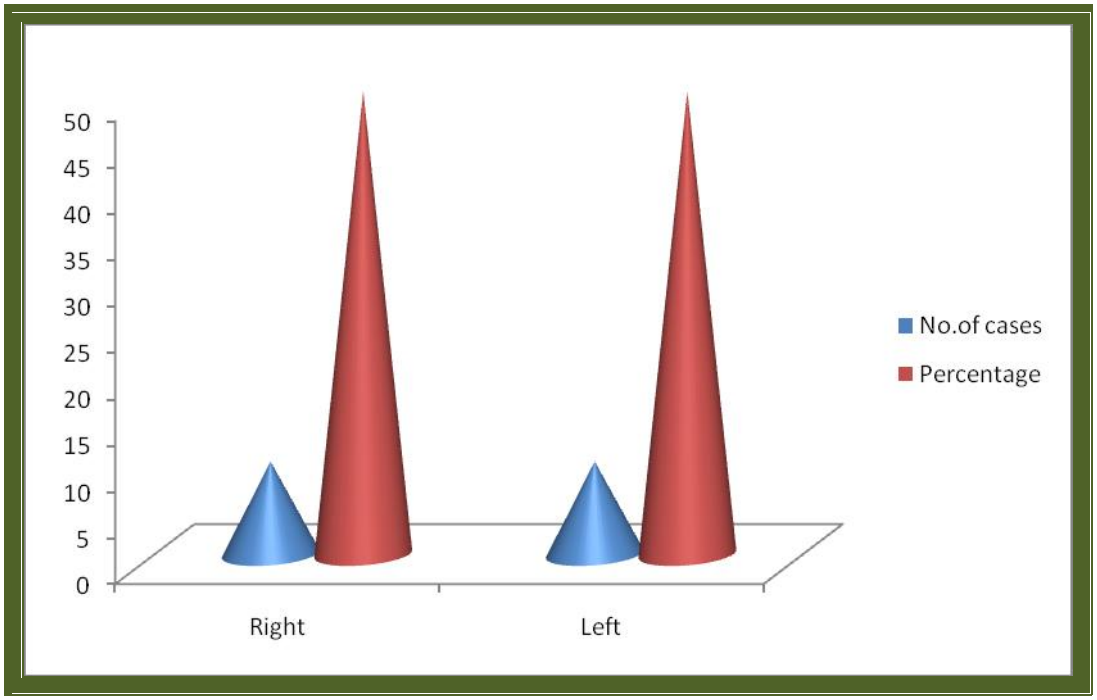


LATERALITY OF FRACTURES:

TABLE – 5

Laterality of fractures	No.of cases	Percentage
Right	10	50
Left	10	50

In our series, the laterality of fractures was equal.



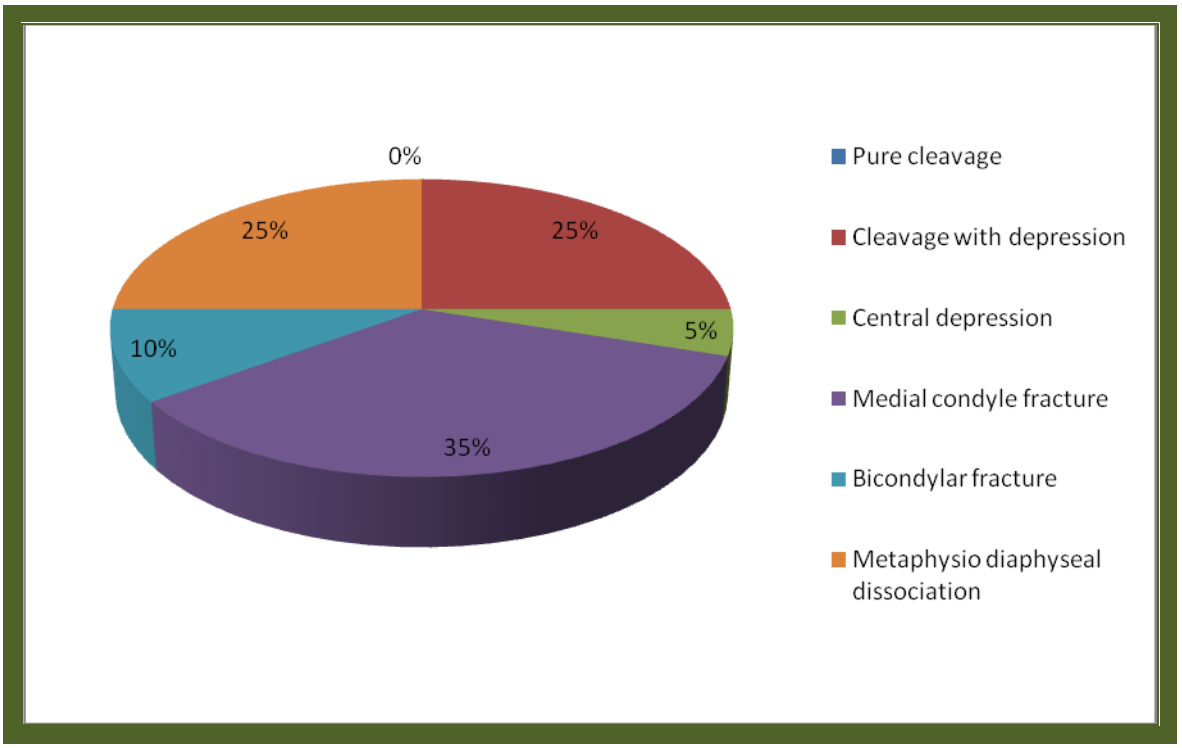
TYPE OF FRACTURE:

