"ARTHROSCOPIC ASSISTED MANAGEMENT OF TIBIAL PLATEAU FRACTURES"

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GOVT MOHAN KUMARAMANGALAM MEDICAL COLLEGE

THE TAMILNADU DR. M.G.R MEDICAL UNIVERSITY

CHENNAI, INDIA

MAY 2020

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LIST OF ABBREVIATIONS USED

ACL	Anterior cruciate ligament
PCL	Posterior cruciate ligament
MCL	Medial collateral ligament
LCL	Lateral collateral ligament
ALL	Anterolateral ligament
ORIF	Open reduction and internal fixation
ARIF/AATPF	Arthroscopic reduction and internal fixation
pTSA	Posterior tibial plateau angle
mTPA	Medial tibial plateau angle
AO	Arbeitsgemeinschaft für Osteosynthesefragen
RF probe	Radiofrequency thermal probe
MIO/MIPPO	Minimally invasive osteosynthesis/ minimally invasive percutaneous plate osteosynthesis

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ABSTRACT

BACKGROUND:

Management of Tibial plateau fractures had witnessed tremendous improvement in surgical techniques over the past decades. The present literature supports that absolute anatomical reduction and stable fixation of peri articular fractures followed by early post-operative rehabilitation. If this is achieved by minimal damage to soft tissue the results are much better. In our study it is achieved by Arthroscopic assistance. Concomitant injuries to the ligaments meniscus & articular cartilage were also treated.

MATERIALS AND METHODS:

It is a single centred prospective study between September 2017 and 2019 on 15 patients with Schatzker type I to IV tibial plateau fractures admitted in Government Mohan Kumaramangalam medical college, Salem. They are treated with arthroscopic reduction and internal fixation. Functional outcome was analysed using modified Rasmussen's clinical and radiological score.

RESULTS:

In our study most 80% were males injured on left side 69%. Most of them 53% were in age group of 30-40 years with RTA being the most common cause in 67%. Schatzker type II were the most common type of fractures about 47% followed by 27 % of type IV. Out of 15 cases 60% cases had associated injuries with ACL being the most common (38%) followed by lateral meniscus (31%). 57% of partial tear of ACL with laxity were treated by RF thermocoagulation. Intercondylar eminence fractures (14%) were treated with arthroscopic pull sutures. Meniscal balancing is done in most of the peripheral tears and repair was done in one case. Average time of fracture union is 9.46 weeks. Our study has overall radiological score of 92.5% and functional outcome score of 93.7%.

CONCLUSION:

Arthroscopic assisted tibial plateau fixation is excellent minimally invasive method for assessment and treatment of tibial plateau fractures. It is the treatment of choice for fractures with concomitant intra-articular injuries. It is best used for Schatzker type III fractures and is used as an adjuvant for types I II and IV. Experience in arthroscopy is essential to avoid complications.

KEY WORDS:

Knee arthroscopy, Tibial plateau fractures, Arthroscopic reduction and internal fixation, knee ligamentous and meniscal injury, intercondylar eminence fractures.

INTRODUCTION

Tibial plateau fractures are periarticular fractures occurring about 1-2 percent of overall long bone fractures. These fractures represent a wide spectrum of severity ranging from minimally displaced articular fractures that heal well with nonoperative treatment to high-energy comminuted fractures that present multiple challenges in management. Each type of fracture has its own mechanism of injury, morphology and prognosis after treatment. Meniscal tear, entrapment, ligament and bony avulsion injuries are the commonly associated injuries with tibial plateau fractures.

Traditionally these fractures were treated with cast immobilisation. After foundation of AO principles of fracture fixation, open reduction and internal fixation (ORIF) became a popular modality of treatment. At present, screws, plates, external fixators, and nails are all successfully used for treatment of tibial plateau fractures.

Mechanism of injury of each case has to be known to assess the fracture pattern. Detailed physical examination should be performed to rule out soft tissue injury, impending compartment syndrome and neurovascular injury.

Adequate imaging including x-rays, 3D computerized tomographic (CT) scans and MRI help to delineate the fracture personality classify and to make a surgical plan. Successful results depend on stable internal fixation with anatomical reduction of fracture, restoration of knee ligamentous stability with preservation of soft tissue. Moreover, good visualization of the articular joint surface with minimal dissection is necessary to achieve this goal. Sub-meniscal arthrotomy is traditionally done while doing open reduction and plating. Newer techniques and minimally invasive surgical approaches have revolutionized treatment for these injuries with the use of arthroscopy.

Arthroscopy-assisted tibial plateau fracture fixation is an emerging treatment option in Schatzker classification types I, II, III, and IV fractures. The option of minimally invasive techniques with use of percutaneous cannulated screw fixation, small fragment plates and buttress plates combined with the use of arthroscopy may allow evaluation of articular fracture reduction, address the meniscal and ligamentous injury, thereby eliminating the need for extensive or sub-meniscal arthrotomy. These patients have the advantage of early mobilisation and better functional and radiological outcome.

AIM OF THE STUDY

TO EVALUATE FUNCTIONAL OUTCOME OF ARTHROSCOPIC ASSISTED MANAGEMENT OF TIBIAL PLATEAU FRACTURES TREATED BY VARIOUS TECHNIQUES

HISTORY AND REVIEW OF LITERATURE

Cotton F.J. Berg R.[1] et al introduced tibial condyle fractures as bumper or fender fractures. Apley and Moore et al published the outcome of such patients treated by traction and immobilization. **Hohl M**[3] in 1956 proved that prolonged immobilization leads to joint stiffness and intra-articular adhesions. AO foundation in 1958 described that the surgical treatment with internal fixation was mandatory for tibial plateau fractures to achieve the primary four goals which are anatomical reduction of fractures through fracture fixation by absolute or relative stability by preservation of blood supply to soft tissue and bone by gentle reduction techniques allowing early safe mobilisation and fracture union.

Sarmiento in 1980s evaluated the complications of mal-alignment, incongruity and instability with conservative treatment of fractures. **Rasmussen**[5] in 1973 treated patients with traction, closed reduction and internal fixation using a wire. **Schatzker** et al. in 1979 achieved good results in cases treated with open reduction Internal fixation and with bone grafting[6]

Duparc and Ficat et. al. in their comparative study showed better results for surgical management than conservative management.

Thomas et. al used sub meniscal arthrotomy to expose and accurately reduce the fractures in the joint. They showed excellent results with this method. **Delamarter**[7] et. al studied the complications of infection and wound dehiscence on operating tibial plateau fractures associated with soft tissue injuries.

Jong-Keun O showed excellent results with MIPPO technique with LCP plates with added benefits of less incidence of infections, soft tissue damage and early fracture union. **Ballmer** et. al used small fragment implants and concluded that 3.5mm small fragment implants had advantage of atraumatic soft tissue dissection especially through MIPPO technique. **Koval** et al used fluoroscopy for tibial plateau fractures and reduced fractures by indirect techniques and showed excellent results.

Caspari et al and Jennings in 1980s were the first to describe the role of arthroscopy in tibial plateau fractures. **Lobenhoffer** et al suggested that fluoroscopy was equivalent to and easier than assessing fractures through arthroscopy.

Richard B[8] suggested the management of associated meniscal and ligament injuries in tibial plateau fractures. Arthroscopic visualisation of articular surface is of key importance. Falste and Jensen in 1990s described that meniscal incarceration is common in tibial plateau fractures and its management by arthroscopy. Lubowitz[11] et al 2006 had described various use of arthroscopy management in tibial plateau fractures like the use of interference screws in reduction of fractures and in 2013 had described various techniques in arthroscopic fixation of tibial spine fractures.

G Burdin[9] in 2013 suggests that arthroscopy is a tool in addition to fluoroscopy in the fixation of fractures and has described various techniques for all type of fractures including complex tibial plateau fractures.

Chan[13] et al had several short to medium term follow-up of cases and had suggested this as good method in simple tibial plateau fractures. Mushal[37] et al describes the role of arthroscopy and ligamentotaxis aiming device in elevating the depressed fractures through metaphyseal window.

Chan[52] et al suggested that arthroscopy is recommended for all tibial plateau fractures. They also described the advantage of loose body removal through this procedure. **Daniel M**[12] in 2017 described arthroscopic suture fixation of avulsed tibial spine by using pull through sutures from mid substance of ACL using cannulated drill bit insertion in tibia.

Kleanthisziogas[54] in 2017 described a new technique of balloon tibioplasty for elevation of type III fractures. **Yufu sun**[13] et al 2018 meta-analysis suggested a better outcome in use of arthroscopy than traditional open reduction in a comparative study.

APPLIED ANATOMY

Anatomy of the knee joint is necessary to diagnose and plan the management of fractures. Tibial plateau is defined as the area extending from articular surface up to the length corresponding to the maximum width of epiphysis[50].

KNEE JOINT

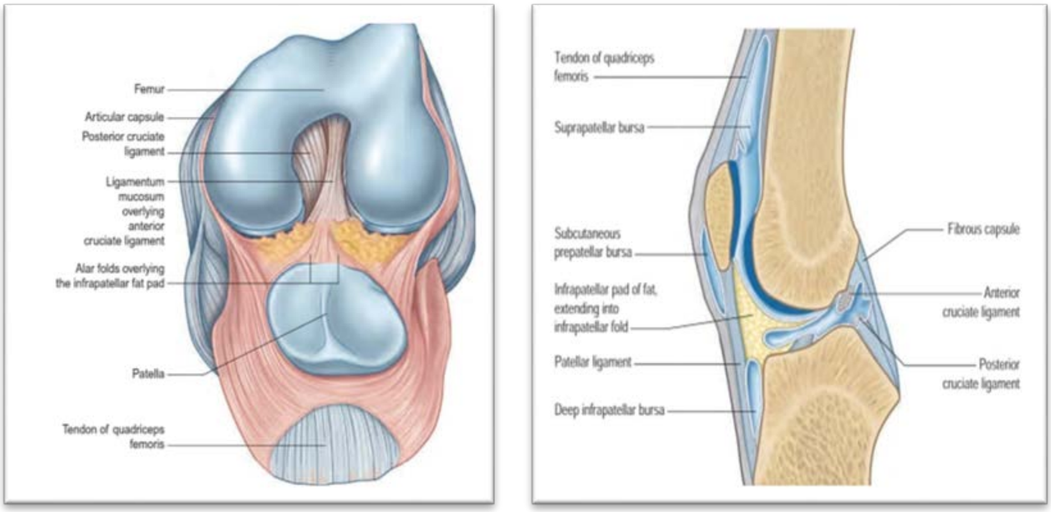


Fig 1 Anatomy of Knee Joint in Sagittal and in Full Flexion View

Knee joint is a modified hinge joint of synovial variety. It has three compartments, one saddle type of patellofemoral and two condylar type of tibiofemoral compartments. Cruciate and collateral ligaments are present connecting the tibia and femur with menisci present between the femoral condyle and tibial plateau.

MEDIAL TIBIAL CONDYLE

Medial tibial condyle articulates with the medial femoral condyle. The medial condyle of tibia is larger than and is distal compared to lateral plateau. Lateral articular surface is wider than medial. Its concave in coronal plane at the center and flat at the periphery. In sagittal plane medial plateau shows no concavity. Peripheral part of medial tibial condyle bears the medial meniscus. It has thick cartilage of 2-3mm and posterior slope of about 10 degree[50]. It bears about 50-60 percent of knees load. Medial tibial plateau is much stronger than the lateral. Therefore, incidence of fractures is much less comparatively and is mostly because of high velocity injury.

Table 1 -Comparison between Medial and Lateral Tibial Plateau

MEDIAL PLATEAU	LATERAL PLATEAU
Concave	Convex
Larger	Smaller
Cartilage thickness 2-3mm	Cartilage thickness 3-4mm
Posterior slope 10 degree	Posterior slope 7 degree

LATERAL TIBIAL CONDYLE

The lateral plateau is comparatively small convex and is elevated than the medial plateau. Its concave in sagittal plane and convex in coronal plane. Its covered by hyaline cartilage 3-4mm thick and has a posterior tibial slope of about 7 degrees. Lateral meniscus is present in the periphery. The poster inferior aspect of the lateral condyle has the tibio-fibular joint

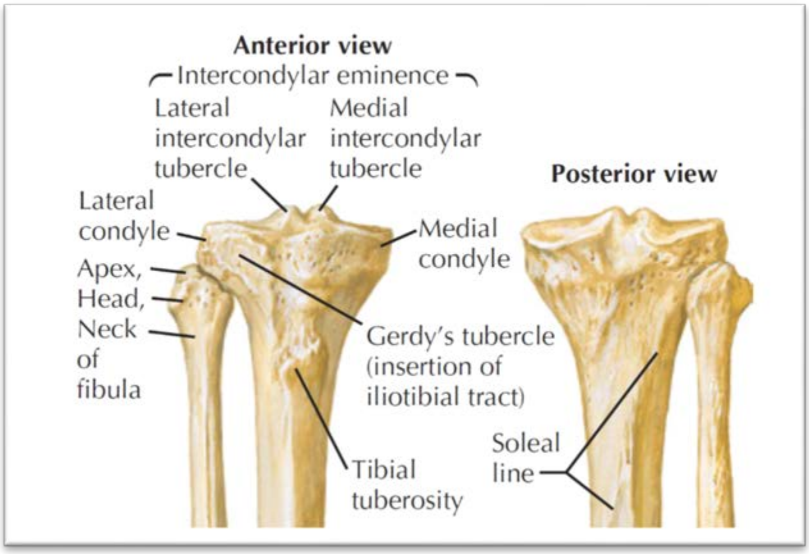


Fig 2 - Medial and Lateral Tibial Plateau

INTERCONDYLAR AREA

It is the area located in the middle of medial and lateral condyles of tibia. Following structures are attached in this area from anterior to posterior.

- Anterior horn of medial meniscus
- Anterior cruciate ligament
- Anterior horn of lateral meniscus
- Posterior horn of lateral meniscus
- Posterior horn of medial meniscus
- Posterior cruciate ligament

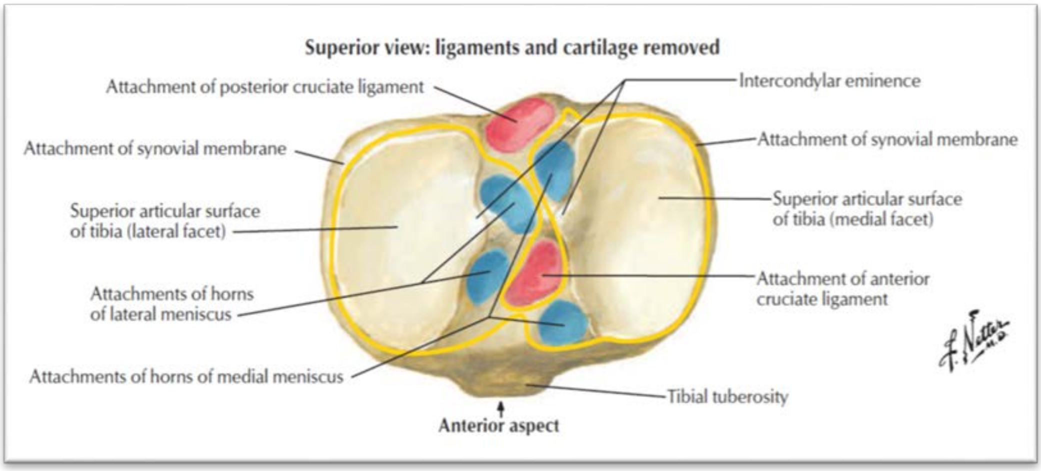


Fig 3 Structures in the intercondylar area

Intercondylar eminence composed of medial and lateral intercondylar tubercle. It is divided into anterior and posterior region. Anterior is the attachment for ACL foot print. Posteriorly the eminence is roughened depression for attachment of PCL.

The tibial tuberosity is located over the anterolateral aspect tibial crest about 1.5-2 cm below the anterior joint line. It provides the attachment for the patellar tendon. Tibial crest divides the tuberosity into a smooth upper portion providing attachment to ligamentum patella and rough lower portion which marks the epiphyseal line. The fibular head provides attachment to the fibular collateral ligament, anterolateral ligament and biceps tendon.

FEMORAL CONDYLE

Distal femur becomes trapezoidal in cross section towards knee. Medial condyle extends more distal than lateral. Posterior condyle of both condyles is posterior to posterior border of shaft. Anatomical axis of distal femur is 6-7 degree of valgus. In the axial plane lateral cortex slopes 10 degrees and medial cortex about 25 degrees.

PATELLA

It is a triangular sesamoid bone in anterior aspect of knee. The proximal portion is broad and forms the superior pole and the narrow apex forms the inferior pole. Patella is attached proximally by quadriceps tendon and distally by patellar tendon. These forms the main knee extensor components.

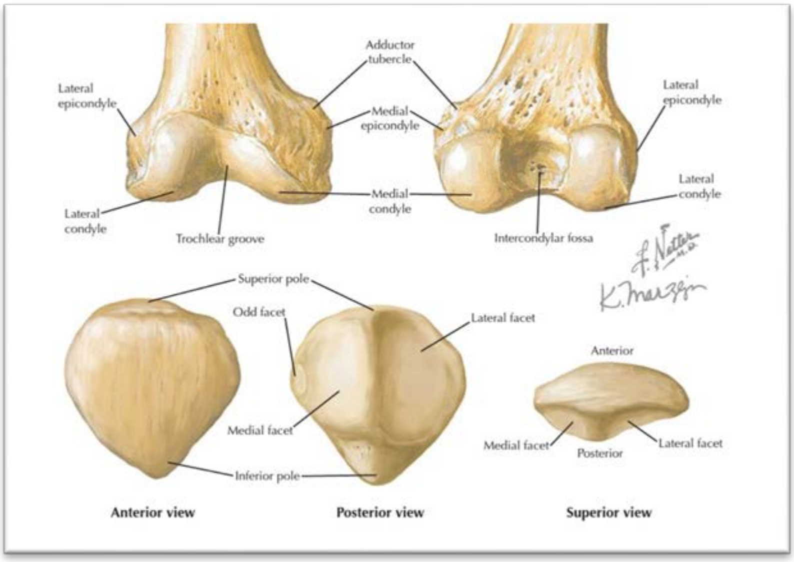


Fig 4. Distal femur and patella bony anatomy

LIGAMENTS OF KNEE JOINT

- **Cruciate ligaments**

1. Anterior Cruciate ligament

Anterior and posterior cruciate ligaments are the ligaments connecting the tibia to the femur in the knee joint. They lie within the capsule of the knee joint, covered by synovial membrane on their anterior and lateral aspect but is deficient in posterior aspect.

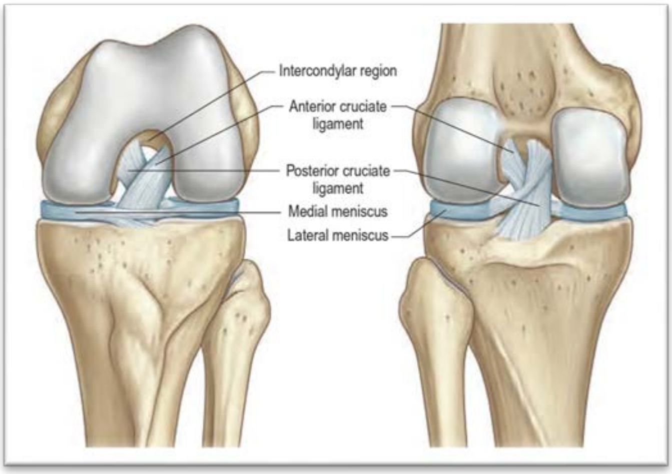


Fig 5Anterior and posterior cruciate ligament

It has two bundles Anteromedial (AM) & Posterolateral (PL) originating from lateral femoral condyle of which, Posterolateral bundle originates posterior and distal to Anteromedial bundle. It has broad and irregular insertion anteriorly in the intercondylar eminence, between attachments of anterior horns of both menisci. AM bundle is parallel in extension and loose in flexion the opposite for PL bundle. PL bundle prevents pivot shift of tibia. ACL receives its blood supply from middle geniculate artery. It had innervation from posterior articular branch of Tibial nerve. It contains mechanoreceptors. 90% of its fibers are made of COL 1. Native ACL has tensile strength about 2200-2400 N.

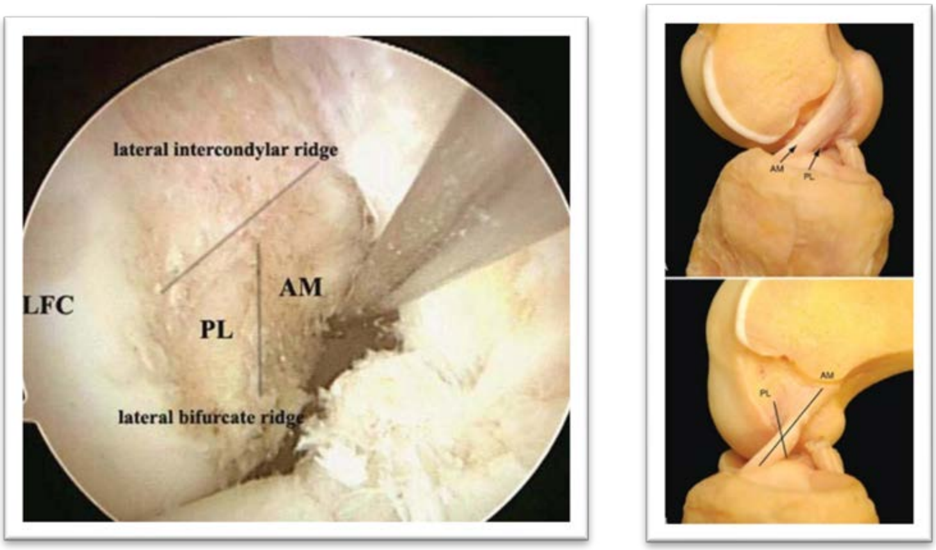


Fig 6 - Anteromedial and Posterolateral Bundle of ACL. Its origin and position in flexion and extension

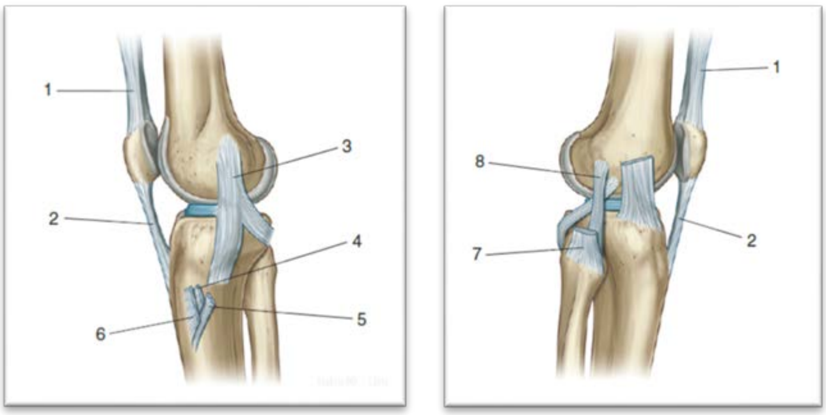
2. Posterior cruciate ligament (PCL)

The posterior cruciate ligament (PCL) is stronger and shorter ligament which prevents posterior translation of tibia. It originates from medial femoral condyle and is attached in the sulcus region on the posterior part of the intercondylar area of tibia. It has two bundles, short thick strong anterolateral bundle and long thin and comparatively weaker posteromedial bundle. From the posterior horn of lateral meniscus originates the meniscofemoral ligament of Humphrey which attaches anterior to PCL and Ligament of Wrisberg which attaches posterior to PCL. PCL is mainly supplied by middle geniculate artery. It has a strength of 2500 N against posterior translation.

➢ COLLATERAL LIGAMENTS OF KNEE JOINT

1. Medial Collateral Ligament (MCL)

MCL is a broad flat membranous band on medial side of the knee. It is attached proximally to the medial epicondyle of femur just below the adductor tubercle and inserts on the upper part of the medial surface of the tibia about 2-3cm distal to joint line. It represents the degenerated tendon of adductor magnus. It has superficial portion (Tibial collateral ligament) which is primary stabilizer to valgus in all angles and a deep portion (Medial capsular ligament) which acts as secondary restraints to valgus stress in full extension. It works in concert with ACL to provide restraint to axial rotation. Biomechanical strength is 4000N



1. Quadriceps tendon
2. Patellar tendon
3. Tibial collateral ligament
4. Gracilis tendon
5. Semitendinosus tendon
6. Sartorius tendon
7. Biceps femoris tendon
8. Fibular collateral ligament

Fig 7 - Medial and Lateral Collateral Ligaments

2. Lateral collateral ligament (LCL)

LCL is a tubular cord like structure present on the outer lateral aspect of knee. It is attached proximally to the lateral epicondyle of femur, posterior and proximal to popliteus insertion. It runs superficial to popliteus and inserts on the fibula, anterior to popliteo-fibular ligament. Greater part of its lateral surface is covered by biceps femoris whose insertion is separated into two tendons by LCL. It is tight in extension and lax in flexion. Its primary restraint to varus stress. Its strength is about 750 N.

