A COMPARTIVE ANALYSIS OF FUNCTIONAL OUTCOME OF TIBIAL PLATEAU FRACTURES TREATED WITH PROXIMAL TIBIAL LOCKING PLATE WITH RAFT SCREW TECHNIQUE AND CONVENTIONAL BUTTRESS PLATING

Dissertation submitted to

M.S. DEGREE-BRANCH II

ORTHOPAEDIC SURGERY

THE TAMILNADU DR.M.G.R.MEDICAL UNIVERSITY

CHENNAI-TAMILNADU

APRIL 2015

CERTIFICATE

This is to certify that this dissertation titled **"A COMPARTIVE ANALYSIS OF FUNCTIONAL OUTCOME OF TIBIAL PLATEAU FRACTURES TREATED WITH PROXIMAL TIBIAL LOCKING PLATE WITH RAFT SCREW TECHNIQUE AND CONVENTIONAL BUTTRESS PLATING"** is a bonafide record of work done by **DR. R. SAMPATH,** during the period of his Post graduate study from May 2012 to April 2015 under guidance and supervision in the INSTITUTE OF ORTHOPAEDICS AND TRAUMATOLOGY, Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai-600003, in partial fulfillment of the requirement for **M.S.ORTHOPAEDIC SURGERY** degree Examination of The Tamilnadu Dr. M.G.R. Medical University to be held in April 2015.

Prof. R.VIMALA M.D.,

Dean,

Madras Medical College & Rajiv Gandhi Government General Hospital,

Chennai - 600 003.

Prof. N.DEEN MUHAMMAD ISMAIL M.S.Ortho., D.Ortho.,

Director I/C,

Institute of Orthopaedics and Traumatology,

Madras Medical College & Rajiv Gandhi Government General Hospital,

Chennai - 600003.

DECLARATION

I declare that the dissertation entitled **"A COMPARTIVE ANALYSIS OF FUNCTIONAL OUTCOME OF TIBIAL PLATEAU FRACTURES TREATED WITH PROXIMAL TIBIAL LOCKING PLATE WITH RAFT SCREW TECHNIQUE AND CONVENTIONAL BUTTRESS PLATING"** *submitted by me for the degree of M.S is the record work carried out by me during the period of* ***July 2013 to September 2014*** *under the guidance of* ***PROF. N.DEEN MUHAMMAD ISMAIL*** **M.S.Ortho.,D.Ortho.,** *Director I/C, Institute of Orthopaedics and Traumatology, Madras Medical College, Chennai. This dissertation is submitted to the Tamilnadu Dr.M.G.R. Medical University, Chennai, in partial fulfillment of the University regulations for the award of degree of M.S.ORTHOPAEDICS (BRANCH-II) examination to be held in April 2015.*

Place: *Chennai* **Signature of the Candidate**

Date: **(Dr. R. Sampath)**

Signature of the Guide

Prof. *N.DEEN MUHAMMAD ISMAIL* M.S.Ortho., D.Ortho.,

Director I/C,

Institute of Orthopaedics and Traumatology,

Madras Medical College, Chennai.

ACKNOWLEDGEMENT

I express my thanks and gratitude to our respected Dean **Prof.R.VIMALA M.D.,** Madras Medical College, Chennai – 3 for having given permission for conducting this study and utilize the clinical materials of this hospital.

I have great pleasure in thanking my guide **Prof.*N.DEEN MUHAMMAD ISMAIL*** **M.S,Ortho., D.Ortho**., Director I/C, Institute of Orthopaedics and Traumatology, for his guidance and constant advice throughout this study.

My sincere thanks and gratitude to P**rof.M.SUDHEER M.S.Ortho., D.Ortho.,** for his constant inspiration and advice throughout the study.

My sincere thanks and gratitude to **Prof.V.SINGARAVADIVELU. M.S.Ortho., D.Ortho**., for his guidance and valuable advice provided throughout this study.

My sincere thanks and gratitude to **Prof.A.PANDIASELVAN. M.S.Ortho., D.Ortho**., for his valuable advice and support. .

I sincerely thank **Prof.NALLI R. UVARAJ .M.S.Ortho**.,

D.Ortho., for his advice, guidance and unrelenting support during the study.

I am very much grateful to **Prof. S. KARUNAKARAN.M.S.Ortho.**, for his unrestricted help and advice throughout the study period.

My sincere thanks and gratitude to my co-guide **Dr.Nalli R.Gopinath,** for his constant advice and guidance provided throughout this study.

I sincerely thank **Dr. S.Senthil Sailesh, Dr.Sarathbabu, Dr. Prabhakaran, Dr. Kannan, Dr. Hemanthkumar, Dr.Kingsly, Dr.Mohammed Sameer, Dr.Kaliraj, Dr.Muthalagan, Dr. Pazhani, Dr. Suresh Anand, Dr. Saravanan, Dr. Raj Ganesh, Dr.Muthukumar,** Assistant Professors of this department for their valuable suggestions and help during this study.

I thank all anesthesiologists and staff members of the theatre and wards for their endurance during this study.

I am grateful to all my post graduate colleagues for helping in this study. Last but not least, my sincere thanks to all our patients, without whom this study would not have been possible.

A COMPARTIVE ANALYSIS OF FUNCTIONAL OUTCOME OF TIBIAL PLATEAU FRACTURES TREATED WITH PROXIMAL TIBIAL LOCKING PLATE WITH RAFT SCREW TECHNIQUE AND CONVENTIONAL BUTTRESS PLATING

Background and objective

Fractures of the tibial plateau range from simple lateral condyle fracture to severe comminuted metaphyseal fractures associated with varying degrees of articular depression. Management of these complicated fractures remains challenging. The aim of this study is to compare the functional outcome of tibial plateau fractures treated with proximal locking plate with raft screws (raft plating) and conventional buttress plating.

Materials and methods

Our study was a prospective cum retrospective study, conducted at the Institute of Orthopaedics and Traumatology, Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai between July 2013 to September 2014. Patients admitted with tibial plateau fractures (type II to VI Schatzker) were divided into two groups of 10 each. One group was treated with raft plating and another with buttress plating. They were followed for a period of 6 months.

Functional outcome was assessed by knee society score devised by the hospital for special surgery.

Results

In raft plating group, 7 patients had excellent results, 2 had good results and 1 had fair result. In buttress plating group, 2 had excellent results, 2 had good results, 5 had fair results and 1 had poor result. The mean knee society score in the raft plating group was 84.8 and in the buttress plating group, it was 71.6. By analysis of the results, there was statistically significant difference in the functional outcome of patients treated by raft plating compared to buttress plating.

Conclusion

Raft plating prevents the late subsidience of articular surface and hence better functional outcome. From this study, it can be concluded that when compared to buttress plating, raft plating is a better and effective method for achieving good to excellent results providing almost full range of motion and maintaining articular congruity in the treatment of tibial plateau fractures.

KEY WORDS: tibial plateau fracture, buttress plating, raft plating, knee society score.

TABLE OF CONTENTS

INTRODUCTION

Fractures of the tibial plateau usually result from high energy trauma. Motor vehicle accidents seem to be the predominant cause worldwide. Knee is the major weight bearing joint of the body. Fractures of the tibial plateau change the knee kinematics alter joint stability and cause joint incongruity. Fractures range from simple lateral condyle fracture to severe comminuted metaphyseal fractures. These fractures are often associated with severe soft tissue compromise. Hence while treating these fractures, the surgeon takes into consideration many factors like type of fractures, soft tissue and ligamentous injury.

Less severe types can be treated operatively or non-operatively. Good results have been reported by numerous authors by either method.

For more severe type fractures there is consensus regarding operative management. The various modalities of treatment aim at elevating depressed articular surface, maintaining the elevation by means of plates and screws and if necessary filling the defect with bone graft to gain maximum range of knee motion.

Various surgical modalities like open reduction internal fixation with cannulated Screw fixation, Condylar plate with or without bone graft, AO/ASIF Buttress plate (T/L) with or without bone graft, Proximal tibial locking plate have been practised. Biomechanical data showed four 3.5mm screws were superior to two 6.5 mm screws in axial compression.[30]

Tibial plateau fractures are serious injuries that commonly result in functional impairment. The objective in treating displaced fractures is to restore the articular surface anatomy, repair of soft tissue injuries and rigid internal fixation to obtain a painless and stable knee joint with normal range of movements.

Design of study : Prospective and retrospective

Duration of study : July 2013 to September 2014

AIM OF THE STUDY

To compare the functional outcome of tibial plateau fractures treated with proximal locking plate with raft screws and conventional buttress plating

OBJECTIVES

1. Pre-operative assessment to evaluate the age wise distribution of fractures, type of fractures and its mechanism of injury.
2. To restore articular anatomy and congruity by open reduction and internal fixation.
3. To assess the time for union of fractures treated by with proximal locking plate with raft screws and conventional buttress plating
4. To assess intraoperative and post operative complications.
5. To assess the range of motion of knee and note the knee score for each patient at every follow up.
6. To compare the functional outcome of patients with tibial plateau fractures treated with proximal locking plate with raft screws and conventional buttress plating.

REVIEW OF LITERATURE

The treatment of tibial plateau fractures has changed dramatically over the past 50 years. Until the late part of 20th century, they were treated conservatively in the form of traction and cast bracing .

Apley [40] reported satisfactory results with traction and early mobilisation of knee.

Duwelius and Connolly[21] treated patients with closed reduction along with percutaneous pinning in some and early mobilisation in a cast brace and reported 89% of good to excellent results.

The favourable results observed in these studies provide an indirect evidence that the proximal tibial articular surface tolerates modest deformities and favorable outcomes can be obtained when reasonable limb alignment is achieved even without perfectly reducing the articular surface.

Koval et al.[17] used fluoroscopy to reduce 18 plateau fractures with screws. Out of 18 patients, 13 had excellent results.

Mills and Nork [11] achieved dual plating with minimal soft-tissue dissection and limiting subperiosteal dissection.

Ballmer, Hertel, and Nötzli reported the use of small fragment (3.5-mm screws) and AO/ASIF T-plates for fixation of 15 tibial plateau fractures.

Palmer I (1952) advocated surgery for any displacement or depression. Courvoisier E. (1965) suggested open reduction for any depression or displacement. Hohl M. (1967) and Rombold C. (1940) said if there is depression of more than 5 mm or lateral displacement of more than one cm, open reduction and internal fixation should be perfomed. Rasmussen (1973) performed open reduction for valgus or varus instability of 10 degree.

Moor T.M. and Harvey J.P. Jr. (1974)[41] used the tibial palteau view to measure the exact degree of depression before planning any surgery. Elstrom J., Pankovich AM, Sasson H. et. al. (1976) advised CT scan before planing any surgery to know the degree of depression, and type of fracture.

A.O. ASIF principles advocate surgery for all plateau fractures except for undisplaced fractures to restore articular anatomy.

Barr JS (1940) suggested using bone graft to elevate the depressed plateau and internal fixation. Autogenous bone grafts can be augmented with allograft. Kenney W.R. (1978) used methylmethacrylate for fixation of fragment. In 1984 Clyton perry and Lawerence G. Evans and Samrile (1984) described a new approach to visualize the fracture after incision of anterior

horn of lateral meniscus. It minimizes the need to free the lateral meniscus from its attachment.

Schatzker and McBroom [22] (1979) concluded that open reduction with anatomical restoration of articular cartilage produces best results. In their study of 70 patients they obtained 78% acceptable results in the operated group as compared to 58% in the non-operated group.

Bowes in 1982 and Hohl [42] reviewed 52 tibial plateaus out of 110 fractures for more than one year. Non operative management was used in 72% of fractures. ORIF was used in 28%. Overall results were acceptable in 84% of patients. They used cast bracing in 31% of cases either as a primary treatment or after open reduction.

Blokker et al [43] in 1984 reviewed 60 tibial plateau fractures of which 75% patients had satisfactory results. According to them, the outcome of tibial plateau fractures was predicted by the adequacy of reduction.

J. J. Dias et. al [25] (1987) recommended CT scanning for evaluation of the degree of comminution, for classifying and measuring the displacement of fracture.

Jensen S et al [44] (1990) reported that conservative treatment is valid alternative to surgery in cases where operation is not feasible.

Honkonen S. E and Jarvienen M.J [45] in 1992 analyzed 131 fractures of tibial condyles in 130 patients. In conservatively treated cases (55) subjective results were acceptable in 49% of cases, functional results in 60% and clinical result in 52.7% cases. In operative cases (76) they were 57.9%, 73.7% and 52.6% respectively. This study utilized single midline incision for open reduction.

Tscherene and Lobenhoffer [46] in 1993 studied 190 out of 255 cases and concluded that open reduction and internal fixation with the objective of obtaining accurate articular reconstruction, stable fragment fixation and allowing early motion , achieved good results even in extremely difficult fractures after open reduction.

Marsh J. L et al [47] in year 1995, treated 21 complex tibial plateau fractures by closed reduction and inter fragmentary screw fixation of the articular fragments and applied unilateral half pin external fixators. They considered this external fixation as a satisfactory treatment for complex plateau fractures.

In 2002 Dennis P.Weigel and J. Lawrence Marsh [48], studied the long-term outcomes of treatment of high-energy tibial plateau fractures. They concluded that these patients treated with external fixation have satisfactory knee function during five years follow up.

In 2002, Gosling et al[18], presented their results in less invasive stabilization system in bicondylar fractures of tibial plateau and concluded that such injuries can be treated satisfactorily with lateral column locking plates.

They concluded that ring external fixation, as a beam-loading system applied in a neutralizing mode is a safe and reliable technique for the treatment of displaced bicondylar tibial plateau fractures in the elderly.

However, in the same year, Gosling et al.[50] published the results of their study comparing the biomechanical stability afforded by lateral locking plate and bicolumn non locked plates. They concluded that both fixation techniques have a high resistance to vertical subsidence even with loads exceeding the average body weight.

Higgins et al[31] (2007) studied the comparative strength of lateral-only locking plate to medial and lateral nonlocking plate in a cadaveric model of a bicondylar tibial plateau fracture. They showed that dual-plate fixation allows less subsidence compared to isolated locked lateral plates. They raised concerns about the widespread use of isolated lateral locked plate constructs in bicondylar tibial plateau fractures.

Mahadeva et al.(2008), in a review of literature, concluded that management of bicondylar/Schatzker 6 type fractures is dificult. Hybrid

external fixators have theoretical advantages in terms of the soft tissues but has no improved outcome over internal fixation.

Weil et al[49] in 2008 described the posteromedial approach to tibial plateau to reduce and fix fractures of medial condyle and bicondylar fractures. They concluded that their approach and antiglide plating provided the solution for posteromedial shear fractures of tibial plateau.

Musahl V et al[3](2009) reviewed the available literature concerning complex tibial plateau fractures and concluded that dual incision bicolumn plating was indicated for fractures with posteromedial fragment, medial fracture dislocations and posterior metaphyseal fragments.

Internal fixation has been achieved with various implants like Dowel bone grafts, K wires (Turner V.C. 1959), wire loops (Rasmussen P.S. 1973), (Gottfries A. Hagert CG and Sorensen S.E. 1971) Bolts and washers (Barr J.S. and McAusland W.R. Jr. (1958), Hohl M. and Luck J.V. 1956) Knowel pins (Robert J.M. 1968), Buttress plates T or L type (Hohl M. 1967), Muller M.E., Allgower M. Wilengger H. 1970), Cancellous screws : Charnely's clamp (Black Burn J.W. 1977)].

Muller M.E., Allgower M. Wilenegger H (1970) stated that a plate may be used to buttress or to support a thin cortical wall and maintain its length. The principle of buttress plate is opposite to tension band plate in that it is always

under compression. Buttress plates are used where cortices are thin, medullary bone is cancellous and often compressed. They prevent deformity due to bone settling or absorption. After applying the plate, the fixation can be supported by filling the defect with cancellous bone grafts to prevent the loss of height. A plate used as a buttress is never under tension. Regular round hole ASIF – A.O. plate, D.C.P. or contoured T or L plate is used as a buttress plate.

Wilson and Jacob JS (1952) independently described an original method of treating severely depressed comminuted fracture of lateral tibial plateau where they removed the patella and used it to replace the articular surface of condyle. Lee H. (1957) used pear shaped graft from anterior superior iliac spine to fill the defect of articular surface of lateral condyle.

Percutaneous bolting of minimally displaced fracture was described by D' Aubigne, R and Mazar F. (1960). Miller T.S. (1965) published the report on closed reduction and traction followed by percutaneous introduction of wire or pins under roentgenographic control.

Newer fixed angle screw and plate systems are used increasingly and comparative studies are awaited to determine their role in complex tibial plateau fractures.

Carlos A. Bermudez et al[28,29](2008) noted that configuration of many plates did not have provision to place screws to the region of the articular

surface that needs support. In posterolateral or posteromedial fractures, the standard plates provide little support of posterior structures when placed from the front or side. Locking screws have the mechanical disadvantage of cantilever loading when screws are placed front-to-back. Posterior plating can be difficult and removal is also difficult if needed later. They described the use of horizontal rafting plates [9] to support the posterior fragments and the articular fragments through standard approaches. This method was used mainly to support the articular fragments in the posterolateral and posteromedial aspects. This is a similar technique to that used multiple K-wires beneath a lateral fragment to prevent secondary displacement.[12] One study reported loss of articular surface in 31% of cases after surgical correction of tibial plateau fractures. This necessitates the need for newer techniques such as rafting screws[14].

In cancellous bone like proximal tibia, 3.5-mm screws are found to have pullout strength equivalent to 6.5-mm and 4.5-mm screws[19]

In a study by S.Patil et al it has been shown that a raft of four 3.5 mm screws is biomechanically stronger than two 6.5 mm screws in resisting axial loads in osteoporotic bones.[30.] This is supported by yet another study by Jabal Ameli et al [20].

APPLIED ANATOMY

The knee is the largest and most complex joint of the body. Being a synovial joint, it is of the modified hinge type: in addition to flexion and extension a small amount of rotation of leg is possible in flexed position. It is a compound joint consisting of two condylar joints between the femur and the tibia and a saddle joint between patella and femur.

The knee is composed of:

1. Osseous structures
2. Extra-articular structures
3. Intra-articular structures

OSSEOUS STRUCTURES

Femoral Condyles

The femoral condyles are two rounded prominences that are eccentrically curved, anteriorly the condyles are somewhat flattened, which creates a large surface area for contact and weight transmission.

The condyles project very little in front of the femoral shaft but more so behind. The articular surface of the medial condyle is longer than that of lateral condyle but the lateral condyle is wider.

Tibial Plateau

- It is the proximal articular surface of the tibia,expanded in transverse axis, transmits weight of the body from the lower end of the femur.
- It is composed of two parts- concave articular surfaces of oval shaped medial and circular shaped lateral tibial condyle.
- Medial plateau is larger, stronger and transmits more weight than the lateral plateau.

The articular surfaces on the plateau are not equal, the lateral being wider than the medial. In the sagittal plane, the lateral plateau appears convex and the medial plateau appears concave. This is to be correlated when viewing lateral X-Rays of knee joint since the lateral plateau is usually visible as it lies at a higher level than medial plateau. Thus neither plateau provides much assistance in stabilising the knee. According to Bohler, tibial plateau slopes posteroinferiorly 5-10 degrees from horizontal, with the plane of the articular surface forming an angle of 76 +/- 3.6 degrees with the tibial crest. It is important to bear this in mind when screws are passed from anterior to posterior in proximal tibial region. The peculiar nature of the articular surfaces results in different injury patterns. The medial tibial plateau is convex to the tibial side and axial load transmission leads to split fractures in medio lateral direction. The lateral tibial plateau is convex to the femoral side and axial load

transmission leads to multifragmantary joint depression with joint broadening[1]. Additionally, the medial plateau has stronger trabecular bone owing to higher physiological stress in medial compartment of knee. Hence, medial tibial plateau fractures are less common compared to lateral plateau fractures. Medial plateau fractures must alert the surgeon to an underlying severe violence and additional neurovascular injury must be surveyed for.