SCHATZKER'S CLASSIFICATION:

TABLE – 6

Type of fractures	No of Cases	%
Pure cleavage	0	0
Cleavage with depression	5	25
Central depression	1	5
Medial condyle fracture	7	35
Bicondylar fracture	2	10
Metaphysio diaphyseal dissociation	5	25

In our series, the majority of the fractures were found to be of type IV fracture i.e. Medial condyle fracture.

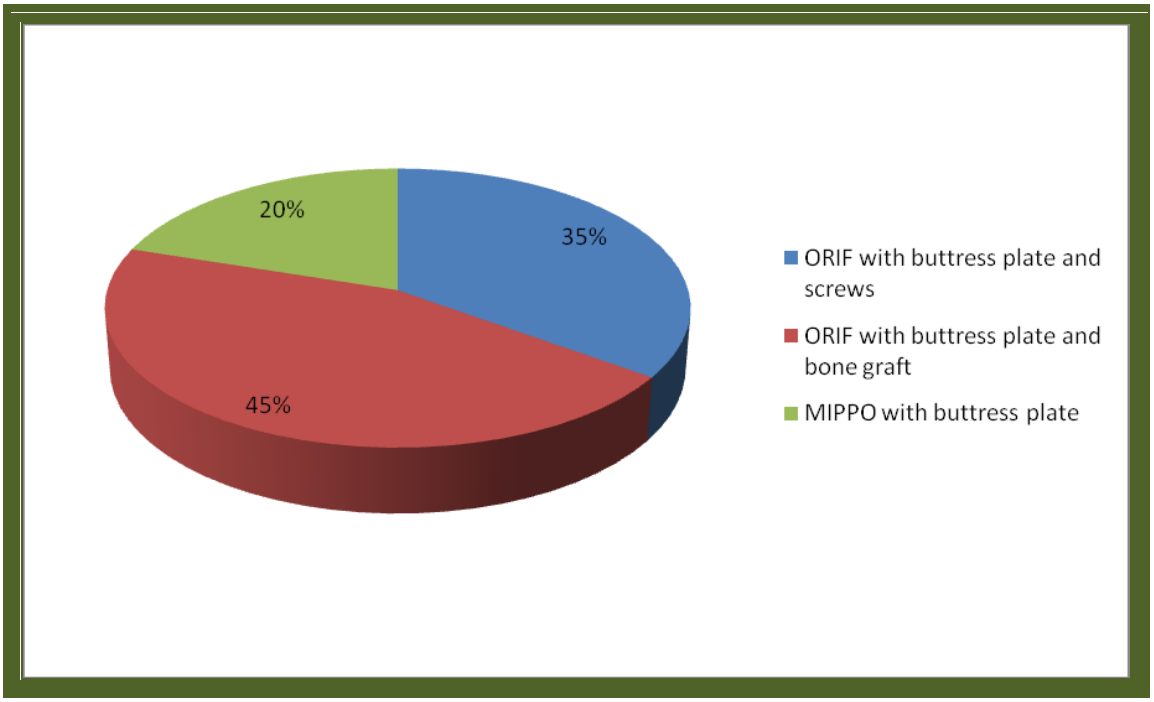


MEHODS OF TREATMENT:

TABLE – 7

Methods of treatment	No. of cases	Percentage
ORIF with buttress plate and screws	7	35
ORIF with buttress plate and bone graft	9	45
MIPPO with buttress plate	4	20

In our series, majority of the fractures were treated with ORIF with buttress plate and bone graft



PERIOD OF IMMOBILISATION:

