SHORT TERM ASSESSMENT OF
FUNCTIONAL RESULTS OF SURGICALLY TREATED
TIBIAL PLATEAU FRACTURES

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CERTIFICATE

This is to certify that this dissertation entitled **"SHORT TERM ASSESSMENT OF FUNCTIONAL RESULTS OF SURGICALLY TREATED TIBIAL PLATEAU FRACTURES"** is the bonafide work done by **Dr. P.R. SENTHIL RAJA** under my direct guidance and supervision in the Department of Orthopaedic surgery, Madras Medical College, Chennai – 3 during his period of study from Aug 2004 – Sep. 2006.

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INTRODUCTION

Fractures of the proximal tibia involve a major weight-bearing joint and are serious injuries that frequently result in functional impairment. They were originally described as “the fender fracture” because they resulted from low-energy pedestrian versus car accidents. In recent literature, majority are reported from high energy motor vehicle accidents and falls from a height.

The tibial plateau fractures make up 1% of all fractures and 8% of fractures in the elderly. Most injuries affect the lateral plateau (55% to 70%) ,medial plateau fracture in (10% to 23%) cases, both plateau fracture in 10-30% of reported series.

The optimal treatment of tibial plateau fracture has been a source of controversy for a long time. Current thinking leave from for both operative and non-operative management depending upon the fracture pattern and clinical examination.

The goal of treatment is to achieve a stable, well aligned, mobile joint with minimum surface irregularity and with adequate soft tissue

healing. Prevention of late degenerative changes is also a purpose of treatment. Hence, now the treatment is marching towards surgical methods.

We have decided to study the short-term assessment of functional results of surgically treated tibial plateau fractures (schatzkers type I to type IV) prospectively done in our institution during last 3 years.

AIM OF THE STUDY

The aim of this study is to analyse the short term assessment of functional results of 28 closed tibial plateau fractures treated by surgeries prospectively done in our institution during the period from August 2004 to October 2006.

HISTORICAL REVIEW

Sir Astley Cooper first described tibial plateau fractures in 1825.Since then many authors tried to describe this with their wide variety of fracture patterns. To conduct a study on tibial plateau fractures, one is forced to consider the changing trends from past to present. In the past these were treated as a separate entity and the patient was not treated as a whole. The discovery of x-ray and the astonishing transformation it brought in diagnosing these fractures has greatly helped the surgeons in planning the treatment.

But the subsequent invention and the universal adoption of metallic implants, following the AO group these fractures were also considered for surgical treatment , but with less in number , due to the fact of stiffness it produced.

Now with available CT scans, MRI and other sophisticated investigations the understanding of fracture personality, planning are made very simple.

The extend of these fractures are often greater than visualised in x-ray, but frequently the patient does well than one actually prognosticates.

As early as *1929,Cotton and Berg* stated that they no longer operate on these fractures if they could help it. *Badgley O'coonor, Terner* and others 1952 maintained that most fractures of tibial condyles can be managed conservatively.

The concept of early mobilization as advocated by *Apley, Hohl* and *Luck 1956* is a major contribution in the treatment of tibial condyle fractures. *Neal in 1961* pointed out that the traditional principle of rest and prolonged immobilization as advocated by Sir Hugh Owen Thomas and Watson and Jones may produce a stiff joint in poor position. The opposite school which supports early mobilization was effectively presented by *Perkins* 1955.*Hohl and Luck* 1956 showed experimentally that the articular adhesions form after knee joint fractures.

Apley outlines the traditional assumption that osteoarthritis will result, unless reduction is perfectly maintained in plaster and that immobilisation is necessary to permit healing of torn ligaments.

Pauwel demonstrated that if the degree of stress within the joint exeeds that of articular cartilage self repair, then post traumatic arthritis likely to develop.

On the other hand some writers seemed to consider closed treatment virtually a form of ‘therapeutic nihilism’ and advised open reduction. *Leadbetter and Hand* 1940 pointed out that the severity of injury cannot be assessed by x-rays, that the meniscus is often torn,the degree of communition precludes closed treatment. *Rombold* 1940 advised the use of multiple plates and screw fixation in order to achieve stability. Cave and Caldwell 1948 stated that, associated injury to the collateral ligament need not be repaired.

Hohl and O'Donoghue however noted that ligament repair is needed.

Palmer 1961 advocated reduction and internal fixation of all tibial plateau fractures.

Lansinger et al 1968 stated that knee instability rather than the amount of displacement is the main indication for surgery.

Bradford ,Killfoile, Kocher 1950 advocated reduction of lateral condylar fracture, by forcing the leg into varus, immobilistaion in cast.

Sarmiento et al 1969 studied the effect of fibula on the anatomic behaviour of condyle fracture and concluded that often the condition of fibula whether fractured or intact determines the angulatory behaviour conditions.

Since it is very difficult to arrive at a definite conclusion and there were no concrete idea derived from the view of various workers, it is the main part of any study to understand the various aspects of tibial plateau fractures in determining the indication for open or closed method of management based on the anatomical considerations, radiological assessment and functional evaluation.The purpose of our study is satisfied if these lacunae are filled.

SURGICAL ANATOMY

The Tibia is the major not bearing bone of the leg, with the fibula serving for mobile attachments. The proximal tibial shaft widens into lateral and medial tibial condyles. The bony articular surface area of the tibia slope informing approximately 10^0 from anterior to posterior. Between the plateaus lies the intercondylar eminence which has medial & lateral tibial spaces and areas for the attachment of menisci and cruciate ligaments.