	
Anterior view of tibial plateau The lateral surface is convex and the medial surface is concave	**Medial view of tibial plateau** The concave medial surface is over ridden by the elevated convex surface in lateral radiographs

The non-articular area in the plateau surface contains anterior and posterior tibial spines. Anterior tibial spine lies medial and just posterior to the insertion of the ACL. The posterior cruciate ligament is attached in the posterior intercondylar area, extending onto the posterior surface of the metaphysis. It is

imperative that the width of intercondylar eminence is reconstructed and to appropriately restore the anatomic width of the proximal end of the tibia.

The tibial tubercle is located over the anterolateral tibial crest about 2 cm below the anterior joint line and provides attachment for the patellar tendon. The Iliotibial band inserts along the lateral tibial flare into a protruberence known as Gerdy's tubercle. Gerdy's tubercle forms an important landmark in anterolateral approach to proximal tibia. The fibular head is prominent along the posterolateral aspect of the tibial condyle and it provides attachment to the fibular collateral ligament and biceps tendon.

Patella

Patella, a triangular sesamoid bone in the extensor mechanism, is situated between the quadriceps tendon and patellar tendon. The proximal wider portion is the base of the patella and the distal pole is narrow called the apex.

EXTRA ARTICULAR STRUCTURES

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

Musculotendinous units:

These are made up of:

i)	Quadriceps femoris	- Anteriorly
ii)	Gastrocnemius	- Posteriorly
	Popliteus	
iii)	Semimembranosus	
	Semitentendinosus	- Medially
	Gracilis	
	Sartorius	
iv)	Bicep femoris	- Laterally
	Iliotibial band	

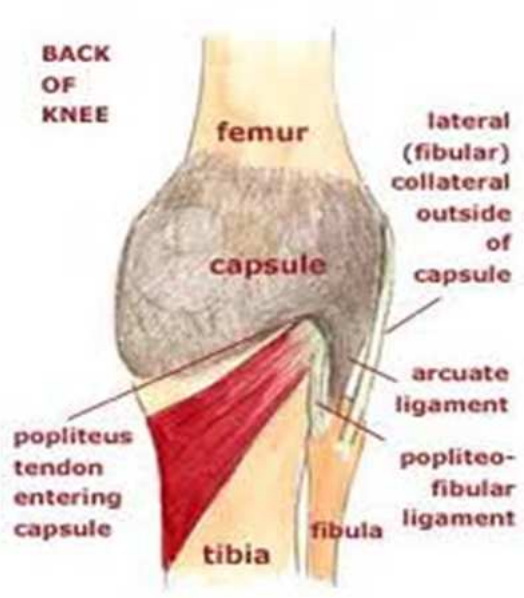
LIGAMENTOUS STRUCTURES:

FIBROUS CAPSULE

The capsule is a sleeve of fibrous tissue extending from the patella and patellar tendon anteriorly. It is attached 0.5 to 1 cm beyond the articular margins.

Femoral attachment

- Anteriorly it is deficient and is replaced by quadriceps, patella and patellar tendon.
- Posteriorly it is attached to intercondylar ridge



- Laterally encloses the origin of poplitieus

Tibial attachment

- Anteriorly it descend to the tibial tuberosity along margins of the condyles.
- Posteriorly it is attached to intercondylar ridge.
- Posterolaterally it allows the passage of popliteus tendon.

The weak capsular ligament is strengthened

- Anteriorly by medial and lateral retinacula (extensions of v. medialis & v. lateralis). They are the principal stabilizers of the knee joint.
- Laterally by iliotibial tract
- Posteriorly by oblique polpliteal ligament
- Medially by tendons of sartorius and semimembranosus

The attachment of menisci is firm medially and less firm laterally. The capsule is well defined medially than laterally.

The tibial collateral ligament is long, rather narrow, well delineated structure lying superficial to the medial capsule inserting 7 to 10 cms below the joint line on the posterior one half of the medial surface of the tibial metaphysis deep to pes anserinus tendons. It provides the principle stability to valgus stress. The lateral or fibular collateral ligament attaches to the lateral femoral epicondyle proximally and to the fibular head distally. It is of prime importance in stabilizing the knee against varus stress with the knee in extension. As the knee goes into flexion, the lateral collateral ligament becomes less influential as a varus stabilizing structure.

INTRAARTICULAR STRUCTURES

These consist of the cruciate ligaments and the menisci. The two cruciate ligaments, anterior and posterior provide stability in the sagittal plane. They are extra synovial in location but intracapsular.

Anterior Cruciate Ligament:

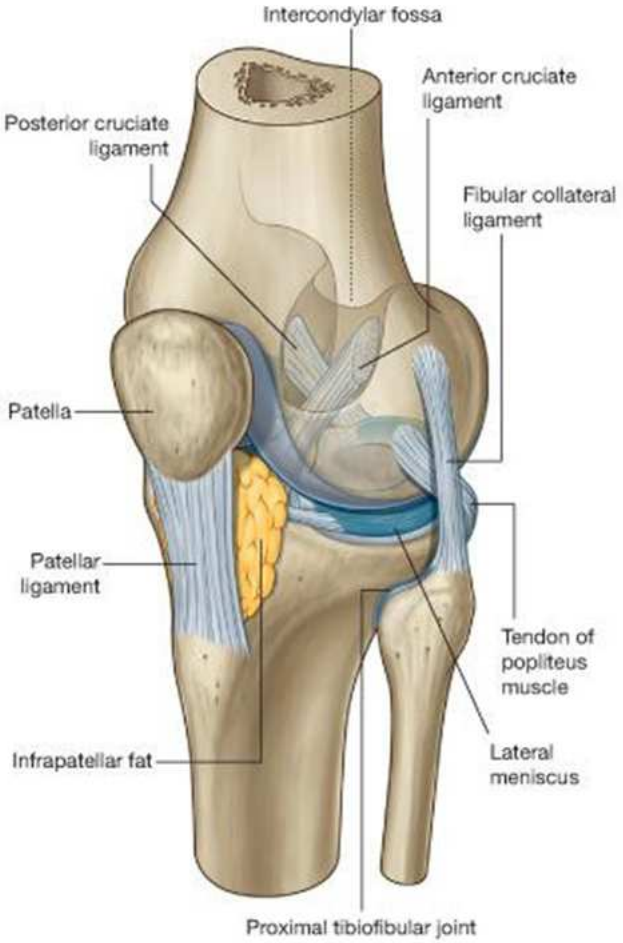
It is made up of bundles of fibres, which are taut in various degrees of knee flexion and extension. The average length of ACL is 3.8 cm and the average width is 1.1cm. The tibial attachment is in front of anterior tibial spine. It is the primary stabilizer against anterior displacement of tibia.

Posterior Cruciate Ligament

It is the primary stabilizer against posterior displacement of the tibia on the femur. It is almost vertical in its alignment in sagital plane. In the coronal plane it passes obliquely upwards and medially to its femoral attachment. The length of PCL is 3.8 cms and the width is slightly bigger than ACL about 1.3 cms and is more robust.

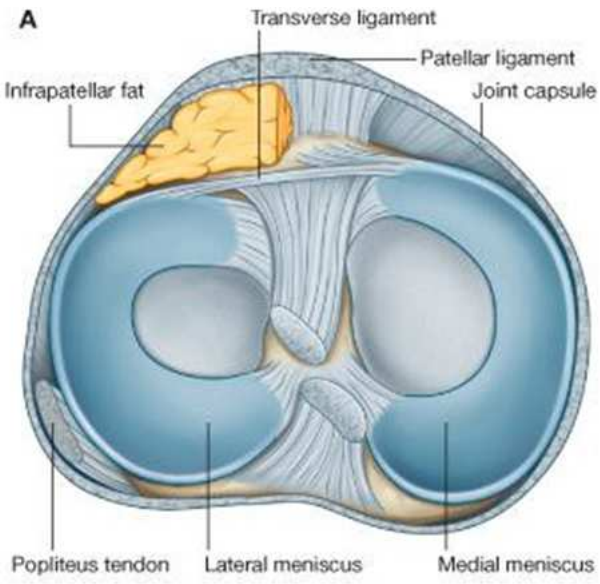
Menisci

These are wedge shaped semicircular fibrocartilaginous structures, two in number; medial and lateral present between femoral and tibial condyles. The important function of Menisci is in load sharing by protecting the articular cartilage from upto 60% of the load encountered by the knee. The meniscotibial ligaments attach these structures to the tibia. These structures should be identified and incised horizontally to gain visualization of the joint through a submeniscal exposure.



Knee joint after removal of joint capsule

Flexed knee – seen from front



Articular surface of tibia – seen from above

MECHANISM OF INJURY

Tibial plateau fractures occur more commonly in adults in 3rd to 5th decade. Men at younger age sustain fracture due to high energy injuries and women in advanced age due to osteopenia.

Road traffic accidents, fall from height and bumper injuries occur in younger age and even simple falls leads to injury in elderly.

The fracture pattern depends on magnitude, type and direction of force.

Axial loading result in worse injuries when compared with angular forces.

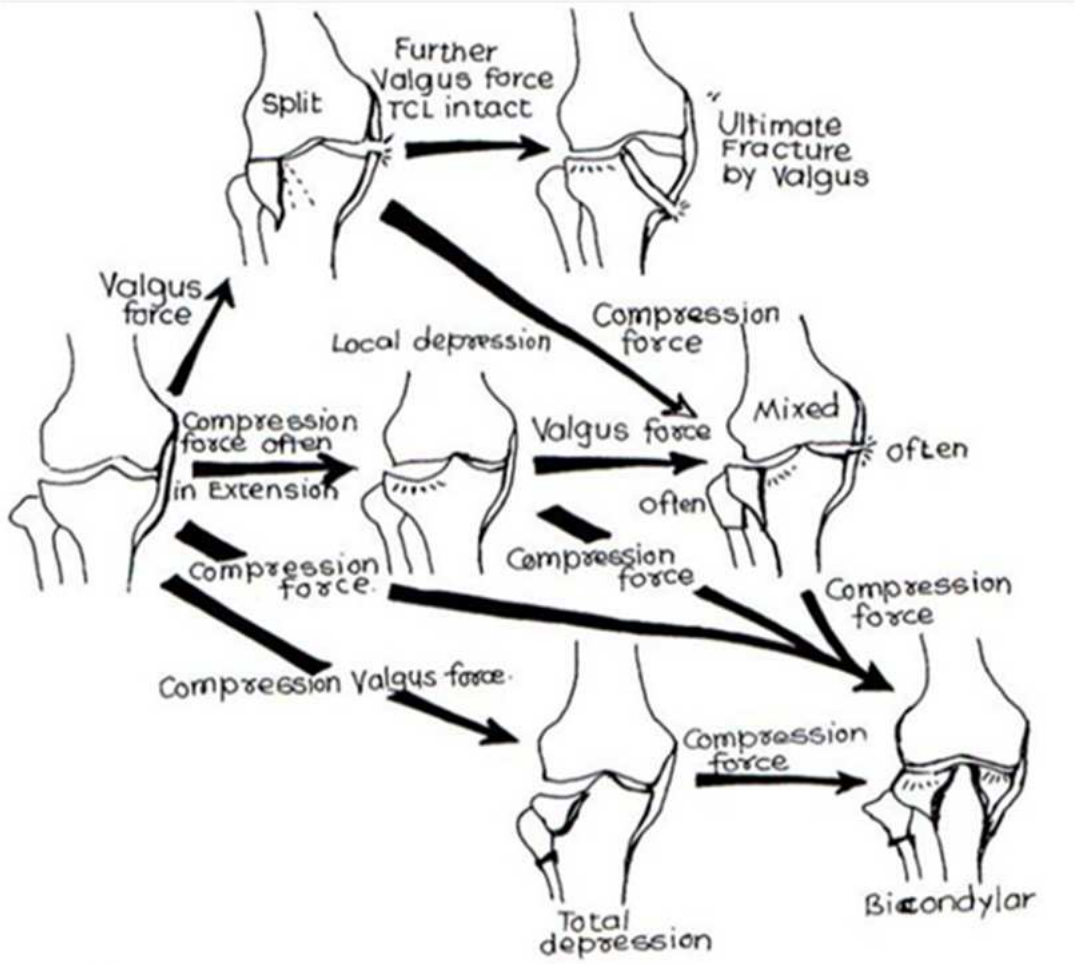
Valgus forces are more common because of normal 5 to 7 degrees valgus alignment of knee and the direct hit is usually on the lateral side.

Combination of valgus and axial loading force results in lateral plateau fractures.

Posteromedial shearing fracture is common on the medial side due to knee flexion, varus and internal rotation.

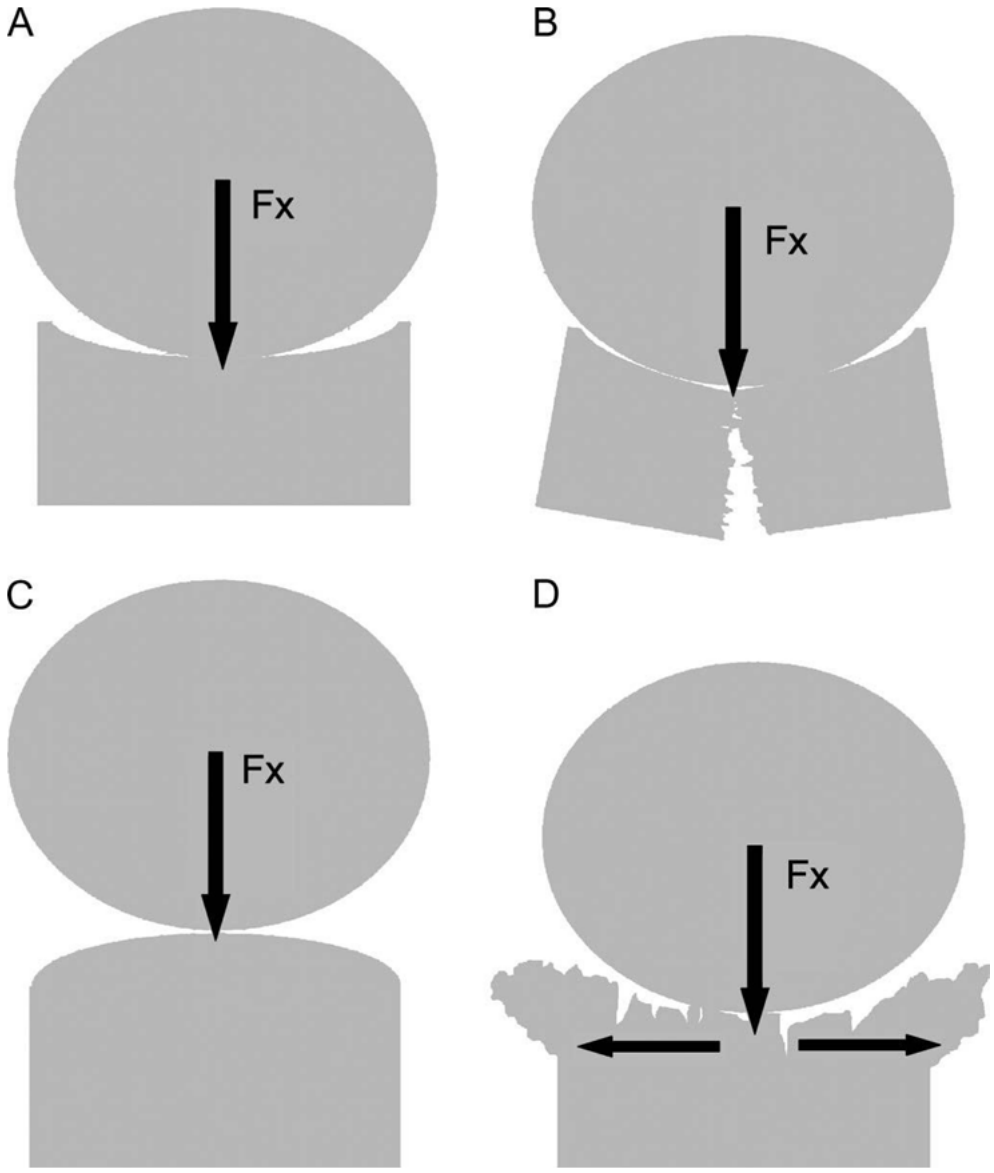
Tibial plateau fractures occur with the leg in weight bearing position. So the axial load is definitely one of the components of forces causing fracture. More the axial load, severe is the fracture.

Metaphyseal fracture occurs due to direct trauma and bumper injuries with the combination of axial load and bending forces.



Relationship of force to tibial condyle fractures

Fracture of the lateral tibial plateau is usually associated with severe comminution and joint widening, and medial plateau fracture has characteristic posteromedial shear fracture. It is explained on the basis of anatomy of the joint[1]. The medial plateau is convex to the tibial side and the femoral condyle glides around a constant center of flexion. Axial loading from the femur to the tibial condyle leads to a blasting of the tibial tray. The medial tibial plateau slopes posteriorly and the resulting force vector acts posteriorly, leading to a posterior split fragment. Similarly the lateral plateau is convex to the side of femur and there is no constant center of rotation. During flexion, the rotation axis moves posteriorly on the tibia. Axial loading produces an impression similar to a push-in of an eggshell. Thus, more the flexion of the knee, the more posterior is the depression of the joint.



Fracture mechanics: A: Medial condyle of knee is convex towards tibia, hence axial loads produce coronal plane split fragments (B). C: Lateral condyle is convex towards femur, and axial loads produce comminution and joint widening (D)

CLASSIFICATION

Commonly used classification systems for tibial plateau fractures

1. Schatzker classification
2. Hohl and Moore classification
3. AO/OTA classification

1. **Schatzker classification**

Most widely used system and familiar to most. There are six types in this system. All six types are treated differently and hence this system proves quite useful.

Type I—pure split: Wedge-shaped uncomminuted fragment. This fracture is common in younger patients without osteoporotic bone.