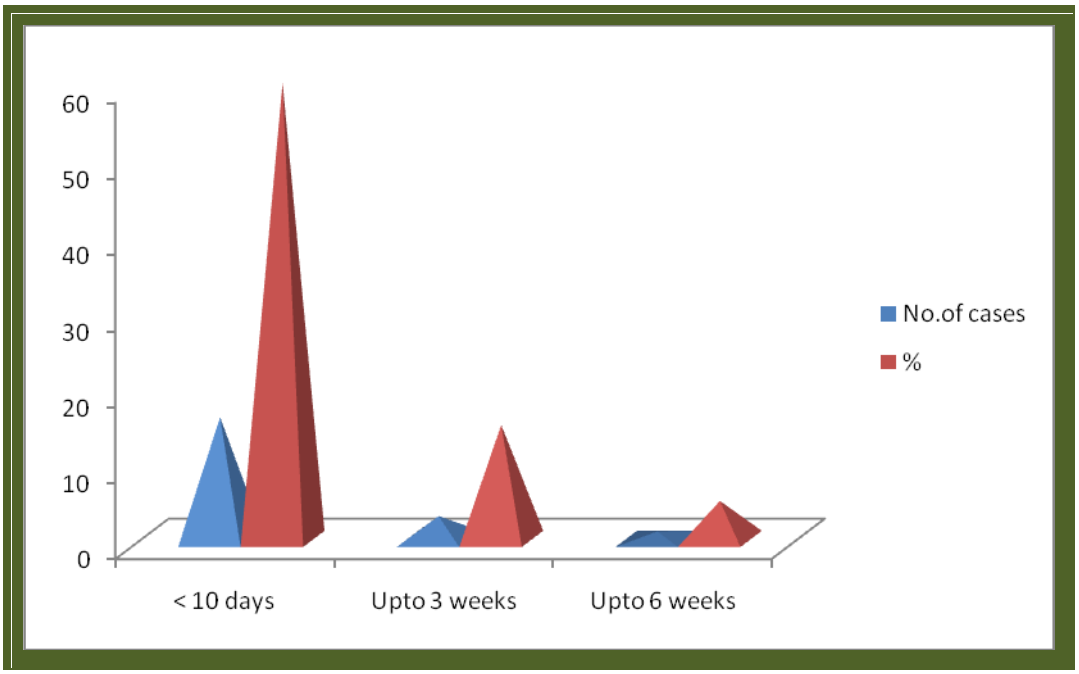
TABLE – 8

Period of immobilization	No. of cases	%
< 10 days	16	60
Upto 3 weeks	3	15
Upto 6 weeks	1	5

None of the patients were immobilized when secure, rigid fixation was done. When there was doubt about rigidity of fixation, associated ligament injury or osteoporosis the immobilization extended preferably in above knee cast upto 3 weeks.

One case of infection and severe metaphyseal comminution had to be immobilized for 6-8 weeks.

Most of the cases had good range of painless knee motion (0-130°), except for two patients developed knee stiffness.



ASSOCIATED INJURIES:

Bony injuries:

1) Ipsilateral femur shaft fracture – treated with intramedullary nail.
2) Contralateral elbow dislocation–closed reduction and POP cast application.
3) Ipsilateral supracondylar fracture femur–ORIF with LCP.
4) Head injuries (1) – Conservative.
5) Chest injury (rib fracture) (1) – Conservative.

All associated skeletal injuries are attended and given due care appropriately. Patient with ipsilateral supracondylar fracture femur has shown knee stiffness even at the end of complete follow-up. The 1 patient who presented with head injury was admitted in ICU initially and the patient who got operated 5-6 days later for tibial plateau fracture. All these associated fractures did not hamper the functional outcome of tibial plateau fracture much.

Ligament injuries:

1) Medial collateral ligament – one case was managed conservatively with cast immobilization.
2) Lateral collateral ligament – one case was managed conservatively with cast immobilization.
3) Anterior cruciate ligament – one case was operated for ACL reconstruction after 6 months of the definitive fracture surgery.

We did not come across any other ligament injuries around the knee joint.