The tibial tubercle located on the anterior tibial crest 3 cm below the joint line, provides attachment for patellar tendon. Gerdy's tubercle located on the anterolateral surface of the lateral tibial flair affords insertion for the ilio tibial band.

The fibula articulates with the tibia in the proximal tibia fibular joint, located posterolatorally on the tibial condyle. Fibula acts a buttress for the proximal tibia and provides attachment for the tibial collateral ligament and biceps tendon.

The tibial plateaus are covered by hyaline cartilage approximately 3mm thick on the medial plateau & 4 mm thick on the

lateral plateau. The medial plateau is the larger of the two, and is concave front to back, as well as from side to side. The lateral plateau is smaller & higher than the medial plateau, and is convex from front to back as well as from side to side. The outer portion of each plateau is covered by a fibro cartilaginous meniscus.

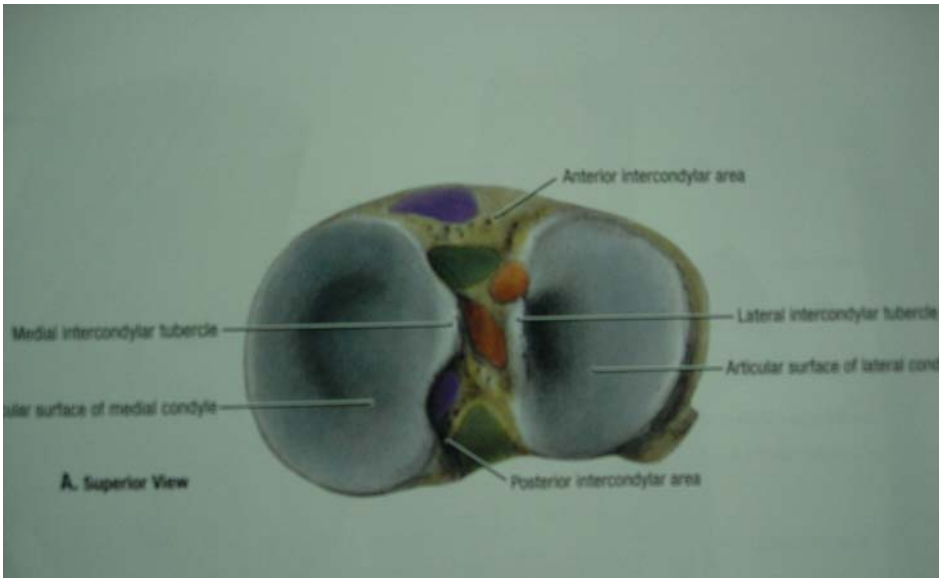
The lateral meniscus covers much larger portion of the articular surface than does the medial. Meniscotibial ligaments attach the menisci to the periphery of the tibial plateau. These structures are crucial to identify, when performing a sub meniscal exposure to visualise the articular surface of the plateau. They are carefully in used in a horizontal fashion to elevate the maximum.

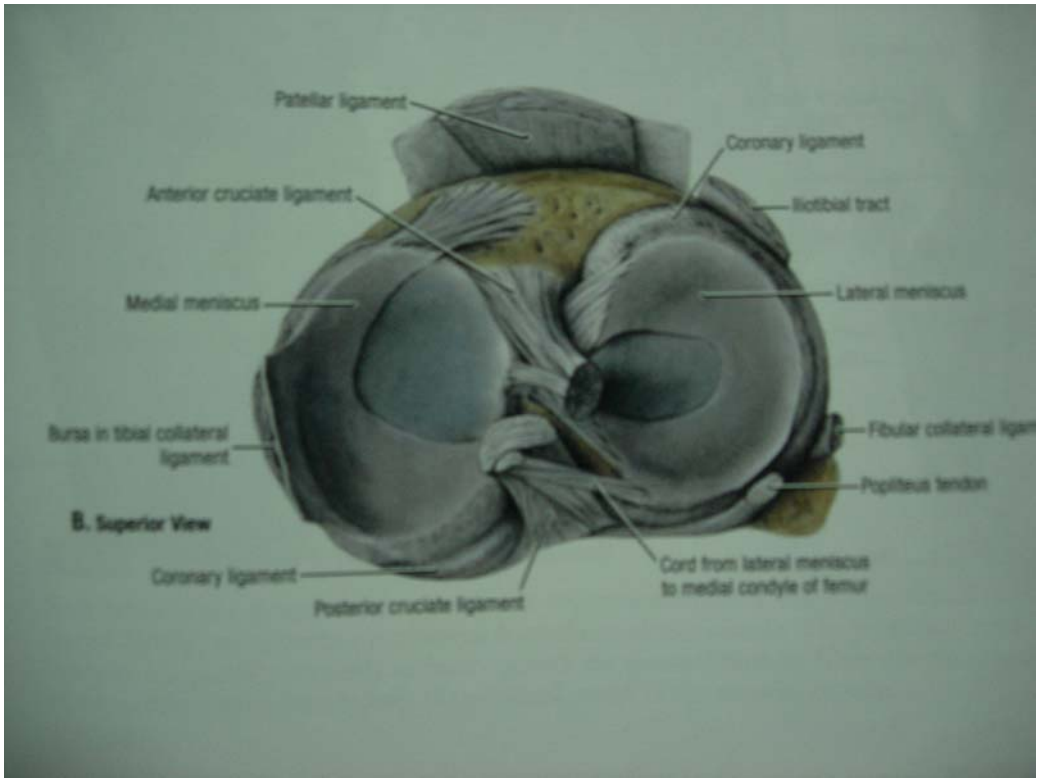
The medial articular surface and the sub condyle medial plateau region is much stronger than the lateral plateau. Because of this lateral plateau # are more common and encompass a broad specturm of low energy fracture pattern. Medial plateau # occur as a result of high energy trauma and have a wide variety of associated injuries, such as ligamentous disruption, poroneal N. injuries, compartment syndrome, popliteal artery damage.