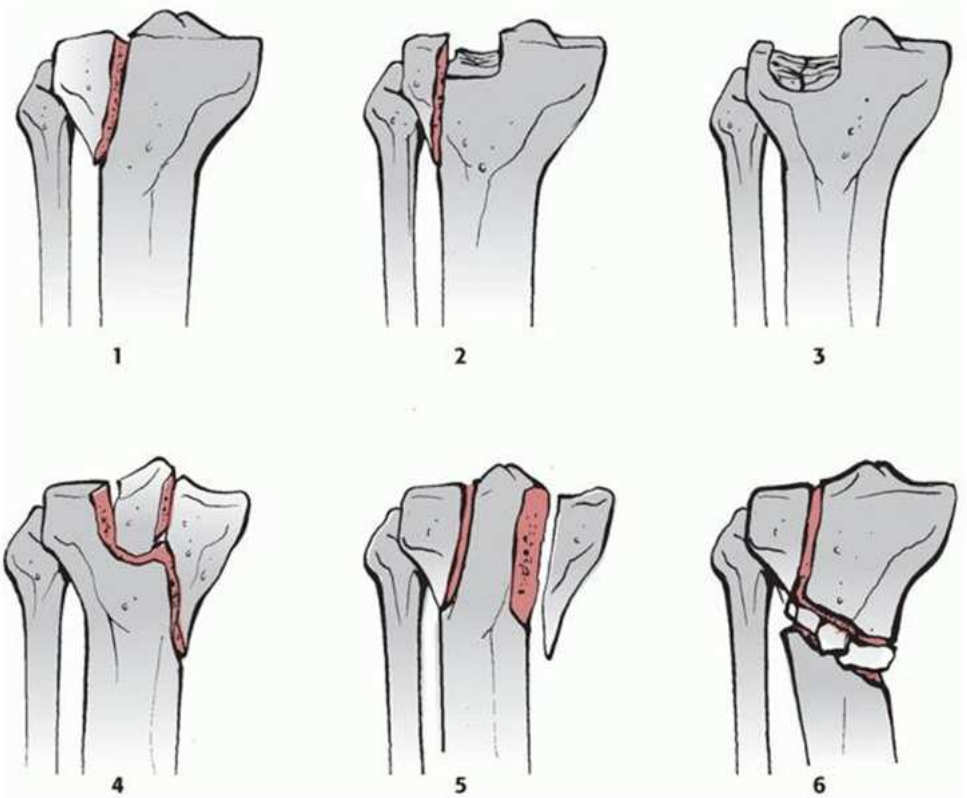
Type II—split with depression : A lateral wedge with articular surface depression .

Type III—pure central depression: The articular surface is driven into the plateau. The lateral cortex is intact. These tend to occur in osteoporotic bone.

Type IV—fractures of medial condyle: These may be split off as a single wedge or may be comminuted and depressed. These fractures tend to angulate into varus.

Type V—bicondylar fractures: Both tibial plateaus are split off. The distinguishing feature is that the metaphysis and diaphysis retain continuity.

Type VI—bicondylar tibial plateau fracture with dissociation of metaphysis and diaphysis.



2. Hohl and Moore classification

Hohl and Moore described a classification system for fracture dislocations injuries and neurovascular injuries.

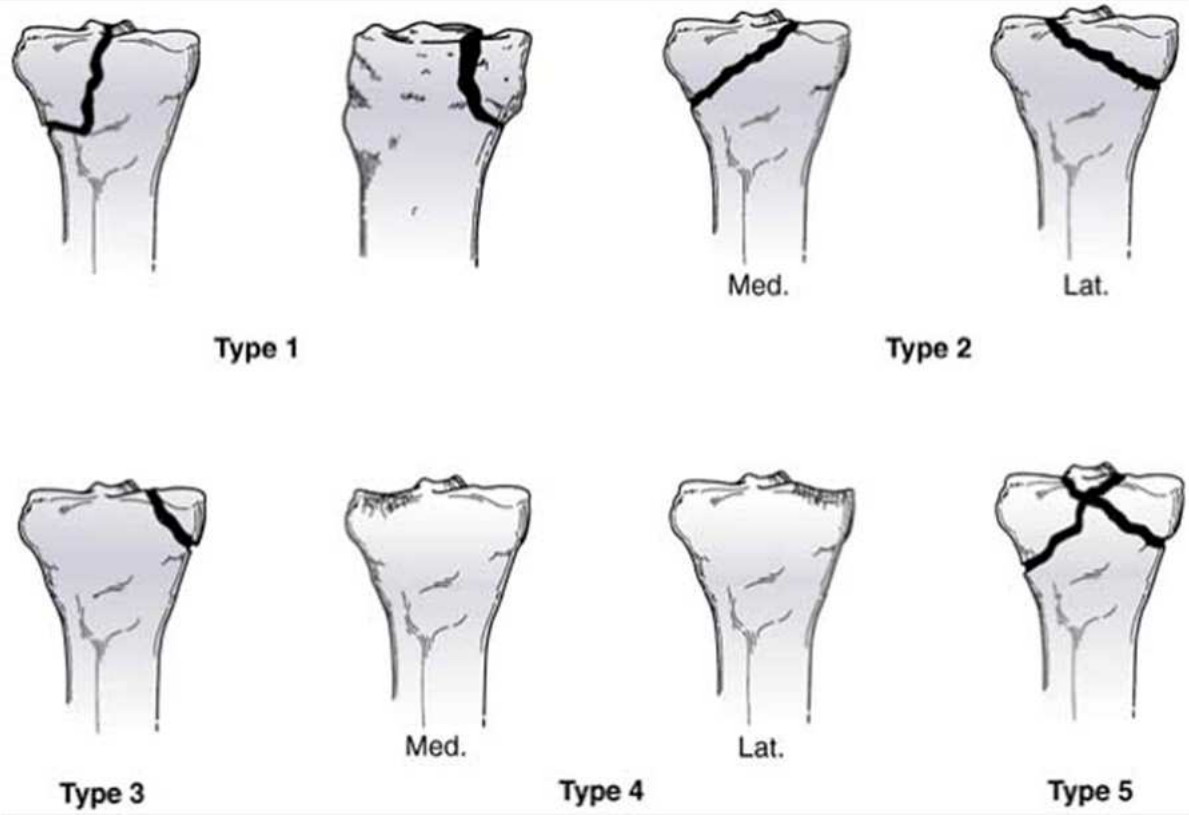
Type I - Coronal split fracture: Fracture of the medial condyle and is seen in lateral view. The fracture may extend to the lateral side.

Type II - Entire condyle fracture: Fracture – dislocation of one of the condyles. This is distinguished from the Schatzker type I and IV by fracture line extending into the opposite compartment under the intercondylar eminence.

Type III - Rim avulsion fracture: Severe valgus/varus stresses cause the capsular and ligamentous attachments to avulse from the rim of the respective plateaus. This is seen almost exclusively in lateral plateau.

Type IV - Rim compression fracture: Opposite side collateral ligament ruptures and causes opposite femoral condyle to compress the rim of the plateau.

Type V four part fracture: In this injury, there is bicondylar fracture, avulsion of both collateral ligaments and separation of intercondylar eminence. These are highly unstable. Neurovascular injuries are seen in almost 50% cases.


Med.
Lat.
Type 1
Type 2
Med.
Lat.
Type 3
Type 4
Type 5

3. AO/OTA Classification

In AO/OTA system, proximal tibia is denoted as 41 and these fractures are divided into extraarticular, partly articular and complete articular fractures.

Type A: Extraarticular, hence tibial plateau is not involved

Type B: Partial articular

B1 – Simple articular split

B2 – Split depression

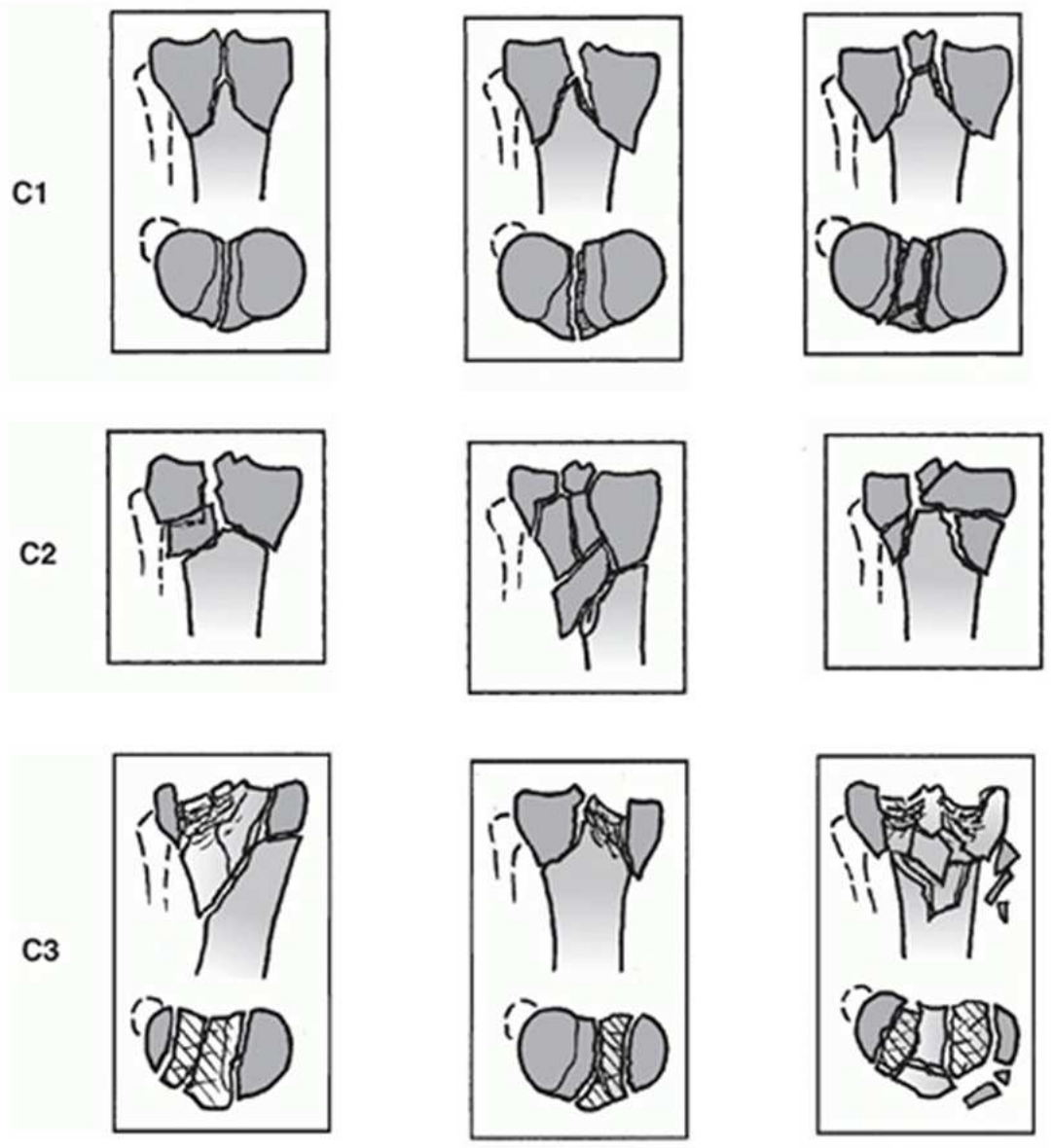
B3 – Comminuted split depression

Type C: Complete Articular

C1 – Non-comminuted total articular fractures

C2 – Metaphyseal comminution with simple articular fracture lines

C3 – Total comminuted articular fractures including the articular surface


C1
C2
C3

PRINCIPLES OF TREATMENT

NON OPERATIVE TREATMENT

Non operative management is used wisely in selected cases of tibial plateau fractures with satisfactory results.

Conservative Management involves treatment with splint, cast and traction with early knee motion.

Indications:

- Fractures that can be expected to heal without a significant deformity

- Elderly patients who have poor surgical risk

- Co existent medical morbidities with poor surgical risk

Lansinger obtained good functional outcomes in fractures of lateral plateau with mild to moderate articular depression (upto 10 mm)[27] by non operative management . But associated split and displaced fragments or larger articular depression usually heals with a valgus alignment and hence have a great risk of osteoarthritis due to uneven joint loading.

Isolated medial condyle fractures, even with minimal displacement, have greater chances of healing in varus malalignment because of the peculiarity of

the fracture pattern, tending to have more obliquity in the coronal plane. Hence anatomical reduction is recommended for all medial condyle fractures [1,3,33].

Given this background, it is usually unacceptable to treat bicondylar fractures in young, active adults non operatively as the functional results can be expected to be substandard.

OPERATIVE TREATMENT

Methods of operative management includes –

- Cannulated Screw fixation,
- Condylar plate with or without Bone Graft
- AO/ASIF Buttress plate (T/L) with or without Bone Graft
- Proximal tibial locking plate with raft screws
- Arthroscopically assisted screw fixation & external fixator

Indications

- Bicondylar fractures

- Associated metaphysiodiaphyseal dissociations

- Split lateral condyle fractures

- Articular depression of more than half the articular surface

- Displaced fractures of medial condyle

- Valgus or varus instability > 10 degrees in 0 to 90 degrees knee arc of motion

- Open fractures

- Associated arterial injury or compartment syndrome

The advantages of surgical treatment are anatomical reduction, rigid fixation, anatomical and mechanical limb alignment and early joint mobilization. The choice is between internal and external fixation, with proponents for each.

Plates and screws

Plates and screws are commonly used implants in management of tibial plateau fractures.

Simplest one is 6.5mm partially threaded lag screws for simple fractures either used alone or along with other implants

Plates are anatomically precontoured and periarticular. They are usually applied on anterolateral surface of tibia, used as a buttress to support fractured lateral cortex.

Plates available are buttress (L/T shaped) and locking compression.

The 3.5mm screws and implants are used most commonly.

Various precontoured plates are available which are very easy to apply.

The most common position of plate in tibial plateau is the anterolateral region of proximal tibia. This plate acts as a buttress to support the weak lateral cortex of tibia in split and depression types of tibial plateau fractures.

Posteromedial plates function in a different way. They serve as antiglide plates to resist shearing forces acting on the posteromedial fragment and thus prevent varus collapse.

Locking plates in lateral column have been extensively used in bicondylar fractures recently; as these are sturdier implants with stronger screws that provide resistance to the deforming forces at play in high energy bicondylar fractures.

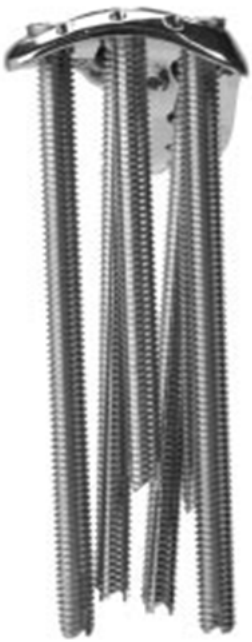
The 3.5-mm implants have superseded the 4.5-mm implants. They are less bulky and easier to fit on the bone

Lateral plates are also provided with multiple parallel slots for 3.5 mm screws near the joint surface. This allows multiple screws to be placed parallel and close to the articular surface – the so called ―rafting screws.[28,29.] These screws support the reduced articular surface and decreases the chances of postoperative settling.

Biomechanical studies[10] show that smaller screws placed nearer to the subchondral bone have

- Adequate construct stiffness while providing greater support to prevent depression
- More favourable elasticity underneath the articular cartilage than larger screws

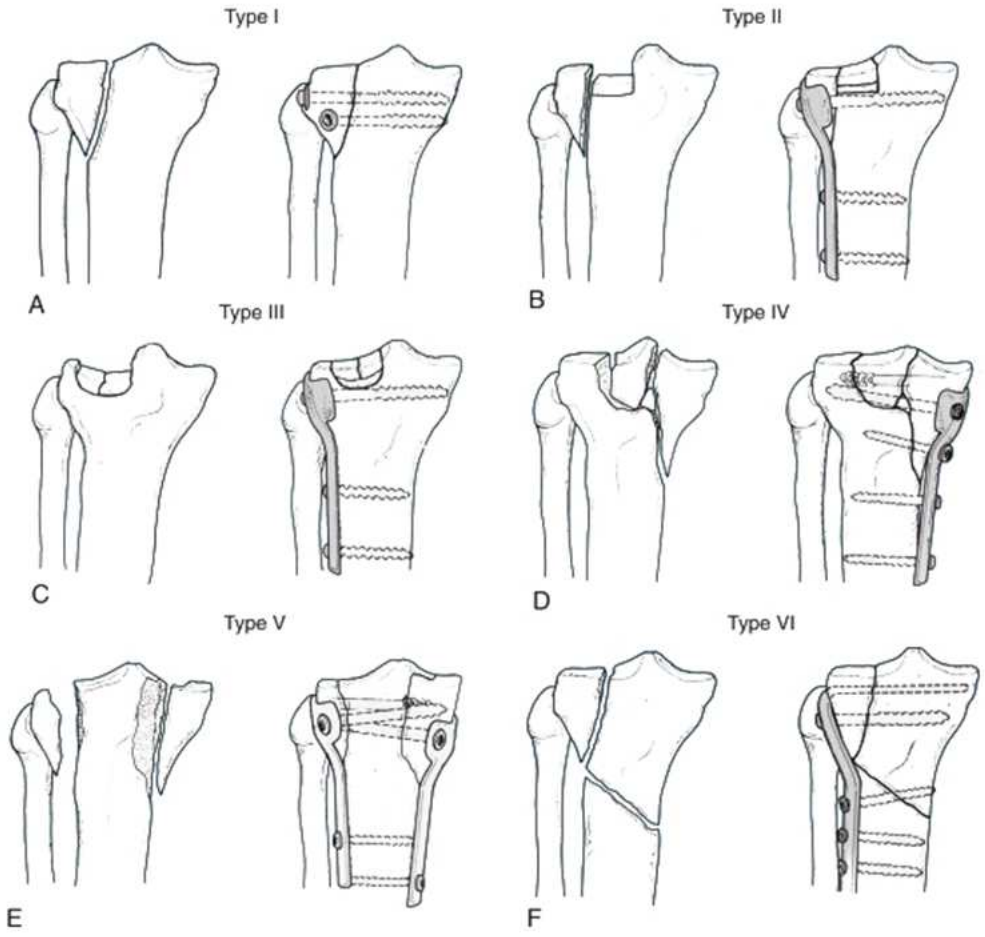
A raft made up of four parallel 3.5 mm cortical screws is advisable for depressed tibial plateau fractures with good bone stock and adequate augmentation of the defect. These screws are placed through lateral locking plates as periarticular raft. They reduce the need for medial plating as the rafting screws support articular fragments of bone in the posterolateral and posteromedial aspects.



Rafting technique	**Buttress plating (Conventional)**
Four horizontal subchondral parallel screws (provide adequate construct stiffness to prevent depression)	2 or 3 screws
Locking screws	Non locking
Allows capture of most medial fragment (reduces need for medial plating)	Need for medial plating
Second row of screws angled proximally to create rigid construct and maximize thread engagement	
Uses two strut screws to complete rigid construct	

***External fixators**:*

Temporary external fixation is applied spanning the knee joint and restores limb alignment and maintains limb length, thus aiding soft tissue recovery before definitive internal fixation. High energy bicondylar fractures may be treated definitively using external fixators when there is severe soft tissue injury or as per the preference of the individual surgeon. The results of definitive external fixation may prove as good as internal fixation in high energy injuries if the frame is applied in a competent manner with adequate stability [37]. Hybrid fixators and joint sparing fixators are useful in this regard.



COMPLICATIONS

Articular fractures of the proximal tibia on treatment may be followed by a number of complications that result from the nature of fracture, the treatment employed and also the patient.

Complications can be divided into two types namely

1. Early
2. Late

EARLY COMPLICATIONS

a) Thrombophlebitis and Embolism

Due to immobilization of a leg or due to knee injury thrombophlebitis develops in the calf or thigh. In the presence of thrombophlebitis, treatment options may be quite limited and results significantly affected.

Pulmonary embolism is seen in a small proportion of patients. It may sometimes occur silently but usually causes pleuritic chest pain, bloody sputum and breathlessness.