TABLE-9

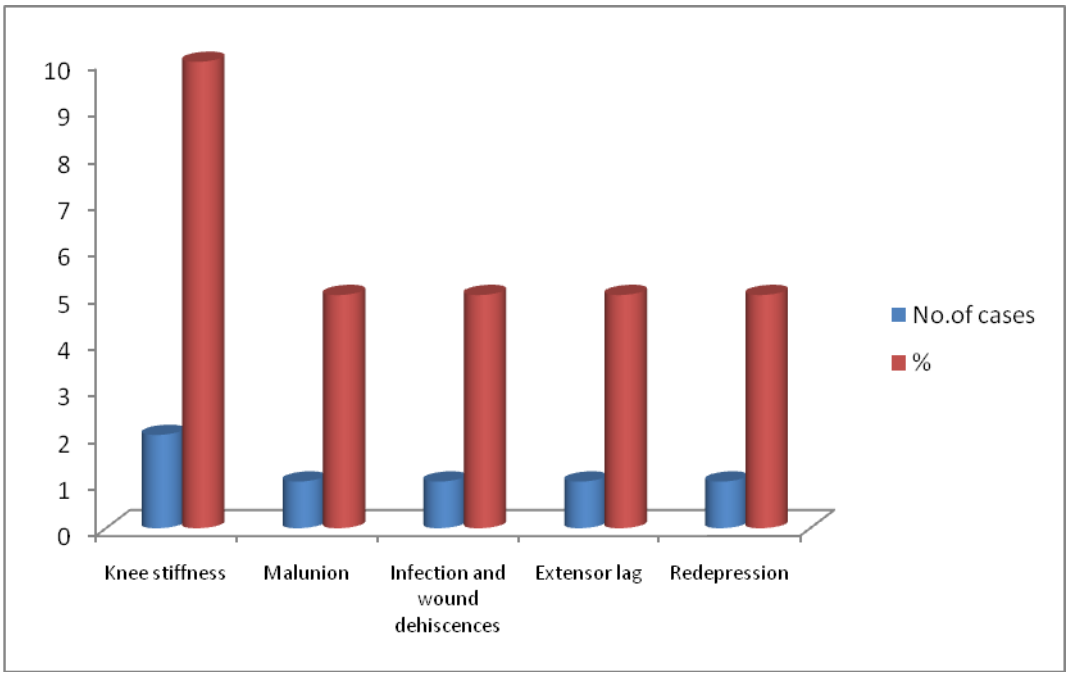
Ligament injuries	Number of cases	%
Medial collateral ligament	1	5
Lateral collateral ligament	1	5
Anterior cruciate ligament	1	5

COMPLICATIONS:

All fractures united within expected time. Not a single case of nonunion noted in our series. Average time for union was 14 weeks (range 10-22 weeks). One case of wound infection was also having stiffness of the knee joint.

TABLE – 10

Complications	No. of cases	%
Knee stiffness	2	10
Malunion	1	5
Infection and wound dehiscence	1	5
Extensor lag	1	5
Redepression	1	5

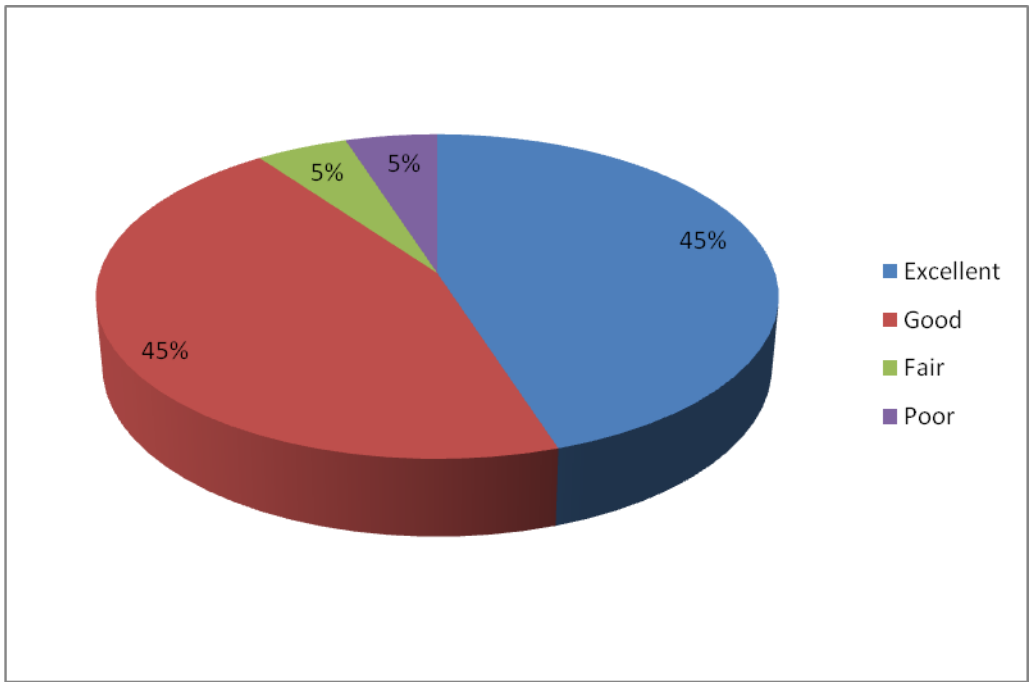


CLINICAL RESULTS:

TABLE – 11

Clinical results	No. of cases	Percentage
Excellent	9	45
Good	9	45
Fair	1	5
Poor	1	5

Out of 20 cases treated with surgical procedure, 9 cases gave excellent result, 9 cases came out with good result, fair in 1 case and 1 case of poor result, mainly due to the severity of the injury and infection. Retrospectively it was found that high velocity injuries (type IV – VI) have poorer outcome than low velocity injuries (type I-III)[41].