- 10% porterior slope of plateau

- lateral plateau converse
- medial plateau concave
- More of medial plateau left exposed by smaller meniscus
- lateral plateau higher than medial plateau
- multiple ligament attachment

Anatomy


Anterior intercondylar area
Medial intercondylar tubercle
Articular surface of medial condyle
A. Superior View
Posterior intercondylar area


Patellar ligament
Coronary ligament
Anterior cruciate ligament
Iliotibial tract
Medial meniscus
Lateral meniscus
Bursa in tibial collateral ligament
Popliteus tendon
B. Superior View
Coronary ligament
Cord from lateral meniscus to medial condyle of femur
Posterior cruciate ligament

MECHANISM OF INJURY

Fractures of the tibial plateau occur as result of strong Valgus (or) varus forces combined with axial loading. The location of the fracture depended on the degree of flexion (or) extension of the knee.

The classic bumper fracture is a fracture of the lateral plateau resulting from a medially directed blow to the lateral aspect of the knee. This creates a Valgus deforming force with associated loading of the lateral plateau by the lateral femonal condyle.

When axial loads exceeded 8000 pounds “explosive” severally comminuted fractures were produced. This mechanism is thought to occur clinically after a fall from a height on an extended knee (or) due to a high energy motor vehicle accident.

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

Isolated split fractures are virtually confined to young adults with dense cancellous bone that is capable of with standing the compressive forces on the joint surface, with age, the strong cancellous bone of the proximal tibia gradually becomes more sparse

and is no longer able to with stand the compressive forces with impact loading, a depressed or split depressed fractures results, and these typically result from low energy forces.

The magnitude of the force determines not only the degree of commination but the degree of displacement. Thus in addition to the fracture, there may be associated soft tissue lesions, such as tear of the medial collateral ligament (or) Anterior cruciate ligament with lateral plateau fractures, conversely tears of the lateral collateral ligament (or) PCL (or) lesions of the peroneal nerve (or) popliteal vessel may be associated with medial plateau fractures.

BIOMECHANICS OF THE KNEE

The upper surface of the tibia inclines 10-15 degrees inferiorly and posteriorly in sagittal plane. But in general the articular surface of the upper end of the tibia is perpendicular to the long axis of the tibia in both sagittal and coronal planes. In sagittal plane the medial plateau is slightly concave and the lateral plateau is convex. In coronal plane both are slightly concave.

The transverse diameter of articular surface of femoral condyle spread on each side of the intercondylar notch.Therefore in flexed position of the knee, the flared portion of the femoral condyle is directly over the plateau and when the knee is extended narrower wedge shaped anterior surface of the femoral condyle is apposed to the tibial table.

The mechanical axis and the anatomical axis of the femur are not coinciding with each other, forming a physiological valgus of 5-7 degrees with the axis of the tibia. Though the mechanical axis of the femur passes in the centre of the normal knee joint , the load predominantly passes through the medial condyle.

During the last degrees of extension , the femur is internally rotated as conjunct rotation. Because of this 'screw home phenomenon' and juxtaposition of the narrower anterior lateral femoral condyle to the lateral tibial condyle when the knee is extended, a substantial portion of tibial plateau is left uncovered. *ULIN*

1934 described this relationship and stated that the surface of lateral tibial condyle extends 1.5cms beyond the femoral condyle.

The fibula on the posterolateral side of the lateral condyle gives buttressing support. This fibular support minimizes the lateral condyle displacement during treatment.

Kennedy and Bailey demonstrated common fracture patterns in cadaver knees. The location of fracture depends on the degree of flexion or extension of the knee. When axial load exceeds 8000 pounds explosive severely comminuted fractures results. The mechanism is thought to occur in a fall from a height.

The menisci distribute load between femur and the tibia by increasing the area of conduct. They are capable of changing their shape with knee movement to facilitate this load bearing action. They are not efficient shock observers and act like washers. *POPE et al 1976* described this.

Martin 1960 in describing the pathomechanics if the knee joint, carried out experiment in cadavers showing that, in abduction strains the medial collateral ligament was responsible for the stability of the knee.In a normal knee the cruciate ligament prevent abduction when the knee is fully extended, but if the cruciate ligaments are ruptured as well as the medial ligaments, tibia subluxates laterally rather than being rotated into abduction.

Martin showed that with static stress, a load of about 150 lbs is necessary to rupture the medial collateral ligament, while the lateral condyle becomes crushed at a load of about 500 lbs.

Thus if the subject falls on the lower limb abducted at the knee, the compression forces are sufficient to crush the lateral condyle, before medial ligaments give way.

On the contrary if the knee is fixed and the force is given to the inner aspect of foot, the reverse will occur.