The diagnosis is made reliably by the available tests.

b) Fat Embolism

Fat embolism is one of the earliest complications in tibial plateau fracture treatment. Diagnosis is usually established by the presence of petechial hemorrhages, change in fatty enzymes and decreased PO2 in arterial blood. Fat embolism is treated with the use of corticosteroids and oxygen to improve respiratory exchange and supportive methods.

c) Compartment Syndrome

It is commonly manifested clinically by pain, which increases with duration and is located most frequently over the proximal portion of the anterior compartment. It is tested by measuring pressures in all the compartments of leg. Early and complete release of fascia comprising the affected compartments is the ideal treatment. In order to avoid compartment syndrome after open reduction of a lateral plateau fracture, the fascia should not be tightly closed.

d) Arterial Injury

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

e) Paralysis of Peroneal nerve

The anatomical course of the common peroneal nerve around the neck of the fibula makes it very much vulnerable to injury due to direct trauma against the lateral aspect of the knee or by similar injuries that may also damage lateral ligaments of knee. Damage to Peroneal nerve usually occurs during fracture but can also result due to direct pressure on the nerve against plaster cast or traction sling, or from retraction in surgery. Late neurolysis of the peroneal nerve is rarely required and the prognosis for recovery is favourable. Mostly nerve injuries recover with normal function within a period of 6 months.

f) Loss of Fracture Reduction

There are strong muscle forces acting across the knee joint. Fractures involving the articular surface of the proximal tibia are affected by these strong muscle forces and hence tend to displace owing to the pressure of the femoral condyle over the tibial plateau.

g) Wound Infection

Wound infection is the most common complication of open reduction of tibial plateau fracture. Problems related to wound healing are seen most commonly after operative treatment of bicondylar fractures, probably because of the ill timed surgical incision through contused skin with extensive exposure, retraction, metallic implants and operating time.[23]

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

h) Avascular Necrosis

Exposure of fractured tibial plateau by their release from soft tissue attachments leads to avascular necrosis. Necrosis of elevated fragments in local compression or split compression fractures is rarely seen. Bony fragments need to be exposed in order to accomplish accurate reduction and rigid fixation. Minimum soft tissue dissection will reduce the risk of avascular necrosis in bony fragments. Avascular necrosis can be prevented by percutaneous methods of fixation in the bony fragments.

i) Nonunion

Pseudoarthrosis of a tibial plateau fracture due to non union is quite uncommon. Cancellous bone in the tibial plateau region is highly vascular,

which favors rapid bony union. Moreover, non union occurs in about only one in 200 plateau fratures[24]

Non-union is commonly seen with Schatzker type VI. Treatment of non-union must be aggressive. In case of aseptic non-union, surgery with grafting is usually successful when combined with rigid internal fixation. In case of infected non-union antibiotic impregnated beads, rotational free flaps and external fixation are the mainstay of treatment.

j) Implant Complications

Internal fixation devices may break up, slip and cause irritation, when skeletal traction or external fixation pins are used. Infection of pin tracts may lead to osteomyelitis rarely. Hardware breakage and displacement occurs more often with wires or bolts rather than cancellous screws or buttress plates.

k) Causalgia

Causalgia is a rare complication following incomplete injury to the infrapatellar branch of the saphenous nerve, such as by stretching during surgery or by local bruising from the initial injury. The treatment is comprised of local anaesthetic injection of the involved nerve, exploration of the nerve with neurolysis or paravertebral sympathetic blocks.

LONG TERM COMPLICATIONS

(a) LIMITATION OF KNEE MOVEMENTS

It is a well-known fact that the process of healing of articular injuries utilizes scar tissue that tends to envelop the articular structures. If the knee is kept immobilized during this period of intense scar formation, dense adhesions arise from the fracture to the synovium, encompassing the menisci and fat pad. Late arthrotomy and arthroscopy confirms the presence of multiple intra articular adhesions.

To ensure functional range of knee movement after a plateau fracture, the best method is treatment that allows early knee motion. If rigid fixation has been obtained, early knee motion should be definitely encouraged. In cases of adhesions formation, Arthroscopic lysis with gentle manipulation of the knee is done.

(b) LACK OF KNEE EXTENSION

In case of lack of knee extension, the gait is altered and walking becomes more difficult. Even few degrees of flexion contracture can cause some degree of gait impairment. Flexion contractures occur due to prolonged immobilisation in flexion, and associated subcondylar fracture that has got united with anterior angulation, and failure to reduce the articular fragments and maintain their anatomical position.

(c) ANGULAR DEFORMITY

As lateral plateau fractures occur more commonly, valgus deformity predominates. The main reasons for angular deformity are healing of a plateau below its normal level, and Traumatic arthritis

Due to loss of articular cartilage and articular bony surface erosions, angular deformity can be prevented by accurate reduction, and its maintenance. In case of established deformity, a subcondylar osteotomy is mainly used to correct the alignment. Unicondylar or total knee replacement is a better choice than osteotomy in case of patients with poor health and patients more than 70 years of age.

(d) INSTABILITY

The reasons for late instability after plateau fractures are failure to reduce and maintain reduction of plateau surface, ligament laxity secondarily to an unrepaired collateral or cruciate ligament injury, and traumatic arthritis with loss of articular cartilage and erosion of the articular cartilage. This instability often leads to the development of late knee pain. If knee instability can be recognized early in the treatment and restored, it will help to minimize pain later on and reduce the degree of traumatic arthritis.

(e) TRAUMATIC ARTHRITIS

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

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

MATERIALS AND METHODS

Our study was a prospective cum retrospective study, conducted at the Institute of Orthopaedics and Traumatology, Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai between July 2013 to September 2014.

Inclusion criteria:

- Age 18 years to 60 years
- Closed Fractures
- Tibial plateau fractures (Schatzker type II to VI)

Exclusion criteria:

- Age <18years
- Open injuries
- Associated Neurovascular injuries
- Type I (Schatzker) tibial plateau fractures

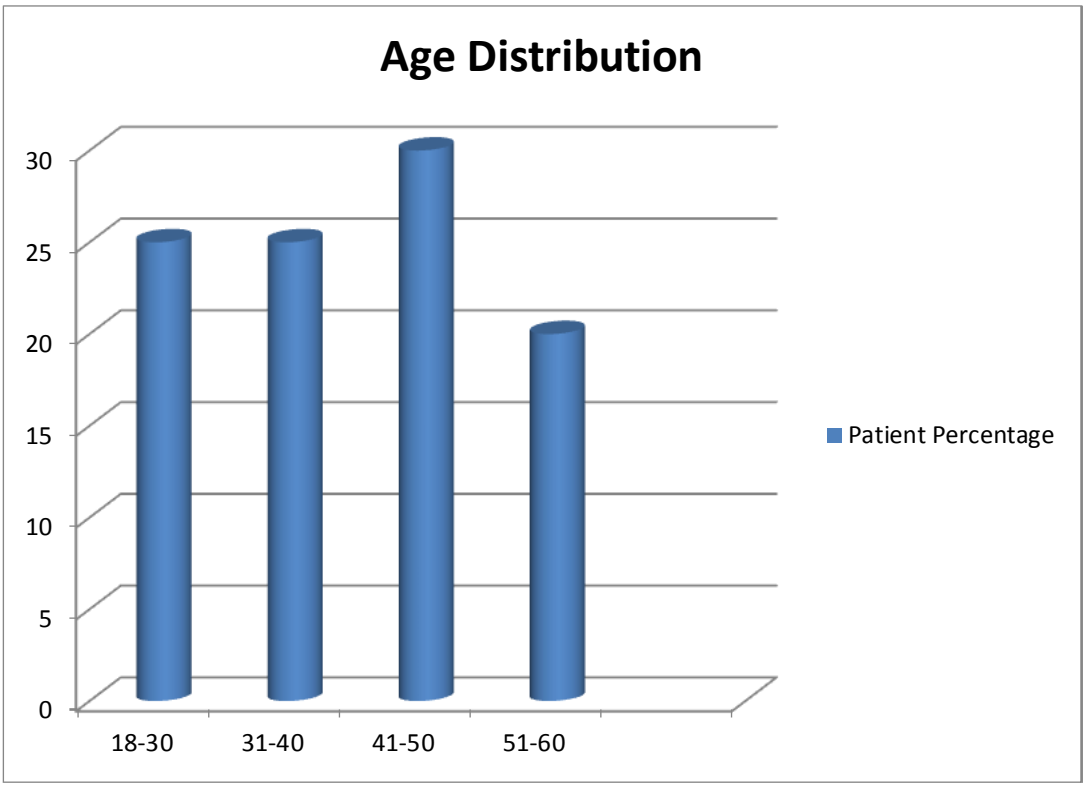
Twenty patients, who met these criteria, were chosen for our study.

They were diagnosed and classified according to Schatzker. Types II to VI were included in the study. They were divided into two groups of 10 patients each. The patients were randomly selected for each group. Every second patient was treated with lateral locking plate with rafting screws (raft plating).Others were treated with buttress plating. They were followed according to the prescribed proforma.

AGE DISTRIBUTION

The age of patients in our study ranges from 19 to 58 years.

Age group	No. of patients	Percentage %
18-30	5	25
31-40	5	25
41-50	6	30
51-60	4	20

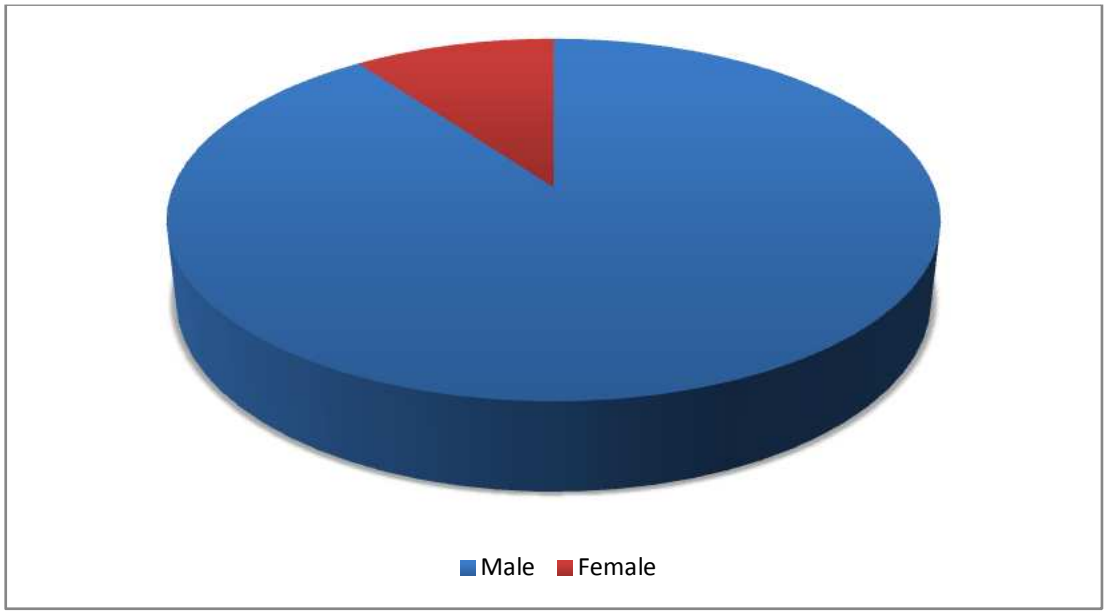


SEX DISTRIBUTION

In our study no. of males were more than females.

Male: 18

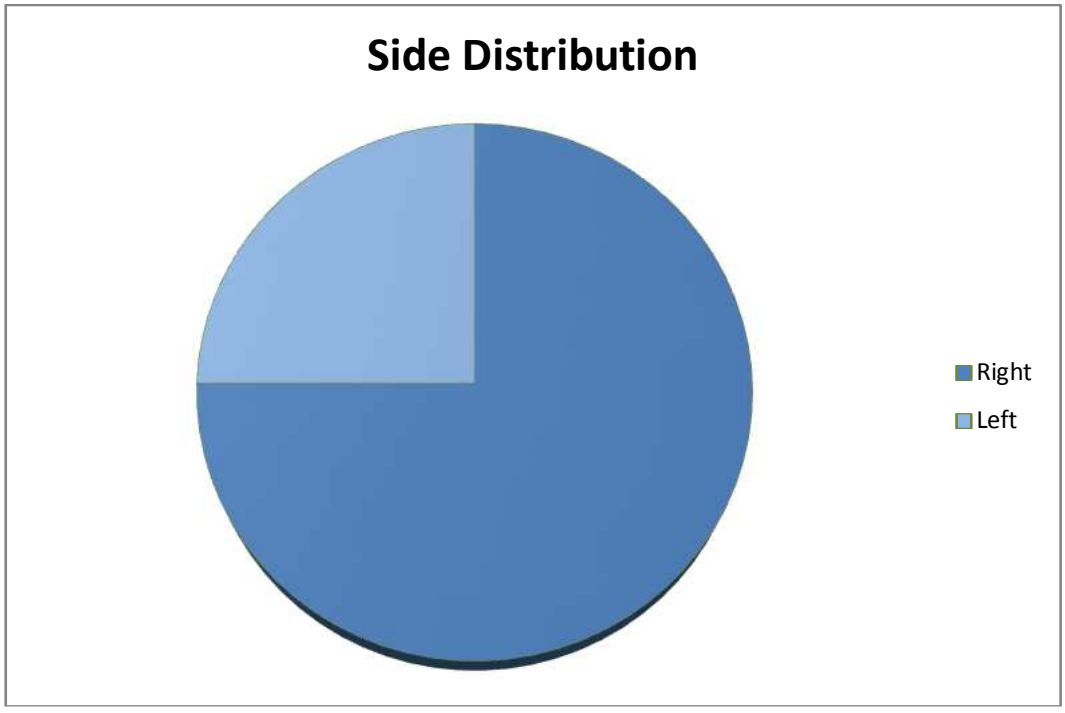
Female: 2



SIDE DISTRIBUTION

Among 20 patients, injury was on right side for 15 patients and left side for 5 patients.

Side affected	No.of patients	Percentage
Right	15	75
Left	5	25



DIAGNOSIS

HISTORY

A detailed history to elicit the mechanism and severity of injury was obtained.

Patient's personal, medical and occupational history was obtained to know the problems and complications that may arise during or after surgery; also to know the functional demand of the patient.

History to look for associated injuries in the head, chest and abdomen was also asked for.

PHYSICAL EXAMINATION

Patients with tibial plateau fractures usually present with painful swollen knee and are unable to bear weight.

High energy injuries are associated with soft tissue compromise and neurovascular compromise.

Soft tissue compromise was evidenced by superficial abrasions, deep contusions, discoloration of skin, blisters and open wound. In these cases surgery was postponed till soft tissue healing takes place.

Compartment syndrome was assessed by frequent examinations of the leg. Disproportionate pain, pain on passive stretch of toes, paresthesia, pallor, absent or diminished pulses point towards onset of compartment syndrome.

In doubtful cases, ankle/brachial index was obtained.

Lachman test was performed to assess ligamentous injury.

IMAGING

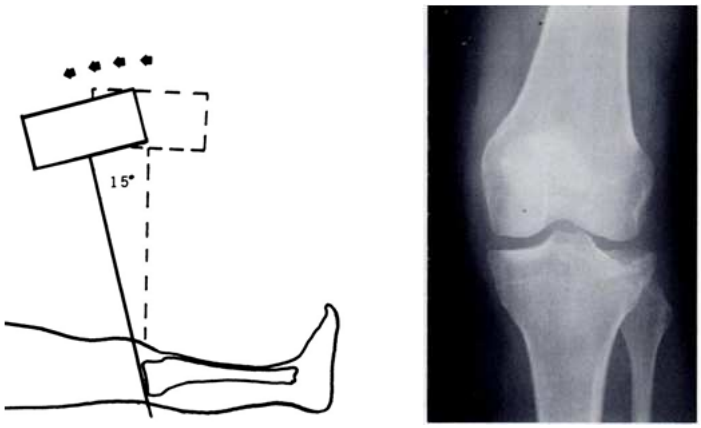
Radiography

Anteroposterior and lateral X-Rays of knee were taken to know the fracture pattern.

In the AP view, 10° caudal tilt view clearly shows the articular surface depression and split than the standard AP view.

Oblique views detect minor degrees of joint impaction and fracture line more clearly.

Traction views are useful in severely comminuted and displaced fractures.



Tibial plateau view: Technique and x ray picture

Computed Tomography (CT)

CT scanning with axial, coronal and sagittal planes is the imaging study of choice to assess the fracture pattern and determine the location of articular comminution and depression. Three dimensional reconstructive images also guide the management[35,36].

CT Scans help to classify the fracture, guide pre-operative planning and decide the choice of treatment.

CT images of posteromedial fracture fragment

Magnetic Resonance Imaging (MRI)

MRI scans are very useful in assessing associated soft tissue injuries such as status of cruciate ligaments and menisci.

Likewise, tears of lateral collateral or medial collateral ligaments can be detected.

MANAGEMENT PROTOCOL

PREOPERATIVE MANAGEMENT

On admission patients were started on an i.v. line and fluids infused. Analgesics were given i.m. The injured limb was temporarily immobilized in Thomas splint and X-ray taken. Anteroposterior, lateral, right oblique and left oblique views were taken. Manual traction was used where appropriate. CT scans were taken routinely to assess three-dimensional fracture geometry.

Ice fomentation and limb elevation were done. After the swelling reduced they were applied above knee slab or calcaneal pin traction. Skin over fracture was closely watched. Those presenting with severe soft tissue edema or blisters were taken up for surgery only after the appearance of—wrinkle sign.

SURGICAL PROCEDURE

Patients were thoroughly investigated, affected knee and iliac crest was prepared. Surgery was done under spinal anaesthesia. All patients were given Inj.Cefotaxime 1g IV preoperatively as routine prophylaxis. Patient was placed in supine position, with folded pillow under knee to allow knee flexion. Femoral distractor was used whenever needed.

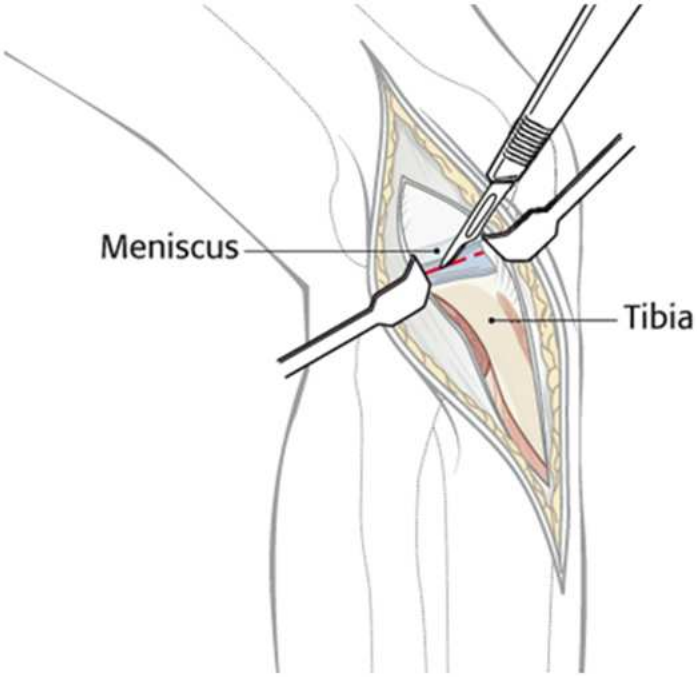
ANTEROLATERAL APPROACH

Lateral plating is done using this approach.

This is the most common approach used to surgically reduce and fix tibial plateau fractures. It is the workhorse approach for split depression fractures. The incision is based on Gerdy's tubercle and extended distally over the anterior compartment. An L-shaped incision over the origin of the anterior compartment muscles provides access to the anterolateral surface of the tibia. Care should be taken along the posterolateral border of the tibia to protect the anterior tibial artery as it passes through the interosseous membrane from posterior to anterior.

With the knee flexed in a varus and internally rotated position, the intra-articular damage was evaluated through a submeniscal arthrotomy.