➢ POSTEROLATERAL CORNER

Posterolateral corner structures include

- LCL
- Popliteus muscle and tendon
- Popliteo-fibular ligament
- Lateral capsule

Popliteus works synergistically with PCL to control external tibial rotation varus and posterior tibial translation.

➢ MEDIAL PATELO FEMORAL LIGAMENT

They provide resistant against lateral translation of patella from 0 to 30 degree of knee flexion. It is isometric between 0 to 90 degree. Femoral insertion is in the medial femoral condyle distal to adductor tubercle and proximal to MCL attachment. It is a fan like structure inserting at junction between proximal middle third of superomedial border of patella. Schottle point is radiographic landmark for its reconstruction

➢ ANTEROLATERAL LIGAMENT[19]

It originates from lateral femoral epicondyle and inserts midway between Gerdey's tubercle and head of fibula. Lateral inferior geniculate vessels contained between lateral meniscus and ALL at the level of joint line. It has no connections with Iliotibial band. Segond's fracture[19] is avulsion of ALL

Fig 8 Anterolateral Ligament

MENISCI (SEMILUNAR CARTILAGE)

These are wedge shaped crescentic laminae of collagenous fibrous cartilage that lie attached on either side of the tibial plateau. It is made up of Fibroelastic cartilage and COL 1. The resilience is because of high water content between the cells. It has radial and longitudinal fibers which help to dissipate hoop stress. It functions to optimize force transmission across knee joint to prevent direct damage to the articular cartilage by acting as a shock absorber. Meniscus deepens the tibial surface and acts as secondary stabilizer.

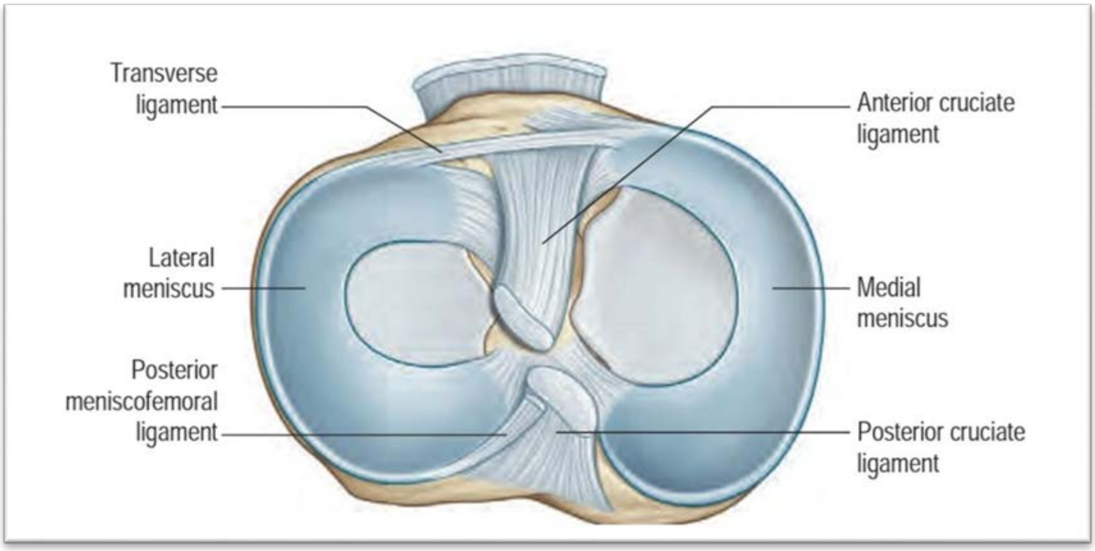


Fig 9 - Medial and Lateral Meniscus

Table 2 - Comparison between medial and lateral meniscus

MEDIAL MENISCUS	LATERAL MENISCUS
C-shaped	More circular
Posterior horn wider than Anterior	More or less equal width
Covers less of articular surface	Covers more of articular surface
Less mobile	More mobile
Bears equal joint reactive force as bone	Bears more joint reactive force

The Medial meniscus is C shaped structure with triangular cross section. Its anterior horn is attached to the anterior intercondylar area in front of the ACL insertion and its posterior horn is attached in front of the PCL insertion. It is intimately attached to MCL making it less mobile and more rigid comparatively. Hence it is the most commonly injured meniscus along with MCL tear. It bears equal joint reactive force as a bone.

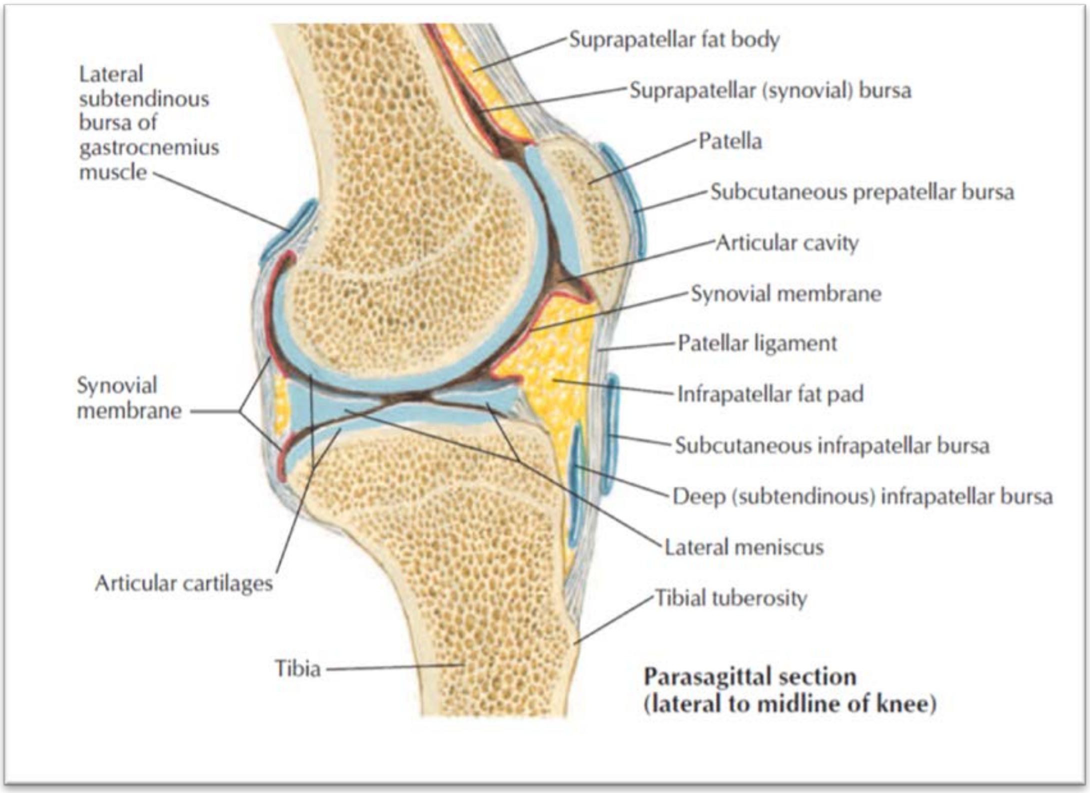


Fig 10 - Sagittal View of Lateral Meniscus

The lateral meniscus is uniformly circular throughout its width unlike medial meniscus which is broad posteriorly. Its anterior horn is attached in the anterior intercondylar eminence of tibia behind the ACL insertion whereas the posterior horn is attached in front of the posterior horn of the medial meniscus. The lateral meniscus covers more surface area of articular surface. Its attached to PCL via ligaments of Humphry (Anterior) and ligament of Wrisberg (posterior). It has no attachment to Lateral collateral ligament or the capsule making it more mobile. It bears more joint reactive force.

Menisco-tibial ligaments are incised horizontally while performing sub meniscal arthrotomy and it must be repaired to avoid an iatrogenic peripheral meniscal detachment. Outer edge of both menisci is attached to tibia by short coronary ligaments. Blood flows only to outer edges from small arteries around the joint. Thus, poor blood supply in the inner zone makes it difficult to repair.

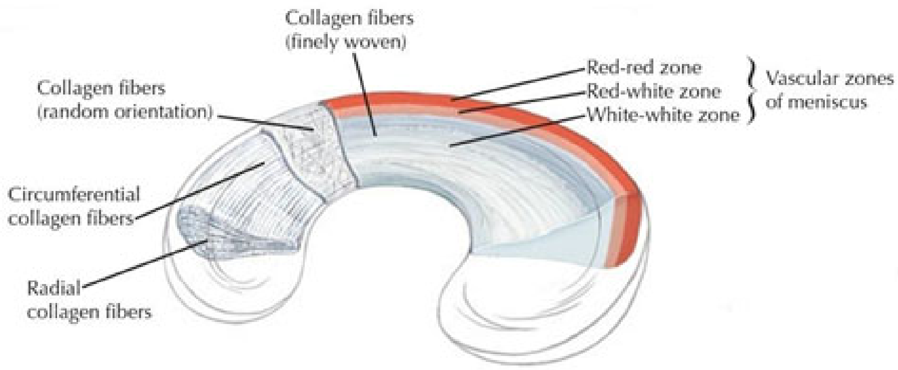


Fig 11 - Internal Architecture of Meniscus

KNEE ARTICULAR CAPSULE

The knee capsule is made up of inner synovial membrane and outer fibrous membrane. Anteriorly synovium's reflection is attached few centimeters above the articular margins of the femur. Infrapatellar fat pad is inserted below the patella between the two membranes. Posteriorly its attached at the cartilaginous margin of the condyles. It is separated from the capsule by popliteus muscle posteriorly and both the cruciate ligaments.

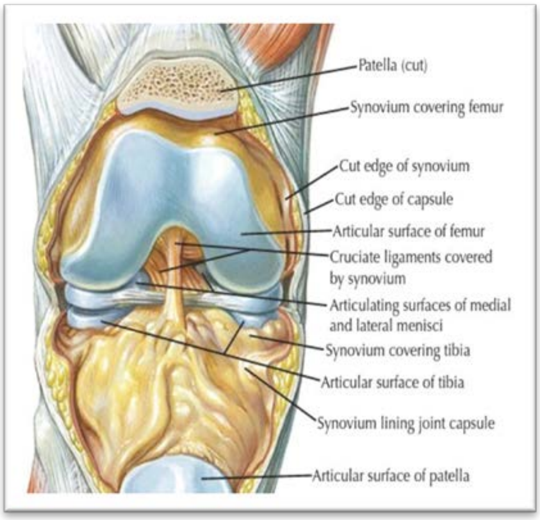


Fig 12 Synovial Membranes reflection and attachment

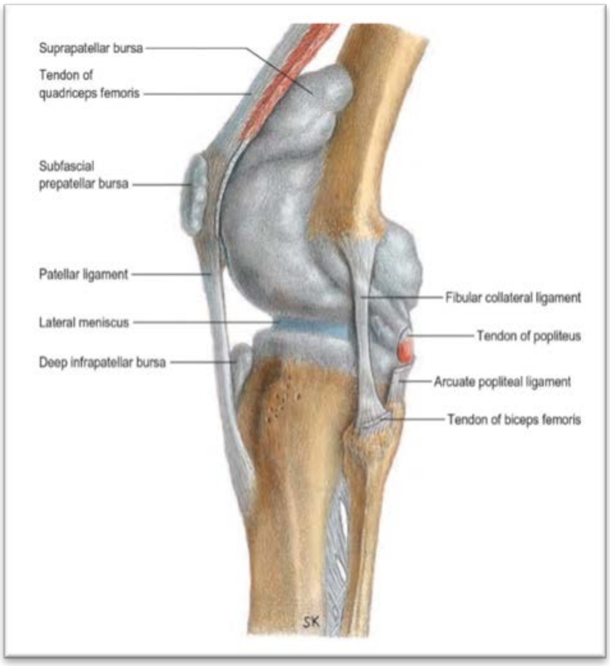


Fig 13 Burse Around the knee joint

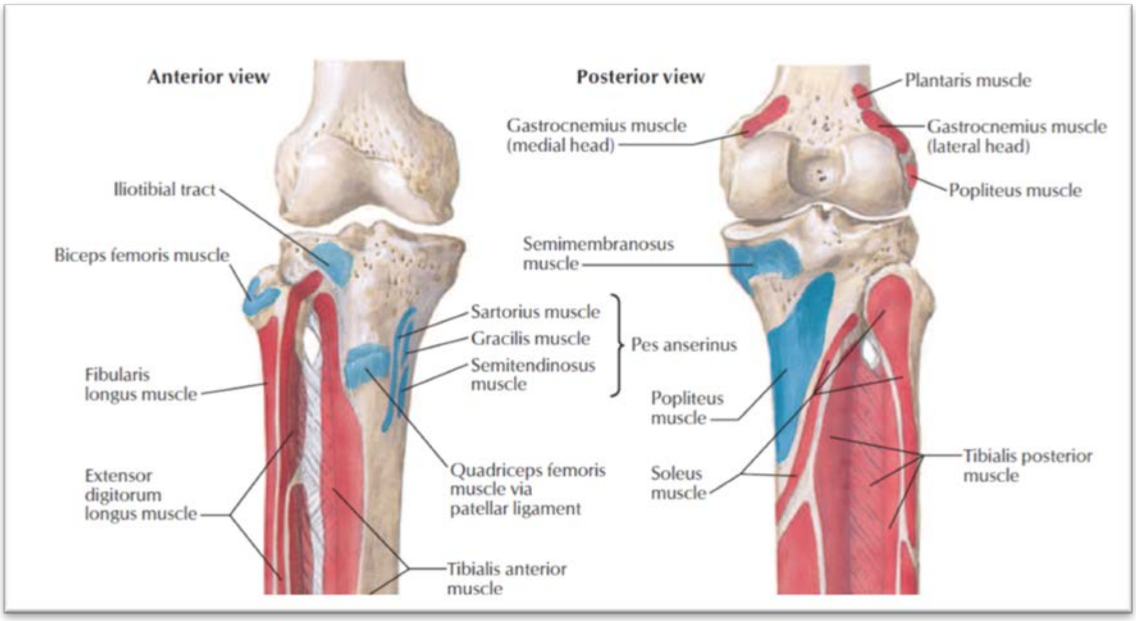


Fig 14 Muscles around the knee joint

BLOOD SUPPLY OF THE KNEEJOINT

Femoral and popliteal arteries genicular branches form a rich anastomosis around knee. Following are the main arteries.

- Superior genicular artery
- Medial genicular artery
- Lateral inferior geniculate artery
- Middle geniculate artery
- Anterior and posterior tibial recurrent arteries

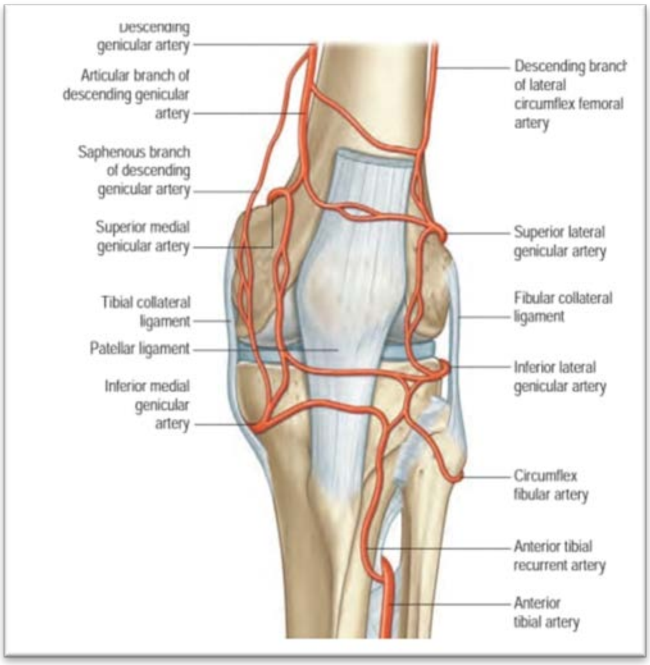


Fig 15 Blood Supply of Knee Joint

NERVE SUPPLY

According to Hilton's law, all three nerves supply the knee joint. Femoral nerve through its branches to vastus especially vastus medialis. Sciatic nerve through genicular branches of common peroneal nerve. Obturator nerve through its posterior division.

MATERIALS AND METHODOLOGY

STUDY CENTRE

Government Mohan Kumaramangalam medical college and hospital, Salem

DURATION OF THE STUDY

2 years between September 2017-2019

STUDY DESIGN

Prospective Study

SAMPLESIZE

20 patients

INCLUSION CRITERIA

- Schatzker Type I II III IV V Tibial plateau fractures
- Patients between 20 to 60 years of age

EXCLUSION CRITERIA

- Open Tibial plateau fractures
- Schatzker Type VI fractures
- Polytrauma patients
- Age more than 70yrs
- Patients declared unfit during surgery
- Patients with generalized ligamentous laxity

DATA COLLECTION AND METHODS

Documentation of history, clinical examination, plain radiographs and 3D CT scan is done. MRI scan is done if suspected ligamentous injury.

METHODOLOGY

Patients with selected tibial plateau fractures are assed and planned for arthroscopy assisted tibial plateau fixation using minimally invasive techniques. Fracture reduction checked under arthroscopy and fluoroscopy. Cases were followed and evaluated using Rasmussen's radiological and functional score.

STUDY PROTOCOL

Patient admitted to GMKMCH with Closed Tibial plateau fractures

↓

History and clinical examination

↓

Treatment as per ATLS/TAEI protocol

↓

X Ray and 3D CT scan

↓

All patients with I II III IV Schatzker type were included in the study

↓

Above knee slab is applied until the patient is assessed for surgery

↓

Diagnostic Arthroscopy done

↓

Meniscal and ligamentous tear assessed and treated

↓

Acceptable fracture reduction achieved with help of minimally

↓

invasive reduction techniques.

↓

Reduction verified under arthroscopy and fluoroscopy

↓

Column specific fracture fixation done with cancellous screws and

↓

small fragment plates

↓

Post-operative X ray

↓

Follow-up and recording of radiological and functional outcome

MECHANISM OF INJURY

Automobile accident is one of the most frequently encountered direct mechanism of injury. Traditionally tibial plateau fractures have been called as bumpers fracture as this is commonly caused by the fenders of automobile. However, depending upon nature of injury trivial fall in old age to high velocity RTA, wide spectrum of fractures can occur around the tibia. Other common nature of injury occurs indirectly by ligamentous structures around the knee especially in athletics where the knee ten to twist tumble.

Split depression lateral plateau fractures are the most common type of fractures about 50-70%. Main reasons are because of physiological 5 to 7 degrees valgus alignment of knee[17] and also because, the direct hit is usually on the lateral side of the knee. When straight leg is subjected to valgus strain medial collateral ligament may tear or if intact it will act as a hinge for lateral tibial plateau fracture to occur. Adults with dense cancellous bone can withstand more compressive forces leading to isolated split fractures. Whereas in elderly patients with less dense cancellous bone, axial forces produce a pure depressed or split depressed fracture.

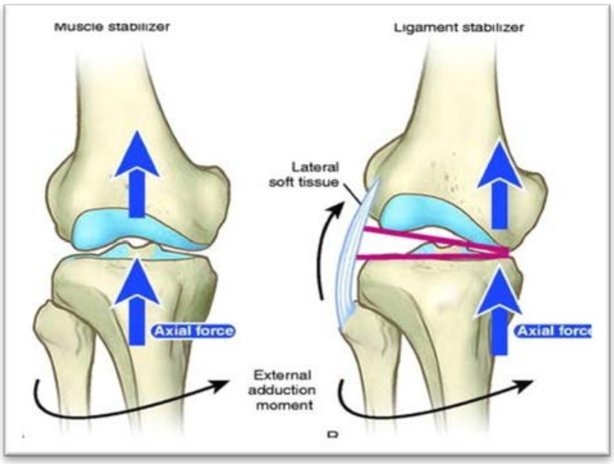


Fig 16 - Mechanism of displacement

Medial condyle of knee is large and concave, hence axial loads produce coronal plane split fragments particularly in posteromedial column. Whereas Lateral condyle is convex and axial loads produce comminution and joint widening.

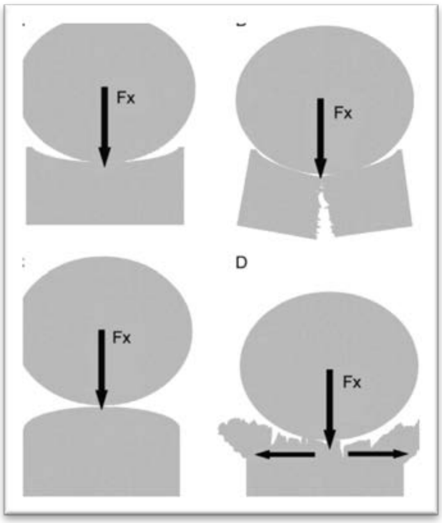


Fig 17 - Outcome of Axial Load in Lateral and Medial Condyles

Magnitude type and direction of force dictate the injury pattern. Axially loading forces are more rapid and release greater energy than angular force. Applied axial load with knee in specific position of flexion and extension determines the mechanism of injury along with coronal plane force of valgus and varus. It helps in determining the nature of injury and its impact on the tibial plateau. Injury mechanism is essential to plan column specific plate fixation. Parameters like posterior tibial slope angle (pTSA) and medial tibial plateau angle (mTPA) can be measured from the X ray and CT and injury mechanism is determined.[20]

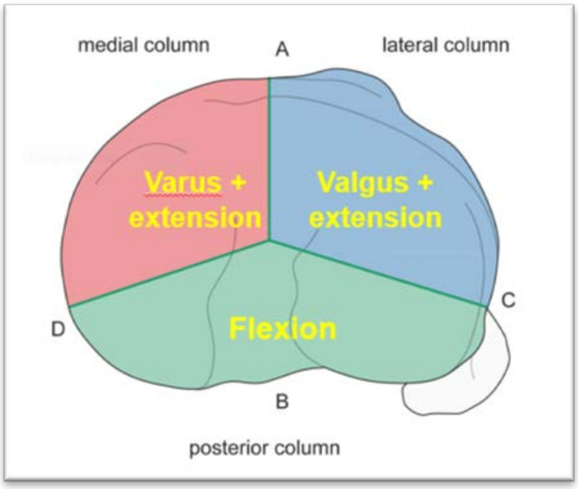


Fig 18 - Mechanism of Injury of Fractures in Each Column

Bicondylar fracture occurs when axial load predominates.[15] Axial force alone with knee in extension produces medial and lateral column fractures. In Flexion valgus pattern of injury Lateral and posterolateral columns are involved. Combination of flexion/extension with varus/valgus produces three column fractures. Posterior column fractures occur when the flexion of knee predominates. Knee flexion with varus and internal rotation produces poster medial fractures and with valgus produces poster lateral fractures.