JOINT STABILITY:

Bony contours of the knee joint contributes nothing to the anteroposterior stability, but the spine of the tibia and concavity of the articular surface of the tibia prevents sideways gliding of femur in tibia.The cruciate ligaments are indispensable to the anteroposterior stability in flexion and stability in extension is by collateral and oblique popliteal ligaments. Muscle function is also important. The vasti by the retinacular expansion contribute greatly and vastus medialis assists in the stability of the patella.

The iliotibial tract stabilizes the slightly flexed knee. Gravity and proprioception also play a major role.

CLASSIFICATION SYSTEMS

Numerous classification system have been proposed to describe tibial plateau fractures. The majority are very similar with each system recognizing wedge, compression and bicondylar types.

Hohl classification was the first widely accepted description of tibial plateau fractures.

Moore expanded Hohl's concepts taking into account higher energy injuries and knee instability.

Thiele , Roberts ,Rasmussen , Courvoisier, Weller, Duparc, Holz tried to classify tibial plateau fractures on various aspects

AO-ASIF classification adopted by Blokker and colleagues applies alphanumeric code to fractures. Injury is graded in this system which has prognostic significance.

Schatzkers in 1979 developed a classification of tibial plateau fracture which is widely accepted and is the most widely used and was the first to make the distinction between medial and lateral plateau fractures.

There are six types each representing a group of fractures that are similar in mechanism of injury, fracture and prognosis. This is a radiological classification based on the study in 94 patients.

Type I:pure cleavage fracture (6%)

Type II:cleavage combined with depression(25%)

Type III:pure central depression(36%)

Type IV:medial condyle fracture(10%)

Type A : split or wedge(1/3)

Type B: depressed or communited(2/3)

Type V :bicondylar fractures

Type VI:with dissociation of metaphysis and

Diaphysis(20%)

Type I:

In younger patients with good bone stock.They result from axial load coupled with valgus stress at the knee. The strong cancellous bone resists articular depression that is seen in older patients leaving the unsupported lateral portion of the lateral condyle vulnerable to fracture. Displacement can signify meniscal tears, entrapment of meniscus, disruption of the tibial collateral ligament.

Type II:

More common in the yelderly because the osteoporotic cancellous bone cannot support the axial load transmitted through the lateral femoral condyle. These are subject to the same soft tissue injury as outlined in type I fracture.

Type III:

Mainly in the older people, due to the less dense cancellous bone.

Type IV:

These are often associated with avulsion of the tibial intercondylar eminence, signifying depression of the anterior and possibly the posterior cruciate ligaments.Continued varus may disrupt the fibular collateral ligaments. Popliteal neurovascular bundle injury can occur. Have the worst prognosis because of associated ligament injuries.

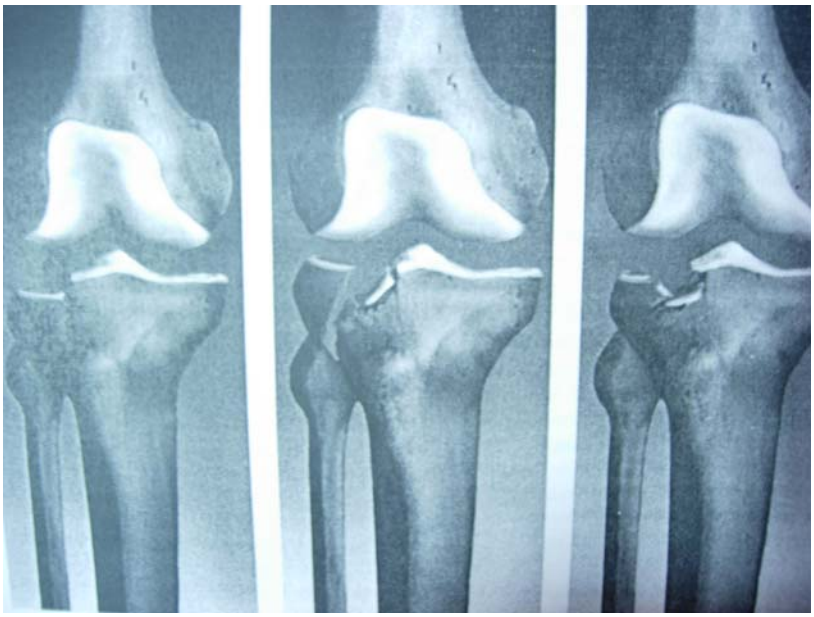
Type V:

The key to the diagnosis of this fracture is that the diaphysis and metaphysic remain in continuity with medial and lateral split off .