TYPE II: CLEAVAGE WITH DEPRESSION

Pre- OP

Immediate Post - Op

TYPE III : CENTRAL DEPRESSION

Pre-op (AP)

Pre-op (Lat)

ORIF with BUTTRESS PLATE and BONE GRAFT

3 Months later-Redepression

TYPE IV : MEDIAL CONDYLE FRACTURE

Pre-op

Immediate Post-op

ORIF with BUTTRESS PLATE

3 Months later

6 Months later

TYPE V : BICONDYLAR FRACTURE

Pre-op

Immediate Post-op

ORIF with BUTTRESS PLATE and SCREWS

3 Months later

6 Months later

TYPE VI : METAPHYSIO-DIAPHYSEAL DISSOCIATION

Pre-op

Immediate Post-op

ORIF with BUTTRESS PLATE and SCREWS

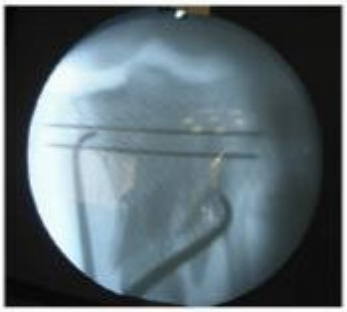
3 Months later

6 Months later

SEVERELY COMMINUTED FRACTURE

Pre-op (AP)

Pre-op (Lat)



STABLE FIXATION with LONG BUTTERSS PLATE

Post-op (AP)

Post-op (Lat)

CLINICAL FOLLOW-UP PHOTOGRAPHS

6 DAYS POST- OP

EXTENSION

FLEXION

6 MONTHS POST – OP

Full weight bearing

Full range flexion

3 MONTHS FOLLOW-UP

Extension

Flexion

Partial weight bearing

Sitting Crossed leg

6 MONTHS FOLLOW- UP

Flexion

Straight leg raising

Full weight bearing

Extension

DISCUSSION

Tibial plateau fractures, one of the commonest intra articular fractures, are major traumatic injury occurring as a result of RTA, fall from height, violence etc. It is sometimes associated with other bony or soft tissue injuries. Any fracture around the joint (especially weight bearing knee joint in the lower limb) is of paramount importance as would result in significant morbidity and quality of life. Hence the treatment of upper tibial fractures with intra articular extension has become a challenge for the orthopaedic surgeons.

Keeping our aims of the study at high, we presented the clinical study of surgical treatment of 20 tibial plateau fractures. The analysis of the results were made in terms of - age of the patient, sex distribution, occupation, mode of violence, laterality of the fracture, analysis of the types, modalities of treatment, complications, associated injuries and the functional outcome.

We have endeavored to present the various types of tibial plateau fractures in our Indian setup. It is found that the zeal for modernization, mechanization and industrial development made more automobile accidents due to increase in the number of population and automobiles.

The majority of fractures occur between the age of 20 and 60 years with maximum incidence being involving the productive age group 31-40 years (45%). Boune in 1981 also found that the majority of the patients are aged between 15-55 years with an average of 38.5 years, correlates well with the study. Seppo[32] also showed age incidence 20-60 years with an average of 39.8 years which correlates with the present study.

TABLE-12

Name of the authors	Year	Average age(yrs)
Bourne	1981	38.5
Seppo	1983	39.8
Our series	2011	39.6

In our series majority of the patients were males 95%. This can be attributed to our Indian setup where the female population largely work indoor or in agricultural fields and do not travel much. So the significant proportions of tibial plateau fractures related sex distribution were not available to comment on them.

Occupationally tibial plateau fractures were seen in people with high level of activity, movement and travel. It is most commonly seen with people who travel more like businessman, agriculturist. In our series majority were businessmen (45%), followed by agriculturist (30%), labourers (15%) and housewives (5%).

In our study the commonest mode of injury being the automobile accident (95%).

There was no difference in the laterality of the fracture. The right and left tibia affected equally.

In this series we studied 20 cases of simple tibial plateau fractures treated only by surgical methods. Different authors use different criteria for the surgical management of these fractures. Seppo E Honkonen conducted 130 tibial plateau fractures taking into consideration of

- Condylar widening of > 5mm
- Lateral condyle step off > 3mm
- All medial condylar fractures for the surgical management.

In our study, the indications for the surgery were the same standard indications as for the tibial plateau fractures. 3mm depression was considered as an indication for surgery in our series.[6]

Table-13

Name of the authors	Year	Amount of Depression
Burri[18]	1979	1mm
Hohl[21]	1979	5mm
David Segal[31]	1991	5mm
Seppo E.[32]	1993	3mm
Our series	**2011**	**3mm**

In our series, Schatzkar type II and type IV dominated the total fractures making 60%. It is also to be noted that bicondylar fracture was not that uncommon.