The fracture was mobilized with a chisel and reduced directly under vision; the articular surface depression was elevated and fracture reduced. The resulting subchondral or metaphyseal defect was then grafted with autograft. A large compression clamp was applied and the transverse diameter of the tibia was controlled under fluoroscopy. Finally, a lateral compression plate or buttress plate was used to stabilize the lateral compartment. This allows the mediolateral direction of the screws.



Anterolateral approach

INTRAOPERATIVE IMAGES

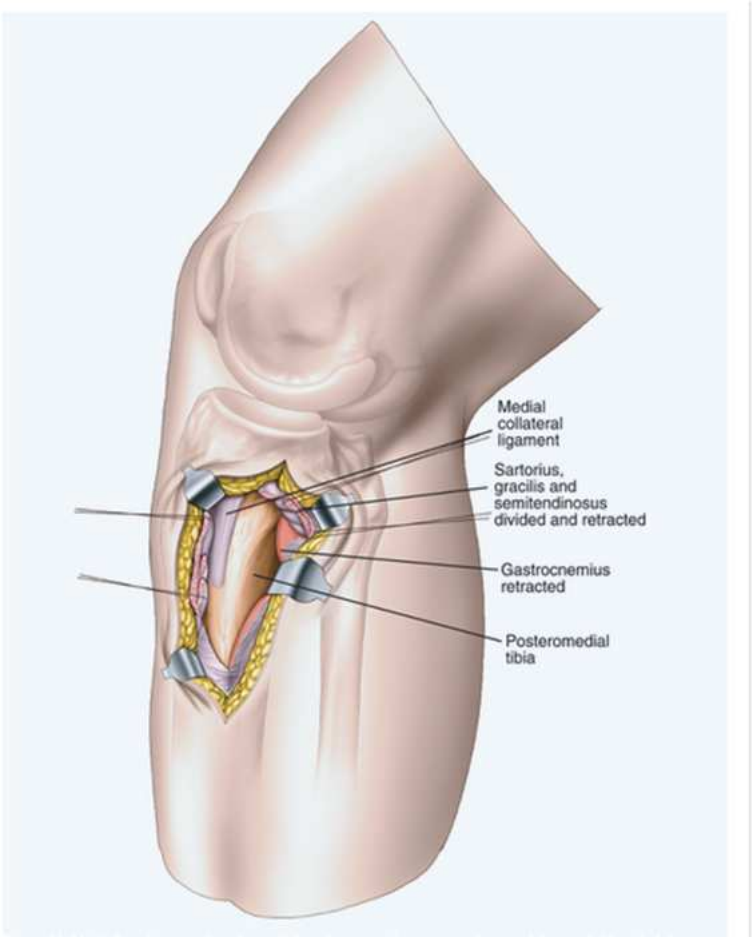
INTRA OPERATIVE FLUOROSCOPY

POSTEROMEDIAL APPROACH

Posteromedial approach is used for medial plating.

The incision was placed approximately 2 cm posterior to the posteromedial edge of the tibial shaft. The fascia overlying gastrocnemius was incised and the pes anserinus was retracted anteriorly. The intra-articular fracture dislocation was visualized with a submeniscal arthrotomy. The medial head of gastrocnemius was elevated from the tibia and the posteromedial wedge fragment was identified. The impacted fragment was then mobilized in flexion and external rotation, which offers the best view on the posterior aspect of the tibia, and reduced. In this position, a 3.5-mm dynamic compression plate was contoured and fixed with screws in distal fragment. The knee was then extended, and the posteromedial fragment is reduced with the 3.5-mm plate acting as a dorsal buttress and was finally fixed with compression screws in a postero-anterior direction

Position of screws was confirmed with image intensifier before closing the wound. Post-operatively patients were given intravenous antibiotics and analgesics.



Posteromedial approach

POST OP PROTOCOL

- Quadriceps exercise started as early as pain tolerates
- Depression fractures - non-weight bearing (NWB) for 6 weeks.
- High energy, unstable fracture patterns are kept NWB until signs of union are visible, usually around 8 to 12 weeks postoperatively.
- Range of motion exercises are started 10 to 14 days postoperatively to allow wound healing.

- Patient was discharged with the instruction of knee mobilisation exercise, quadriceps exercise and non-weight bearing.
- Range of motion was noted.

FOLLOW UP

- Patients are followed up at monthly interval and outcome analysed by knee scoring system devised by the hospital for special surgery.
- Every month pain, range of knee motion and angular deformity was measured. Check x-ray also taken. Data obtained were filled in the proforma.
- Partial weight bearing started after 12 weeks.
- Full weight bearing was started after 16 weeks.
- The results were classified as in below table:

Excellent	If the patient felt no pain ,knee flexion > 110°,and the patient returns to his or her original work.
Good	If the patient felt no pain, knee flexion 90° -110° and returned to work
Fair	Moderate pain, knee flexion <90°,pain on walking long distance, changed to lighter work.
Poor	Moderate to severe pain, knee flexion <60, walking with crutches.

ASSESSMENT

- Functional assessment was done using Knee Society Score devised by the hospital for special surgery.

KNEE SCORING SYSTEM BY THE HOSPITAL FOR SPECIAL SURGERY

Pain -30 points	
While walking	
None	15
Mild	10
Moderate	5
Severe	0
At Rest	
None	15

Function-22points	
A)**Walking** and Standing UNLIMITED	12
5-10 blocks walking/standing 30 MIN	10
1-5 Blocks walking/standing 15-30 MIN	8
LESS THAN 1 Block/standing <15 Min	4
Cannot walk	0
B)stairs	
Normal	5
With support	2
C)Transfer	
Normal	5
With support	2

Range of Motion	
120 Degrees	15
110 Degrees	14
100 Degrees	12
90 Degrees	11
80 Degrees	10

Muscle strength -15 points	
Gr-5	15
Gr-4	12
Gr-3	9
Gr-2	6
Gr-1	3
Gr-0	0

Flexion deformity -10 points	
None	10
0-10 Degrees	8
10-20 Degrees	5
>20 Degrees	0

SUBTRACTIONS

- ONE CANE 1
- ONE CRUTCH 2
- TWO CRUTCHES 3
- **ENTENSOR LAG**
- 5 – DEGREES 2
- 10- DEGREES 3
- 15-DEGREES 5
- **DEFORMITY**
- (5 DEG. = 1 POINT)
- VARUS
- VALGUS
- TOTAL SUBTRACTION

KNEE SCORE = (TOTAL POINTS) – (TOTAL SUBTRACTION)

- **EXCELLENT** **85 POINTS OR MORE**
- **GOOD** **70 - 84 POINTS**
- **FAIR** **60 -69 POINTS**
- **POOR** **< 60 POINTS**

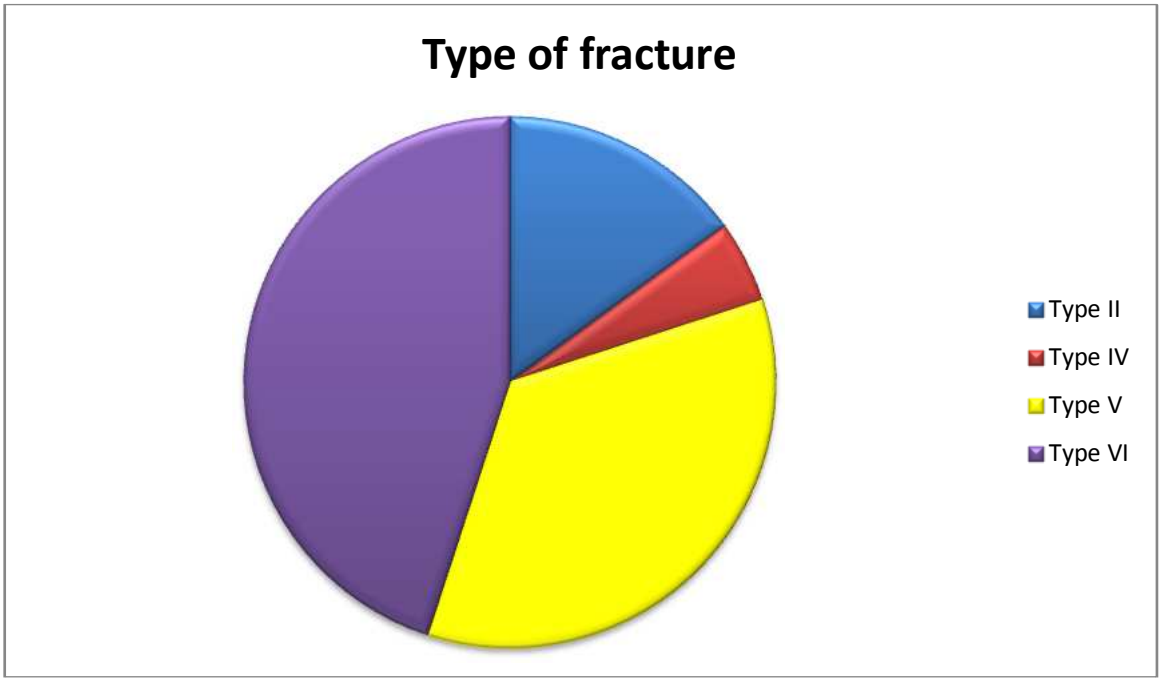
SUCCESS RATE: The percentage of patients achieving excellent and good results.

OBSERVATION

- In our study males were more than females in the ratio of 9:1. Road traffic accident was the cause in all cases.
- Lateral plating was done either by buttress plating or proximal tibial locking plate with raft screws. Medial plating was also done in four cases when buttress plating was done.
- Incidence is more on right side – 75% in right side and 25% in left side.
- The mean age in our study was 40.1 years.
- Out of 20 cases, incidence in > 40 years group was 50% .
- All patients in our study had sustained injury due to road traffic accidents with high energy injuries.
- Old individuals with osteoporotic bones can be expected to sustain complex tibial plateau fractures resulting from low energy injuries, but we have not come across any such case in our series.
- Of the 20 cases, Schatzker type II was found in 15% of patients, type IV in 5%, type V in 35% and type VI in 45%

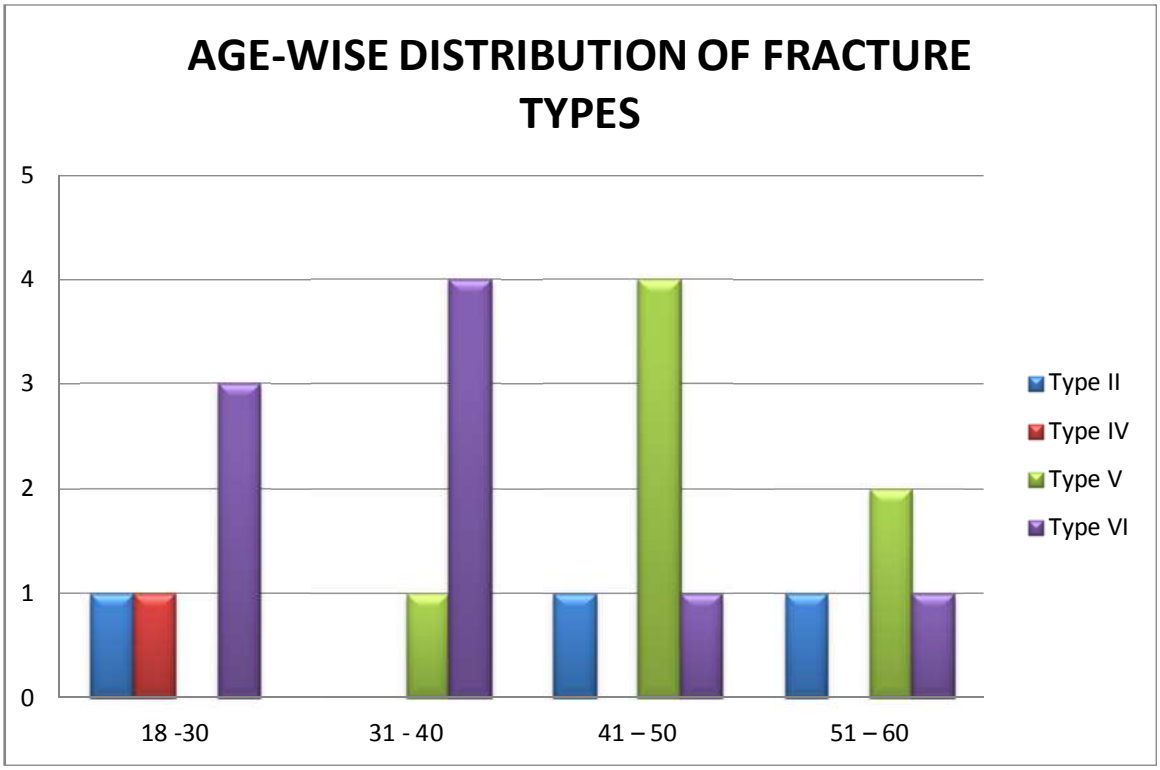
TYPE OF FRACTURE

Type of fracture	No. of patients	Percentage
II	3	15
IV	1	5
V	7	35
VI	9	45



AGE-WISE DISTRIBUTION OF FRACTURE TYPES

Age Group	Type of Fracture				
	Type II	Type III	Type IV	Type V	Type VI
18 -30	1	-	1	-	3
31 - 40	-	-	-	1	4
41 – 50	1	-	-	4	1
51 – 60	1	-	-	2	1



ASSOCIATED INJURIES

Among 20 patients, five patients had associated injuries.

1) Fracture mandible

2) Ipsilateral fracture shaft of femur

3) Contralateral grade III B compound fracture both bone leg

4) Contralateral fracture medial condyle of femur.

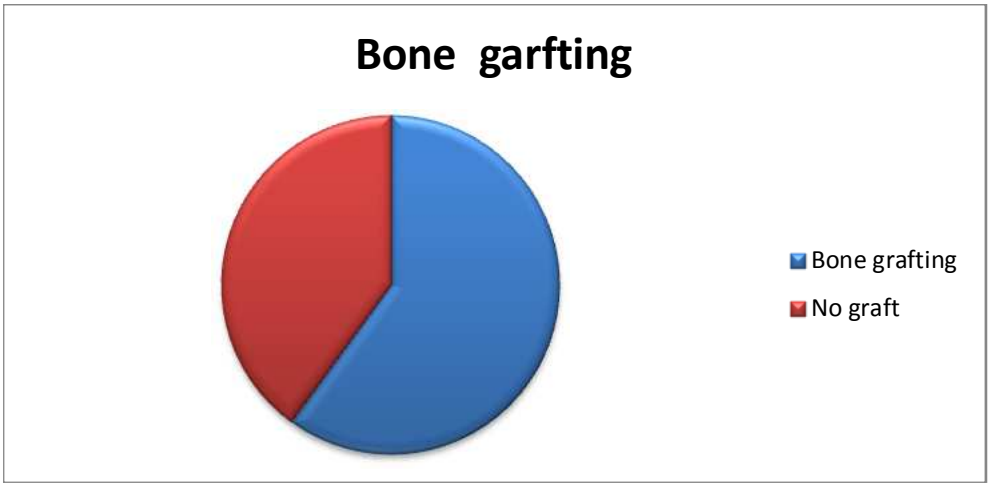
5) Ipsilateral iliac wing fracture

Time of surgery:

The average time duration from day of injury to day of surgery was 8.95 days ranging from 2 to 20 days.

BONE GRAFTING

Bone grafting was done in 12 patients out of 20 (60%)



- All patients underwent a standard surgical approach with anterolateral approach. In four cases medial plating was done using posteromedial incisions in the buttress plating group.
- Lateral locking plate with raft screws was used in 10 patients and lateral buttress plate was used in 10 patients.

COMPLICATIONS

The following complications were noted in our study.

- Knee stiffness
- Superficial infection
- Varus collapse
- Knee pain

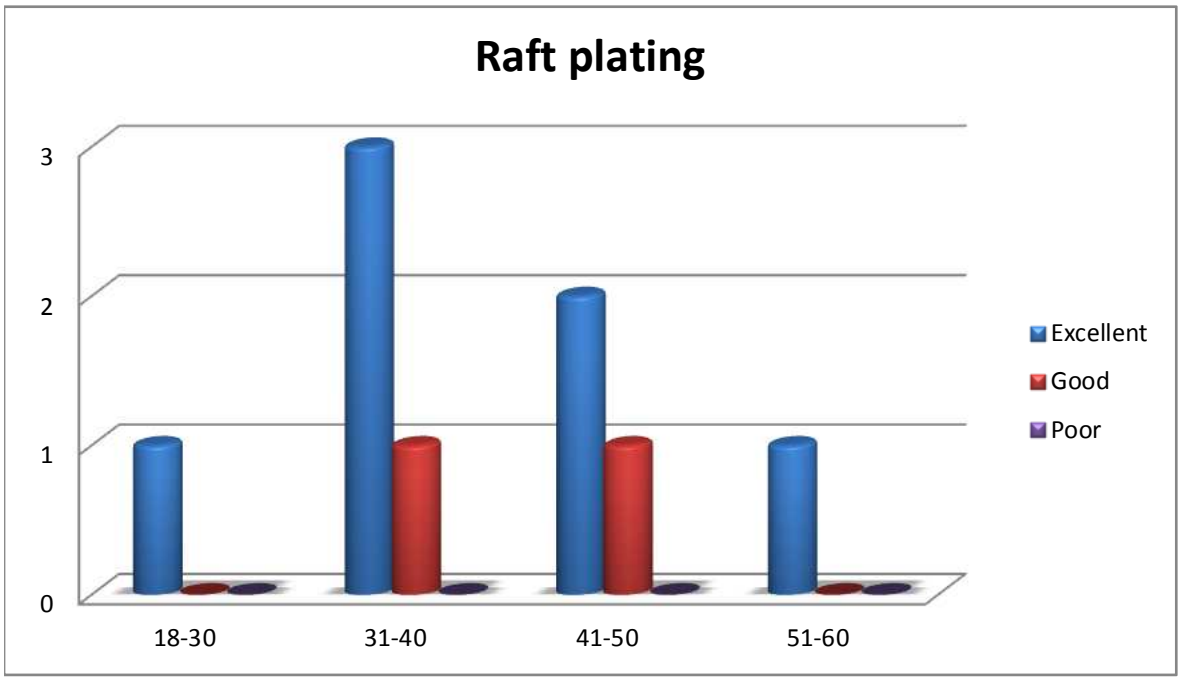
RESULTS AND ANALYSIS

Functional analysis was done using Knee Society Score, which is a clinical scoring system filled by the surgeon.