ASSOCIATED INJURIES[19]

Among the various associated injuries, meniscus is the most common to be involved. Usually medial meniscus is commonly injured as it is firmly attached to MCL and joint capsule[21]. However, when associated with tibial plateau fractures, the prevalence of lateral meniscus tear is more especially in Schatzker type II fractures and medial meniscus tear is commonly involved in type IV fractures. Meniscus may also get incarcerated or get entrapped between the fracture. Types of meniscal tears and zones are necessary to determine the plan of management

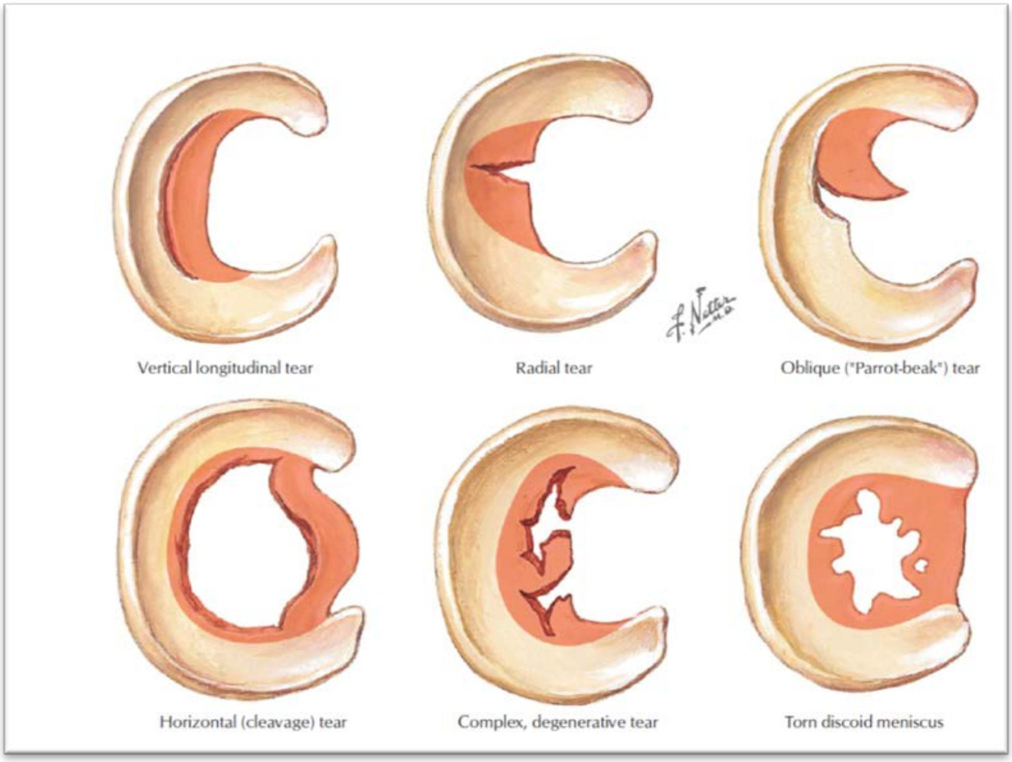


Fig 19 Types of Meniscal Tears

Ligament injuries[22] have been associated with tibial plateau fractures. In lateral tibial plateau fractures Tibial Collateral Ligament acts as a pivot in producing a split. However, in continuing forces it may also rupture. Likewise, Lateral collateral ligament may be injured in medial tibial plateau fractures.

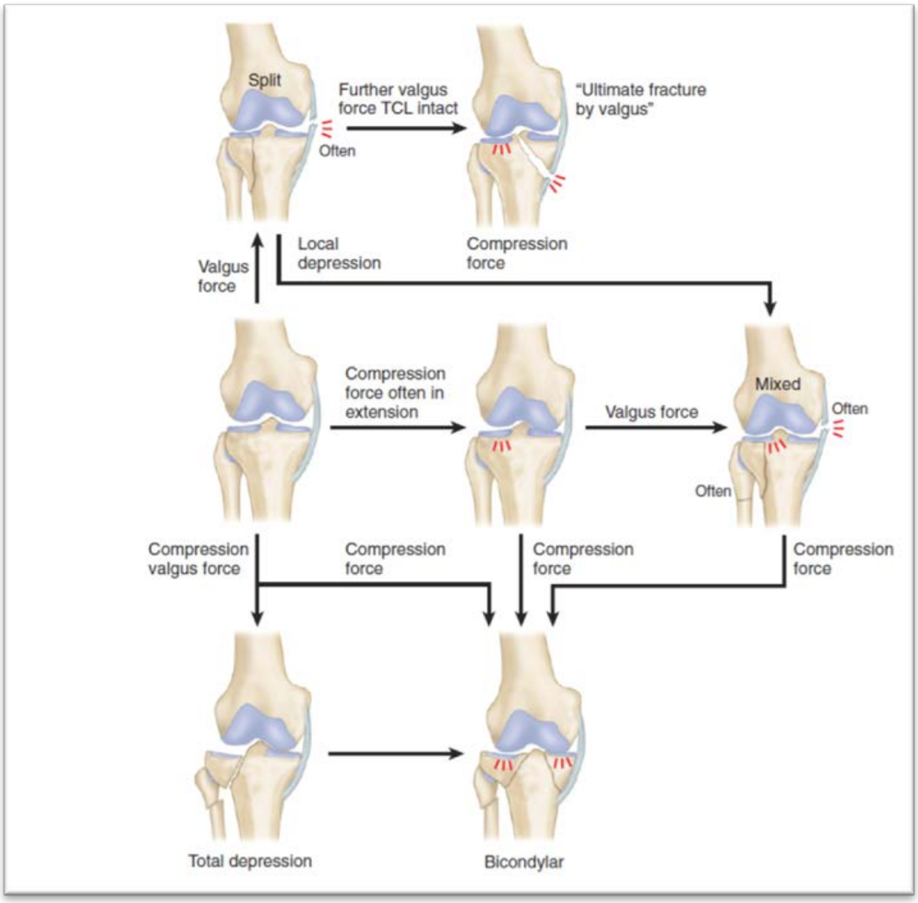


Fig 20 - Mechanism of injury

ACL Is commonly injured ligament mostly associated with high velocity and sports injuries. It can be either a mid-substance ACL tear or can be an avulsion fracture from intercondylar eminence. Other avulsion injuries[23] are seconds fracture, reverse Segonds fracture and anterolateral ligament injuries.

The Joint instability is also an important factor responsible for post traumatic arthritis. This suggests the importance of MRI as an investigation[24] in every tibial plateau fracture, in addition to CT and the role of arthroscopy in the management.

Soft tissue injuries are commonly associated with high energy tibial plateau fractures. In all patients, abrasions contusions fracture blisters and severity of swelling must be carefully examined and evaluated. Tscherene described classification of soft tissue injury for closed fractures and Gustilo Anderson for open fractures. Compartment syndrome is associated with high energy fractures. Careful monitoring of compartment pressure and damage control orthopedics must be followed in such patients.

Vascular injuries must be anticipated in fracture dislocation types. Popliteal artery is fixed at the level of trifurcation and will commonly get injured in complete anterior and posterior knee dislocation. Whereas lateral dislocation can damage the common peroneal nerve directly or indirectly.

CLASSIFICATION

- **SCHATZKER CLASSIFICATION[6]**

Type I-Pure split

A wedge-shaped fragment is split off and displaced laterally from the plateau. Common in young individuals with medial collateral ligament injuries

Type II- Split with depression

A lateral wedge of fragment is split off from the plateau and the articular surface is depressed and driven into metaphysis. This is most common type.

Type-III – Pure depression

The articular surface of lateral plateau is depressed and driven into the metaphysis. The lateral cortex rim is intact. This type is rare and it occurs in elderly patients with osteopenia.

Type IV – Fractures of medial condyle

Large medial condyle of the tibia is completely split off as a wedge or may be comminuted.

Type V – Bicondylar fractures

Fracture of both medial and lateral tibial plateaus. Intercondylar eminence may or may not be fractured.

Type VI – Tibial plateau fractures with dissociation of metaphysis and diaphysis

A transverse fracture of the proximal tibia is present in addition to fracture of tibial plateau. The defining characteristic is metaphyseal diaphyseal dissociation along with varying comminution of the articular surface. The fracture extends more distally than in type V. It may also appear as proximal tibial fracture with an intraarticular extension.

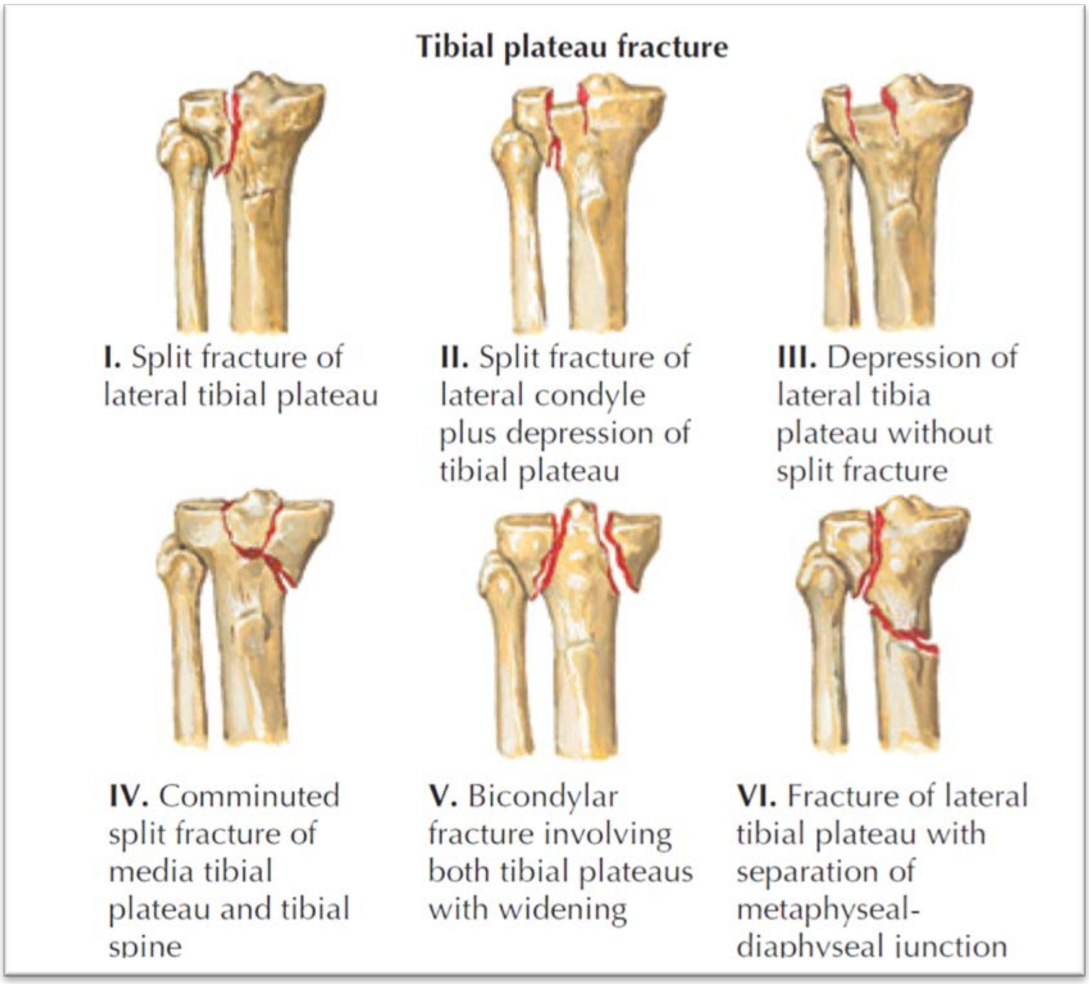


Fig 21 - Schatzker Classification of Tibial Plateau Fractures

➢ HOHL AND MOORE'S FRACTURE DISLOCATION CLASSIFICATION[3]

Type I: Coronal split fracture dislocation.

Type II: Entire condylar fracture dislocation.

Type III: Rim avulsion fracture dislocation.

Type IV Rim compression fracture dislocation.

Type V: Four-part fracture dislocation.

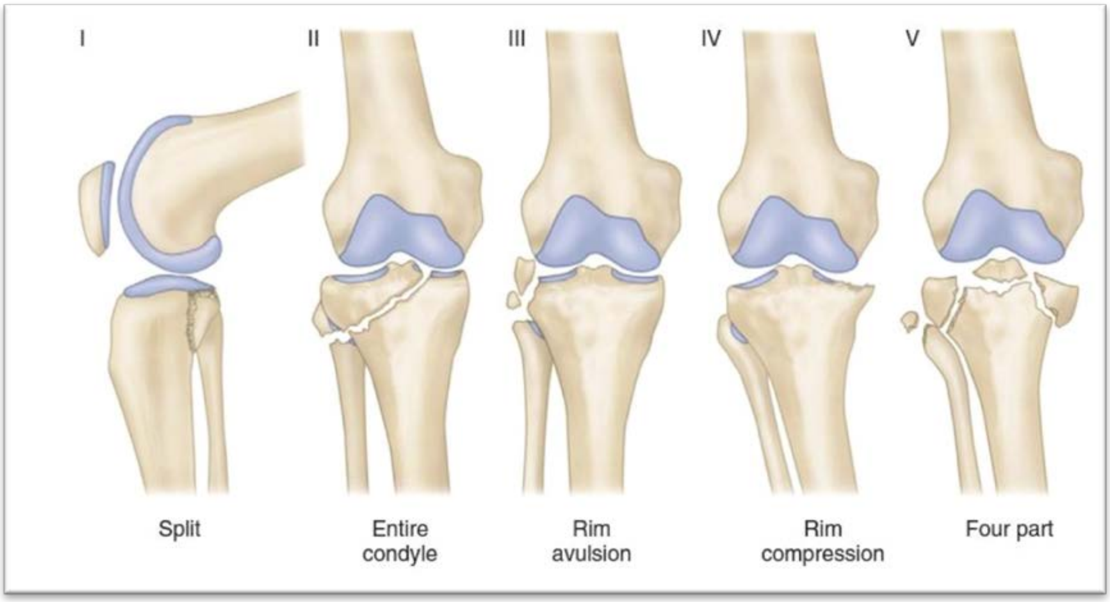


Fig 22 - Hohl and Moore Fracture Dislocation Classification

- **UPDATED AO CLASSIFICATION OF PROXIMAL TIBIAL FRACTURES**

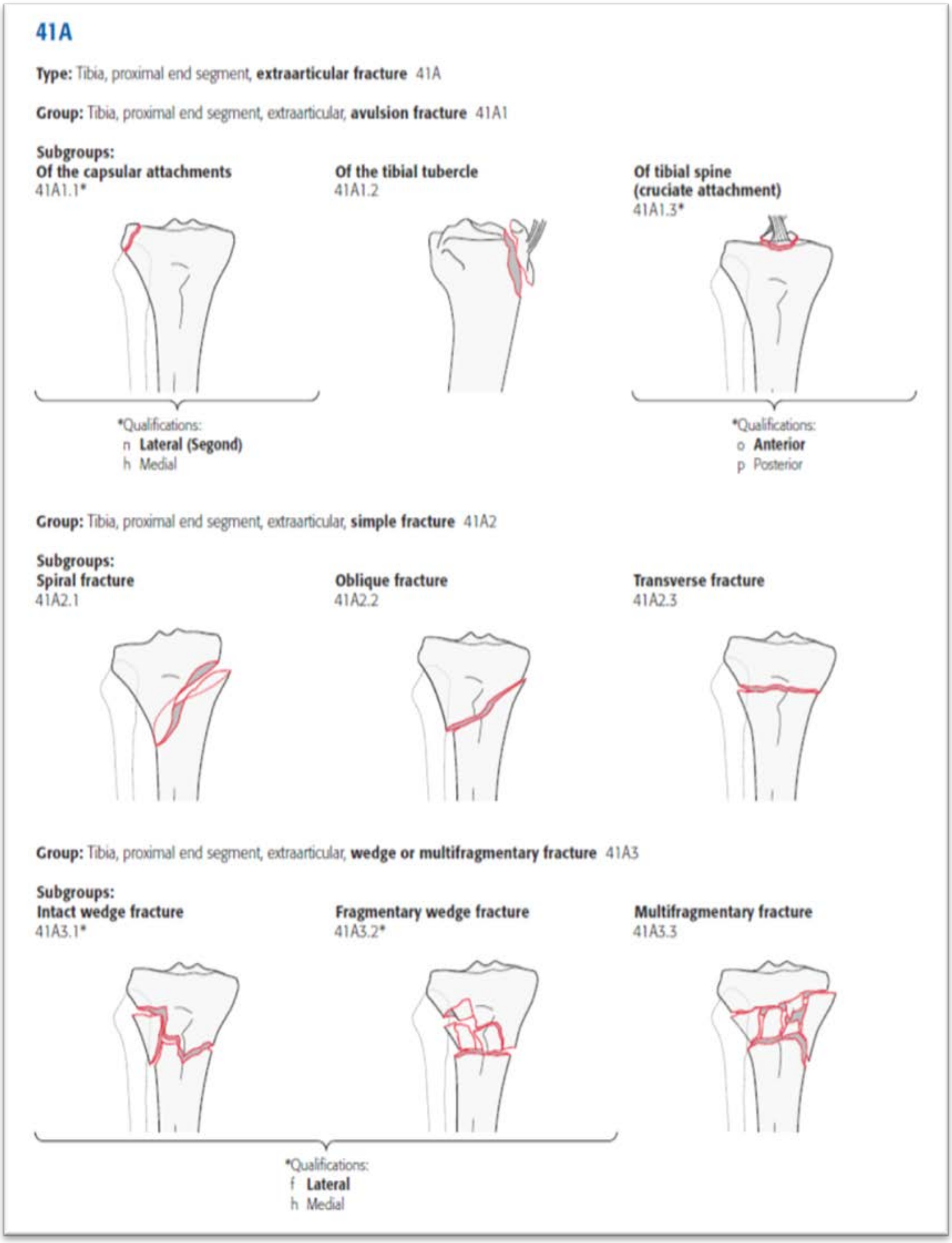


Fig 23 - AO Classification of Extra-articular Fracture

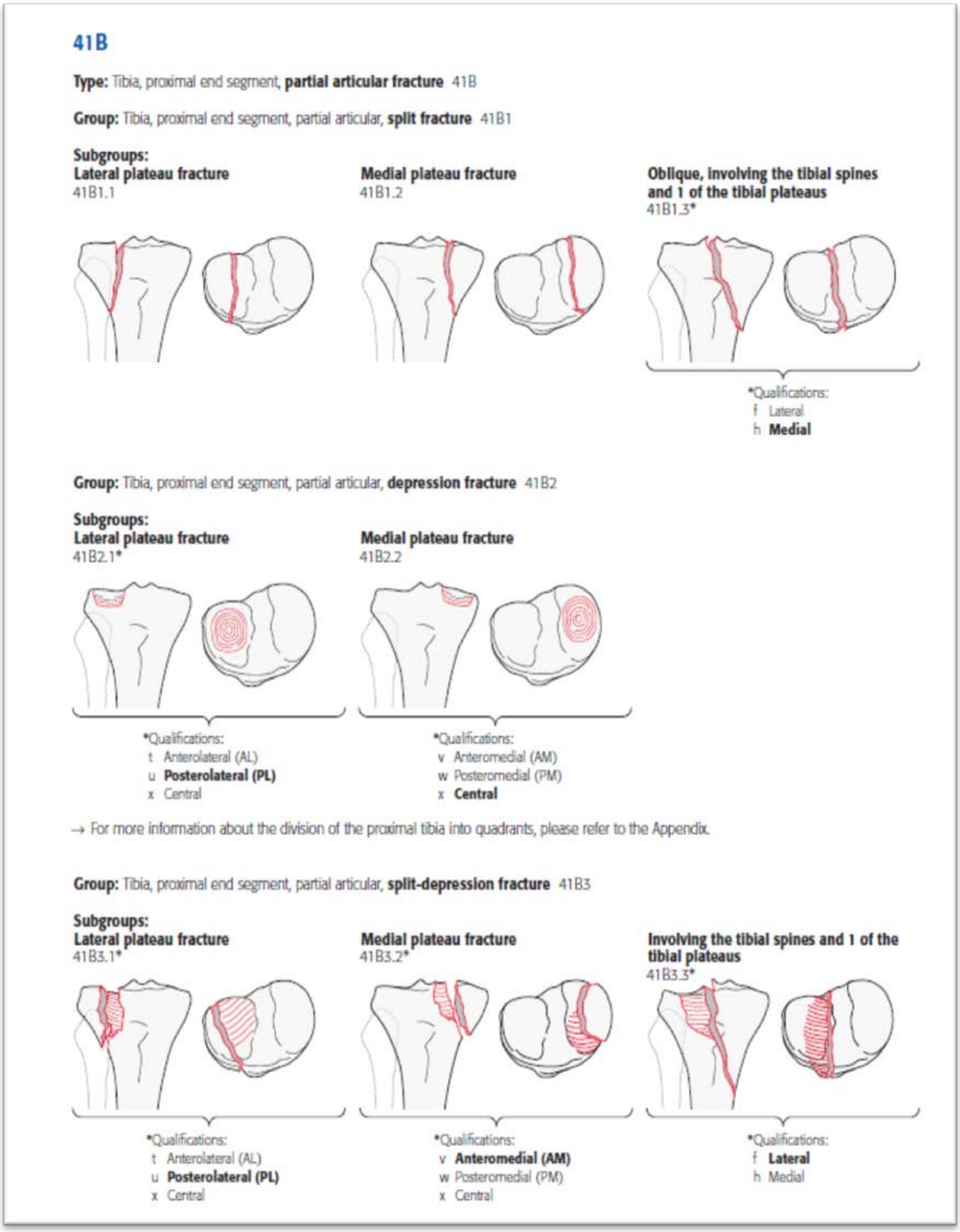


Fig 24 - AO Classification of Partial-articular Fracture

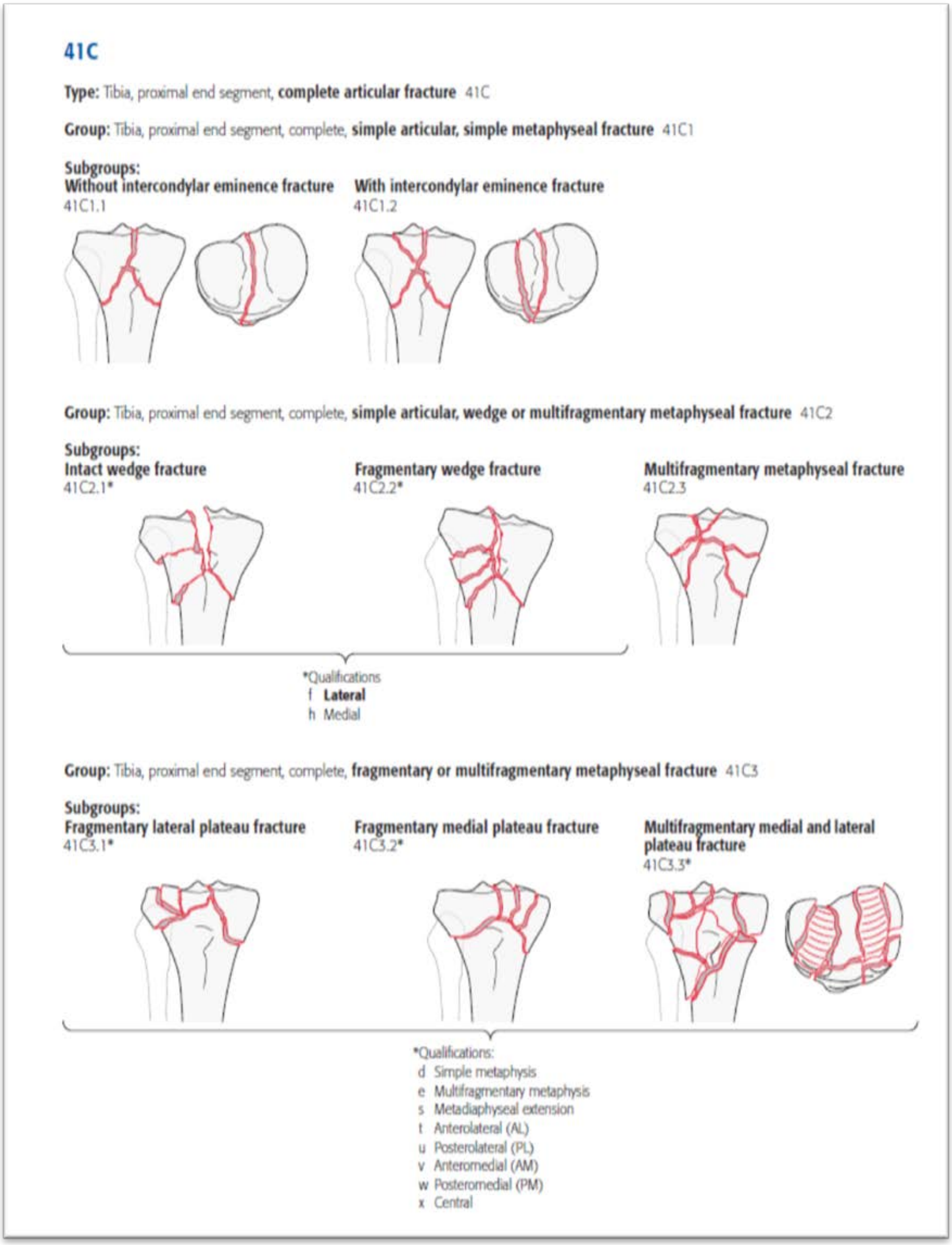
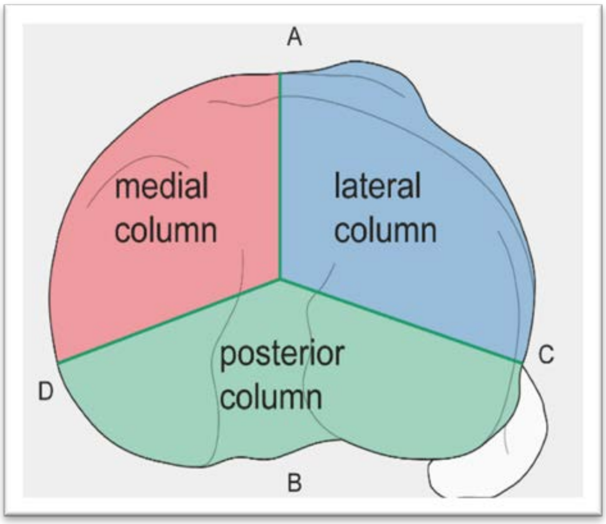


Fig 25 AO Classification of Intra-Articular Fracture

➢ LUO THREE COLUMN CLASSIFICATION[10]

Luo et al introduced a CT based classification of Tibial plateau and to plan for column specific fixation of fractures. Most of the current classification is based on x-rays in two dimensional images. High energy injuries results in comminuted fractures which are difficult to interpret. Understanding fracture is the basis of successful treatment. This is Classified by 3-Dimentional Axial CT in which it is divided into Medial lateral and posterior column by four point on axial CT.