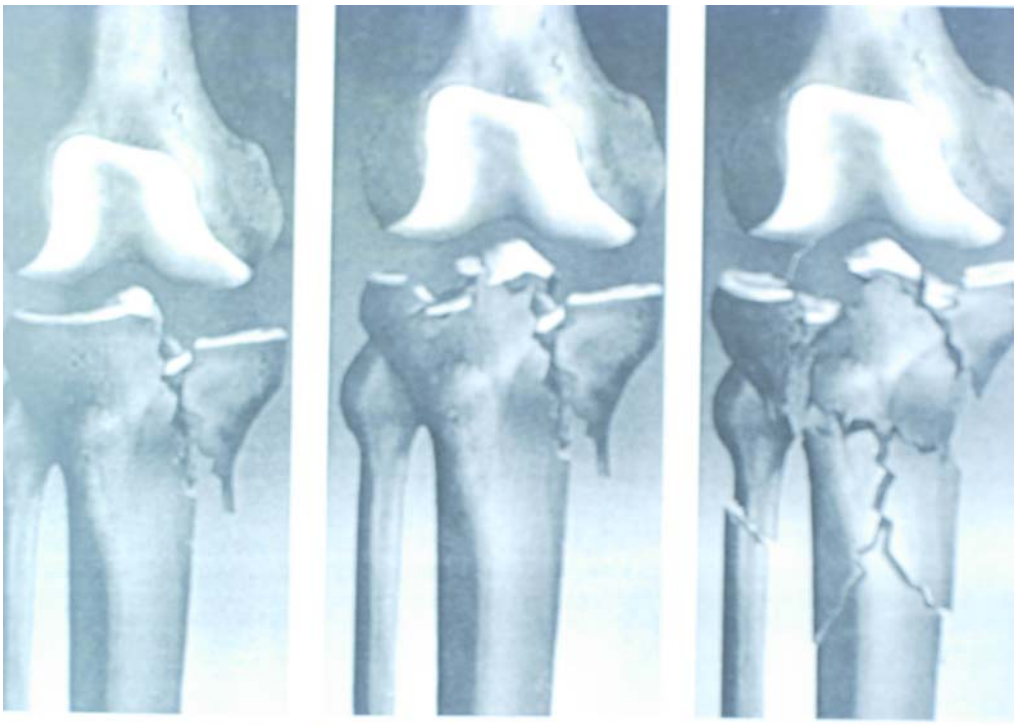
Type VI:

High energy complex injuries. Disruption of all soft tissues is possible. Occurs in older age.

SCHATZKERS TYPES:



Type I Type II Type III

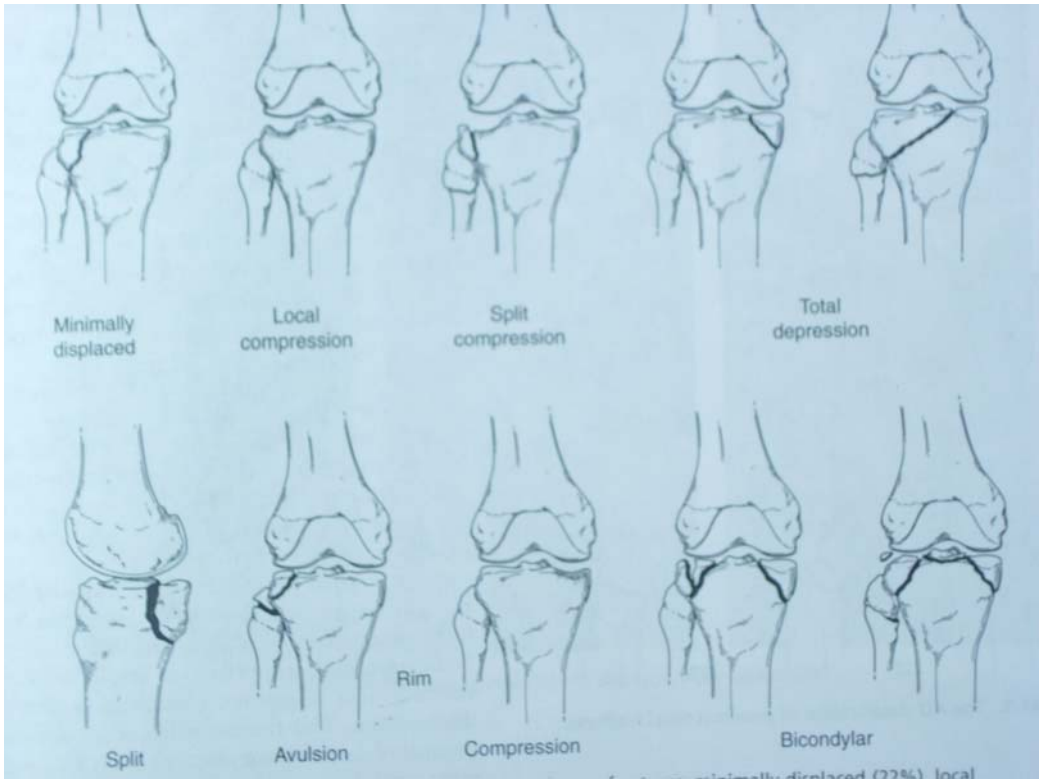


Type IV Type V Type VI

Hohl CLASSIFICATION:

Hohl first published his classification in 1956 and revised it in 1967.With Moore he devised a classification which was not very effective. There fore he changed it and now he has anew classification.