AGE WISE FUNCTIONAL SCORING

i. Raft Plating

S.No.	Age group	No.of patients	Average Knee Society Score	Grading			
				Excellent	Good	Fair	Poor
1	18-30	1	86	1	-	-	-
2	31-40	4	85.75	3	1	-	-
3	41-50	4	82.25	2	1	1	-
4	51-60	1	90	1	-	-	-



ii. Buttress plating

S.No	Age group	No. of patients	Average Knee Society Score	Grading			
				Excellent	Good	Fair	Poor
1	18-30	4	74	1	1	2	-
2	31-40	1	77	-	1	-	-
3	41-50	2	61	-	-	1	1
4	51-60	3	73.7	1	-	2	-

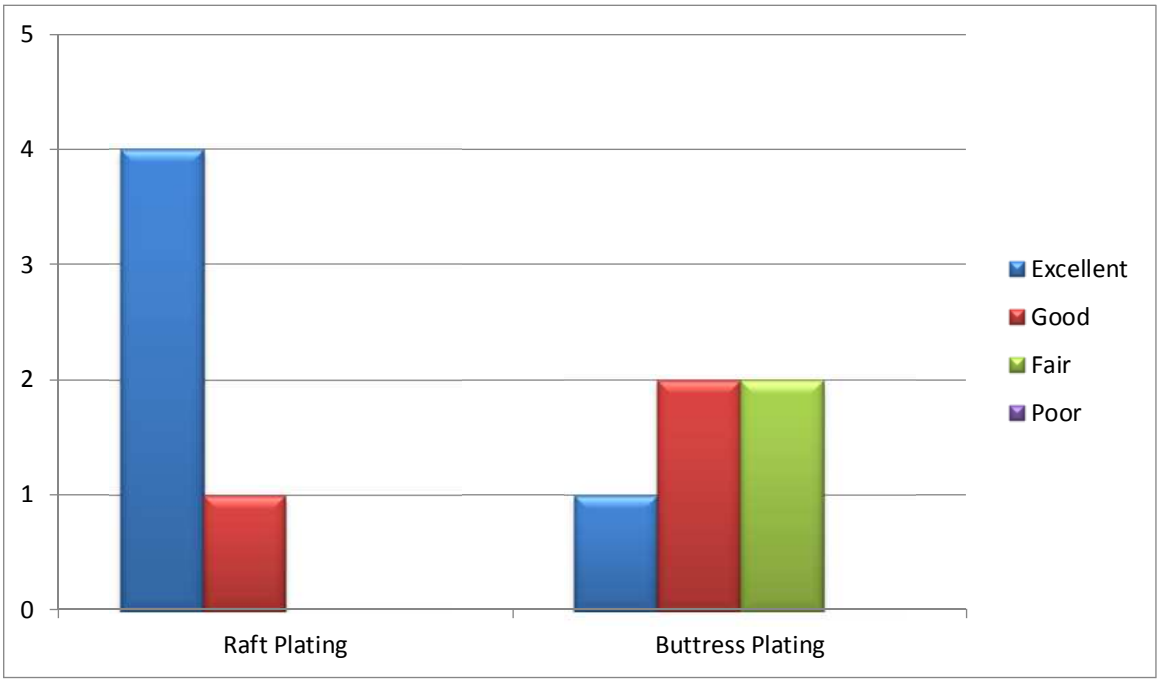
Results in patients < 40 years

Among raft plating group, 4 patients had excellent results and 1 patient had good result. Success rate is 100%.

Among buttress plating group, 1 patient had excellent result, 2 had good result and 2 had fair result. Success rate is 60%.

	Excellent/Good	Fair/Poor	Marginal Row Totals
Raft Plating	5	0	5
Buttress Plating	3	2	5
Marginal Column Totals	8	2	10 (Grand Total)

The Chi-square statistic is 2.5. The P value is 0.113846. This result is not statistically significant.



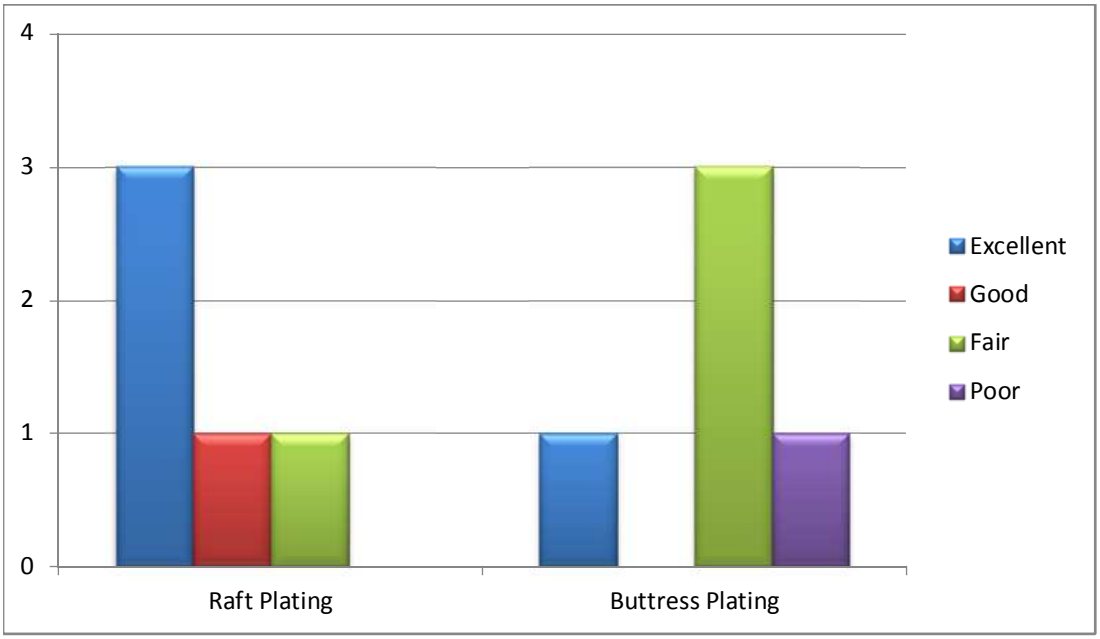
Results in patients > 40 years

Among raft plating group, 3 patients had excellent results, 1 patient had good result and 1 patient had fair result. Success rate is 80%.

Among buttress plating group , 1 patient had excellent result, 3 had fair result and 1 had poor result. Success rate is 60%.

	Excellent/Good	Fair/Poor	Marginal Row Totals
Raft Plating	4	1	5
Buttress Plating	1	4	5
Marginal Column Totals	5	5	10 (Grand Total)

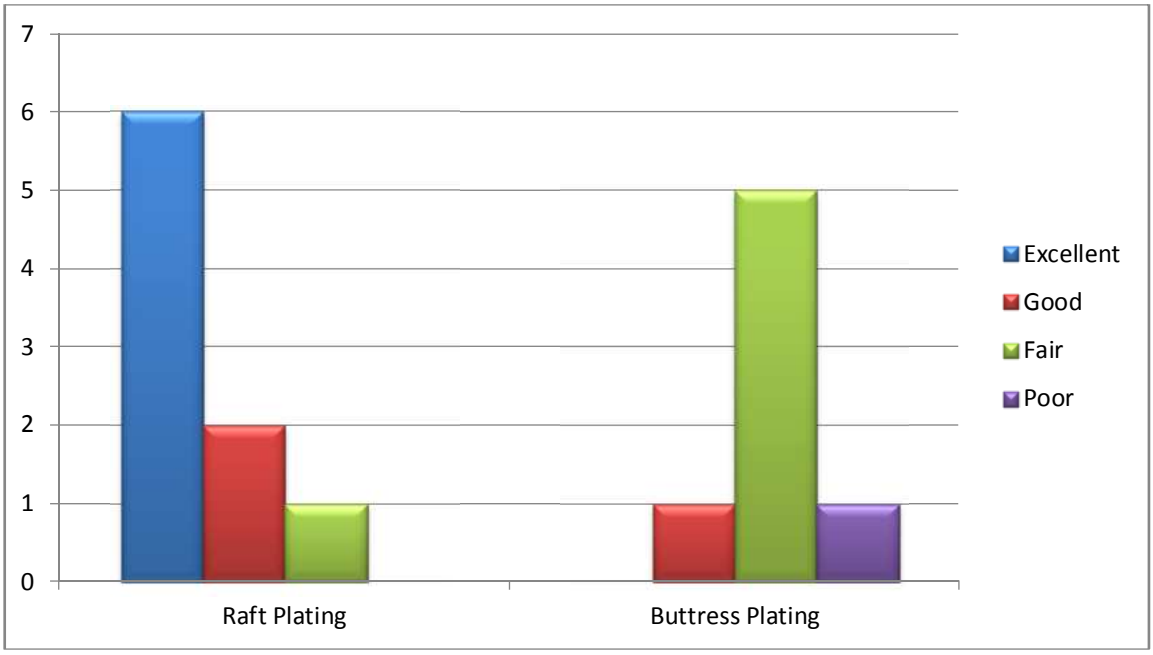
The Chi-square statistic is 3.6. The P value is 0.05778. This result is not statistically significant.



Results in high energy fractures (Type V & VI).

Of the 20 patients, Type V & VI constitute 80%.

Mode of Treatment	No. of Patients	Average KSS	Grading			
			Excellent	Good	Fair	Poor
Raft Plating	9	84.2	6	2	1	0
Buttress Plating	7	66.1	0	1	5	1

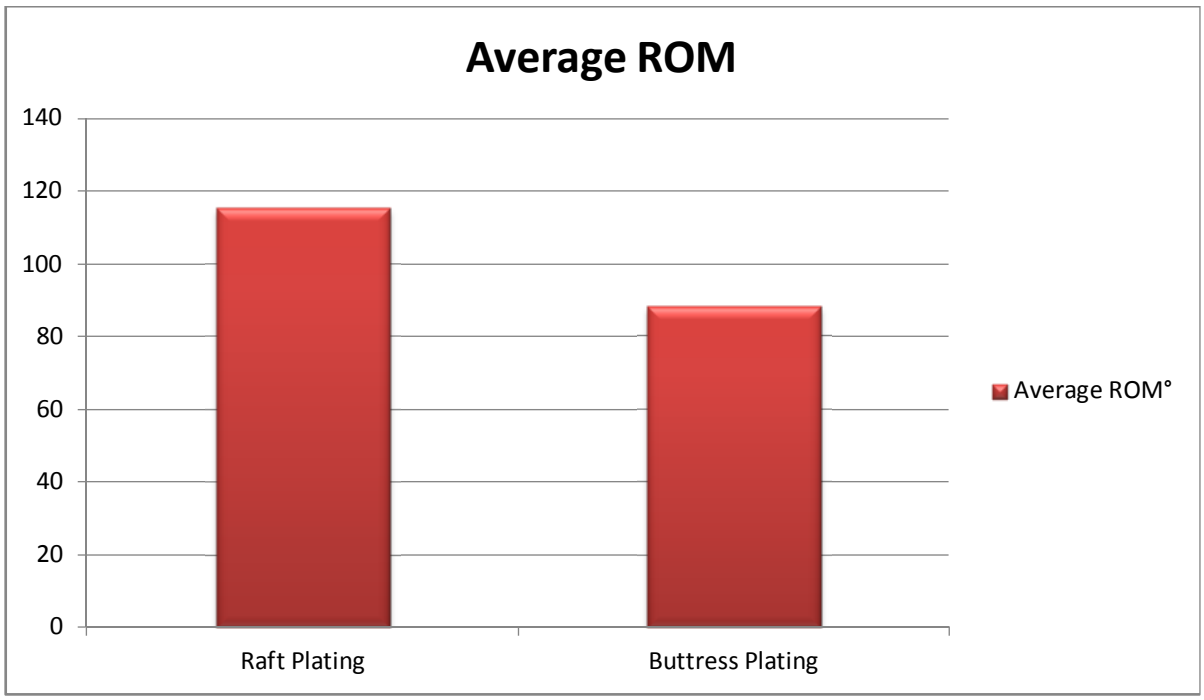


	Excellent/Good	Fair/Poor	Marginal Row Totals
Raft Plating	8	1	9
Buttress Plating	1	6	7
Marginal Column Totals	9	7	16 (Grand Total)

The Chi-square statistic is 8.905. The P value is 0.002844. This result is significant at $p < 0.05$.

Range of movements

The mean range of movement (knee flexion) for patients with Raft plating was observed as 115° and for patients with buttress plating was 88°.



FUNCTIONAL OUTCOME

Results in raft plating group:

Of the 10 patients studied, 7 had excellent score,2 had good score and1 had fair scoring according to Knee Society Score. The average score was 84.8

Results in buttress plating group:

Of the 10 patients studied, 2 had excellent results, 2 had good results,5 had fair results and 1 had poor result according to Knee Society Score. The average score was 71.6

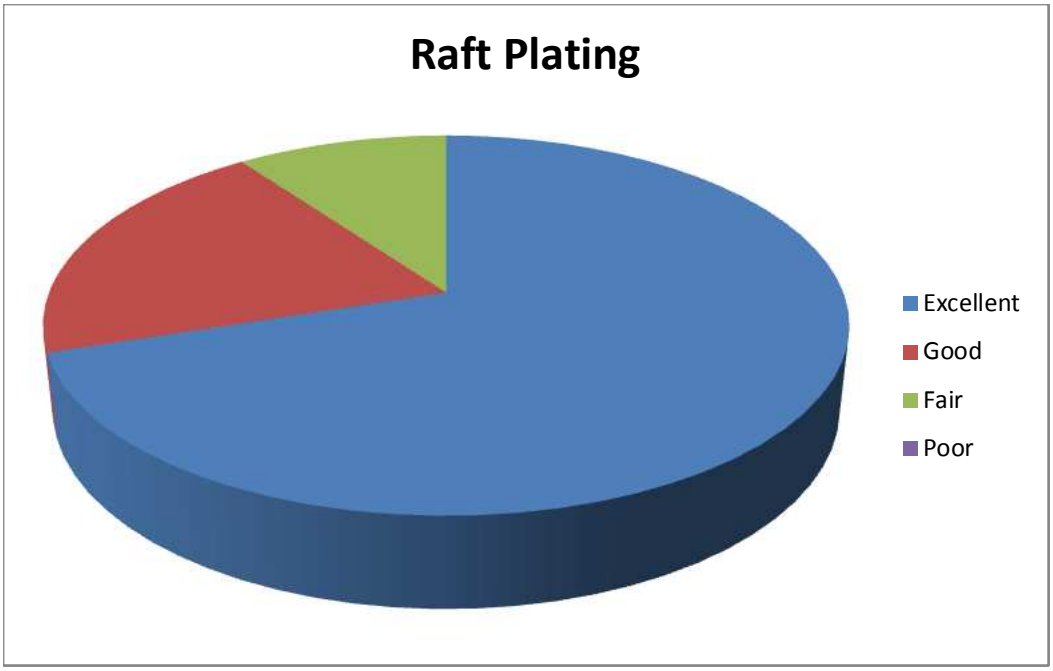
Mode of Treatment	No. of patients	Average knee society score	Grading			
			Excellent	Good	Fair	Poor
Raft plating	10	84.8	7	2	1	-
Buttress plating	10	71.6	2	2	5	1

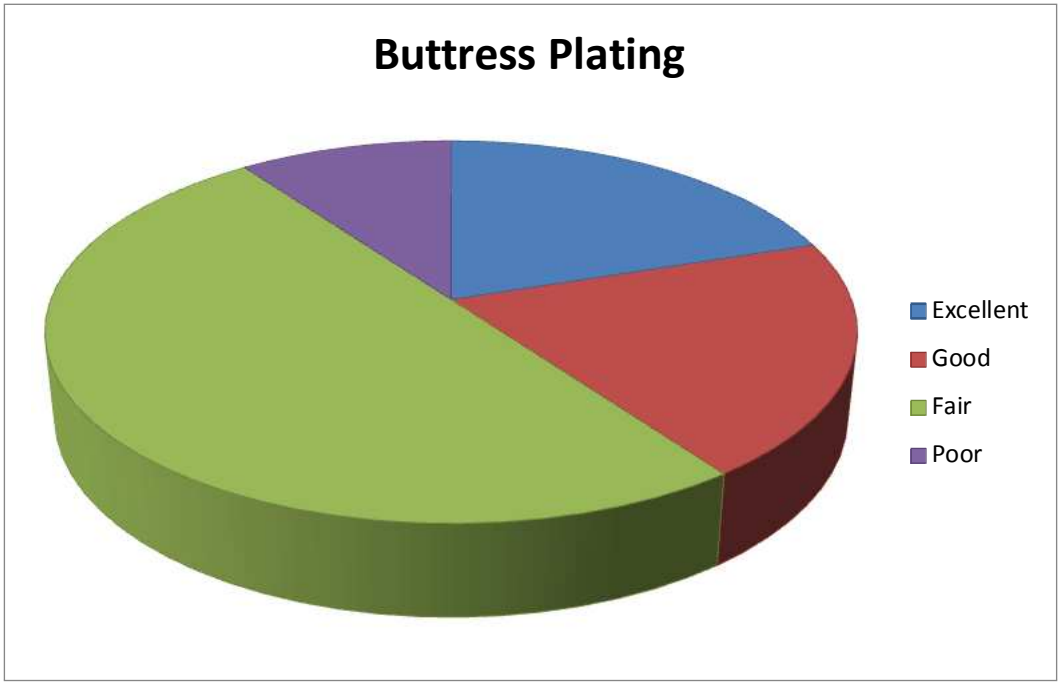
COMPARISON OF FUNCTIONAL OUTCOME OF RAFT PLATING AND BUTTRESS PLATING

Mode of Treatment	Excellent/Good	Fair/Poor	Marginal Row Totals
Raft plating	9	1	10
Buttress plate	4	6	10
Marginal Column Totals	13	7	20 (Grand Total)

The Chi-square statistic is 5.4945. The P value is 0.019076. This result is significant at $p < 0.05$.

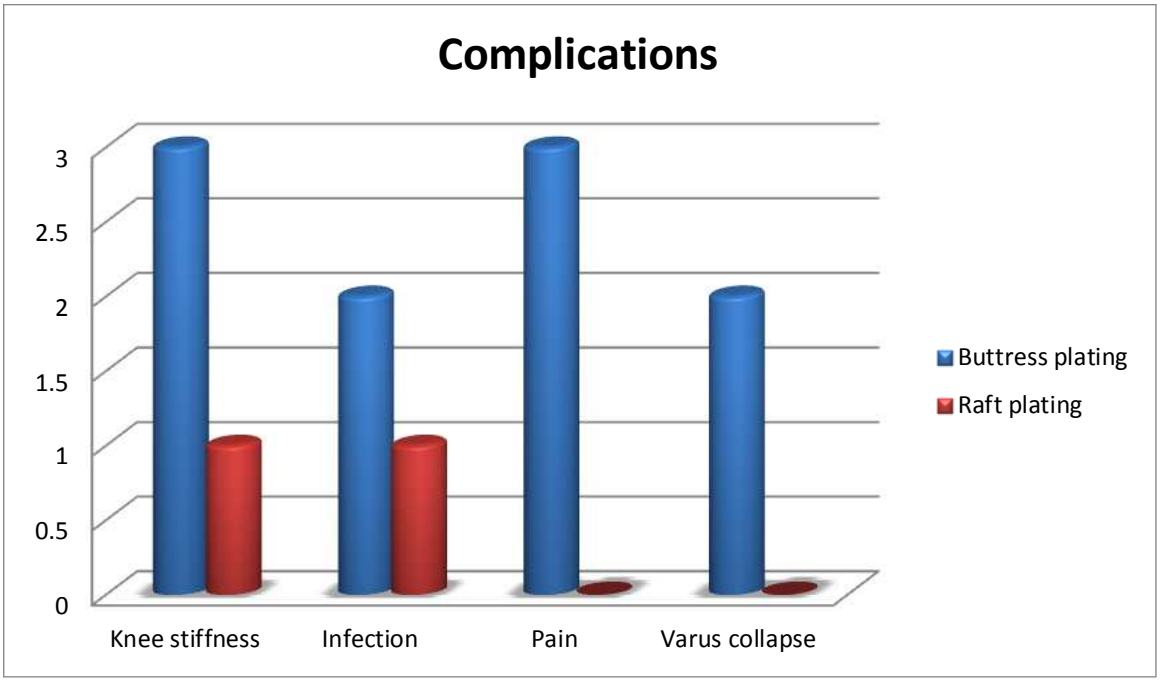
Hence, there is significant difference in the functional outcome of patients treated by raft plating when compared to buttress plating.