A- Anterior tibial tuberosity
B - Posterior sulcus of tibial plateau.
C- Most anterior point of fibular head.
D- Posteromedial ridge of proximal tibia

Fig 26 Luo Classification of Tibial Plateau Fractures

Zero column- Pure articular depression like Schatzker type III fractures

One column-Simple split fractures and split with depression fractures belongs to one column like Schatzker I & II fractures. It can be isolated lateral medial and Posterior wall fracture which are individually represented as one column fractures

Two column- Medial and lateral column, Lateral & posterior column; Medial & posterior column are the three possible varies of fractures

Three column- at least one independent articular fragment inn each column (Schatzker V & VI)

This is mainly useful in management of posterior tibial plateau fractures especially posteromedial fragment and in complex bicondylar fractures. Malreduction is defined by two parameters Medial tibial plateau angle (mTPA) and posterior tibial slope angle (pTSA) measured on x-ray or in CT scan. Intraarticular step off 2mm, mTPA less than 80 or more than 95, pTSA less than -5 or more than 15 is defined as malreduction.

- **KUFRI AND SCHATZKER CLASSIFICATION[30]**

Kufri and Schatzker divided proximal tibia into quadrants. This classification is useful in understanding the mechanism of injury and its significance in management of fractures. Localization of main fracture plane is identified and compressive and tensile side of fracture is addressed accordingly. Tridimensional understanding of fracture is done. Four quadrants are determined by drawing two imaginary lines. Anterior and posterior segments is created by line drawn from anterior aspect of fibular head (FH) to posterior edge of MCL, which coincides with medial tibial crest. Medial and lateral segment is determined by line drawn from medial side of Anterior tibial tubercle to posterior cortex, which runs between the two tibial spines

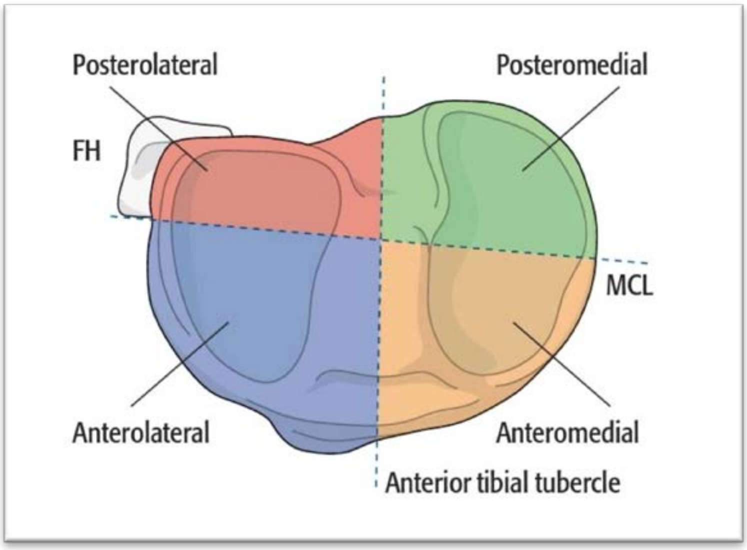
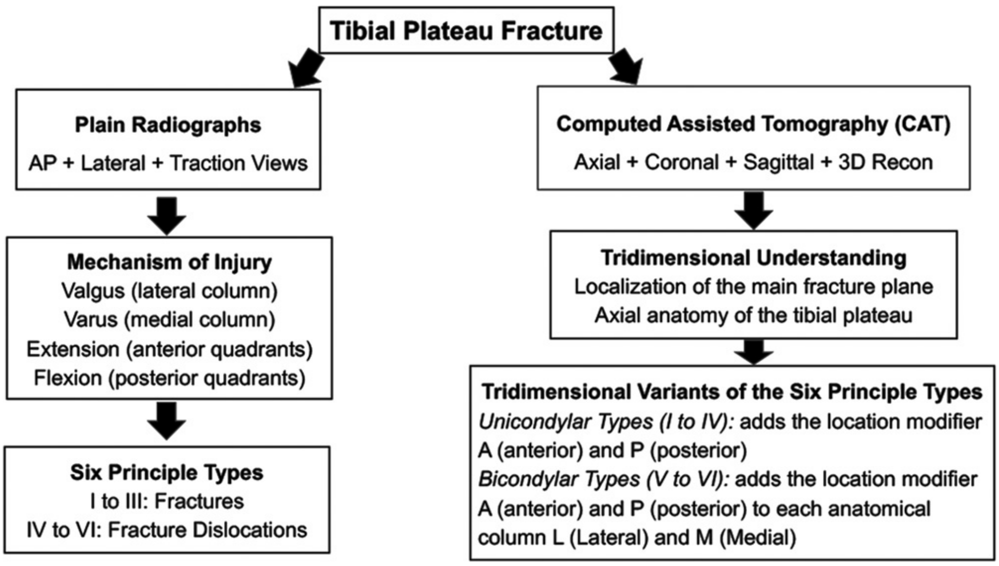


Fig 27 Kufri and Schatzker CT Classification of Fractures



- **TIBIAL INTERCONDYLAR FRACTURES- MODIFIED MEYERS *AND McKEEVER CLASSIFICATION*[23]**

Type I - Non displaced; minimally displaced fragment at anterior margin

Type II- Minimally displaced anterior half of avulsed bone with intact posterior hinge resembling bird beak

Type III- Completely displaced

Type III A- Involves ACL insertion only

Type III B- Involves entire intercondylar eminence

Type IV-Completely displaced, rotated and comminuted

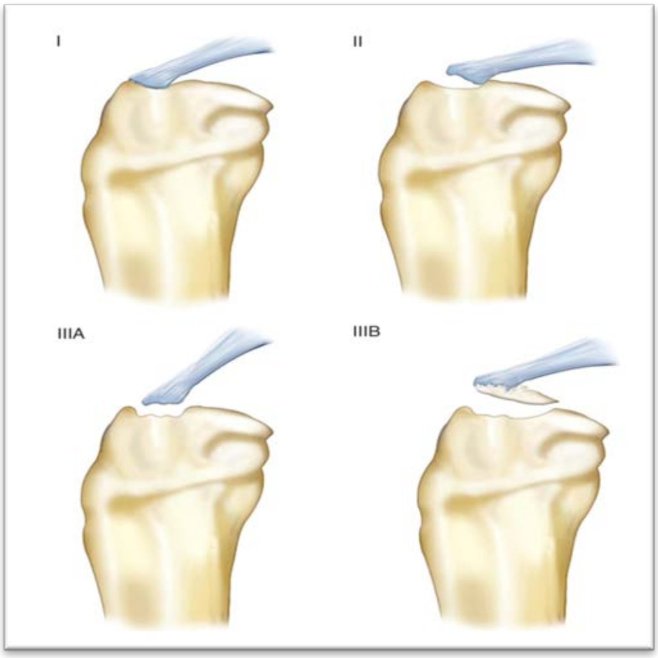


Fig 28 Modified Meyers and McKeevers Classification of Tibial Eminence

INVESTIGATIONS

Plain Radiograph

Anteroposterior Lateral views and 15-degree caudal Anteroposterior view. Traction films are done to assess the efficacy of an applied ligamentotaxis. Stress x-rays are done for checking collateral and cruciate ligament integrity. Gardner[44] et al suggests that Widening of condyles are measured which suggestive of entrapped a damaged meniscus within the plateau. Tibial plateau[25] views are taken with 10 degree of caudal tilt which helps in better identifying the articular congruity.

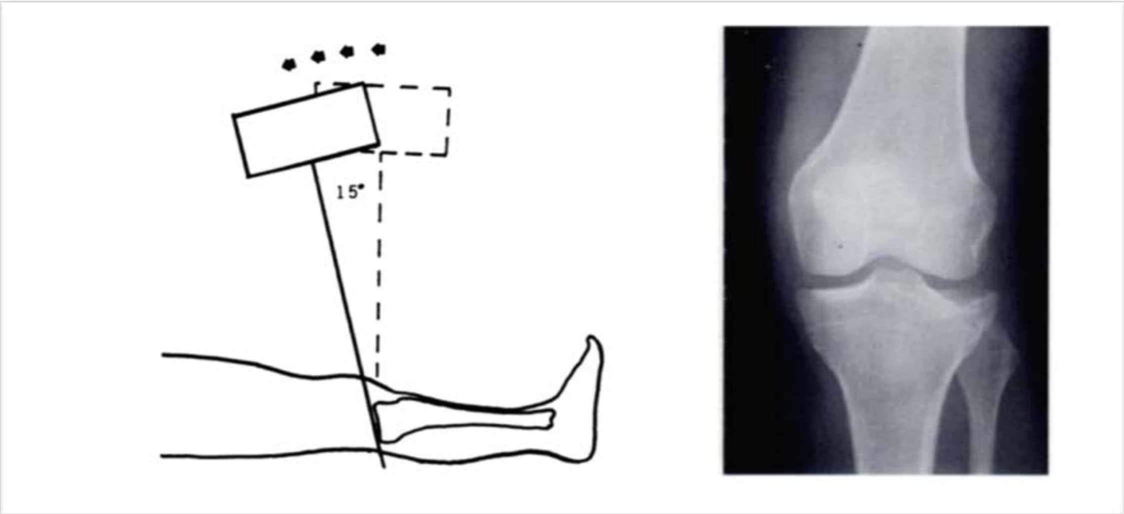


Fig 29 Tibial plateau view

3D CT Scan

CT is the most useful investigation in determining the mechanism of injury, pathoanatomic of fractures and to plan for column specific fracture fixation. CT cuts helps in determining the location of depression, size of articular fragment, and the location and orientation of fracture lines. In an acute setting, 3D CT[10] is useful in determining the spatial relationship of fracture fragments.

Magnetic Resonance Imaging[24]

MRI is more accurate in delineating soft tissues injuries of ligaments, menisci and capsules. They are important in identification of occult fracture lines.

Angiography[28]

Lower limb CT angiography is Useful in High velocity injuries associated with vascular compromise. Popliteal fossa can be assessed when charactering the fracture in normal CT scan. Ankle brachial pressure index (ABPI) is an easier screening test. If less than 0.90 must predict for vascular injury.

INSTRUMENTATION AND IMPLANT

➢ **Arthroscopic cart**

- Television monitor
- Camera console
- Shaver system
- Light source
- Connecting cables
- Radiofrequency thermo-coagulation unit
- Tourniquet set

➢ **Arthroscopic Surgical equipment:**

Fig 30 Degree and 70 Degree Arthroscope

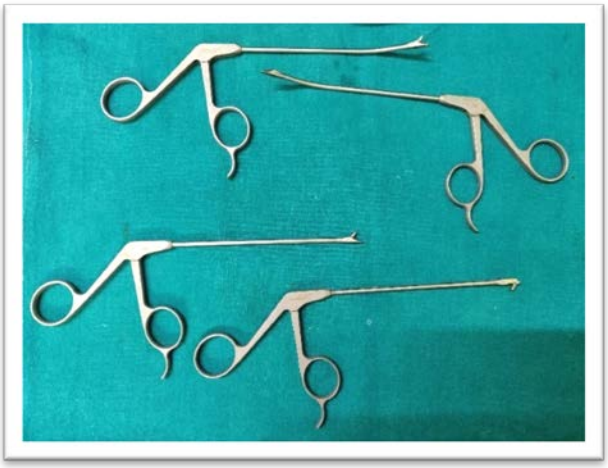


Fig 31 Meniscal Punch **Fig 32Sheath and Blunt Trocar**

Fig 33 Arthroscopic Tibial ACL Zig

Fig 34 Shaver blade

Fig 35 Arthroscopic probe

Fig 36 Femoral aimer

Fig 37 Arthroscopic rasp

Fig 38 Cannulated drill

Fig 39 Beath pins (2.4mm)

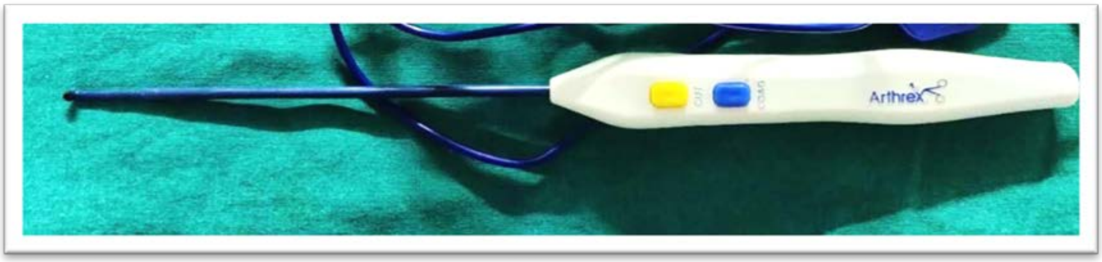


Fig 40 Radiofrequency thermocoagulation Device

- **Fracture Reduction Equipment:**

Fig - 41 Point reduction clamps

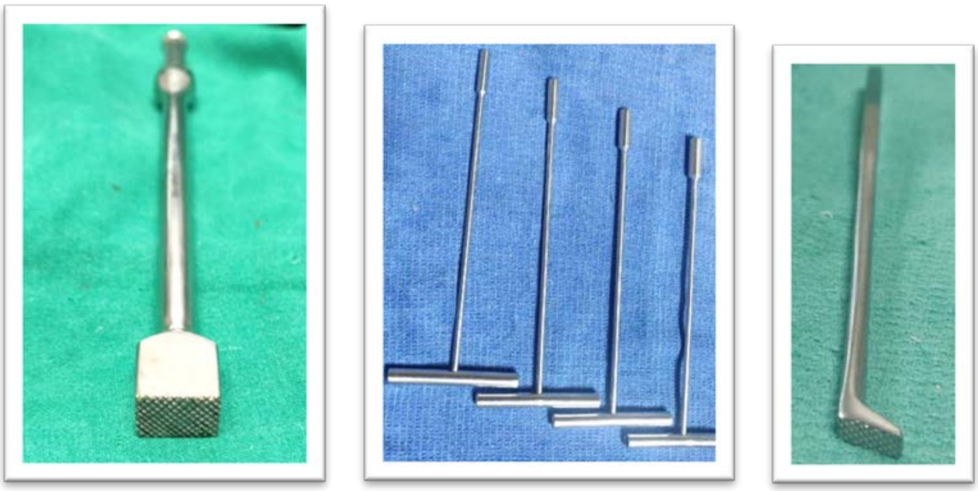


Fig 42 Bone Graft Impactor, Bone Tamp and punch

➢ CANNULATED CANCELLOUS SCREW SYSTEM

Most commonly used implants are 6.5 mm cancellous screws. Partially threaded screws are used as lag screws to compress the reduced fragment. Fully threaded screws are used for comminuted fractures. Screws alone can also be used as raft construct after reduction of fractures.

Fig 43 Cannulated Cancellous Screws

➢ BUTRTESS PLATE

4.5mm T or L shaped buttress plates are traditionally used with 6.5mm cancellous subchondral lag screws and 4.5mm cortical diaphyseal screws. These plates are used to support the weak cortex of metaphysis from crumbling or displacing by applying axial compression from pre-contoured plate. It is mostly used in anterolateral region. L buttress allows more buttressing without getting into way of fibula. Locking plates are used for osteoporotic bones.

Fig 44 Buttress Plates (T and L)

- **SMALL FRAGMENT PLATE**

Its anatomically precontoured fragment specific LCP plates available with 3.5mm screw system. 3.5mm raft construct allowed significantly less displacement than 6.5mm cancellous screws. Some plates are even updated with polyaxial or variable angled screws. There are three varieties

- **Medial proximal tibial plate**: Three proximal screws available in converging pattern. Screw hole pattern allows a raft of subchondral screws to hold and maintain the articular surface. Two Angled locking screws present in proximal shaft which allows convergence with the head screws. LCP has combi holes in the plate shaft that combine dynamic compression unit hole with locking screw hole.
- **Standard and low bent Lateral plate**: It has four proximal raft screw. Proximal bend has two varieties of standard and low bent

profile. Angled proximal shaft screws present to support medial fragment.

Fig 45 Small fragment plate (Medial plate and low bent lateral plate)

- **Posteromedial plate**: posterior column fracture pattern is identified and accordingly plate is placed posteriorly or posteromedially. It has two proximal screws with 10 degrees divergent trajectories each diverging 5 degrees from plate midline. Low profile head with 1.9mm is present to avoid soft tissue disruption. It has elongated combi holes to allow plate adjustment and allow locking or compression accordingly.

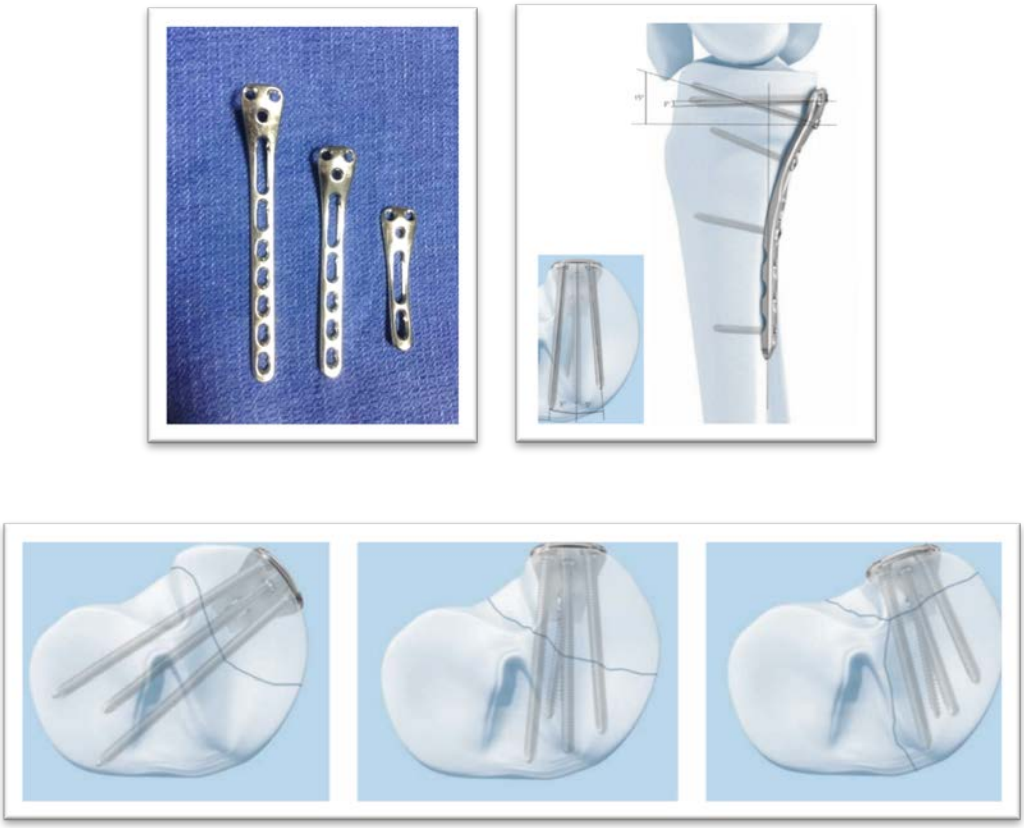


Fig 46 Small fragment plate (Posteromedial plate).

➢ PROXIMAL TIBIAL LCP

4.5mm Locking plates are sturdier implants with stronger screws that provide resistance to deforming forces. They are precontoured anatomically. Locking capacity is important for creating a fixed angled construct in osteopenic bones. Proximal head has three screws which can be used as raft screws. Proximal two holes in shaft can accept cancellous and cortical screws. Third screw is angled in a way that it supports the medial fragment and buttress it. Rest of the screws have combi holes with distal most screw accepts articulated tension device. Locking screws provide fixed angle construct in metaphysis whereas conical screws can be used as interfragmentary compression screw through the plate. It is also used as bridge plating for comminuted metaphyseal fractures.

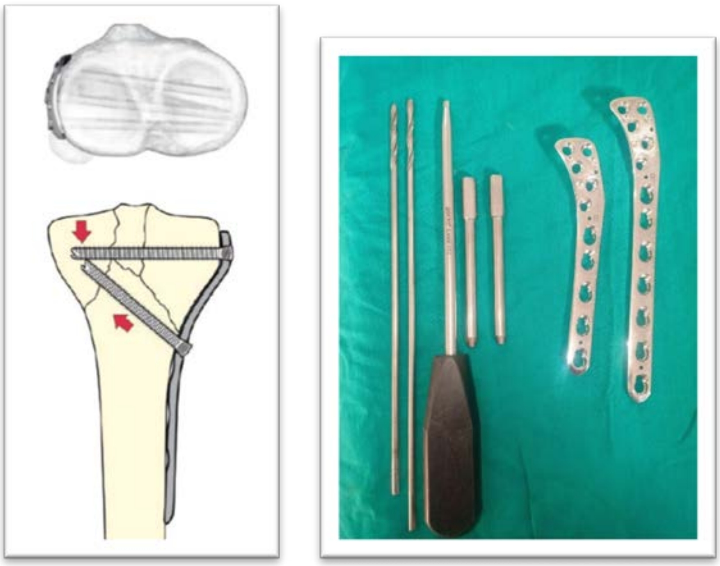


Fig 47 Proximal tibial LCP

- **GRAFT FIXATION DEVICES**

Aperture fixation devices:

Fig 48 Titanium and bio- absorbable screws

Suspensory fixation devices:

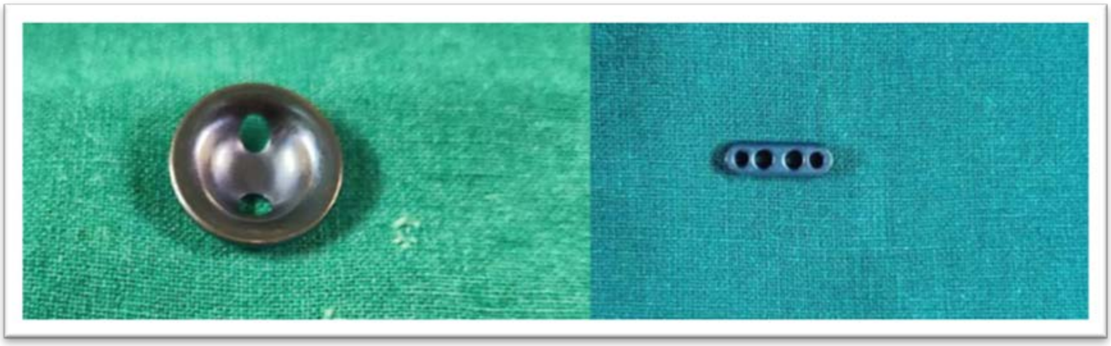


Fig 49 Suture wheel and endobutton

APPROACHES

ANTEROLATERAL APPROACH

Lazy S or Inverted L shaped incision is made over the lateral aspect of tibia centring over the Gerdy's tubercle. Deep fascia opened anterior to iliotibial tract. Proximal attachment of tibialis anterior is released subperiosteally. Full thickness skin flaps

created and fracture site is exposed

Fig 50 Anterolateral approach

ARTHROSCOPIC APPROACH

Anterolateral portal is made in the soft spot adjacent to the patellar tendon. 5 mm stab incision is made and arthroscopic shaft is inserted. Trocar is removed and arthroscope is inserted. Knee joint cavity is irrigated. Anteromedial portal is made in soft spot adjacent to patella tendon. 5 mm stab incision is made and working postal is established. Reduction tools can be inserted through this portal.