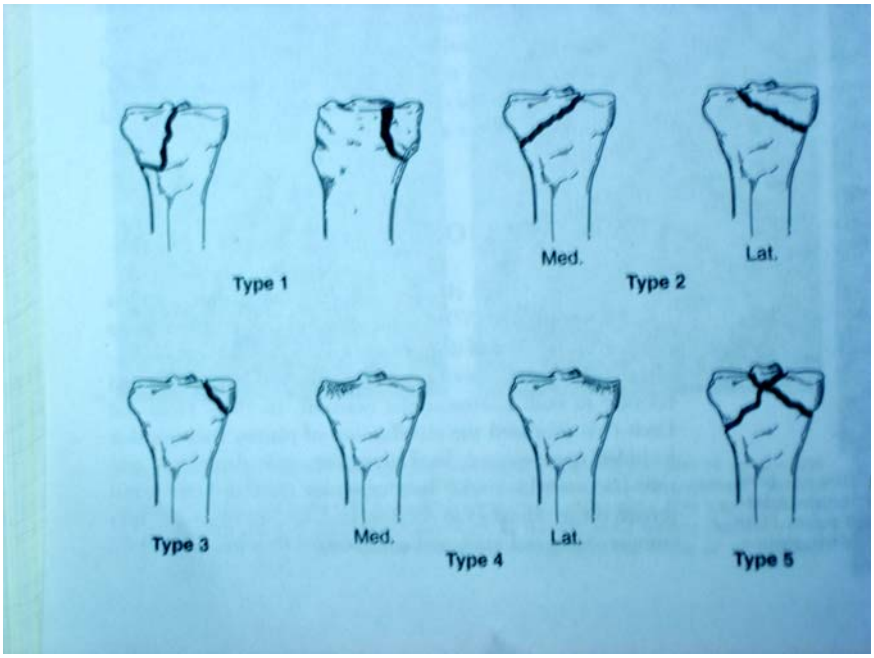
Type I:Minimally displaced(22%)
TypeII:Local compression
Type III:Split compression both contributing to (26%)
Type IV:Total condylar(15%)
Type V:Split(3%)
Type VI:Rim avulsion or compression(11%)
Type VI:Bicondylar(15%)



MOORE'S CLASSIFICATION:

The classification is based on the observation of 132 fracture dislocations

Type I:Split(37%)
Type II:Entire condyle(25%)
Type III:Rim avulsion(15%)
Type IV:Rim compression(12%)
Type V:Four part(11%)



AO CLASSIFICATION:1990

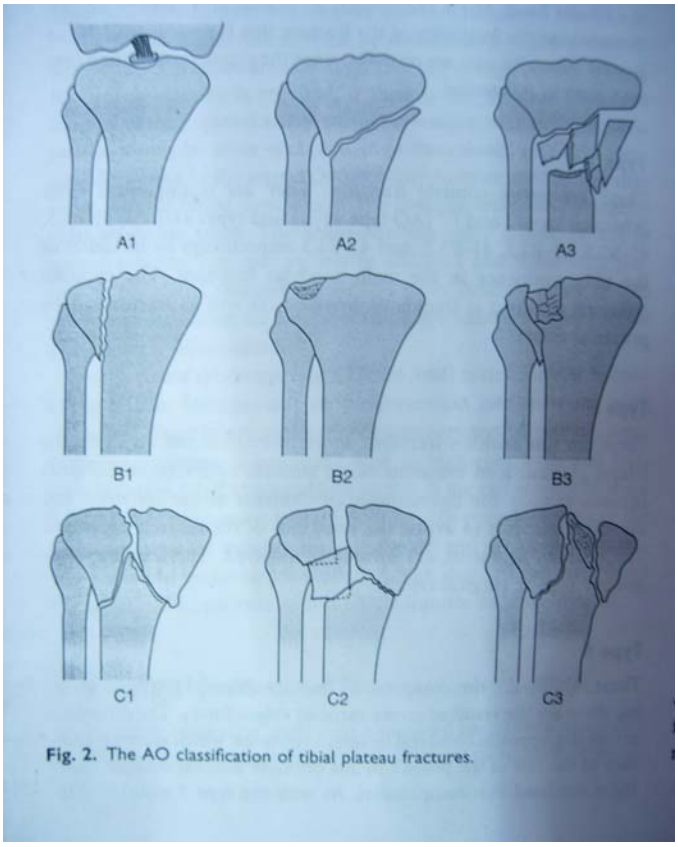


Fig. 2. The AO classification of tibial plateau fractures.

RASMUSSEN CLASSIFICATION:

One of the most widely used .

Lateral plateau fracture(70%)

Spilt, splitcompression, compression

Medial plateau fracture(12%)

Spilt, split compression, compression

Bicondylar fracture(18%)

Spilt, split compression

INDICATIONS FOR SURGICAL MANAGEMENT

Surgical treatment usually is recommended for

1. fractures associated with instability
2. ligamentous injury
3. significant articular displacement
4. open fracture
5. fractures associated with compartment syndrome
6. malalignment
7. failure to achieve reduction by conservative methods

For displaced fractures, most authors point out that the most significant factor influencing long term results and hence treatment approach is the degree of displacement and depression.

It depression (or) displacement exceed 10mm, surgery to elevate and restore joint surface is indicated.

If the depression is less than 5mm in stable fractures, non-operative treatment is usually satisfactory.

If the depression is 5-8mm, the decision of treatment depends to a great degree on the patients age and the demands of activity of the knee. If a patient is yelderly and sedentary, non-operative treatment is suitable. If a patient is young (or) active, attempts at surgical reconstruction of joint surface is justified.

Instability is another indication for operative treatment ligament injures occur in 10% to 33% of tibial plateau fraction.

According to Rasmussen, the major indication for surgery is not the measure of depression of the fracture (or) articular surface, but the presence of varus (or) valgus instability of 10 degrees (or) more with the face flexed less than 20 degrees.