Table-14

Type of %	Tampere Hosp. Finald		Wellesley Hosp. Toronto[16]		University of ULM W -		Our series	
	No.	%	No	%	No	%	No	%
Type I	15	11.5	4	6	4	6	**0**	**0**
Type II	40	30.5	18	25	18	25	**5**	**25**
Type III	13	9.9	25	36	25	36	**1**	**5**
Type IV	12	9.2	7	10	7	10	**7**	**35**
Type V	18	21.3	2	3	2	3	**2**	**10**
Type VI	23	17.5	14	20	14	20	5	25

We have not formulated the stringent criteria as to particular method of fixation for particular type of fracture. So each case was individualized and treated accordingly as it needs. Most of the type VI, all patients of type V and type III were treated with ORIF with Buttress Plating and Bone Grafting.

Most of the patients with type IV were treated with ORIF with Buttress plating. Most of the patients with type II were treated with MIPPO with Buttress Plating.

All the medial plateau fractures were treated surgically as illustrated by Seppo E. in 1993. The patients with collateral ligament injuries were managed by POP cast immobilization for 3-4 weeks.[5,30]

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. Schatzker, Robert McBroom in 1978, Magonhobi, Steven and Gauscwitz in 1984 stated that the prognosis is given by the degree of displacement, type of fracture, method of treatment and quality of postoperative care.[16]

Patients in whom operation could not be carried out and in patients who have <3mm articular step off are treated conservatively which are not included in our study.

The major problem faced by us during the study was infection and wound dehiscence in one patient, hence immobilization was more in this patients. The infection might be attributed to nosocomial infection.

Inspite with all these associated bony fractures, ligament injuries and complications, we are able to achieve 45% excellent result 45% good results (overall 90% acceptable results) with our standard surgical care. In addition we have 5% fair and 5% poor results in terms of functional outcome. These results are comparable and on par with other documented standard studies.

Rambold 1992	-	93% acceptable
Seppo E. 1993	-	86% satisfactory
Joseph Schatzkar 1986	-	86% satisfactory
Our study 2011	-	**90% acceptable.**

Many centers have shown good results with arthroscopic assisted internal fixation[35], hybrid external fixator[1], minimal internal fixation supplemented with external fixation[34] and Ilizarov ring fixation. We have not employed any of these techniques though had satisfactory results with the standard conventional methods. Probably, if we were less invasive at surgery, still more rigid in fixation and further aggressive in physiotherapy, we would not even have these complications and at the same time achieving these goals much earlier.

CONCLUSION

- Tibial plateau fractures are increasing (especially the high velocity injuries) with the increase in automobile accidents.
- These fractures need optimum treatment as most of them involve the productive men.
- Preoperative soft tissue status and their repair at right time, significantly changes the outcome.
- Surgical treatment when indicated (particularly in depressed and displaced fractures) is advantageous to get a stable knee.

Hence, to conclude, the surgical management of tibial plateau fractures is challenging and gives excellent anatomical reduction & rigid fixation to restore articular congruity, facilitate early knee motion by reducing post-traumatic osteoarthritis and thus achieving optimal knee function. In the background, it reminds us to remember the remarks given by Hohl at the presidential guest lecture at the Chicago Orthopaedic Society (1997). ***"These fractures are tough".***

SUMMARY

- We present a review of the surgical management of intra articular fractures of the proximal tibia in 20 cases.
- A review of the literature of the management of upper tibial fractures with special reference to surgical management has been presented.
- Tibial plateau fractures have a equal predominance of right side and left side i.e., 50% and 50% respectively.
- Automobile accidents or road traffic accidents appeared the commonest cause of tibial plateau fractures, i.e. 95%.
- Males are more prone for tibial plateau fractures, i.e. 95% in contrast to females 5%.
- Majority of the fractures were cleavage with depression (type-II), i.e. 25% and medial condyle fracture (type -IV), i.e. 35% in our series.
- The patients were admitted and operated within 2 or 5 days, or depending upon the wound status or general condition of the patient.
- Each case needs to be individualized and treated.
- All operated patients were mobilized postoperatively as soon as possible, mostly on the 3rd post-operative day, i.e. 80%.
- Partial weight bearing was allowed after 1.5 months or 6 weeks for all patients.
- Full weight bearing was allowed usually after 12 weeks (3 months).
- All fracture united well in time (before 6 months). No nonunion.
- Mode of violence, amount of force and direction of force, rate of loading, valgus and varus stresses, age, quality of bone, ligament injuries and instability influence fractures type, pattern, treatment and outcome of result.
- Infection plays a vital role in influencing the result of the surgical outcome i.e.

5%.