MIO APPROACH

This is commonly used for Arthroscopic tibial plateau fixation. After satisfactory reduction and visualisation of joint arthroscopically, plate is inserted through this minimal approach.

Fig 51 MIO Arthroscopic approach

5cm straight skin incision is made posterior to Gerdy's tubercle running distally and anteriorly. Deep fasci is opened from Gerdy's tubercle onwards. Tibia is exposed by releasing the anterior attachment of tibialis anterior. Articular reduction is done with the help of medial portal.

POSTEROMEDIAL APPROACH

Position the patient in supine wit leg abducted and externally rotated in figure of four manner. Curved incision is made from medial epicondyle towards posteromedial wedge of tibia. Pes anserinus identified and exposed. Pes retracted anteriorly and gastrocnemius retracted posteriorly to expose the medial edge of tibial plateau. Sub meniscal arthrotomy done or Arthroscopically joint is visualised. Anterior edge of gastrocnemius identified and transacted close to its insertion and retracted laterally. posteromedial capsule is exposed.

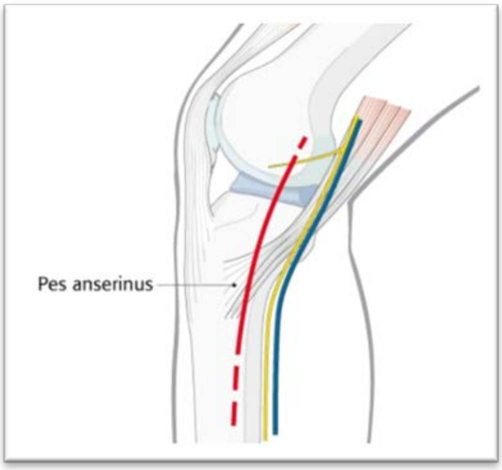


Fig 52 Posteromedial approach

SURGICAL PROCEDURE

Anaesthesia:

All our patients were assessed and were taken up for surgery under spinal anaesthesia.

Pre-op antibiotic:

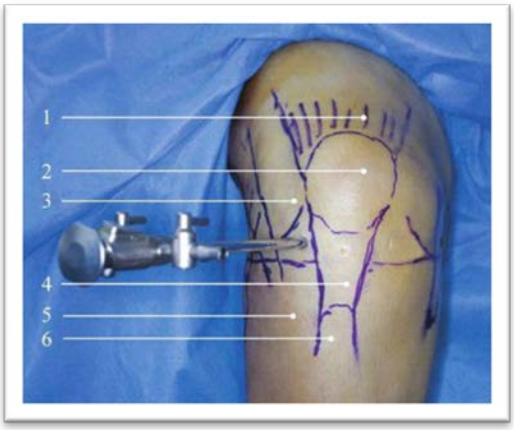
A single dose of IV antibiotic is given 1 hour before the start of procedure.

Patient positioning:

Fig 53 Patient positioning

Patient positioned in supine position, in a radiolucent table. Lateral thigh support was placed to ipsilateral thigh and foot stopper kept at foot end. A pneumatic tourniquet is applied. Local preparation and prewash of knee was done. Limb is then painted and draped. The limb is elevated and exsanguinated using Esmarch bandage. Tourniquet pressure was then raised.

Portal placement and diagnostic arthroscopy:



1. Quadriceps muscle
2. Patella
3. Lateral femoral condyle
4. Patellar ligament
5. Lateral tibial condyle
6. Tibial tuberosity

Fig 54 portal placement

With the knee in 90 degrees of flexion, **standard antero-lateral viewing portal** is made lateral to the patellar tendon in the soft spot about 1cm above the joint line. Stab incision wit 11 blade is done to make the portal. It is then dilated using straight haemostat. The knee is then gently extended and sheath along with blunt trocar is passed through the patella-femoral joint. The trocar is then removed and hemarthroses is evacuated and knee joint is lavaged to remove the debris.

30 degrees arthroscope is introduced and then diagnostic arthroscopy is done and the following structures are visualised supra-patellar pouch, lateral and medial gutter and patella-femoral joint.

Fig 55 Evacuation of hemarthrosis and joint lavage

The knee is brought to 90 degrees flexion and the arthroscope is brought into intercondylar notch area. The standard **anteromedial portal** is then established in a similar way, medial to medial border of patella tendon between lower border of patella tendon and lateral joint line.

Using minimally invasive techniques fracture reduced and fixed using plate and screws depending upon the fracture pattern. Associated injuries are treated arthroscopically. Post fracture fixation joint congruity visualised arthroscopically.

POSTOPERATIVE CARE

- Limb elevation
- IV antibiotics 48 hours
- Long knee brace or Hinged knee brace
- Active and passive strengthening of quadriceps
- Knee patella ankle mobilisation exercise
- Early continuous passive motion
- Partial weight bearing 4-6 weeks
- Full weight bearing 8-10 weeks

FOLLOW-UP PROTOCOL

- At 2 weeks first follow-up done during which the scar inspection and suture removal done.
- At 6 weeks an X-ray was taken to look for signs of fracture union and loss of reduction if any.
- At 8 weeks X-ray was taken to check for union done and allow weight bearing.
- At 12 weeks evaluation was done using the modified Rasmussen clinical and radiological criteria.
- Further follow-up was done every 3 months

PRINCIPLES OF TREATMENT

Like any intra-articular fracture main treatment goals are

- Anatomic reduction of the articular surface
- Restoration of joint congruity
- Mechanical alignment
- Avoidance of complications

NON-OPERATIVE RECOMMENDATIONS[53]:

- Articular incongruity less than 2mm
- Stable knee in full extension
- Normal valgus/ Varus alignment
- Fractures that can be expected to heal without a significant deformity
- Elderly patients who have high surgical risk
- Co existent medical morbidities with high surgical risk

Closed manipulation and above knee cast application is commonly used for tibial plateau fractures. The technique of close reduction is usually a combined maneuverer. Traction to the leg along with adduction or abduction at the knee depending upon the type of fracture is given. Ligamentotaxis principle is applied to elevate the depressed fragments.

Some Type I tibial plateau fractures, properly reduced usually has good functional outcomes managed conservatively. However, in Schatzker type II and III fractures, with greater split and depression usually heals with a valgus mal-alignment and hence have a great risk of osteoarthritis. Schatzker type IV fractures have greater chances of healing in varus malalignment because of obliquity of fractures. Therefore, conservative management is mostly avoided in such fractures.

OPERATIVE RECOMMENDATIONS

- 5mm> depression (joint surface depression equal to depth of cartilage which is 4mm for lateral and 2.5mm for medial tibial plateau)[53]
- valgus/ varus instability more than 10 degrees
- valgus/ varus tilting proximal tibia more than 5 degrees
- Articular displacement or gapping is present

TREATMENT OPTIONS

- Percutaneous Cannulated Screw fixation,
- ORIF with AO ASIF Buttress plate
- ORIF with Proximal tibial locking plate
- Minimally invasive percutaneous plate osteosyntheses (MIPPO)
- Arthroscopically reduction and internal fixation (ARIF)
- Hybrid/ Ilizarov external fixator Application

DAMAGE CONTROL ORTHOPEDICS

Fracture pattern has to be identified and classified as high or low velocity injury. Soft tissue envelope has to be identified for any swelling, ecchymosis or signs of compartment syndrome. In such high-risk patients, damage control orthopedics should be followed. It is a method to prevent complications from second hit in polytrauma patients. Temporary stabilization is provided by spanning external fixator across the knee joint until the soft tissue settles by placing the pins out of zone of primary fracture fixation. Open reduction is performed once soft tissue settles and serum lactate levels return to normal.

REDUCTION METHODS

Open reduction or direct reduction is a method in which the fracture site is surgically exposed, fracture fragments are fixed anatomically under direct vision after which internal fixation is done. In closed reduction or indirect reduction method the fracture site is not exposed surgically. it is reduced indirectly using the ligamentotaxis principle where fracture fragments fall back into position. longitudinal Traction to the leg along with varus or valgus stress at the knee depending upon the type of fracture. longitudinal traction is given by using fracture table or femoral distractor. Reduction can be heled using reduction clamps and Provisionally fixed using Kirschner wires. Internal fixation can be done by minimal invasive technique or arthroscopy without exposing the fracture site.

PRINCIPLES OF FRACTUTRE FIXATION

With regard to fracture types. Joint depression fractures have to be reduced from below and void has to be filled with graft or cement. Large isolated spit fragments are compression with partially threaded lag screws and washer. Comminuted fractures are fixed with fully threaded screws.

Once the fracture reduction and articular congruity is maintained, Cancellous screws or cortical are used in the proximal tibia as raft parallel to joint surface to prevent further slippage of depression. Anti-glide screws are placed at the apex of split fragment. Buttress plate fixation is preferred for column fractures. It functions in a manner opposite to tension band plate. They are used where the cortex is thin and metaphysis is cancellous. Anatomically reduced fractures must be buttressed as they tend to fail in axial load. Buttress plate prevent slow progressive recurrence of deformity. Plate location depends on the fracture morphology. They are placed parallel to main fracture line.[30]

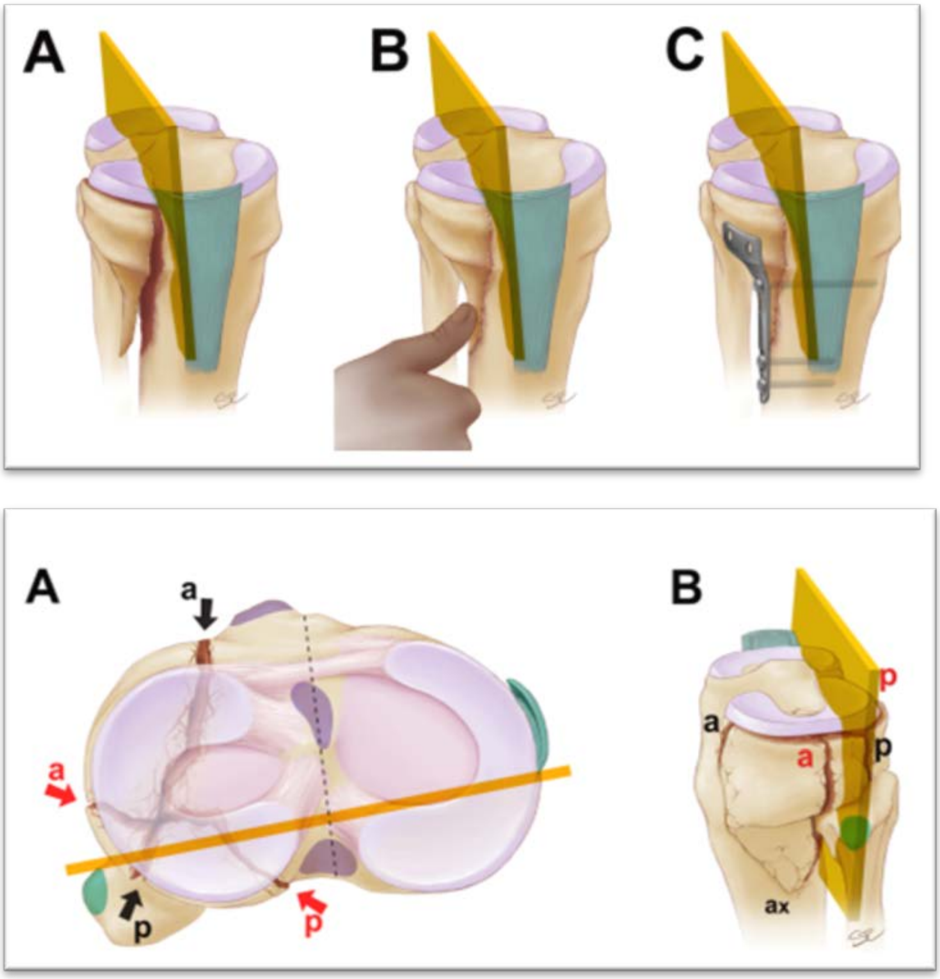


Fig 56 Plate fixation principles

In column fractures[20], Primary plating with main Buttress Plate on the compression side and Supporting secondary plate on tension side if the fracture is comminuted or unstable.

The locking plates and screws act as a single unit. They have sturdier implants with stronger screws that provide resistance to the deforming forces in high energy fractures. They are also commonly used in elderly patients with osteoporotic bones. Locking plates in lateral column have been extensively used in bicondylar Fractures.

TECHNICAL CONNSIDERATIONS[9]

SCHATZKER TYPE 1

Arthroscopy is useful in evacuating haematoma, direct visualisation of joint articular surface, removing chondral fragments if any and to treat the associated injuries. After reduction using point reduction clamp if the articular congruity is maintained and after satisfactory reduction, two parallel guide pins inserted 1 cm beneath the joint surface perpendicular to the direction of split. And fixed using 6.5 mm cancellous screws as lag screws or 4.5mm raft screws. Washer is added for compression. In young patients screws alone is sufficient. In elderly patient additionally anti-glide screws or buttress plate is used

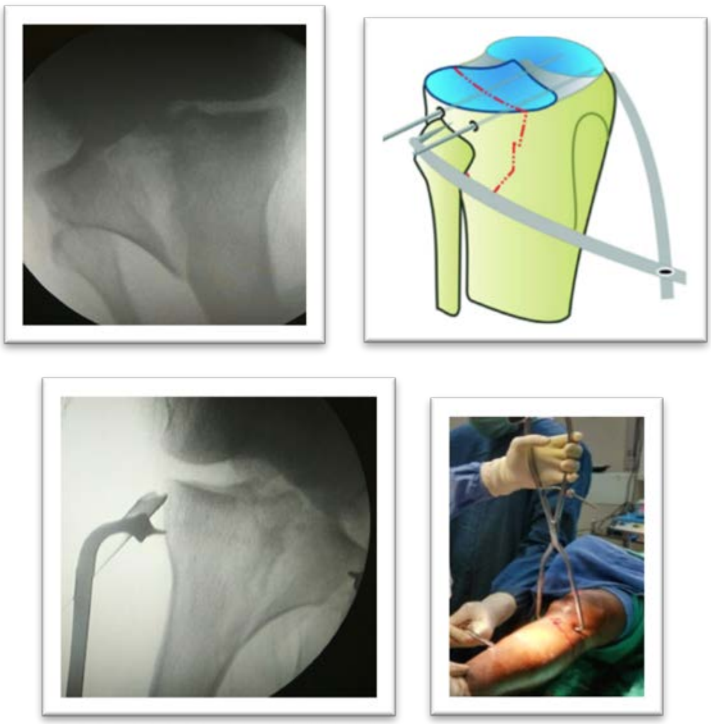


Fig 57 Fixation using K wires and point reduction clamp

SCHATZKER TYPE II

External reduction by ligament traction method is initially done mainly to restore and maintain the condylar architecture and less to elevate the depressed fragment. Knee is placed in varus which elevates the lateral fragment. This is done under fluoroscopic guidance. Temporary fixation is achieved using one or two K-wires.

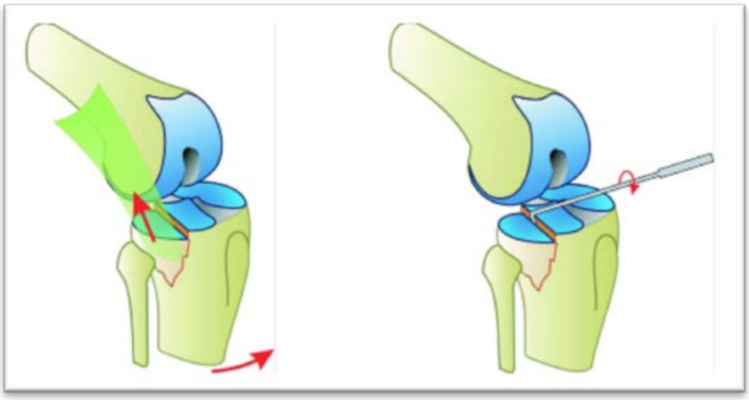


Fig58 Dis-impaction of fracture by hook and reduction using ligamentotaxis principle

Arthroscopically probe can be inserted into the fracture site to dis-impact the bone fragments. One or two K-wires into the fractured plateau and used as joystick to elevate the fragment and when joint congruity is achieved k wires are inserted parallel to the joint surface followed by cancellous screws.

SCHATZKER TYPE III

Pure joint depression fractures have to be elevated from below. The subchondral bone is elevated using a bone tamp / impactor inserted through a cortical window in the metaphysis. Depending upon the fracture pattern anterolateral or a medial cortical window is created. Advantage of medial window is long bone tunnel and more bone graft support than the lateral. initially a guidewire is inserted in the middle of the depression using an ACL zig 10 cm distal to joint line. And using 10mm drill bit, drill is done up to 20 mm below the subchondral bone. Bone tamp/impactor is introduced and subchondral elevation is done. Temporary k wire fixation done and depending upon nature of injury either raft screws or plating is done.

In axial CT, cortical envelope[43] is checked. It must be Intact or easily restored. Containment is necessary before elevating depression. If it is not intact, they will displace laterally or medially as they are elevated. For lateral tibial plateau, medial column must be intact to do a cortical window.

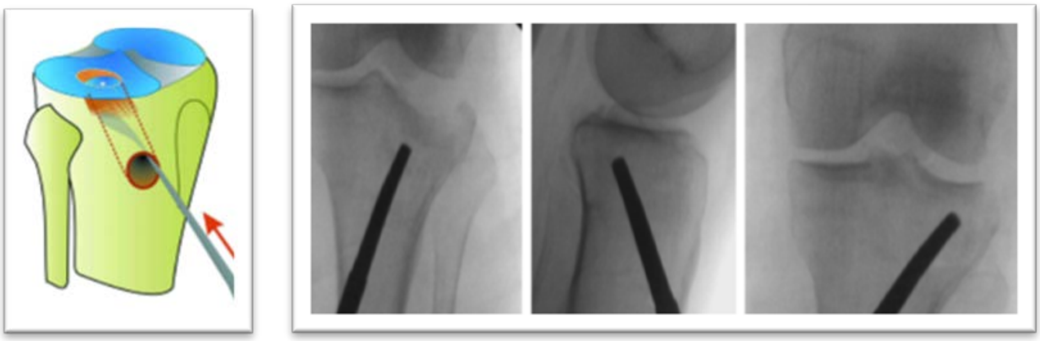


Fig 59 Elevation using bone tamp

Bone must be of good quality to support elevation. Minimally elevated fragments can be fixed with raft screws alone. If cortical tunnel is drilled, gap is filled with bone graft or bone substitutes. Though both have equal union rates Calcium phosphas[33] is better than iliac crest in prevention of subsidence.

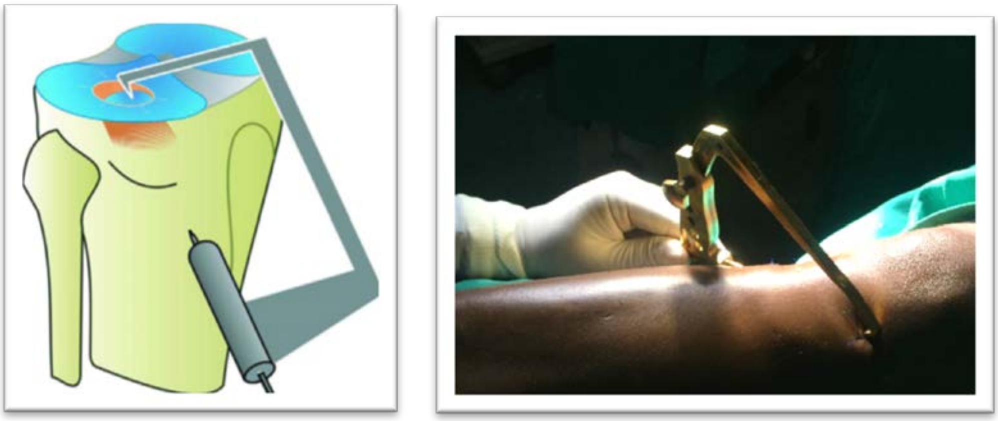


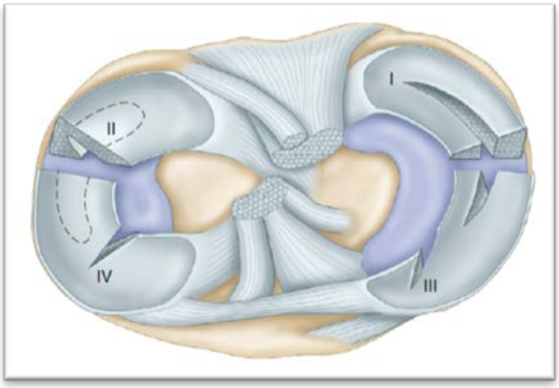
Fig 60 Using ligamentoplasty aiming system for elevation

SCHATZKER TYPE IV

These are commonly high velocity injuries. Most of the fractures have an oblique plane comminution. Associated injuries including compartment syndrome must be anticipated. Lag screws alone is not sufficient in such fractures. They are treated with buttress plate to counteract the shearing force acting on medial plateau. Varus malalignment is a common unacceptable complication in medial buttress plating, which must be avoided. Coronal split fractures are fixed with AP screws

TREATMENT OF MENISCAL INJURIES[22]

Arthroscopically meniscus is defined stable if length of tear is less than 10mm, cannot be displaced into intercondylar notch and if inner edge of meniscus cannot touch central part of femoral condyle. If meniscus is unstable, treatment options are meniscal, repair and meniscectomy. Meniscectomy is performed only when suturing is not feasible. If tear is in white-white zone and if its horizontal or bucket handle tear more than 20 mm, they are usually not repaired and meniscectomy is done. Arthroscopic Punch forceps is used to take bites in the torn meniscus and shaver is used to evenly trim the meniscus. All inside, fast-fix and meniscal clinch are newer methods of meniscal repair



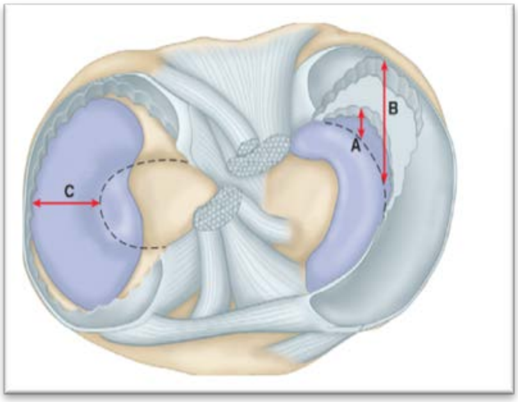
I -Longitudinal

II -Horizontal

III- Oblique

IV-Radial

Fig 61 Meniscal tears



A- Partial meniscectomy

B- Subtotal meniscectomy

C- Total meniscectomy

Fig 62 Meniscal balancing

TREATMENT OF LIGAMENT INJURIES

Ligament injuries are commonly associate with tibial plateau fractures. It can be a partial tear or complete substance tear. Partial tear of ACL diagnosed intraoperatively by probing and checking its laxity. It can be conservatively or radiofrequency thermo-coagulation[40] and shrinkage is done. Such ACL have histological changes but they don't have any initial difference is biomechanical properties. Complete tear of ACL though can be reconstructed primarily, is always preferred to do it after fracture stabilisation in a staged manner. Intercondylar fractures treatment depends upon amount and displacement of fracture types. Though there are various treatment options, arthroscopic screw fixation and arthroscopic pull through suture fixation[12] have given better results. Most collateral ligament lesions are managed conservatively. Avulsion fractures are primarily fixed using suture anchors. Mid substance tear is managed conservatively with knee brace.

Fig 63 Intact but lax ACL being probed

Fig 64 Radiofrequency thermocoagulation of lax ACL

CHONDROPLASTY[48]

It's common for cartilage to undergo degeneration post trauma and due to chronic wear and tear. Microfracture is a technique of multiple drilling of an osteochondral lesion which causes release of multipotent mesenchymal stem cells and forms a clot which helps in healing. It is first line treatment of well-contained Outerbridge grade III or IV cartilage lesions and lesions less than 4 cm^2.