CONTRAINDICATIONS:

1) Severe Communition
2) unhealthy skin
3) older age
4) severe osteoporosis
5) Poor environment

ADVANTAGES:

1) Perfect reduction is possible
2) Reduction can be maintained by internal fixation
3) Early movements can be done
4) Repair of associated soft tissue injury improve the prognosis considerably.
5) The patient needs to be in the hospital only 10-14 days.

DISADVANTAGES:

1) Risk of skin infection
2) Perfect reduction and positioning both are necessary. If it fails, malunion is being perpetuated and instability would require external splintage, so that advantage of early motion is lost.

PRE-OPERATIVE EVALUATION

A) History

A thorough history should be obtained, including deformation of the mechanism of injury and the patients overall medical status, age and functional and economic demands.

B) Clinical Evaluation

- Inspection of skin
- Open fractions should be debrided, irrigated with in 6 hrs.
- Assess Neurovascular status
- Look for compartment syndrome.

C) Pre-operative radiographic Assessment:

The goal of preoperative radio graphic assessment is to conform the diagnosis leaking to surgical intervention, and to allow for accurate restoration of joint anatomy and biomechanics.

Radiographic evaluation starts with a standard knee AP and lateral view, other views specially taken are Moore view – which is 10^0 – 15^0 caudal tilt AP view. This takes into account the posterior slope of the plateau, which allows better visualisation of the joint surface.

Oblique views of 45^0 self to delineate the plateau further, with internal rotation showing the lateral plateau and the external rotation view demonstrating the medial plateau.

- Stress views under anaesthesia are helpful to delineate source of ligamentous laxity.

- **OTHER SPECIAL STUDIES INCLUDE**

  i. CT – to assess the degree and size of the depressed articular fragments.

  ii. MRI - Very sensitive and useful but are not constantly indicated.

  iii. Compartmental pressure measurements if clinically suspicious of compartment syndrome.

SURGICAL MANAGEMENT

The general goals includes (1) restoration of articular congruity, (2) axial alignment, (3) joint stability, and (3) functional motion and (5) prevention of secondary arthritis of the knee joint.

If operative treatment is choosen, fixation must be classic enough to allow early motion and there operative technique should minimize wound complications.

TIMING OF SURGERY:

If open reduction and internal fixation is planned, it is done on the day of injury (or) else are delayed to 7-to 10 days until edema and soft tissue reaction have settled.

If surgery is delayed, the patients should be placed in calcaneal (or) distal tibial traction.

EQUIPMENTS:

1) Femoral director to achieve reduction by ligamentotaxis
2) large bone clamps capable of compressing the condyles together.
3) Cannulated screw set
4) image intensifier
5) appropriate plates (L Buttress – Plate, T-Buttress Plates)
6) External fixation system and with pins (or) wire fixation
7) Be prepared for
    - Bone graft
    - Neuro vascular repair
    - Fasciotomies

TREATMENT METHODS

Treatment methods proposed for fractures of the tibial condyle include

a) Extensive approach with arthrotomy and reconstruction of the joint surface with plates and screw fixation.
b) Arthroscopy (or) limited arthrotomy and percutaneous screw fixation.
c) External fixation with pin (or) wire fixation.
d) Closed manipulation and reduction, especially with a cast brace and fraction with early motion.
e) MIPO- Never plating techniques with less soft tissue stripping and usually use smaller incision.

No method can be used routinely for all fractures, and each patient must be individually evaluated. Lateral split fractures schatzhkers type I) can be reduced open (or) percutaneous using traction and reduction forceps under arthroscopic (or) fluorscopic control. Many lateral split fracture can be stabilised adequately by percutaneously placed large cancellous screws. It the lateral fracture is

associated with fibula head fracture, a lateral buttress plate provides additional stability.

Depressed articular segments cannot be reduced by ligamentotaxis alone and requires elevation through a cortical window, bone grafting and fixation with large cancellous screws (or) a buttress plate. Traditionally arthrotomy and submeniscal incision used. Nowadays, arthroscopy assisted reduction and bone grafting (or) Bone graft substitutes and percutaneous screws fixation done for schatzkers type II & III fractures.

Displaced fractures of the medial condyle (schatzkers type IV) often are quite constable and generally one best treated with open reduction and fixation with a medial buttress plate.

The treatment of severe (or)”complex” tibial plateau fractures are quite difficult. Severe (or) complex fracture pattern includes Bicondylar fractures (schatzkers type V) tibial plateau fractures with metaphyseo diaphyseal disruption (Schatzkers type VI) and fractures with – wounds, severe soft tissue injury, compartment syndrome (or) vascular injury.

Methods adopted are

a) Medial and lateral plates (dual plating) (MIPO) with minimal soft tissue dissertation.
b) Small fragment ‘T’ plate
c) Temporary knee spanning with fixation in patients with severe soft tissue injury. Internal fixation then can be done after swelling has decreased.
d) External fixation using half pin fixation (or) ring and wire fixation also used as definite fixation. Cannulated cancellous screws can be used as accessory fixation of the articular surface. Pin site infection if occur are minor and can be treated with antibiotics.
e) Immobilization of the knee for 6 weeks did not happen to adversely affect the ultimate knee range of motion.