- Period of joint immobilization plays a major role in the end result, i.e. 10%.
- Rigid internal fixation is mandatory whenever possible.
- Excellent results were obtained in 45% of cases and good in 45% of cases.
- Depressed and split depressed fractures with 3mm were taken as borderline.
- Cleavage combined with depressed fractures or pure central depression fractures give excellent results with and internal fixation and bone grafting.
- A 10° increase in medial or lateral deviation of involved knee compared; was recorded as instability.
- Medial unicondylar fractures and medially tilted bicondylar fractures tend to redisplace in to varus, i.e. 5%.
- Valgus alignment of tibial plateau was tolerated well than varus alignment.
- Benefits of early motion have to be balanced with risk of fracture reduction, failure of internal fixation and compromised ligamentous and soft tissue healing.
- As the duration of study and follow up was short, it is difficult to comment about past-traumatic osteoarthritis. A longer follow up is required to comment on it.
- X-ray beam has to be tilted to 10°-15° while taking AP view in doubtful fractures and to know articular surface status.
- Meniscal tears if present can be diagnosed and repair or excision has to be done.
- Status of ligaments, soft tissues around the knee play a pivot role in the functional outcome, so has to documented and treated appropriately.

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ANNEXURE - I

PROFORMA

NAME :

I.P.NO. :

AGE & SEX : OCCUPATION : ADDRESS :

D.O.A. :

D.O.S :
D.O.D. :

PRESENTING COMPLAINT:

HOSPITAL:

Pain, swelling, loss of function, inability to bear

weight since---------- on right/left leg.

HISTORY OF THE INJURY:

1) Date & time of injury:

2) Place of accident : Indirect

3) Nature of violence Trivial

Direct - Stumbling -

Automobile accident Slipping - Twist

Fall from height - Twist

Assault - Missing steps –

Industrial Others

Valgus stress

Varus stress

Athletics

4) Any treatment received :

5) History of massage :

6) Pain : Site : - Onset : Sudden/Gradual

- Natural: continuous/Intermittent

Related to movements: Increased/Remaining same

7) Did patient able to walk soon after the injury (or) carried to hospital.

GENERAL PHYSICAL EXAMINATION:

1) Build & Nourishment : Obese, Moderate, Poor

2) Signs : Anemia, Jaundice, Clubbing, Cyanosis, Pallor

3) Lymphadenopathy : General/Local

4) Pulse :Rate

Rhythm

Volume

5) B.P. :

SYSTEMIC EXAMINATION:

CVS, RS, P/A, CNS

Other joint functions

LOCAL EXAMINATION: Right / Left Leg

INSPECTION:

A) Attitude / deformity

B) Abnormal Swelling - Site

Size

Shape

Extent

C) Shortening

D) Skin - Oedema, Ecchymosis, Bruise, Abrasions, Wasting

E) Popliteal Fossa:

F) Compound injury if any :

PALPATION:

A) Local tenderness

B) Bony irregularities

C) Abnormal Movements

D) Crepitus

E) Pain elicited by manipulation

F) Transmitted movements

G) Swelling

H) Valgus / Varus deformity

I) Instability

J) Ligament Injury

MEASUREMENT:

Shortening: Apparent

Real

COMPLICATIONS:

Associated Injury

Vascular Injury

Neurological Injury

Ligament Injury

MANAGEMENT: (RECEPTION AT CASUALITY)

FIRST AID, SLAB/CAST

TRACTION

ASSOCIATED INJURIES

INVESTIGATIONS:

1) Urine Albumin Sugar Micro

2) Blood Hb%

FBS

Blood Urea Blood grouping

3) E.C.G

4) X-ray of the Knee Anterior view with beam angled 10-15^{o}

Lateral View

Oblique view with leg in internal and external rotation

Stress X-ray.

5) X-RAY CHEST :

Report:

6) Arthroscopy :

7) Any Other :

TREATMENT:

RECEPTION IN CASUALTY Initial

treatment given

1) General conditions of the patient- fluids/blood

2) To the fracture- Manipulative reduction:

Attempted/unattempted

Pop immobilization: Duration:

3) Radiological Examination :

OPERATIVE TREATMENT

TIME BETWEEN INJURY AND OPERATION

1) Date and time of operation

2) Indication

3) Anaesthesia : Spinal : G/A

4) Tourniquet used (or) not

5) Approach

6) Operative findings

7) Type of plate / screw

8) Bone grafting : Yes / No

9) Any other problems encountered

10) Comments

POST OPERATIVE TREATMENT:

1) Antibiotics and Analgesics

2) Transfusions : Fluids Blood

3) Post - op : Limb position

4) External splint/ cast/ fixator Duration :

5) Check X-ray

Date:

Report:

6) Date of suture removal:

7) Active motion started on:

8) Partial weight bearing on:

9) Full weight bearing on:

COMPLICATIONS:

1) Intra operative - shock / any other complications

2) Post operative Sepsis

A) Early complications:

1. Bleeding
2. Wound infection /Dehiscence - Superficial or Deep
3. Sepsis
4. Compartment syndrome
5. Knee stiffness
6. Nerve Injury (Lateral popliteal. N)
7. Vascular Injury (Anterior tibial A)
8. Loss of fracture reduction
9. Limb length discrepancy
10. Deep vein thrombosis