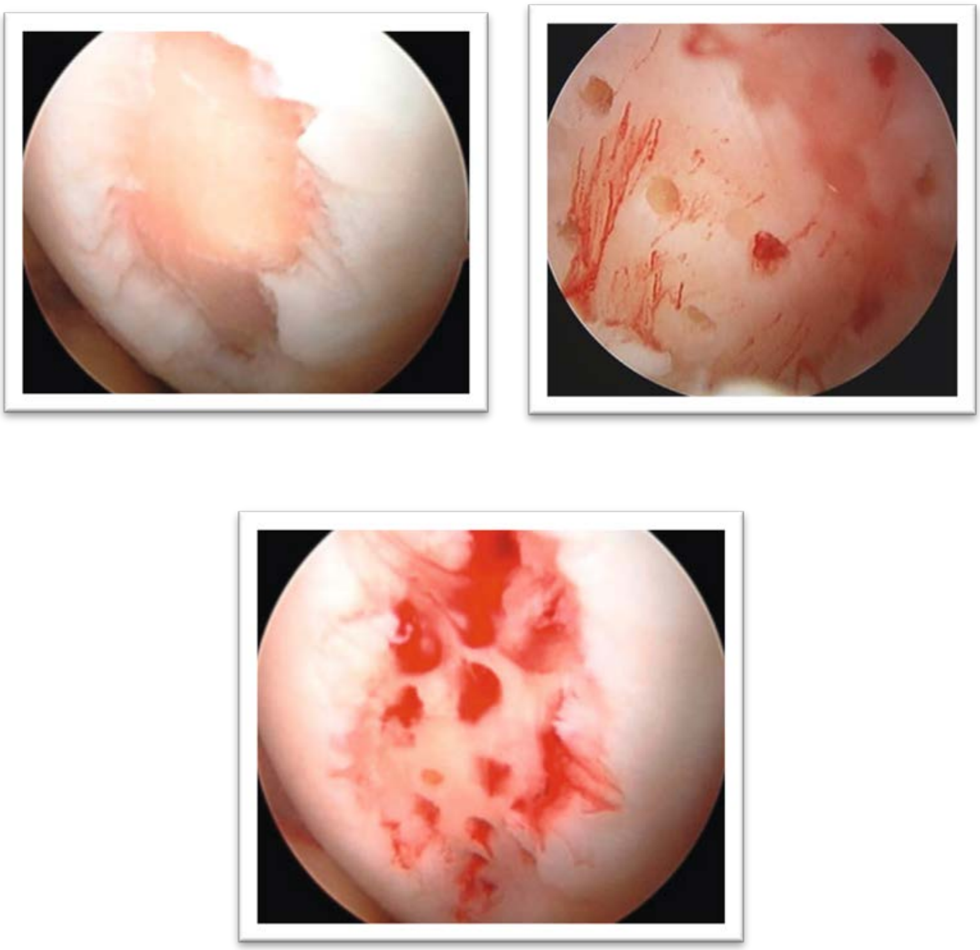


Fig 65 Microfracture technique

RESULTS

The present study included 15 patients. Mean age of the patients is40.3 years. Majority of the patients 5 were in age group of 30-40 years. Next common is 40-50 years and the rest equally distributed.

Table 3: Distribution of study participants according to age

AGE (YEARS)	FREQUENCY	PERCENTAGE
20-30	3	32%
30-40	5	53%
40-50	4	42%
50-60	3	32%

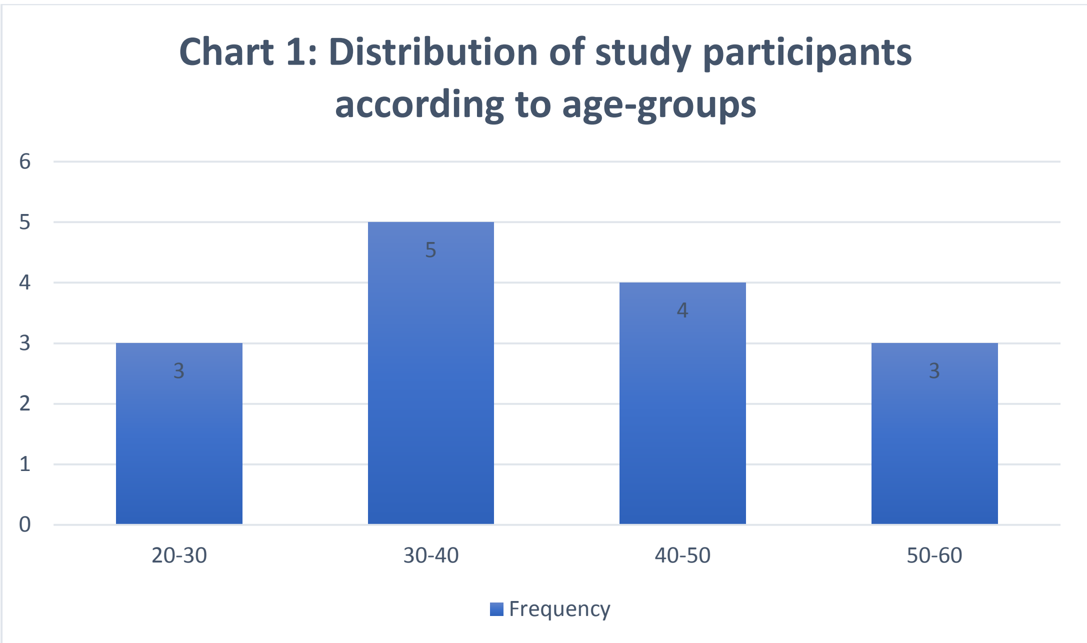


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Table 4: Distribution of study participants according to sex

SEX	PATIENTS	PERCENTAGE
MALE	12	80%
FEMALE	3	20%

Among the participants in study, majority were patients were male, which is about 80 percent. Only 3 female participants (20%) were there in the study.

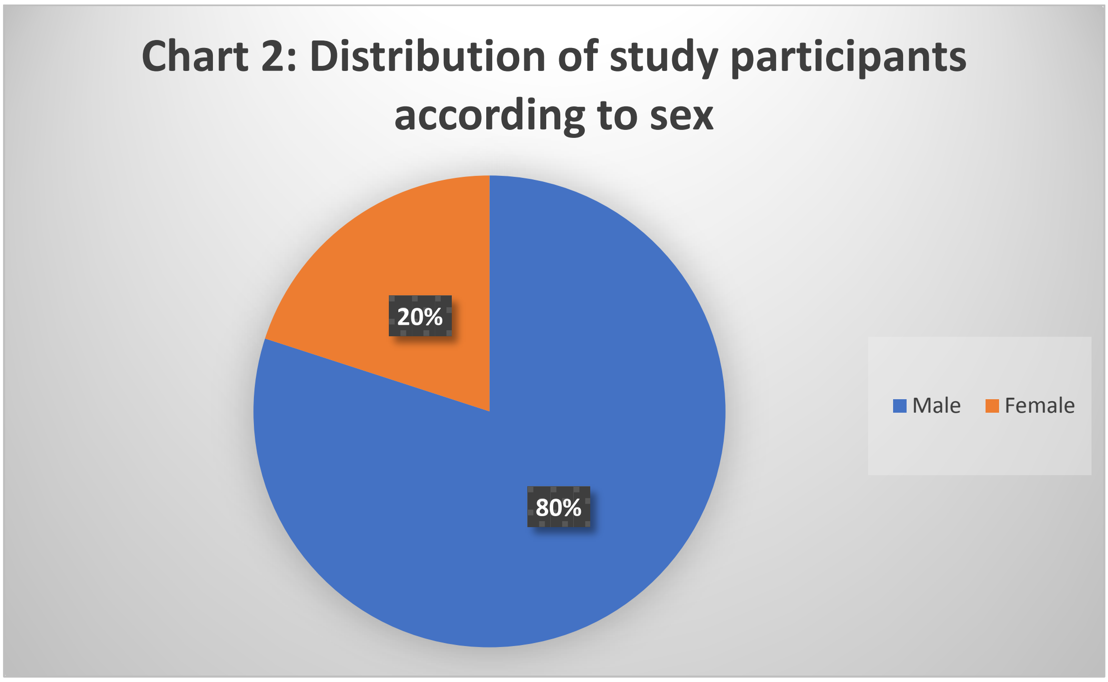


Table 5: Distribution of study participants according to side of injury

SIDE	SIDE OF INJURY	PERCENTAGE
Right	5	31%
Left	10	69%

Majority of the patients about 10 were injured in the left side (69%) while only 5 (31%) were injured in the right side of knee.

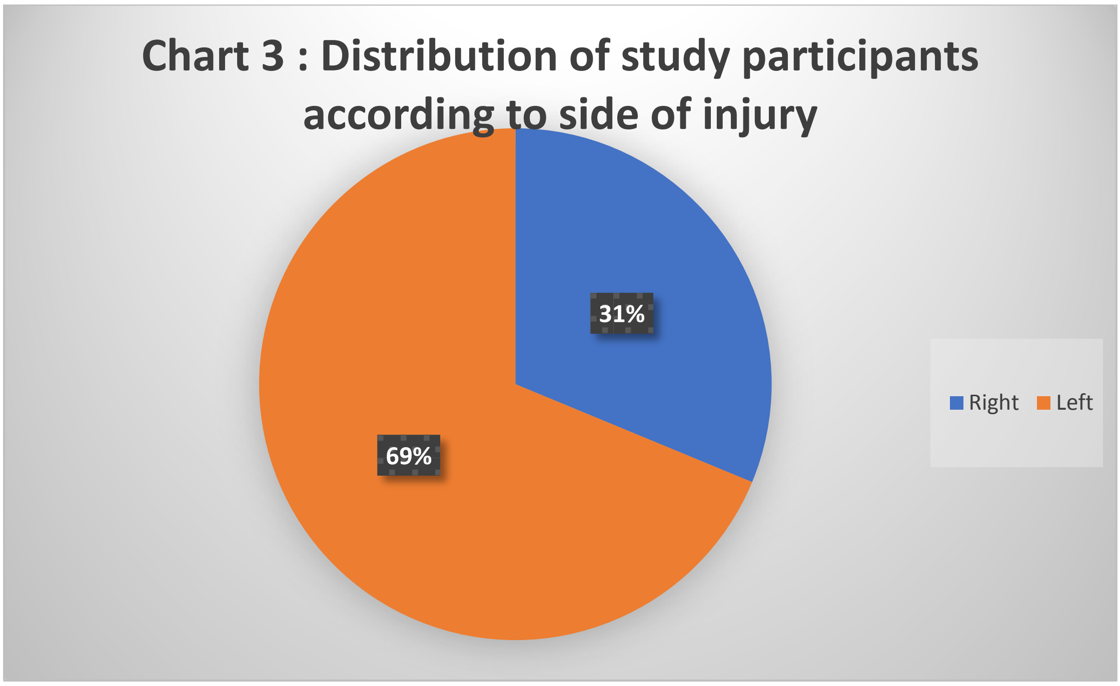


Table 6: Distribution of study participants according to mode of injury

MODE OF INJURY	PATIENTS	PERCENTAGE
ACCIDENTAL FALL	3	20%
ASSAULT	1	6%
SPORTS	1	7%
RTA	10	67%

Most of the patients, about 10 patients (67%) were as a result of RTA, next common being accidental fall (20%). There was only one case of assault and sports injury in the study.

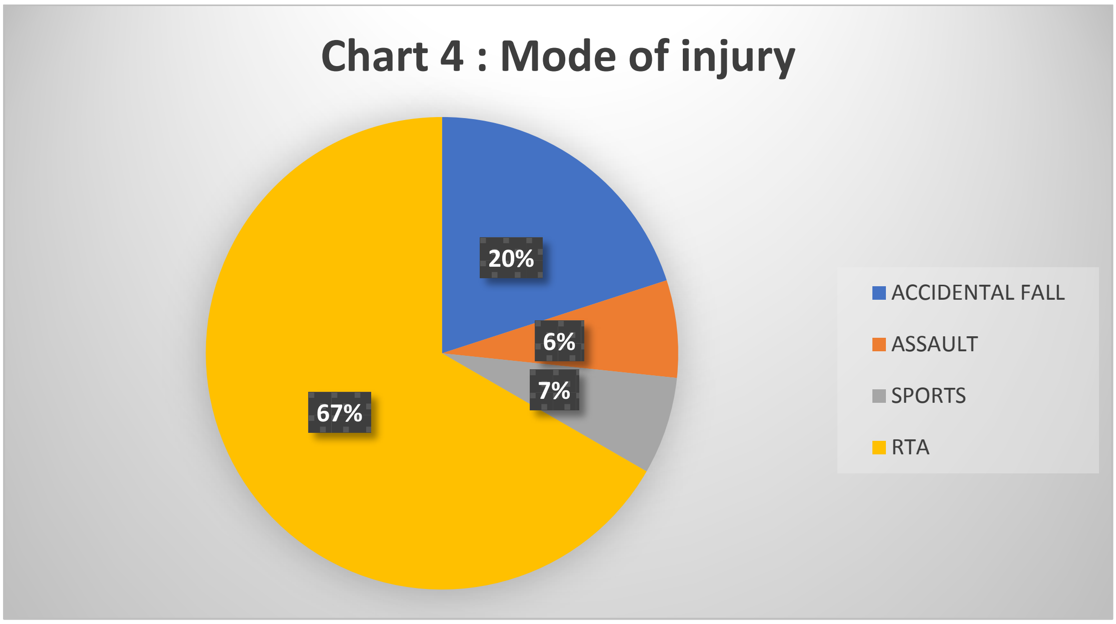


Table 7: Distribution of study participants according fracture types

TYPES	PATIENTS	PERCENTAGE
I	2	13 %
II	6	47%
III	3	13%
IV	4	27%

Most of the cases, about 6 (47%) are from Schatzker type II fractures. Next common being Schatzker type IV (27%). Schatzker type V and VI were not included in our study

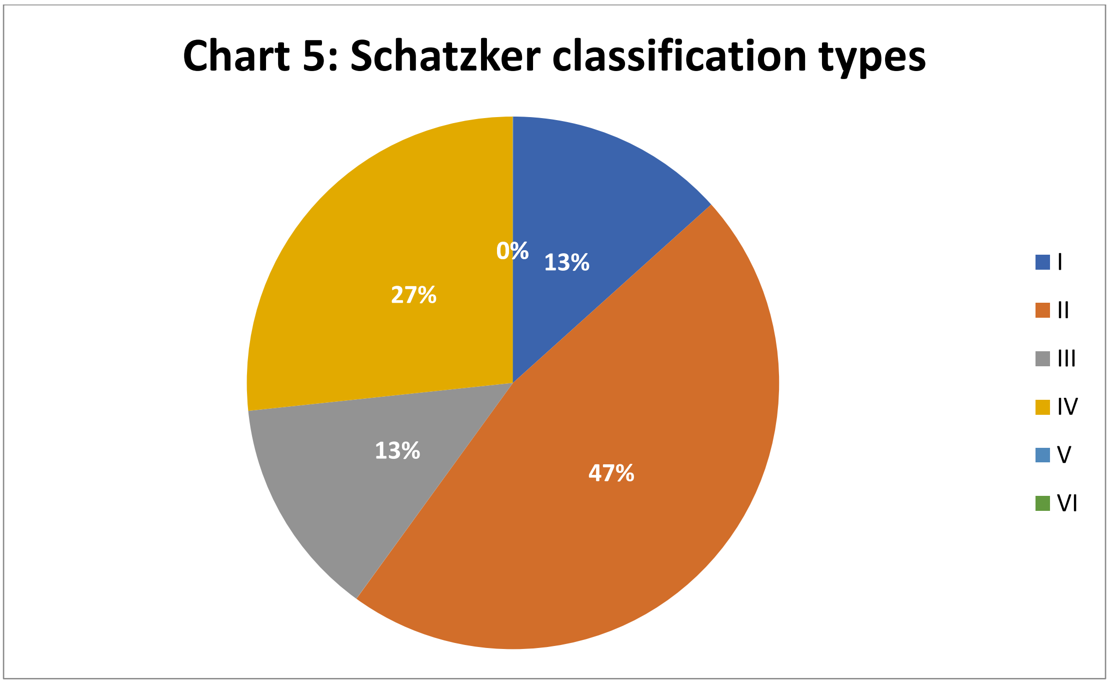
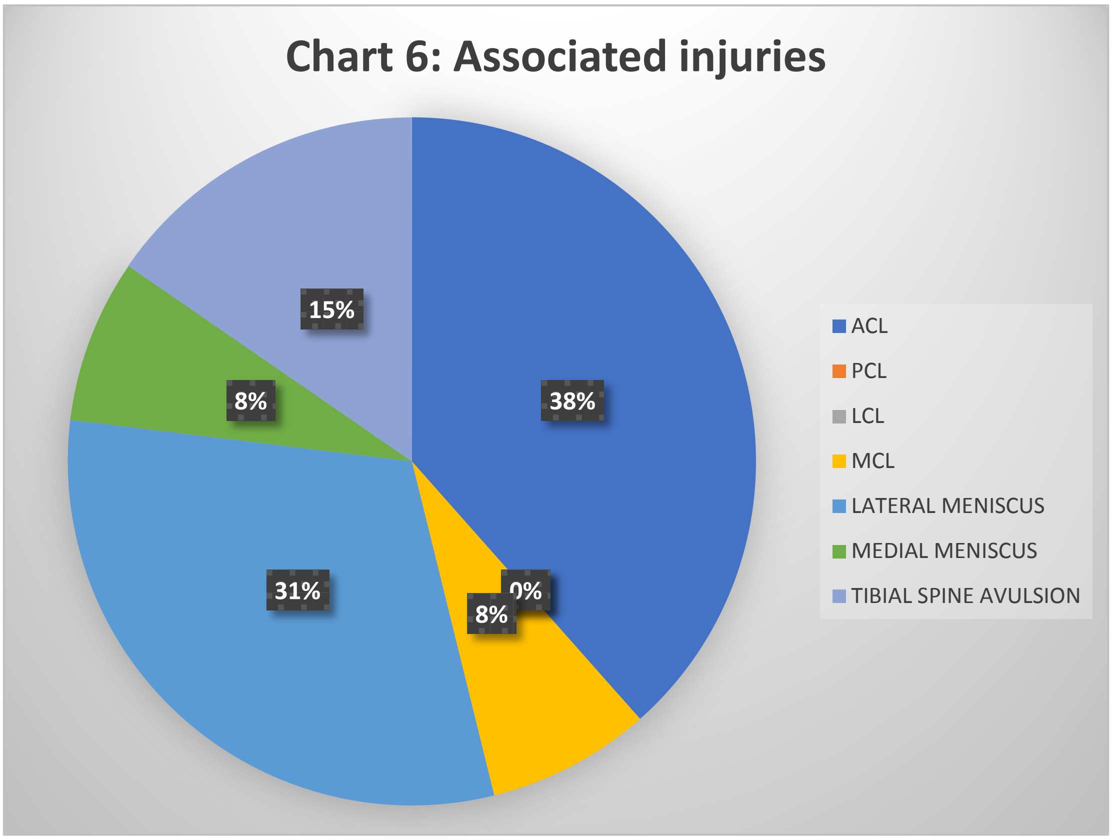
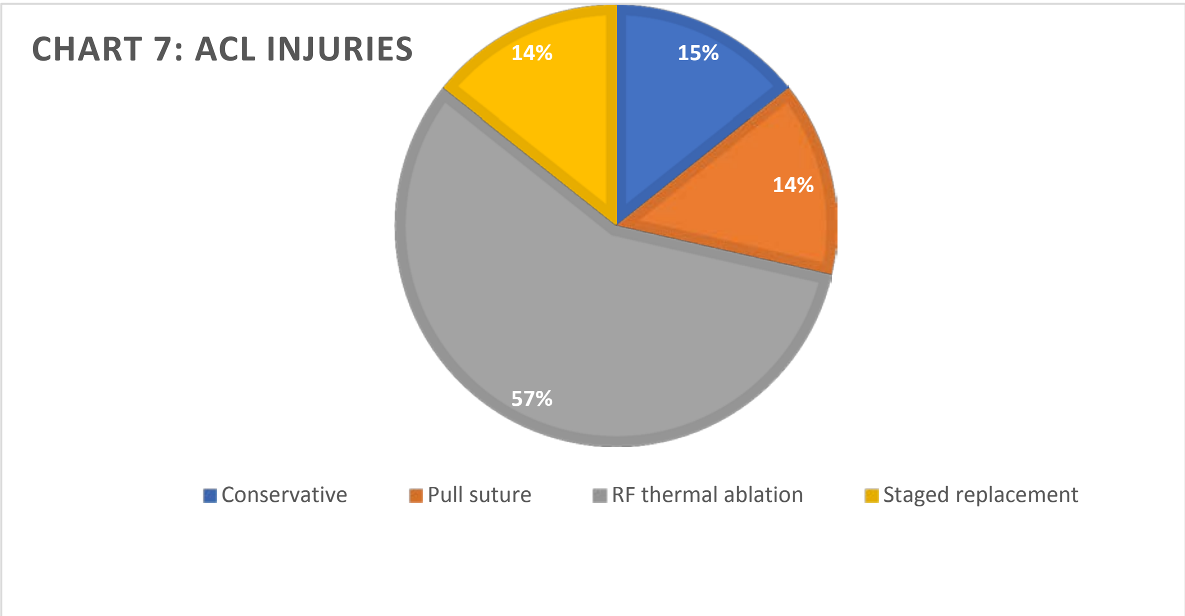


Table 8: Distribution of study participants according to associated injuries

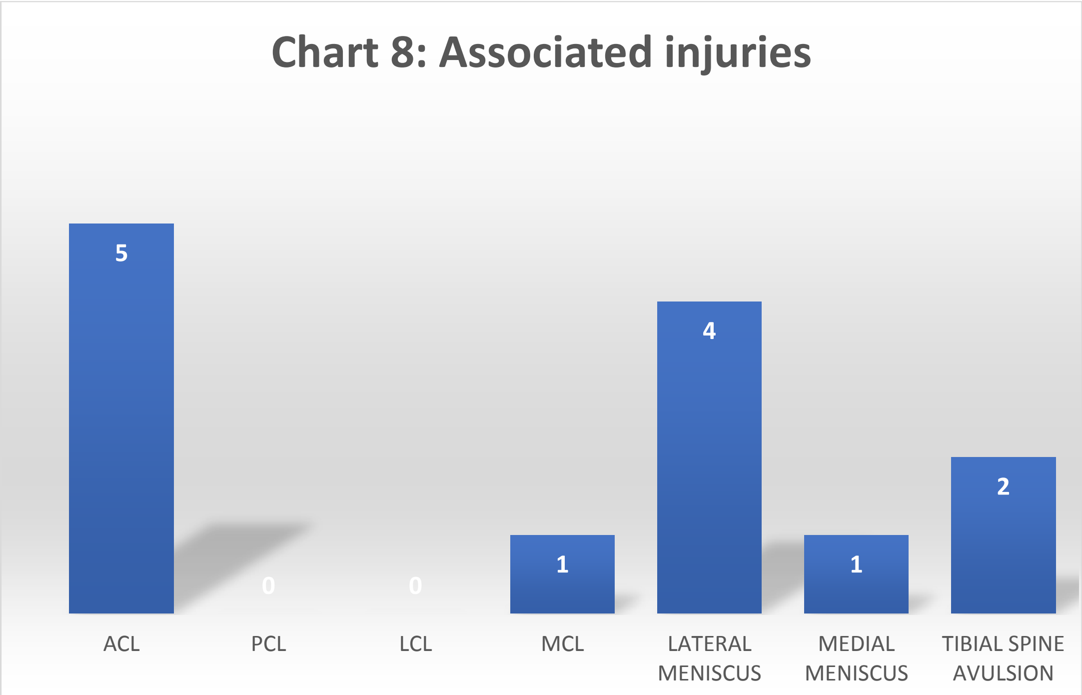
TYPES	NUMBER	PERCENTAGE
ACL	5	38%
PCL	0	0%
LCL	0	0%
MCL	1	8%
LATERAL MENISCUS	4	31%
MEDIAL MENISCUS	1	8%
EMIINENCE FRACTURE	2	15%



Out of 15 cases, 9 cases (60%) had associated injuries. Most common associated injury is partial ACL tear or ACL laxity which is about 38%. Out of 5 cases of ACL injury, 4 cases (57%) had intraoperative laxity which was treated by radiofrequency thermal shortening. One patient had complete mid substance ACL tear, which was treated by staged ACL reconstruction using hamstring graft. Two patients had anterior intercondylar eminence fractures. One was treated with arthroscopic pull sutures and the other was managed conservatively



Next most common injury is lateral meniscal tear (31%). Most of them were peripheral longitudinal tears which was managed by meniscal balancing, whereas in one case lateral meniscus was entrapped between the tibial plateau fracture which was arthroscopically released and repaired. One patient had medial meniscal tear in Schatzker type IV type fracture.