Raft Plating
Excellent
Good
Fair
Poor


Buttress Plating
Excellent
Good
Fair
Poor

COMPLICATIONS

- Knee stiffness and flexion less than 90 degree were noted in three patients in buttress plate group and one in raft plate group. Range of flexion in these patients was 0° to 80°, 10° to 80°, 0° to 90°, 10° to 90° respectively.
- Superficial wound infection was noted in three patients and treated with antibiotics and debridement.
- Knee pain was observed in seven of twenty patients. Six patients were from buttress plate group and one in raft plate group.
- Varus collapse was noted in 2 patients in the buttress plating group.



DISCUSSION

Treatment of tibial plateau fractures is a very challenging entity for the surgeon. Road traffic accidents are increasing day by day resulting in high energy injuries. These contribute to the rising incidence of complex proximal tibial fractures presenting to the healthcare provider. Elderly patients with osteoporotic bones sustain complex tibial plateau fractures due to low energy injuries such as domestic falls.

The aim of the treatment is to provide the patient a painless, mobile joint and it needs a very strong technical knowledge and surgical expertise. Good surgical techniques and implants are essential for accurate articular reduction.

The initial disrepute of bicolumn fixation of complex tibial plateau fractures owes itself to poor surgical technique practiced earlier on[1]. The use of a single midline incision and extreme soft tissue handling led onto a high incidence of wound breakdown and infection and put the orthopaedic fraternity on guard regarding bicolumn fixation [5,6,7]. The advent of locking plates shifted the spectrum towards isolated lateral plating using locking compression plates and stabilizing medial fragment through screws passed via the locking plate [13,18.] Several reports of excellent functional results from this technique were questioned later by the peculiar problem of varus collapse in a large subset of

these patients [1,15,16]. Analysis revealed the consistent occurrence of a posteromedial fracture fragment in several patients and inadequacy of its stabilization when a lateral plate alone was done.

However, in the same year, Gosling et al.[50] published the results of their study comparing the biomechanical stability afforded by lateral locking plate and bicolumn non locked plates. They concluded that both fixation techniques have a high resistance to vertical subsidence even with loads exceeding the average body weight. No statistically significant difference was seen between the two methods of fixation.

Several studies have published the superiority of locking plates in proximal tibial fractures [13,18] . There has been a huge development in the field of locking plates and precontoured plates.

3.5 mm screws applied subchondrally parallel to the joint as a " raft" through a proximal lateral locking plate applied on the lateral side improves construct stability and thus prevent articular depression. This plate allows the placement of a screw to capture the posteromedial fragment[9]. This reduces the need for medial plating.

In our study, males outnumbered females in the ratio of 9:1. This is explained by the more active lifestyle of males and hence more chances of road traffic accidents. This is in accordance with the series of 14 patients reported by

Eggli et al., in which 10 were male and 4 female[1]. But in the study of Lee et[32] al there were 21 males and 24 females.

SEX DISTRIBUTION

Study	**Total no. of patients**	**No. of males**	**No. of females**
Eggli et al	14	10	4
Lee et al	45	21	24
Walia et al [26]	50	45	5
Mohd Ali Tahririan et al	41		
Our study	20	18	2

The mean age of patients in our study was 40.1yrs (range 19 to 58 yrs). This is similar to the mean age of 41yrs in Eggli et al study and 49.1 yrs in the Lee et al[32] study.

Road traffic accidents were the cause of injury in all patients. Right side fractures are more common than left.

Lateral plating was done either using locking plate with raft screws or buttress plates.

Medial column fixation was done using reconstruction plates in 4 cases.

The mean follow up in our study was 24.2 weeks.

Raft plating group had seven excellent scores, two good scores and one fair score. This is similar to the functional outcome obtained by Ehlinger et al[34] who studied 20 patients of tibial plateau fractures with a medial component(Type IV,V,VI) treated by a single lateral locking plate and reported mean Lysholm score of 94.1 and HSS score of 93.6. Similar results were obtained by Mohammed Ali Tahhririan et al[38] study comparing locking and non-locking plating. They reported functional outcome with KSS of 80.2 in the locking plate group and 75.52 in the non-locking group.

Buttress plating group had 4 excellent to good scores and 6 fair to poor scores.

In our study younger patients (<40 yrs) treated with raft plating had very good outcome of 100% compared to 60% in patients treated with buttress plating. This may be attributed to good bone quality, better stability provided by locking plates, prevention of late depression by rafting screws and higher compliance of the younger individuals for post op physiotherapy. But we couldn't find any statistical significance.

Older patients (>40 yrs) treated with raft plating had good outcome of 80% compared to 60% in patients treated with buttress plating. This may be attributed to the better stability provided by locking plates in osteoporotic bones and prevention of late depression by rafting screws. This is similar to the finding by Unnikrishnan et al[39].

In the high energy fracture types (Schatzker types V & VI), we found statistical difference in the functional outcome of patients treated by raft and buttress plating. This is because the locking plates and screws act as a single unit whereas in conventional buttress plating, screws are not locked, hence increasing the chances of screw movement and failure at screw head, plate interface. This can cause screw breakage, screw movement or subsidience of fragment. But the study by Lee et al[32] found no statistical difference in the functional outcome among two groups treated by dual plating (mean functional score – WOMAC 36.5) and lateral locking plating(WOMAC 34.1).

Bone grafting was employed in 12 patients out of 20 , mainly to fill up metaphyseal defect after elevation of depressed lateral articular surface fragment.

The mean time to union was 13.5 weeks, ranging from 11 to 16 weeks. Bone grafting did not contribute to faster healing as metaphyseal fractures can

be expected to heal fast even without grafting. In the report published by Eggli et al., bone grafting was employed in 11 of 14 patients [1.]

In patients with fair and poor functional score , lateral buttress plate was used which did not fix posteromedial fragment which lead to varus collapse and these patients had constant knee pain leading to restricted ROM and knee stiffness. In patients who had infection, weight bearing and knee mobilization was delayed and this led to decreased ROM. This is not the case in patients with raft plate as the raft screws inserted from plate placed laterally fixes the medial fragment.

This proves the superior stability afforded by Raft plating in tibial plateau fractures and the prevention of late varus collapse, which seems to be the result in isolated lateral buttress plating.

COMPLICATIONS

- Knee stiffness and flexion less than 90 degree were noted in three patients in buttress plate group and one in raft plate group. Range of flexion in these patients is 0° to 80° ,10° to 80° ,0° to 90° , 10° to 90°.Raft plating group obtained result comparable with Ehlinger et al[34] study (knee stiffness-1 out of 13 patients).

- Superficial wound infection was noted in three patients (15%) and treated with antibiotics and debridement. This is comparable to Mohd Ali Tahririan et al[38] study, in which infection rate was 14.6%

- Knee pain was observed in seven of twenty patients. Six patients from buttress plate group and one in raft plate group

- Varus collapse was noted in 2 patients in the buttress plating group. These two patients sustained type V and VI fractures and were treated by lateral buttress plating only. No bone grafting was done. Weight bearing was delayed in these cases. This is comparable with the series of Eggli et al [1] ., who had one case of varus collapse (83 degrees) and one case of valgus collapse (91degrees) in their series of 14 patients with an average 25 months follow up. In the series of Barei et al. [4], of 31 patients studied, 28 had satisfactory coronal alignment, but two patients developed varus malalignment and one developed valgus malalignment.

CONCLUSION

- Raft screws placed in the subchondral bone provide adequate construct stiffness and support to prevent articular depression.
- Lateral locking plate with rafting screws provides support for postromedial and posterolateral fragments. This reduces the need for medial plating and dual incision.
- Locking plate provides better stability than conventional buttress plating. Hence this aids in better range of movements and reduced pain during post-operative knee mobilization and this leads to better final range of motion.
- There is no difference in the time for union between two plating methods. But the difference lies in the prevention of subsidience of articular surface in the raft plating group and hence better functional outcome.
- So, from this study it can be concluded that when compared to buttress plating, proximal tibial locking plate with raft screws technique is a better and effective method for achieving good to excellent results providing almost full range of motion and maintaining articular congruity in the treatment of tibial plateau fractures.

CASE ILLUSTRATION

Case 1

Name	Mathialagan
Age	40 years
Sex	Male
Mode of Injury	RTA
Side injured	Right
Schatzker type	Type VI
Time Interval between injury and surgery	2 days
Procedure	ORIF with lateral locking plate with raft screws + Bone grafting
Post-op period	Uneventful
Knee mobilization	2 days
Partial weight bearing	12 weeks
Full weight bearing	16 weeks
At follow-up	26 weeks
Knee Society Score	90
KSS Result	Excellent

Pre-Operative

Immediate Post-Op

6 months follow up

Case 2

Name	Sinthamani
Age	30
Sex	Female
Mode of Injury	RTA
Side injured	Left
Schatzker type	Type VI
Associated injury	Fracture mandible
Time Interval between injury and surgery	12 days
Procedure	ORIF with lateral locking plate with raft screws
Post-op period	Uneventful
Knee mobilization	2 days
Partial weight bearing	12 weeks
Full weight bearing	16 weeks
At follow-up	24 weeks
Knee Society Score	86
KSS Result	Excellent

Pre-Operative

Immediate Post-Op

6 months follow up

Case 3

Name	Gnanasekar
Age	38
Sex	Male
Mode of Injury	RTA
Side injured	Right
Schatzker type	Type VI
Time Interval between injury and surgery	3 days
Procedure	ORIF with lateral and medial buttress plating + Bone grafting
Post-op period	uneventful
Knee mobilization	2 days
Partial weight bearing	12 weeks
Full weight bearing	16 weeks
Follow-up	24 weeks
Knee Society Score	77
KSS Result	Good

Preoperative

Immediate postoperative

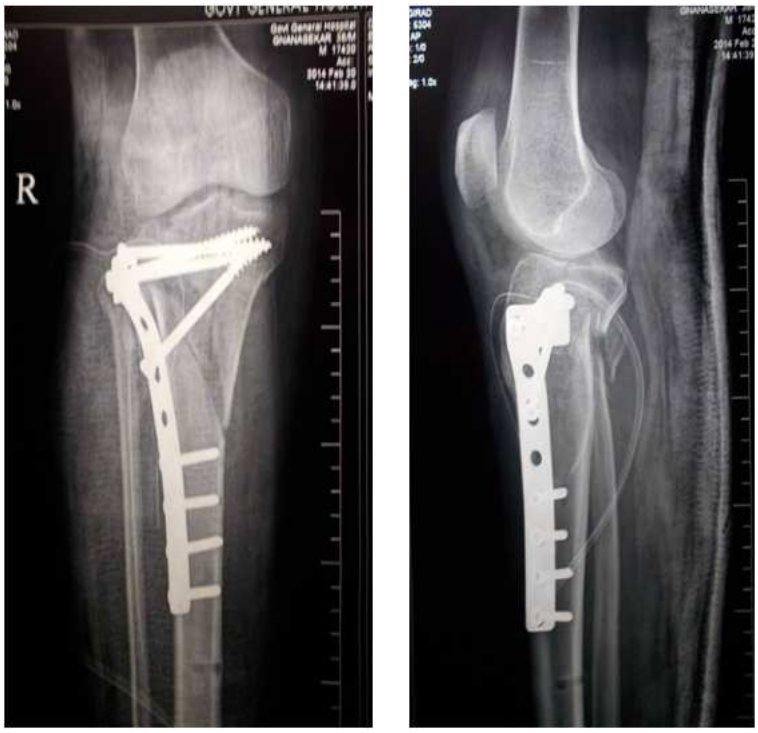
6 months follow up

Case 4

Name	Dhanavandhan
Age	57
Sex	Male
Mode of Injury	RTA
Side injured	Right
Schatzker type	Schatzker Type VI
Time Interval between injury and surgery	10 days
Procedure	ORIF with lateral buttress plating + Bone grafting
Post-op period	Uneventful
Knee mobilization	2 days
Partial weight bearing	12 weeks
Full weight bearing	18 weeks
At follow-up	26 weeks
Knee Society Score	67
KSS Result	Fair

Pre-Operative

Immediate PostOperative

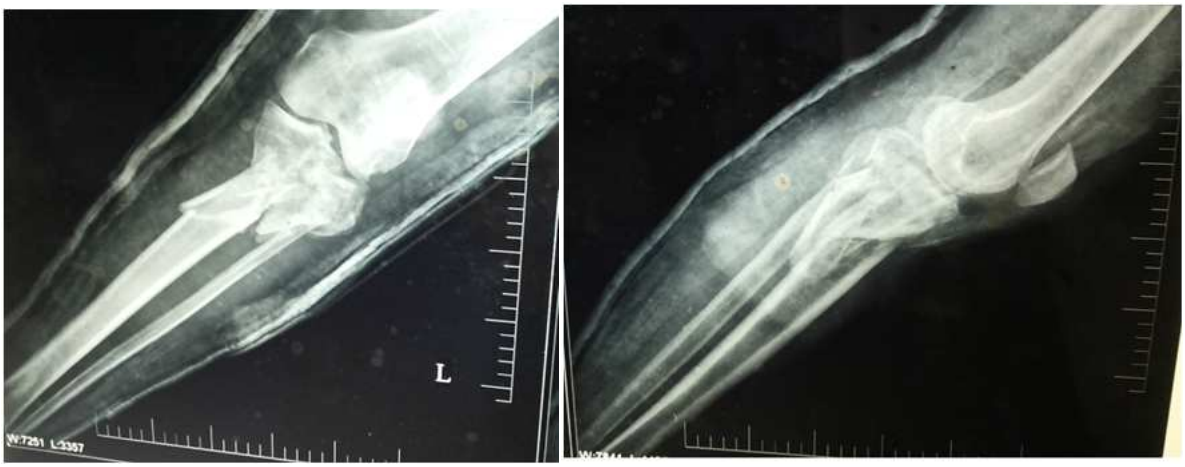


6 months follow-up

Case 5

Name	Mani
Age	59
Sex	Male
Mode of Injury	RTA
Side injured	Left
Schatzker type	Type VI
Time Interval between injury and surgery	20 days
Procedure	ORIF with lateral buttress plating
Post-op period	Uneventful
Knee mobilization	2 days
Partial weight bearing	16 weeks
Full weight bearing	Not allowed
At follow-up	20 wks
Knee Society Score	58
KSS Result	Poor

Preoperative



Immediate postoperative

4 months follow-up (Varus Collapse)

BIBLIOGRAPHY

1) Eggli et al. Unstable bicondylar tibial plateau fractures: A clinical investigation. *J Orthop Trauma 2008;22:673–679*

2) Hithin Mathur, Shankar Acharya, Nijhawan VK,Mandal SP. Operative results of closed tibial plateau fractures. *IJO 2005;39(2):108-12*.

3) V Musahl et al. New trends and techniques in open reduction and internal fixation of fractures of the tibial plateau. *J Bone Joint Surg [Br] 2009;91-B:426-33.*

4) Barei et al. Functional outcomes of severe bicondylar tibial plateau fractures treated with dual incisions and medial and lateral plates. *J Bone Joint Surg [Am] 2006;88 A: 1713-1721*

5) Young MJ, Barrack RL. Complications of internal fixation of tibial plateau fractures. *Orthop Rev. 1994;23:149–154*

6) Moore TM, Patzakis MJ, Harvey JP. Tibial plateau fractures: definition, demographics, treatment rationale, and long-term results of closed traction management or operative reduction. *J Orthop Trauma. 1987;1:97– 119*.

7) Mallik AR, Covall DJ, Whitelaw GP. Internal versus external fixation of bicondylar tibial plateau fractures. *Orthop Rev. 1992;21:1433–1436*

8) Georgiadis GM. Combined anterior and posterior approaches for complex tibial plateau fractures. *J Bone Joint Surg Br.* 1994;76:285–289.

9) Carlos A. Bermu´dez, MD, Bruce H. Ziran, MD, and Mary-Kate Barrette-Grischow, MA: Use of Horizontal Rafting Plates for Posterior Elements of Complex Tibial Plateau Fractures: Description and Case Reports.*J Trauma.* 2008;65:1162–1167.

10) William W. Cross ,Bruce A. Levy,Joseph A. Morgan, Bryan M. Armitage,Peter A. Cole : Periarticular raft constructs and fracture stability in split-depression tibial plateau fractures. *Injury, Vol.44(6),June 2013:796-801*.

11) Barei DP, Nork SE, Mills WJ, et al. Complications associated with internal fixation of high-energy bicondylar tibial plateau fractures utilizing a two incision technique. *J Orthop Trauma. 2004;18:649–65*.

12) Beris AE, Soucacos PN, Glisson RR, et al. Load tolerance of tibial plateau depressions reinforced with a cluster of K-wires. *Bull Hosp Jt Dis 1996;55:12-15.*

13) Ehlinger M et al. Reliability of locked plating in tibial plateau fractures with a medial component. *Orthop Traumatol Surg Res. 2012;98:173-179*

14) Ali AM, El-Shafie M, Willett KM. Failure of fixation of tibial plateau fractures. *J Orthop Trauma 2002;16:323-329.*

15) Ricci WM, Rudzki JR, Borrelli J Jr. Treatment of complex proximal tibia fractures with the less invasive skeletal stabilization system. *J Orthop Trauma.2004;18:521-527*

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

17) Koval KJ, Sanders R, Borrelli J, et al. Indirect reduction and percutaneous screw fixation of displaced tibial plateau fractures. *J Orthop Trauma 1992;6:340-346*.

18) Gosling T, Muller M, Richter M, et al. The less invasive stabilization system for bicondylar fractures of the proximal tibia. Presented at: *Orthopaedic Trauma Association 18th Annual Meeting; 2002; Toronto, Canada.*

19) Westmoreland GL, McLaurin TM, Hutton WC. Screw pullout strength: a biomechanical comparison of large-fragment and small-fragment fixation in the tibial plateau. *J Orthop Trauma 2002;16:178-181*

20) Jabal –Ameli et al:Cortical screws in tibial plateau fracture.*Minerva Ortopedica e Traumatologica 2014;65(2):171-8*

21) Duwelius PJ, Connolly JF. Closed reduction of tibial plateau fractures. A comparison of functional and roentgenographic end results. *Clin Orthop Relat Res 1988:116-126.*

22) Schatzker J, McBroom R, Bruce D: The tibial plateau fracture. The Toronto Experience 1968-1975: *Clin Orthop 138:94-104; 1979.*

23) Young MJ, Barrack RL. Complications of surgical intervention of tibial plateau fractures. *Orthop Rev 1994;23:149-54*.

24) Thomas A Russel,Ross K Leighton. Comparison of autogenous bone graft and endothermic calcium phosphate cement for defect augmentation in tibial plateau fractures: *A multicentre prospective randomized study. JBJS Am 2008;90(10)2057-61.*

25) Dias JJ, Stirling AB, Finlay DB et al: Computerised tomography for tibial plateau fractures: *J Bone Joint Surg Br.1987; 69(1);84-88.*

26) JPS Walia, Avinash Gupta, SurinderKumar, SonamkaurWalia, Sargun Singh.Role of tibial buttress plating in fracture of upper end tibia:A study of 50 cases. *Pb Journal of Orthopaedics Vol-XII, No.1, 2011*

27) David M. Hahn, MB Ch B, FRCS Ortho: Current principles of treatment in the clinical practice of articular fracture: *CORR No.423, pp.27-32;2004*.

28) Karunakar MA, Egol KA, Peindl R, et al. Split depression tibial plateau fractures: a biomechanical study. *J Orthop Trauma 2002;16:172-177*.