B) Late Complications:

Wound Infection Knee stiffness Malunion

Knee instability – varus/valgus/anterior/posterior Extensor lag

Angular deformities

Persisting pain/swelling

Redepression Refracture

Delayed union Non-union

Assessment at the time of Discharge:

1) Wound
2) Range of movements
3) Shortening
4) Check X-ray Date : Report :
5) Any other complaints :
6) Advice given :

7) Discharged on :

FULLOW UP:

Clinical and Radiological Assessment

1 (6 weeks) :

2 (12-14 weeks) :

3 (6 months) :

CRITERIA FOR EVALUATION OF RESULTS BY POINTS (at the end of 6 months):

		Points
1.	Pain	
2.	Waking capacity	
3.	Extension of leg	
4.	Range of motion	
5.	Stability	
	Total score :	_____

ANNEXURE - II

CONSENT FORM FOR ANAESTHESIA / OPERATION Etc.

I .....Hosp. No.....in my full senses hereby give my complete consent for .....or any other procedure deemed fit which is a/and diagnostic procedure/biopsy/transfusion/operation to be performed on me/ my son/ my daughter/my ward .....age under any anaesthesia deemed fit. The nature and risks involved in the procedures have been explained to me to my satisfaction. For academic and scientific purpose the operation/procedure may be televised or photographed.

Date : Signature/Thumb Impression/

of the Patient/Guardian

Name

Designation : Guardian

Relationship

Full Address

KEY TO MASTER CHART

#	Fracture
ACL	Anterior cruciate ligament
BG	Bone graft
BP	Buttress plate
F`	Female
INF	Infection
L	Left
LCL	Lateral collateral ligament
M	Male
MCL	Medial collateral ligament
ORIF	Open reduction internal fixation
R	Right
RTA	Road traffic accident
STIFF	Knee stiffness

MASTER CHART

Sl. No.	Name	Age	Sex	IP No.	Occupation	Mode of injury	Laterality	Schatzkar # type	Treatment procedure	Associated injury	Immobilization period	Complication	Result outcome
1	Shivanna	38	M	521028	Farmer	RTA	L	II	MIPPO with BP	-	< 10 days	-	Good
2	Govindappa	46	M	534187	Business	RTA	L	II	ORIF with BP	-	< 10 days	-	Excellent
3	Govinda gowda	40	M	577350	Business	RTA	R	VI	ORIF with BP & BG	R # SHAFT FEMUR	6 weeks	INF	Poor
4	Babu	40	M	598653	Labourer	RTA	R	II	MIPPO with BP	LCL	< 10 days	-	Good
5	Munivenkata reddy	48	M	600467	Farmer	RTA	R	IV	ORIF with BP	-	< 10 days	-	Excellent
6	Srinivas	45	M	608043	Business	RTA	R	VI	ORIF with BP & BG	-	< 10 days	-	Excellent
7	Jaya.G	50	F	608213	House wife	RTA	L	VI	ORIF with BP & BG	R ELBOW DISLOCA	3 weeks	Extensor lag	Good
8	Nagaraja	26	M	610098	Labourer	RTA	L	V	ORIF with BP & BG	MCL	3 weeks	Varus	Good
9	Rama krishnappa	57	M	614654	Farmer	RTA	L	IV	ORIF with BP	-	< 10 days	-	Excellent
10	Rajesh	30	M	656623	Engineer	FALL	L	IV	ORIF with BP & BG	ACL	3 weeks	STIFF	Good
11	Manoj	35	M	663142	Business	RTA	L	IV	ORIF with BP	-	< 10 days	-	Good
12	Yelappa	60	M	669999	Farmer	RTA	L	IV	MIPPO with BP	-	< 10 days	-	Excellent
13	Shaffi	29	M	671214	Business	RTA	L	V	ORIF with BP & BG	-	< 10 days	-	Excellent
14	vijay	38	M	673124	Labourer	RTA	R	IV	ORIF with BP	-	< 10 days	-	Good
15	Markondappa	40	M	692668	Farmer	RTA	R	IV	ORIF with BP	-	< 10 days	-	Excellent
16	Ashwath Narayan swammy	36	M	694834	Business	RTA	R	II	ORIF with BP & BG	R # SC FEMUR	< 10 days	STIFF	Fair
17	Narayan swamy	33	M	715705	Teacher	RTA	L	VI	ORIF with BP	-	< 10 days	-	Excellent
18	Subba reddy	45	M	716683	Farmer	FALL	R	III	ORIF with BP & BG	-	< 10 days	Redepression	Good
19	Krishna gowda	26	M	717290	Business	RTA	R	II	MIPPO with BP	-	< 10 days	-	Good
20	Amaranth reddy	31	M	719649	Business	RTA	R	VI	ORIF with BP & BG	-	< 10 days	-	Excellent