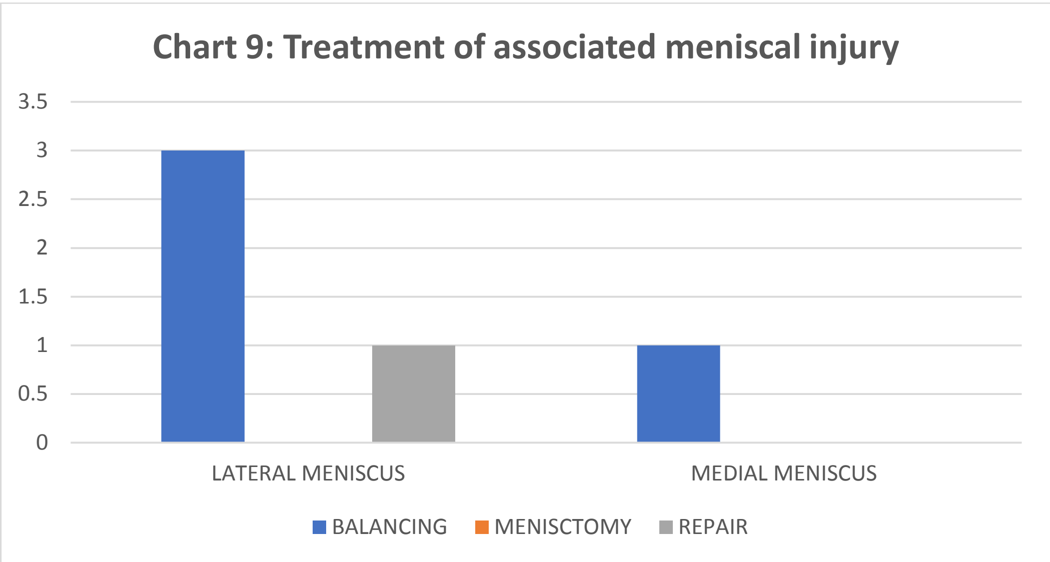


Table 9: Distribution of study participants according to surgical procedure

TYPE	PATIENTS	PERCENTAGE
CANCELLOUS SCREW	5	33%
BUTRESS PLATE	6	40%
SMALL FRAGMENT PLATE	3	20%
LCP	1	7%

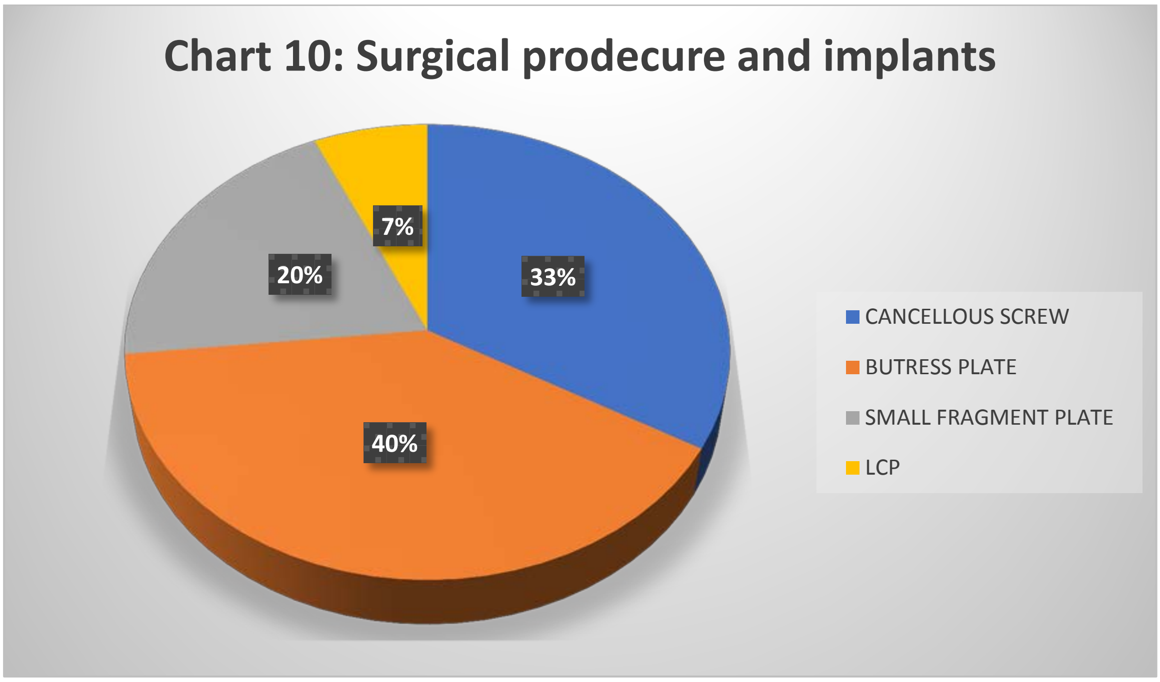
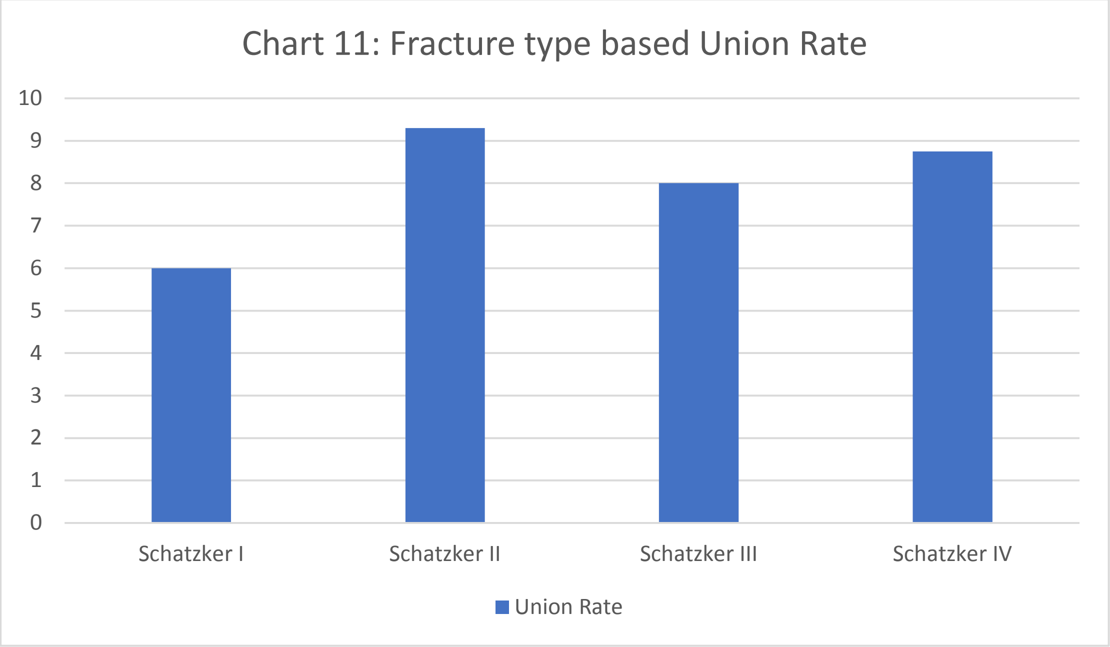
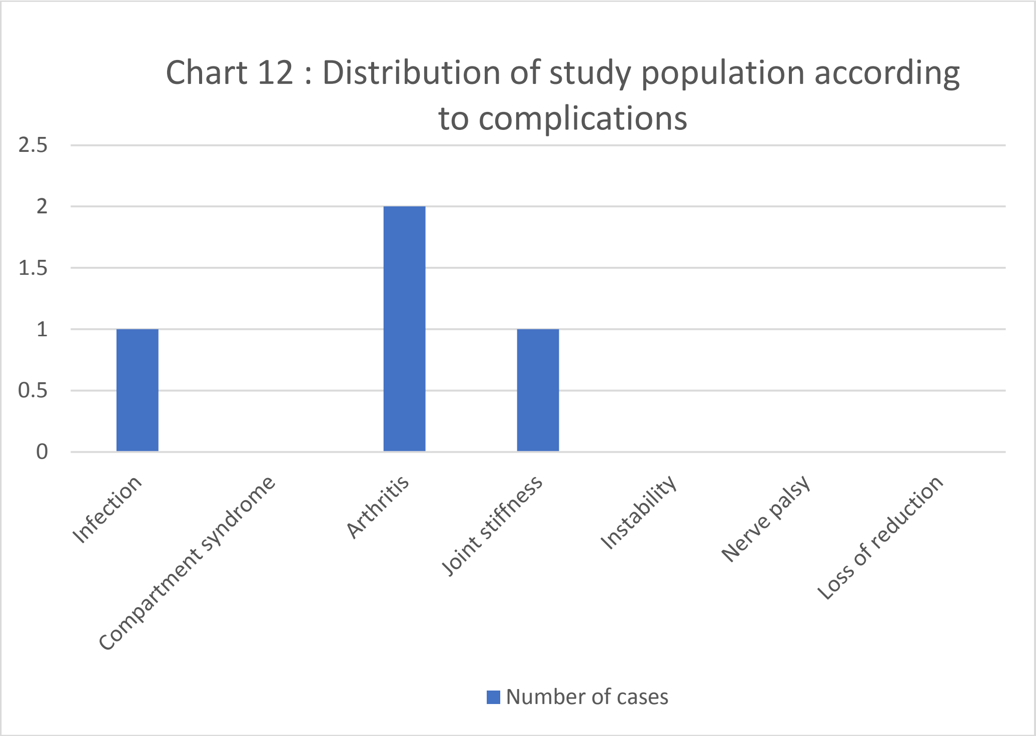


Table 10 Distribution of study population according to rate of union

Type	Union Rate(weeks)
Schatzker I	7
Schatzker II	10.3
Schatzker III	9
Schatzker IV	9.75

Average time of union in our study is 9.46 weeks. Schatzker type I fractures have the quickest union rates of 7 weeks in two cases. Schatzker type II has the least rate of 10.3 weeks.

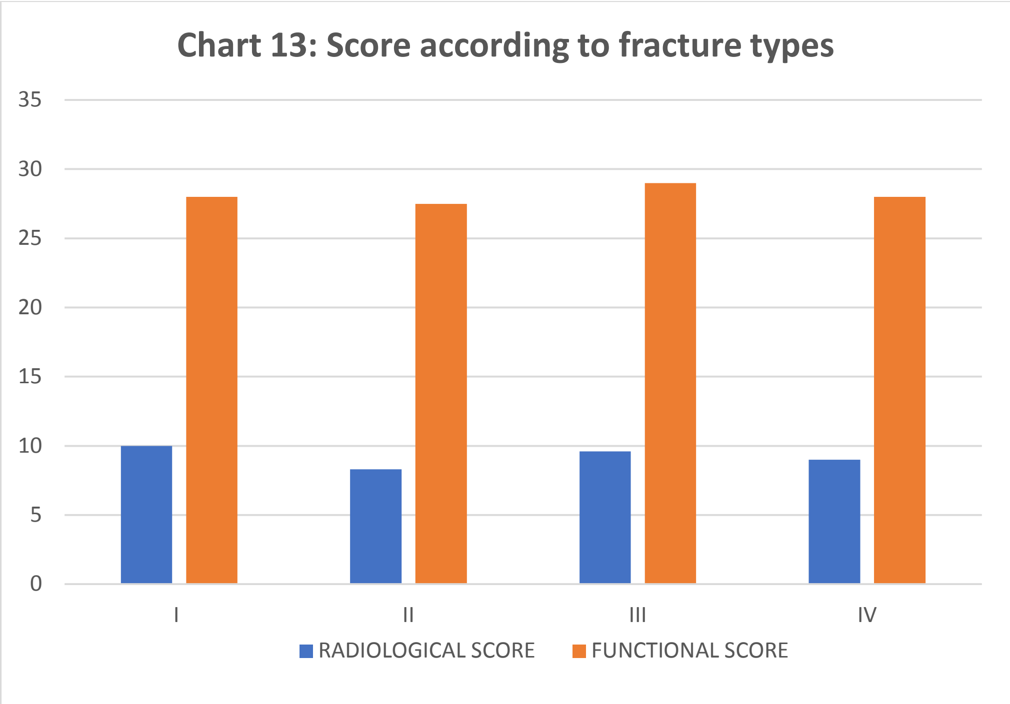




In our study there was one case of infection and two case of mild and moderate arthritis. There were no complications of compartment syndrome, nerve palsy and instability. Two patients had joint stiffness out of which one patient was treated with physiotherapy and had full range at end of 2 years follow-up.

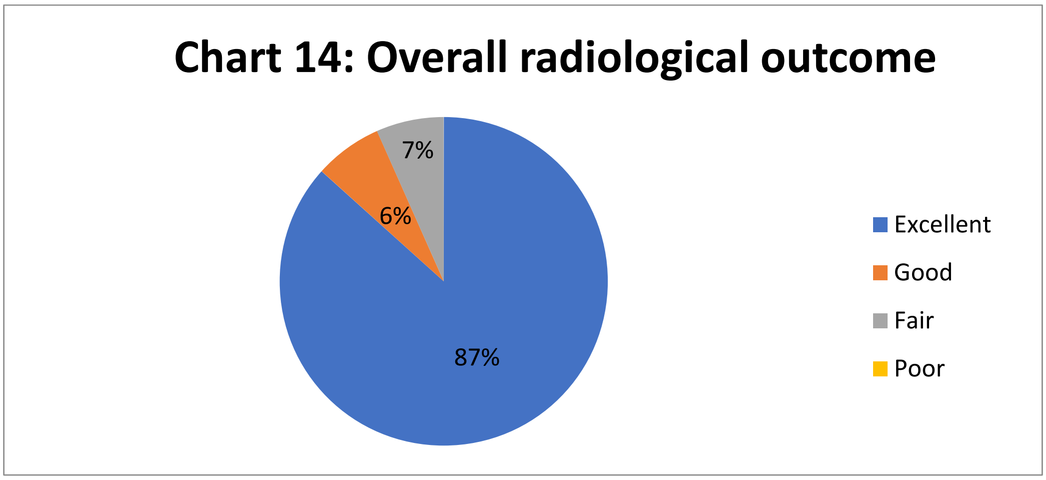
Table 11: Rasmussen radiological and functional score according to fracture types

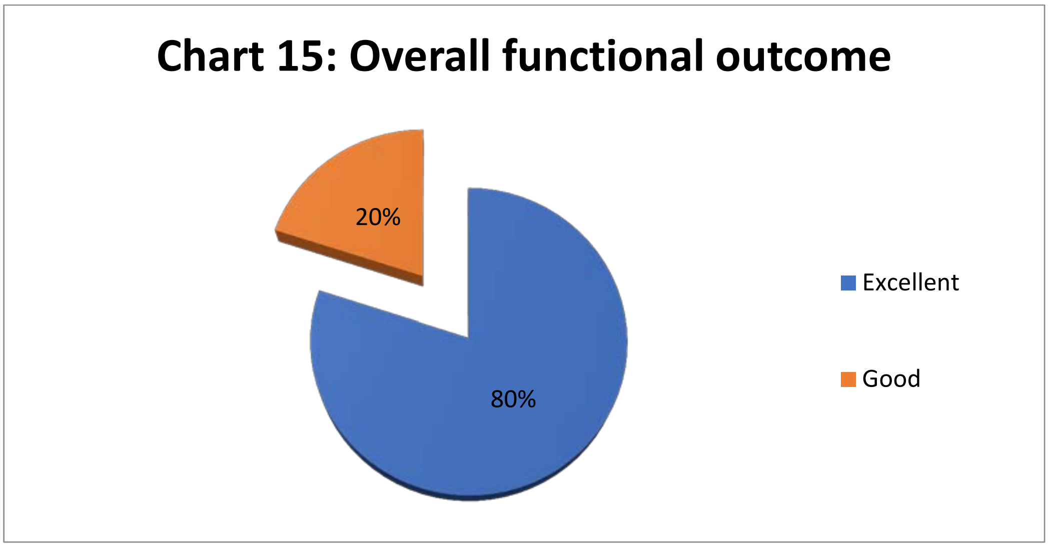
SCHATZKER TYPE	RADIOLOGICAL SCORE	PERCENTAGE	FUNCTIONAL SCORE	PERCENTAGE	OVERALL
I	10	100%	28	93.3%	95.6%
II	8.3	83%	27.5	91.6%	87.3%
III	9.6	96%	29	96.6%	96.3%
IV	9	90%	28	93.3%	91.65%
TOTAL	9.25	92.5%	28.12	93.7%	92.71%



OVERALL OUTCOME

Our study has overall radiological score of 92.5% and overall functional score of 93/7%/ Most of the type I fractures have excellent outcome with 100% radiological and 93.3 % functional outcome. Next best were Type III fractures with 96 % excellent outcome. Of all cases operated 87% cases had good radiological and 80% have good functional outcome.





DISCUSSION

Tibial Plateau fractures have always been a challenge for orthopaedic surgeons. As these are intraarticular fractures of a weight bearing joint, Tschere[36] described that the primary goal is to restore anatomical articular surface by stable internal fixation to allow early mobilization. Right from nature of injury to the type of implants there has been various updates in its management. Associated soft tissue, ligamentous and meniscus injury must be managed along with restoration on anatomic and mechanical axis to give a better functional outcome. Management of these by minimally invasive methods has been the debate in literature. Arthroscopic assisted tibial plateau fixation is one of the minimally invasive techniques first described by Caspari and Jennings[8] in 1985.

Most of the injury in our study were in the young age group of 30 -40 years (53%) and amongst that most were men (80%) with RTA being the most common cause of fractures. Anatomic reduction is more important in young adults because of their higher functional demands.

Though arthroscopy can be done in all type of Schatzker fractures[9], like in most of the recent case series, our study was done only in Schatzker I -IV. Most common type in our study is

Schatzker type II (47%) followed by type IV (27%). Lubowitz[11] defined ARIF as "surgery where anatomic reduction and rigid internal fixation is achieved without arthrotomy".

Table 12: Incidence of fractures compared with other studies

TYPES	Myatt et al	Chan et al	Our study
I	16.5%	11%	13%
II	50%	69%	47%
III	8.5%	6%	13%
IV	25%	14%	27%

Mushal[37] et al suggested that, tibial plateau fractures treated by open reduction and internal fixation may have chances of soft tissue complications. Even if managed conservatively with plaster cast, most of the fractures had complications either like joint stiffness due to prolonged immobilisation or fracture displacement due to cast intolerance.

Hohl et al suggested that conservative management for Schatzker type I tibial plateau fractures yielded 95% good results. Our study with ARIF has excellent outcome of 96.6% with type I fractures and 96.3% for Schatzker type III fractures. Making ARIF the treatment of choice for Schatzker Type III fractures. Most of the type II fractures which was elevated without need of metaphyseal window and had 91.6% functional outcome. Intact cortical envelope is needed for metaphyseal window. But many studies suggest the use of metaphyseal window on same side of fracture. In our study, for two cases, metaphyseal window was made on contralateral intact cortex as suggested by Rossi et al[39].

After elevation of fractures, most of the metaphyseal void needed bone substitutes or cement for filling. Though bone substitutes like calcium phosphate was better than allograft in preventing subsidence, we used ipsilateral iliac bone graft in two cases to fill the metaphyseal cortical window post elevation of fracture. The rate of union is said to be equal in both substitutes.

In our study about 60% of cases had associated intraarticular injuries which will usually be neglected in case of ORIF. ACL was the commonest about 38%. It was found to be lax in 4 patients for which radiofrequency thermal shrinkage was done. And in one patient who had complete tear, staged arthroscopic reconstruction of ACL was done. In contrast to G.M. Buchko and johnson[34] et al we believe that immediate ACL reconstruction, will be an added injury to fractured knee. Of the two patients with intercondylar eminence fracture, one had Meyers and McKeevars type III fracture which was treated by arthroscopic suture fixation augmented with recon plate and the other was managed conservatively. D.M. Meyer[12] et al concluded that cannulated screws alone can be difficult in comminuted fractures and can cause impingement making suture fixation best technique.

Table 13: Incidence of associated injuries compared with other studies

Associated injuries	Hung et al 2003	Abdel-hamid[49] 2006	Chan et al[51] 2013	Our study
ACL partial/complete tear	38%	14%	5.5%	38%
Tibial eminence fractures	-	10%	16.7%	15%
PCL	13%	2%	5.5%	0%
Collateral ligament injury	19%	4%	22.3%	8%
Lateral meniscus	31%	37%	38.9%	31%
Medial meniscus	13%	18%	22.2%	8%

Hohl and Hopp in 2014 reported several injuries of collateral ligament associated with tibial plateau fractures. However, we had only one case of MCL tear which was manged conservatively and did not have any lateral collateral and posterior cruciate ligament injuries in our study.

Lateral meniscal tear in in four cases (31%) and medial meniscus in one case. Most of them were peripheral tear, which was balanced arthroscopically. One entrapped meniscal tear was repaired by inside out technique.

Cartilage defects are common with tibial plateau fractures in femoral and tibial condyles. Kwang Won Lee[45] in 2019 did second-look arthroscopy post tibial plateau fracture fixation and concluded that even if radiologic and clinically normal, cartilage healing is poor especially if depression is more than 2 mm. Hence making Arthroscopy is best modality to directly visualise damage of articular cartilage[46] and allows for the debridement, removal of chondral fragment and chondroplasty. In our study, loose osteochondral fragments were removed arthroscopically and micro-fracturing of femoral cartilage defect was done.

With adaptation of minimally invasive osteosynthesis technique, most of our cases (40%) were fixed with buttress plate and for five patients (33%) cancellous screws alone were used. One patient had a long undisplaced fracture extending into the diaphysis for which LCP was used. With the evolution of fragment specific fixation, isolated column was fixed with 3.5 mm raft plate for 3 patients (20%) in our study.

John Campa et al in 2015 was first to describe patient report on post-operative activity levels of arthroscopy assisted surgeries and had reported excellent outcome on activity levels with early union of fracture and implant exit. In our study average union time was 9.5 weeks. As suggested by Shen G et.al our study too had faster fracture healing time in ARIF compared to ORIF. Our results are comparable with other results published post ARIF by various authors.

Table 14: Outcome compared with other similar studies

S. No	Levy 2008	Siegler 2011	Dall`oca 2012	Nabian 2015	Current study
Number of patients	16	21	50	11	15
Mean age(yrs.)	44.8	43	47.19	36.6	40.3
Mean follow-up (mo.)	41	59.5	22	21	23
RAS R score	16.8	-	16.56	18	18.5
RAS C Score	29.2	25.5	27.62	29	28.12

Esmatelabjer et al in 2017 concluded that both ORIF and ARIF provide an equally good outcome in Schatzker type I to III fractures with ARIF having advantage managing intraarticular associated injuries.

Comparative study by Yufu sun et al in 2018 concluded that AIRF had advantage of incision length, hospital stay, perioperative complications and better Rasmussen score. Waz et al suggests Arthroscopy assisted technique led to better radiological results than open reduction and internal fixation techniques.

Konstantinos tilkeridis et al 2018 suggests to have a well-designed study to evaluate a long term and short-term functional outcome and to assess post traumatic osteoarthritis in such patients as most of the studies are small poorly controlled with potential bias.

COMPLICATIONS

By eliminating the need of heavier implants and by following damage control orthopaedics, we had only one case of infection. It was superficial infection which was managed conservatively with antibiotics and implant exit was done after union of fracture in 15 months. Deep Infection post arthroscopic surgery were reported by Hung et al, Bren Feld GM et al. Our study didn’t have any case of deep infection and septic arthritis.

One patient had an iatrogenic injury with broken drill bit in metaphysis of tibial plateau which however caused no physical complications.

In our study, there was no cases of varus collapse. One patient had medial tibial plateau angle of 85.25 degree. However, on comparison with opposite limb it was only of 0.21-degree excess.

ARIF has been suggested as a risk factor of compartment syndrome. Belanger[30 38] et al reported only two cases requiring fasciotomy back in 1990s. Chen et al concluded in recent studies that there are no cases of compartment syndrome reported in recent case series. In our study we used tourniquet pressure of 320 mmHg and with adequate post-operative care we had no cases of compartment syndrome.

Caspari et. al. showed that few of his patients had iatrogenic peroneal nerve palsy which was probably due to extravasation of fluid and compression of nerve. There was no peroneal nerve palsy in our study.