29) Koval KJ, Polatsch D, Kummer FJ, et al. Split fractures of the lateral tibial plateau: evaluation of three fixation methods. *J Orthop Trauma 1996;10:304-308*

30) Patil S, Mahon A, Green S, et al. A biomechanical study comparing a raft of 3.5 mm cortical screws with 6.5 mm cancellous screws in depressed tibial plateau fractures. *Knee 2006;13:231-235*.

31) Higgins TF, Klatt J, Bachus KN .Biomechanical analysis of bicondylar tibial plateau fixation: how does lateral locking plate fixation compare to dual plate fixation?. *J Orthop Trauma. 2007 May;21(5):301-6*

32) Lee et al.: Comparison of outcome of unilateral locking plate and dual plating in the treatment of bicondylar tibial plateau fractures. *Journal of Orthopaedic Surgery and Research 2014 9:62.*

33) Higgins TF, Kemper D, Klatt J. Incidence and morphology of th posteromedial fragment in bicondylar tibial plateau fractures. *J Orthop Trauma.2009 Jan;23(1):45-51*

34) M.Ehlinger et al, Reliability of locked plating in tibial plateau fractures with a medial component. *Orthopaedics & Traumatology: Surgery & Research 2012;98:173-179*

35) Liow RY, Birdsall PD, Mucci B, et al. Spiral computed tomography with two and three-dimensional reconstruction in the management of tibial plateau fractures. *Orthopedics 1999;22:929-932*

36) Wicky S, Blaser PF, Blanc CH, et al. Comparison between standard radiography and spiral CT with 3D reconstruction in the evaluation, classification and management of tibial plateau fractures. *Eur Radiol 2000;10:1227-1232*

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

38) Mohammad Ali Tahririan, Seyyed Hamid Mousavitadi, and Mohsen Derakhshan: Comparison of Functional Outcomes of Tibial Plateau Fractures Treated with Nonlocking and Locking Plate Fixations: A Nonrandomized ClinicalTrial. *ISRN Orthopedics 2014 ; Article ID 324573, 6 pages.*

39) Unnikrishnan J, Jacob PJ, Jose Francis. Functional outcome of tibial condyle fractures treated with open reduction and internal fixation with plate and screws. Kerala Journal of Orthopaedics 2013; 98-106.

40) Apley A G: fractures of the lateral tibia condyle treated by skeletal traction and early mobilization. A review of sixty cases with special reference to the long term result. *J Bone Joint Surg 38-B: 699, 1956*

41) Moore T.M, Harvey J.P, JR.: Roentogenographic measurement of tibial plateau depression due to fractures. *J Bone Joint Surg 56A: 155, 1974*.

42) Bowes D N, Hohl M: Tibial condyle fractures: evaluation of treatment and outcome. *Clin Orthop 171: 104, 1982.*

43) Blokker CP, Rorabeck CH, Bourne RB. Tibial plateau fractures. An analysis of the results of treatment in 60 patients. *Clin Orthop 182:193, 1984*.

44) Jensen DB, Rude C, Duus B, Bjerg-Nielsen A. Tibial plateau fractures. A comparison of conservative and surgical treatment. *J Bone Joint Surg; 72 B: 49-52, 1990*

45) Honkonen S.E, Jarvienen M.J,: Classification of fractures of tibial condyles, *JBone Joint Surg 74B: 840, 1992*

46) Tscherne H, Lobenhoffer P. Tibial plateau fractures. Management and expected results. *Clin Orthop Relat Res. 1993; 292:87-100.*

47) Marsh JL, Smith ST, Do TT. External fixation and limited internal fixation for complex fractures of the tibial plateau. *J Bone Joint Surg 77A: 661, 1995.*

48) Weigel DP, Marsh JL, High energy fracture of the tibial plateau: knee function after longer follow-up. *J Bone Joint Surg 84-A; 1541-1551, 2002.*

49) Weil et al., Posteromedial Supine Approach for Reduction and Fixation of Medial and Bicondylar Tibial Plateau Fractures. *J Orthop Trauma 2008;22:357–362*

50) Gosling T et al., Less Invasive Stabilization of Complex Tibial Plateau Fractures: A Biomechanical Evaluation of a Unilateral Locked Screw Plate and Double Plating. *J Orthop Trauma* 2004;18:546–551

LIST OF ABBREVIATIONS

ACL – Anterior Cruciate Ligament

A.O – Arbeitsgemeinschaft für Osteosynthesefragen

ASIF – Association for the Study of Internal Fixation

BG – Bone Grafting

DCP – Dynamic Compression Plating

KSS – Knee Society Score

NWB – Non Weight Bearing

PCL – Posterior Cruciate Ligament

ROM – Range of Motion

PATIENT EVALUATION PROFORMA

PRE-OPERATIVE

Name	_____		
Age	__	Sex	☐ Male ☐ Female
IP Number	_____	Admission Date	_____
	__		
Time from Injury to Admission	_____	Injury Mode	_____

Diagnosis	
Associated injuries	
Co-morbidities	
X-Ray finding	
CT finding	
Classification	
Distal neurovascular status	

INTRA-OPERATIVE

Time form injury to surgery	
Position	
Anesthesia	
Approach	
Procedure done	
Plate placement	
Plates used	
Blood loss	
Duration of surgery	
Post-Op immobilization	

POST-OPERATIVE	
Drain collection	
Day of drain removal	
Postoperative x ray	
Wound status at discharge	
Suture removal	
IV antibiotics	
Oral antibiotics	
Associated injury treatment	
Distal neurovascular status	

FOLLOW-UP		
Date	Visit number	
Postoperative month		
Wound status		
X ray		
Weight bearing		
Knee society score		
1.) Pain		
2.) Range of Motion		
3.) Stability	☐ Anteroposterior	☐ Mediolateral
4.) Deductions	Flexion Contracture Extension Lag Alignment	

MASTER CHART

S. No.	Name	Age	Sex	I.P.No	Mode of Injury	Side Affected	Associated injuries	Time before surgery (Days)	Schatzker Type	Treatment	Time for union	Knee score	Complication	Follow up (Weeks)	ROM	Result
1	Gnanasekar	38	M	11614	RTA	Right	-Nil-	3	VI	Buttress plating(Bicolumn) + BG	12 wks	77	-Nil-	24	90	Good
2	Mani	43	M	26297	RTA	Right	-Nil-	20	V	Buttress plating	15 wks	55	Knee stiffness, Varus collapse, Pain	20	60	Poor
3	Chinnadurai	52	M	45786	RTA	Left	-Nil-	12	V	Raft plating + BG	12 wks	90	-Nil-	28	120	Excellent
4	Kesavan	20	M	18986	RTA	Right	-Nil-	7	VI	Buttress plating (Bicolumn)	16 wks	65	Infection, Knee stiffness, Pain	28	70	Fair
5	Janakiraman	58	M	51533	RTA	Left	-Nil-	14	II	Buttress plating + BG	14 wks	85	-Nil-	20	120	Excellent
6	Sindhamani	30	F	51468	RTA	Right	# mandible	12	VI	Raft plating	12 wks	86	-Nil-	24	130	Excellent
7	Suresh	31	M	48849	RTA	Right	# shaft of femur(R)	3	V	Raft plating	14 wks	80	-Nil-	28	100	Good
8	Mehavarnan	22	M	39206	RTA	Left	-Nil-	10	II	Buttress plating + BG	12 wks	88	-Nil-	24	120	Excellent
9	Vimalraj	28	M	43266	RTA	Right	Gr IIIB Compd# BB(L) leg	10	IV	Buttress plating (medial plating)	16 wks	80	-Nil-	24	110	Good
10	Mathialagan	38	M		RTA	Right	-Nil-	2	VI	Raft plating + BG	12 wks	90	-Nil-	36	130	Excellent

S. No.	Name	Age	Sex	I.P.No	Mode of Injury	Side Affected	Associated injuries	Time before surgery (Days)	Schatzker Type	Treatment	Time for union	Knee score	Complication	Follow up (Weeks)	ROM	Result
11	Kumar	40	M	47523	RTA	Right	-Nil-	2	VI	Raft plating + BG	14 wks	85	-Nil-	24	120	Excellent
12	Dhanavandhan	57	M	56415	RTA	Right	-Nil-	10	VI	Buttress plating + BG	14 wks	67	Pain	26	80	Fair
13	Shanmugam	50	M	78338	RTA	Right	# iliac wing (R)	20	V	Raft plating + BG	14 wks	69	Knee stiffness, Pain	24	70	Fair
14	Sasikumar	19	M	1203	RTA	Right	# medial femoral condyle(L)	3	VI	Buttress plating	12 wks	63	Knee stiffness, Varus collapse, Pain	20	80	Fair
15	Kumaresan	43	M	63612	RTA	Right	-Nil-	2	V	Raft plating + BG	16 wks	82	Infection	24	110	Good
16	Sigamani	40	M		RTA	Left	-Nil-	3	VI	Raft plating	12 wks	88	-Nil-	24	120	Excellent
17	Subramanian	50	M	54532	RTA	Right	-Nil-	7	II	Raft plating + BG	14 wks	90	-Nil-	22	120	Excellent
18	Natarajan	54	M	72032	RTA	Right	-Nil-	12	V	Buttress plating (Bicolumn) + BG	16 wks	69	Infection Pain	24	70	Fair
19	Sundari	45	F	73286	RTA	Left	-Nil-	20	V	Buttress plating	12 wks	67	Pain	20	80	Fair
20	James Ambrose	43	M		RTA	Right	-Nil-	7	VI	Raft plating + BG	11 wks	88	-Nil-	20	130	Excellent

turnitin

Digital Receipt

This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

The first page of your submissions is displayed below.

Submission author:	221212008.M.S,Orthopaedics Samp..
Assignment title:	TNMGRMU EXAMINATIONS
Submission title:	comparison raft vs buttress plating
File name:	oct_10_-_FOR_PLAG.docx
File size:	10.75M
Page count:	106
Word count:	10,291
Character count:	56,198
Submission date:	11-Oct-2014 04:33PM
Submission ID:	451983375

A COMPARTIVE ANALYSIS OF FUNCTIONAL OUTCOME OF TIBIAL PLATEAU FRACTURES TREATED WITH PROXIMAL TIBIAL LOCKING PLATE WITH RAFT SCREW TECHNIQUE AND CONVENTIONAL BUTTRESS PLATING

Dissertation submitted to

M.S. DEGREE-BRANCH II

ORTHOPAEDIC SURGERY

THE TAMILNADU DR.M.G.R.MEDICAL UNIVERSITY

CHENNAI-TAMILNADU

APRIL 2015

ANNEXURES

INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE, CHENNAI-3

EC Reg No.ECR/270/Inst./TN/2013
Telephone No. 044 25305301
Fax : 044 25363970

CERTIFICATE OF APPROVAL

To
Dr.R. Sampath,
Post Graduate, MS (Orthopaedics),
Institute of Orthopaedics & Traumatology,
Madras Medical College,
Chennai – 600 003.

Dr.R.Sampath,

The Institutional Ethics Committee has considered your request and approved your study titled **"A prospective and retrospective study on comparative analysis of functional outcome of Tibial plateau fractures treated with proximal tibial locking plate with raft screw technique and conventional buttress plating "** No.**25072014**.

The following members of Ethics Committee were present in the meeting held on 01.07.2014 conducted at Madras Medical College, Chennai-3.

1.	Dr.C.Rajendran, M.D.,	: Chairperson
2.	Dr.R.Vimala, M.D., Dean, MMC, Ch-3	: Deputy Chairperson
3.	Prof.B.Kalaiselvi, M.D., Vice-Principal, MMC, Ch-3	: Member Secretary
4.	Prof.R.Nandhini, M.D., Inst.of Pharmacology, MMC	: Member
5.	Dr.G.Muralidharan, Director Incharge, Inst.of Surgery	: Member
6.	Prof.Md.Ali, M.D., D.M., Prof & HOD of MGE, MMC	: Member
7.	Prof.K.Ramadevi, Director i/c, Inst.of Biochemistry, MMC	: Member
8.	Prof.Saraswathy, M.D., Director, Pathology, MMC, Ch-3	: Member
9.	Prof.Tito, M.D., Director i/c, Inst.of Internal Medicine, MMC	: Member
10.	Prof.Umashanthi, Director i/c, IOG	: Member
11.	Thiru S.Rameshkumar, Administrative Officer	: Lay Person
12.	Thiru S.Govindasamy, B.A., B.L.,	: Lawyer
13.	Tmt.Arnold Saulina, M.A., MSW.,	: Social Scientist

We approve the proposal to be conducted in its presented form.

Sd/ Chairman & Other Members

The Institutional Ethics Committee expects to be informed about the progress of the study and SAE occurring in the course of the study, any changes in the protocol and patients information/informed consent and asks to be provided a copy of the final report.

Member Secretary, Ethics Committee

MEMBER SECRETARY
INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE
CHENNAI-600 003

ஆராய்ச்சி ஒப்புதல் கடிதம்

ஆராய்ச்சி தலைப்பு

கால் எலும்பு (டிபியா) மேல் தட்டு முறிவிற்கு இரு வகையான உட்பொருத்துதல் தகடுகள் (லாக்கிங் பிளேட் மற்றும் பட்ரஸ் பிளேட்) மூலம் மேற்கொள்ளப்படும் அறுவை சிகிச்சையின் செயல்பாட்டு விளைவுகள் பற்றிய ஒப்பீட்டு ஆராய்ச்சி

பெயர்	:	தேதி	:
வயது	:	உள் நோயாளி எண்	:
பால்	:	ஆராய்ச்சி சேர்க்கை எண்	:

இந்த ஆராய்ச்சின் விவரங்களும் அதன் நோக்கங்களும் முழுமையாக எனக்கு தெளிவாக விளக்கப்பட்டது.

எனக்கு விளக்கப்பட்ட விஷயங்களை நான் புரிந்துகொண்டு எனது சம்மதத்தை தெரிவிக்கிறேன்.

இந்த ஆராய்ச்சியில் பிறரின் நிர்பந்தமின்றி என் சொந்த விருப்பத்தின்பேரில் பங்கு பெறுகின்றேன். இந்த ஆராய்ச்சியில் இருந்து நான் எந்நேரமும் பின்வாங்கலாம் என்பதையும் அதனால் எந்த பாதிப்பும் ஏற்படாது என்பதையும் நான் புரிந்துகொண்டேன்.

நான் என்னுடைய சுய நினைவுடனும் மற்றும் முழு சுதந்திரத்துடனும் இந்த மருத்துவ ஆராய்ச்சியில் என்னை சேர்த்துக்கொள்ள சம்மதம் தெரிவிக்கிறேன்.

கையொப்பம்

ஆராய்ச்சி தகவல் தாள்

தலைப்பு :

கால் எலும்பு (டிபியா) மேல் தட்டு முறிவிற்கு இரு வகையான உட்பொருத்துதல் தகடுகள் (லாக்கிங் பிளேட் மற்றும் பட்ரஸ் பிளேட்) மூலம் மேற்கொள்ளப்படும் அறுவை சிகிச்சையின் செயல்பாட்டு விளைவுகள் பற்றிய ஒப்பீட்டு ஆராய்ச்சி

சென்னை இராஜீவ்காந்தி அரசு பொது மருத்துவனையில், கால் எலும்பு (டிபியா) மேல் தட்டு முறிவிற்கு இரு வகையான உட்பொருத்துதல் தகடுகள் (லாக்கிங் பிளேட் மற்றும் பட்ரஸ் பிளேட்) மூலம் மேற்கொள்ளப்படும் அறுவை சிகிச்சையின் செயல்பாட்டு விளைவுகள் பற்றிய ஒப்பீட்டு ஆய்வு இங்கு நடைபெறுகிறது.

முடிவுகளை அல்லது கருத்துகளை வெளியிடும்போதோ அல்லது ஆராய்ச்சியின் போதோ தங்களது பெயரையோ அல்லது அடையாளங்களையோ வெளியிடமாட்டோம் என்பதையும் தெரிவித்துக் கொள்கிறோம்.

இந்த சிறப்பு சிகிச்சையின் முடிவுகளை ஆராய்ச்சியின்போது அல்லது ஆராய்ச்சியின் முடிவின் போது தங்களுக்கு அறிவிக்கப்படும் என்பதையும் தெரிவித்துக் கொள்கிறோம்.

இந்த ஆராய்ச்சியில் பங்கேற்பது தங்களுடைய விருப்பத்தின் பேரில் தான் இருக்கிறது. மேலும் நீங்கள் எந்நேரமும் இந்த ஆராய்ச்சியிலிருந்து பின்வாங்கலாம் என்பதையும் தெரிவித்துக் கொள்கிறோம்.

ஆராய்ச்சியாளர் கையொப்பம் **பங்கேற்பாளர் கையொப்பம்**

நாள் :
இடம் :

PATIENT CONSENT FORM

Study Detail : **"comparative analysis of functional Outcome of Tibial plateau fractures treated with Raft plating and conventional buttress plating "**

Study Centre : Rajiv Gandhi Government General Hospital, Chennai.

Patient's Name :

Patient's Age :

Identification Number :

Patient may check (V) these boxes

a) I confirm that I have understood the purpose of procedure for the above study. I have the opportunity to ask question and all my questions and doubts have been answered to my complete satisfaction. ☐

b) I understand that my participation in the study is voluntary and that I am free to withdraw at any time without giving reason, without my legal rights being affected. ☐

c) I understand that sponsor of the clinical study, others working on the sponsor's behalf, the ethical committee and the regulatory authorities will not need my permission to look at my health records, both in respect of current study and any further research that may be conducted in relation to it, even if I withdraw from the study I agree to this access. However, I understand that my identity will not be revealed in any information released to third parties or published, unless as required under the law. I agree not to restrict the use of any data or results that arise from this study. ☐

d) I agree to take part in the above study and to comply with the instructions given during the study and faithfully cooperate with the study team and to immediately inform the study staff if I suffer from any deterioration in my health or well being or any unexpected or unusual symptoms. ☐

e) I hereby consent to participate in this study. ☐

f) I hereby give permission to undergo detailed clinical examination, radiographs ,blood investigations and surgical procedure as required. ☐

Signature/thumb impression

Patient's Name and Address:

Signature of Investigator

Study Investigator's Name: Dr. R.SAMPATH

PATIENT INFORMATION SHEET

TITLE OF THE STUDY: **Comparative analysis of functional Outcome of Tibial plateau fractures treated with Raft plating and conventional buttress plating.**

We are conducting a study on **"comparative analysis of functional Outcome of Tibial plateau fractures treated with Raft plating and conventional buttress plating "** among patients admitted in the Institute of Orthopaedics & Traumatology, Rajiv Gandhi Government General Hospital, Chennai.

The purpose of this study is to evaluate and analyse the clinical, radiological and functional outcome of raft plating and conventional buttress plating in tibial plateau fractures.

We are selecting certain cases based on radiographic pattern of tibial plateau fracture and if you are found eligible,we perform surgical procedure for the fractured limb by either raft plating or conventional buttress plating technique or if you are already operated for the fracture by one of the above mentioned techniques we will evaluate the outcome of surgery, which in any way do not affect your final report or management.

The privacy of the patients in the research will be maintained throughout the study. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

Taking part in this study is voluntary. You are free to decide whether to participate in this study or to withdraw at any time; your decision will not result in any loss of benefits to which you are otherwise entitled.

The results of the special study may be intimated to you at the end of the study period or during the study if anything is found abnormal which may aid in the management or treatment.

Signature of Investigator

Signature of Participant

Date :