One disadvantage in this procedure is the visualisation of outer sub meniscal articular surface as described by Lubowitz et al[11]. In our study visualisation and elevation of the depression at the periphery was difficult. In such case double hook self-retaining meniscal retractors provides adequate visualisation.

In studies, post tibial plateau fixation with missed meniscal tear, many had early joint space narrowing and complaints of locking and instability were present. No patients had complaints of locking or instability postoperatively.

Maximum follow-up of our study is 2 years, which was very short duration to analyse the early osteoarthritis radiographically. However, two patients had mild and moderate arthritic changes.

Harris[42] et al suggests poorly executed ARIF can never substitute a well done ORIF as ARIF requires basic arthroscopy training and requires a long learning curve.

Despite all complication of associated with knee injuries our study had excellent Rasmussen clinical score of 93.7% and radiological score of 92.5% in fifteen patients. This result is comparable with those published by numerous authors. In our study 80% patients have excellent score and 20% have good score.

Advantages of Arthroscopy:

- Direct reduction visualization of articular surface reduction without need for sub meniscal arthrotomy
- Minimally invasive methods with reduction tools can introduced through the standard viewing and working arthroscopic portal
- Minimally invasive approaches are used for introduction of plates
- Diagnosis and management of associated meniscal injuries. Meniscal balancing, meniscal repair and release of entrapped meniscus can be done
- Diagnosis and management of associated ligamentous injuries. RF thermal shrinkage for laxity of ACL and arthroscopic reconstruction of ACL can be done.
- Intercondylar eminence fractures can be fixed with pull sutures
- Removal of loose fracture fragments in the joint
- Thorough joint lavage the hemarthrosis
- Chondroplasty in degenerated cartilage
- Directly Identify the site of maximum depression intraoperatively and elevate the depression arthroscopically using ACL zig.

- Use of interference screws post elevation of fractures which even can be bio degradable thereby completely eliminating the need for implant exit
- Can be used in pregnant ladies and those who have high risk for radiation without the use of fluoroscopy
- Cosmetic surgery with minimal surgical scars
- Reduced morbidity and early postop rehabilitation

LIMITATIONS OF OUR STUDY

- Short term study
- Could not achieve 20 patients target list

CONCLUSION

Arthroscopic assisted tibial plateau fixation is excellent minimally invasive method for assessment and treatment of tibial plateau fractures. In our study, 60% of cases with tibial plateau fractures had associated intraarticular injury which may be missed in case of traditional open reduction an internal fixation. Thus, making this the treatment of choice for fractures with concomitant intra-articular injuries. Our study has excellent radiological and functional outcome on par with other similar studies. Of all the Schatzker types of fractures, it is best used for Schatzker type III fractures and is used as an adjuvant for types I II and IV fractures. Experience in arthroscopy is essential to avoid complications.

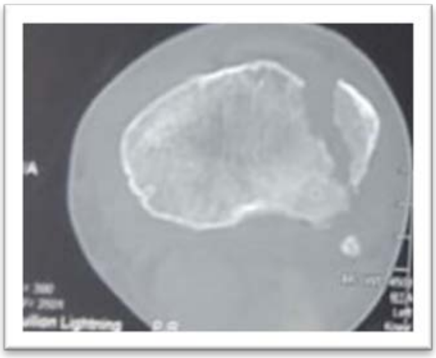
CASE ILLUSTRATION

CASE 1

Name	SUBRAMANI
Age/sex	35/Male
Mode of Injury	RTA
Side	Left
Schatzker type	I
Ligament injury	Laxity of ACL
Management	RF thermal shrinkage done
Meniscal injury	Lateral Meniscal Entrapment and rim avulsion
Management	Lateral Meniscal Repair Using Inside Out Technique
Procedure	6.5 mm Cancellous screw fixation
Technique	Arthroscopic release of entrapped meniscus and freshening of fracture ends
Union time	7 weeks
Follow-up	14 months
Rasmussen radiological score	Excellent 10
Rasmussen clinical score	Excellent 28
Complications	Nil

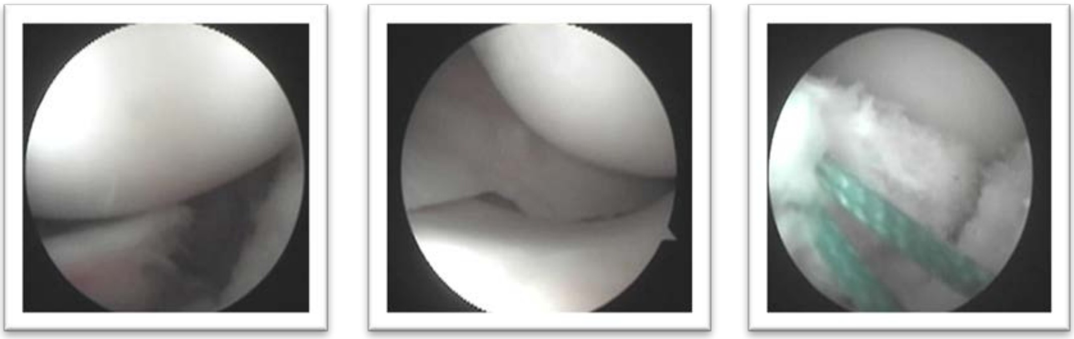
PRE – OPERATIVE X-RAY

PRE – OPERATIVE CT

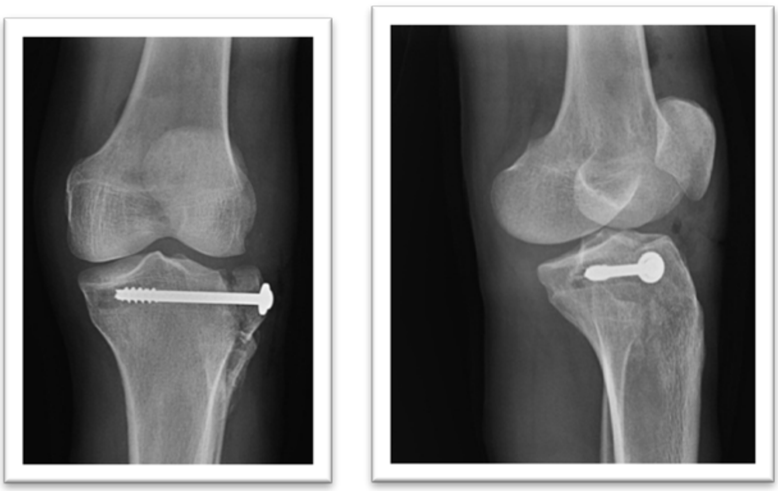


ARTHROSCOPIC RADIO FREQUENCY THERMAL COAGULATION OF LAX ACL

ARTHROSCOPIC INSIDE OUT MENISCAL REPAIR



POST OPERATIVE X-RAY



X- RAY AND FOLLOW UP

CASE 2

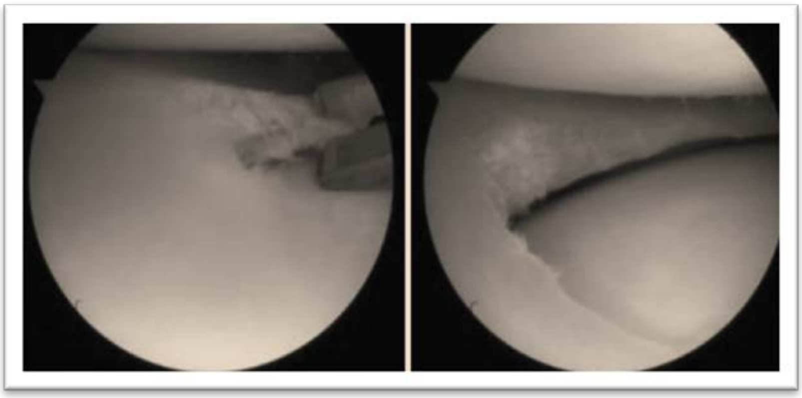
Name	NEELAKANDAN
Age/sex	28/M
Mode of injury	RTA
Side	Left
Schatzker type	II
Ligament injury	Laxity of ACL
Management	Arthroscopic ACL shrinkage
Menisci injury	Lateral meniscal tear
Management	Lateral meniscal balancing
Procedure	9 holed L buttress plate by MIPPO
Technique	Arthroscopic release of entrapped tissues; Pointed reduction clamp
Union time	11 weeks
Follow-up	17 months
Rasmussen radiological score	Excellent 10
Rasmussen clinical score	Excellent 28
Complications	Nil

PRE-OPERATIVE X – RAY

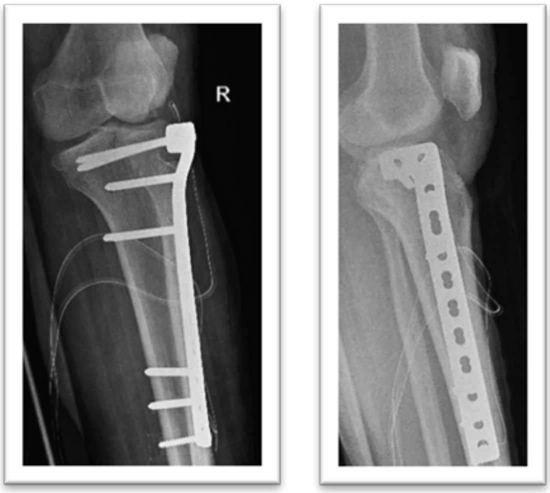
PRE-OPERATIVE CT

INTRAOPERTIVE C-ARM IMAGE

ARTHROSCOPIC RADIO FREQUENCY THERMAL COAGULATION OF ACL/ LATERAL MENISCAL BALANCING



POSTOPEREATIVE X RAY



FOLLOW UP X-RAY

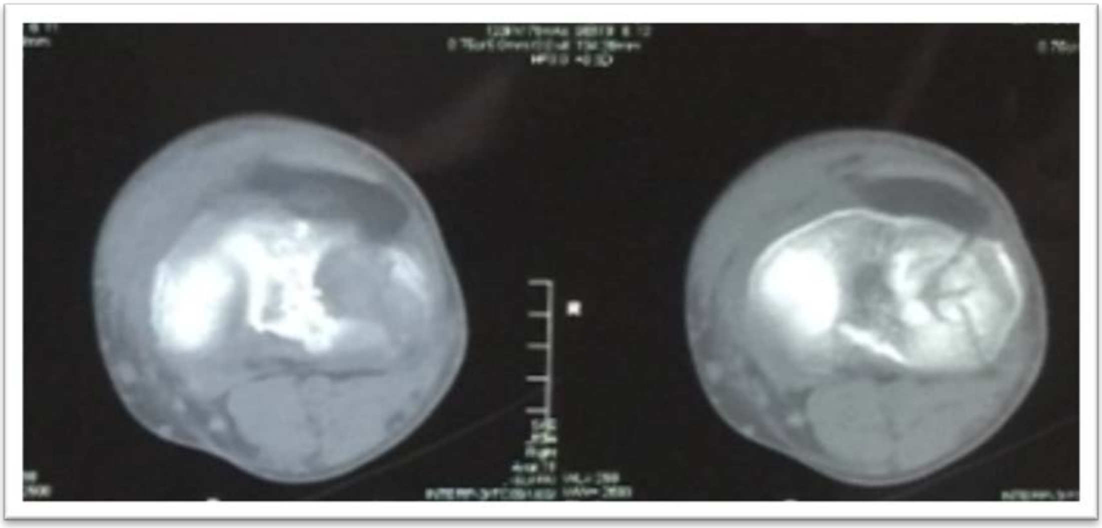
IMPLANT EXIT AND FOLLOW UP

CASE 3

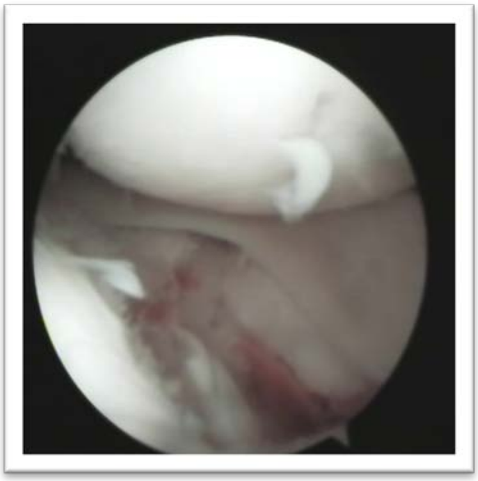
Name	**KUMARAVEL**
Age/sex	60/Male
Mode of injury	Accidental fall
Side	Left
Schatzker type	III
Ligament injury	Laxity of ACL
Management	Arthroscopic Radiofrequency shrinkage
Menisci injury	-
Management	-
Procedure	6.5 mm cancellous screws
Technique	Elevation using ACL Zig at depression and cortical window
Union time	8 weeks
Follow-up	20 months
Rasmussen radiological score	Excellent 9
Rasmussen clinical score	Excellent 30
Complications	Nil

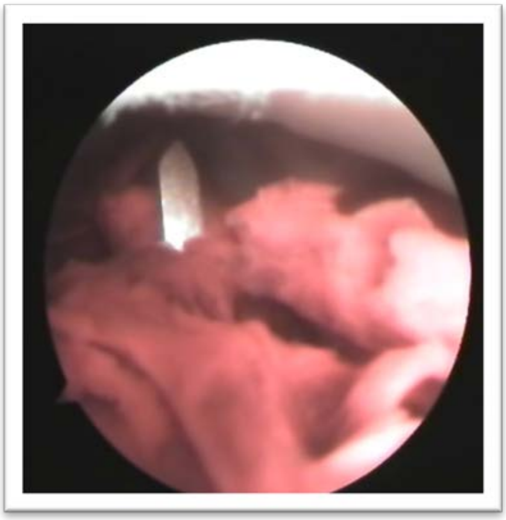
PRE-OPERATIVE X – RAY

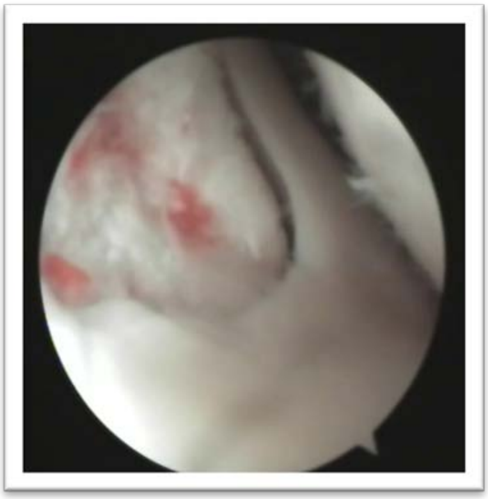
PRE-OPERATIVE CT

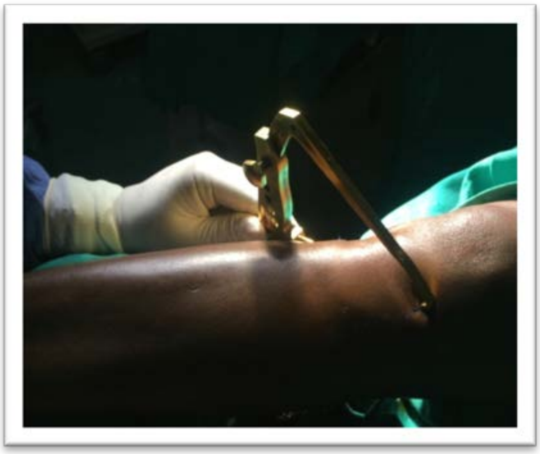


ARTHROSCOPIC ELEVITION OF FRACTURE USING ACL ZIG









FOLLOW UP X-RAYS



IMPLANT EXIT





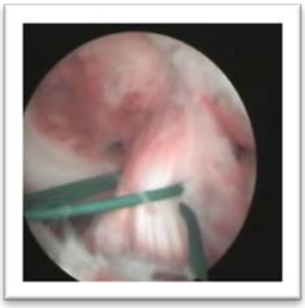
CASE 4

Name	**MANIVASAGAM**
Age/sex	45/Male
Mode of injury	RTA
Side	Left side
Schatzker Type	IV
Ligament Injury	Meyer Mckeewer Type III Tibial spine avulsion
Management	Arthroscopic fixation using pull sutures and recon plate
Menisci injury	-
Management	-
Procedure	7 holed small fragment lateral plate
Union time	9 weeks
Follow-up	19 months
Rasmussen radiological score	Excellent 10
Rasmussen clinical score	Excellent 29
Complications	Nil

PRE-OPERATIVE X – RAY

PRE OPERATIVECT

ARTHROSCOPIC ACL PULL SUTURE REPAIR



FOLLOW UP X-RAY **RECON PLATE EXIT**

FOLLOW UP

CASE 5

Name	**BALRAJ**
Age/sex	54/Male
Mode of injury	RTA
Side	Left side
Schatzker type	I
Ligament injury	Complete ACL tear
Management	Staged Arthroscopic reconstruction using quadrupled hamstring graft
Menisci injury	-
Management	-
Procedure	6.5 mm cancellous screw fixation
Union time	7 weeks
Follow-up	12 months
Rasmussen radiological score	Excellent 10
Rasmussen clinical score	Excellent 28
Complications	Nil

PRE-OPERATIVE X – RAY

PRE-OPERATIVE MRI

POST OPERATIVE X – RAY

ARTHROSCOPIC ACL RECONSTRUCTION USING QUADRUPLED HAMSTRING GRAFT

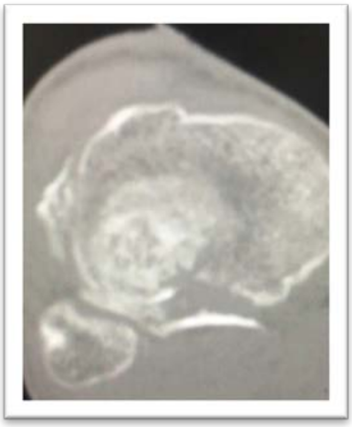
POST OPERATIVE XRAY AND FOLLOW UP

COMPLICATIONS

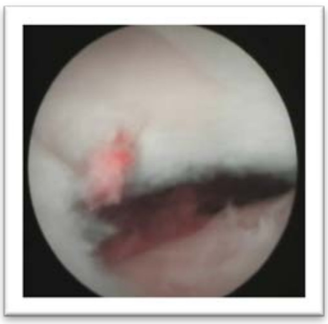
Name	**MUNIYAPPAN**
Age/sex	35/Male
Mode of injury	RTA
Side	Right
Schatzker type	II
Ligament injury	-
Management	-
Menisci injury	Lateral meniscus tear
Management	Lateral meniscal balancing
Procedure	9 holed Proximal tibial LCP
Technique	Elevation using medial cortical tunnel and bone grafting;
Union time	15 weeks
Follow-up	19 months
Rasmussen radiological score	Fair 6
Rasmussen clinical score	Good 24
Complications	wound infection; Knee stiffness

PRE-OPERATIVE X-RAY

PRE OPERATIVECT



ELEVATION USING MEDIAL CORTICAL TUNNEL AND BONE GRAFTING



POST OPERATIVE X-RAY POST OPERATIVE ABRATION

FOLLOW UP X –RAY **IMPLANTEXIT**

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PROFORMA

A. CASE PROFORMA

Name:

Age/sex:

I.P No:

D.O.A:

B. CHIEF COMPLAINTS/ HISTORY:

Complaints:

Date of Injury:

Time since injury:

Mode of Injury:

Brief history:

C.CO MORBIDITIES:

D. LOCAL EXAMINATION OF KNEE:

E. INVESTIGATIONS

1. X ray knee and 3D knee
2. Routine blood investigations

F. DIAGNOSIS AND CLASSIFICATION:

G. OPERATIVE NOTES:

PRIMARY PORTAL	SECONDARY PORTAL
Anterolateral: Viewing portal	Posteromedial:
Anteromedial: Working portal	Posterolateral:
	Trans patellar:

Diagnostic arthroscopy was done and following findings were noted.

1	Suprapatellar pouch	
2	Under surface of Patella	
3	Medial and Lateral Gutter	
4	ACL	
5	PCL	
6	Medial Meniscus	
7	Lateral Meniscus	
8	Posteromedial & Posterolateral corner	
9	Other findings	

MODIFIED RASMUSSENS FUNCIONAL SCORE

PAIN	Score
None	6
Occasional	5
Stabbing pain in certain position	3
Constant pain after activity	1
Significant rest pain	-3
WALKING CAPACITY	
Normal walking capacity for age	6
Walking outdoor more than one hour	5
Walking outdoor 15 min to 1 hr	3
Walking outdoor <15 mins	1
Walking indoor only	0
Wheel chair or bedridden	-3
KNEE EXTENSION	
Normal	4
Lack of Extension<10 degree	2
Lack of Extension>10 degree	0
Lack of Extension>20 degree	-2
TOTAL RANGE OF MOTION	
Full	6
At least 120 degree	5
At least 90 degree	3
At least 60 degree	1
< 60 degree	-3
STABILITY	
Normal stability in extension and 20-degree flexion	6
Abnormal instability in 20-degree flexion	4
Instability in extension <10 degree	2
Instability in Extension >10 degree	0
POWER OF QUADRICEPS	
Grade 5	2
Grade 3-4	1
Grade <3	-2
Maximum score	**30**
Excellent	28-30
Good	24-27
Fair	20-23
Poor	<20

MODIFIED RASSMUSSENS RADIOLOGICAL SCORE

Articular depression	**Score**
None	3
<5mm	2
6-10mm	1
10mm>	0
Condylar widening	
none	3
<5mm	2
6-10mm	1
10mm>	0
Varus/valgus angulation	
None	3
<10 degree	2
10-20 degree	1
20 degree>	0
Osteoarthrosis	
None/no progress	1
Progression by grade 1	0
Progression by grade 1>	-1
Maximum score	**10**
Excellent	9-10
Good	7-8
Fair	5-6
Poor	<5

MASTER CHART

S.NO	NAME	AGE	SEX	IP NO	MOI	SIDE	SCH	ACL	MANAGEMENT	MENISCI	MANAGEMENT	IMPLANT	UNION TIME (Weeks)	FOL UP (Months)	ROM (Degrees)	RAS R	RAS C
1	RAJ	54	M	7644	RTA	L	IV	LAX	RFA	LM tear	Balancing	7H Plate	11	6	135	G8	G25
2	SELV	33	M	3236	RTA	R	III	N	-	N	-	3H Plate	9	22	140	E10	E28
3	MAD	42	M	4667	ACC	L	II	SPI	Conservative	N	-	3 Screw	8	22	140	E10	E30
4	KUM	60	M	7958	ACC	L	III	Lax	RFA	N	-	2 Screw	8	20	140	E9	E30
5	SEL	35	M	2545	RTA	L	IV	N	-	N	-	5H Plate	9	20	140	E9	E29
6	MUN	35	M	4577	RTA	R	II	N	-	LM tear	Balancing	9H Plate	15	19	90	F6	G24
7	MAN	45	M	7858	RTA	L	IV	SPI	Pull sutures	N	-	7H SFP	9	19	140	E10	E29
8	SUB	35	M	6488	RTA	L	I	Lax	RFA	LM entrap	Inside out repair	1 Screw	7	14	135	E10	E28
9	SAK	28	M	7648	SPO	L	II	N	-	N	-	5H SFP	10	6	130	E9	G27
10	NEL	28	M	7569	RTA	L	II	Lax	RFA	LM tear	Balancing	9H Pl	11	14	140	E10	E28
11	ESW	39	F	8068	RTA	R	II	N	-	N	-	2 Screw	9	13	140	E9	E28
12	BAL	54	M	6535	RTA	L	I	TEAR	ACLR	N	-	1 Screw	7	12	140	E10	E28
13	VIJ	29	M	3870	RTA	L	IV	N	-	MM tear	Balancing	Plate	10	6	140	E9	E29
14	MYL	43	F	9709	ASS	R	II	N	-	N	-	Plate	9	7	135	E9	E28
15	MNI	45	F	5632	ACC	R	III	N	-	N	-	SFP	10	8	140	E10	E29

KET TO MASTER CHART

SCH- Schatzker classification

MOI- Mechanism of injury

RAS R -Rasmussen’s radiological score

RAS C -Rasmussen’s clinical score

RTA- Road traffic accident

ACC- Accidental fall

SPO- Sports injury

N- Normal and intact

SPI- Tibial spine avulsion

ACLR- Arthroscopic ACL reconstruction

LM- lateral meniscus

MM- Medial meniscus

H- Holed

SFP- Small fragment plate

E- Excellent

G- Good

F-Fair