The implants we used in fixing the tibial plateau fractures include

1) cancellous screws
2) cannulated cancellous screws
3) buttress plates
4) k wires
5) ss wire
6) cortical screws

CANCELLOUS BONE SCREWS :

cancellous bone screws are charecterised by a relatively thin core and a wide and deep thread. The increase in the ratio of the outer diameter to the core gives such a screw considerably increased holding power in fine trabecular bone. These screws are either fully or partially threaded. They also differ in size. They are non self tapping screws. Threads tapped only in the near cortex. In the metaphysis no tapping of the opposite cortex needed.

Design :

6.5 mm and 4mm are used.

6.5mm cancellous screws :

consists of 8-mm spherical head,3.5 mm hexagonal recess

thread length-16mm & 32 mm& fully threaded

all have 6.5mm diameter,4.5mm shaft, and 3mm core.

We used 3.5mm drill bit and 6.5 mm tap

We have no experience in using small fragment cancellous bone screws.

Cannulated cancellous screws:

AO has recently introduced cannulated screws which can be inserted over k wires.

BUTTRESS PLATES :

As the function of the buttress plate is to support, it must be firmly anchored to the main fragment but need not necessarily be fixed with screws to the fragment it is supporting.

The screws must be inserted in such a way that under load there must be no shift in the position of the plate.

The recommended method is to first contour the plate very accurately to the segment of the bone and begin its fixation to the bone in the middle of the plate and advance the screw insertion towards the ends.

The different buttress plates for plateau fractures

a) 4 holed T plate

b) T buttress plate

c) L buttress plate (left & right)

Double bend of the buttress plate designed for the lateral plateau

d)lateral tibial head plates with 5. 7, 9 holes for buttressing the lateral plateau.

The oval hole in the plates is used for temporary fixation of the plate to the bone, which still permits some up and down movement. Once fixation is complete , the temporary screws can be removed.

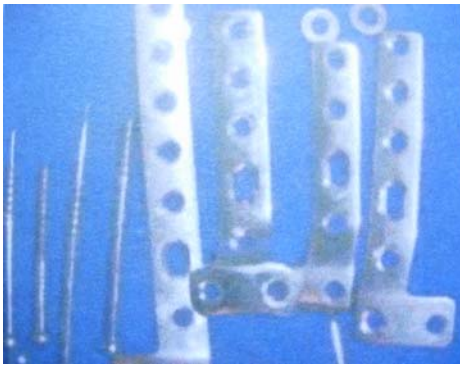
CORTICAL SCREWS :

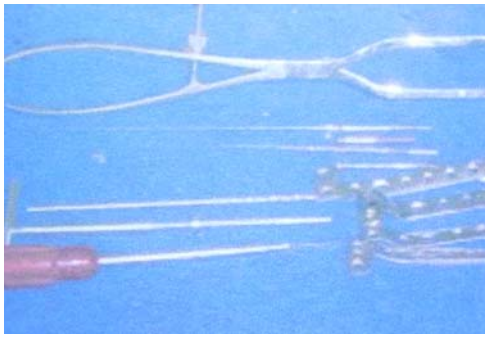
4.5mm cortical screws are used to fix the buttress plate in the diapyhsis.

SS – WIRES:

We used 18 gauge ss wire in fixing avulsion fracture of the lateral condyle along with 2mm k wires.

AO rods and schanz pins and clamps were used to externally fix a bicondylar fracture spanning the knee temporarily, supplemented by minimal internal fixation.





BUTTRESS PLATES AND CANNULATED CANCELLOUS SCREW SYSTEM

SURGICAL PROCEDURE

PREPARATION OF THE PATIENT:

On the day of surgery, the skin is prepared using povidone iodine solution and covered with sterile clothes and brought to the theatre, where the final preparation is done.

Prophylatic antibiotic is given on the table. We prefer a third generation cephalosporin in the done of 1gm give IV.

ANAESTHESIA USED AND POSIT INJURY:

- Epidermal is usually employed. The patient is then positioned supine on the operating table.

LATERAL APPROACH:

- Except in patient with severe soft tissue injury, apply a tourniquet.
- For fractures of the lateral condyle make an anterolateral incision starting 3 cm above the patella proximally and extending distally, below the inferior margin of the fracture site. This incision provides good exposure while avoiding skin

complications. Make the fascial incision parallel tot he anterior border of the iliotibial tract. Take care not to undermine soft tissue flags more than recovery. If necessary for exposure, reflect a portion of the iliotibial band from its insertion of the Gerdy's tubercle.

- To escape the longitudinal fracture of the lateral condyle, skip the origin of the extensor muscles, from the anterolateral aspect of the condyle. Through an incision shaped like an invested. Then reflect the muscle origin laterally until the fracture line is exposed.

ELEVATION OF DEPRESSED ARTICULAR FRAGMENTS:

A cortical window can be made below the area of depression to allow reduction by using perosteal elevator well beneath the depressed articular fragments, and by slow and meticulous pressure elevate the articular fragments and compressed cancellous bone in one large mass.

FIXATION OF THE FRACTURE FRAGMENTS:

As the fragments are elevated and reduced, temporarily for their with small thickness wires. We apply a contoured T (or) L Buttress plate for defective fixation. The plate is applied to the anterolateral tibial condyle and fixed with cancellous screw of sufficient length to engage the opposite medial cortex. Cortical screws (4.5mm) are used to attach the plate to the shaft of the tibia.

If the fracture consists of only one (or) two large fragments with little (or) no commination and little central depression, replacement and internal fixation with cancellous screw have been used.

Insert the screw from lateral side of the lateral fragment directly transverse to the longitudinal axis of the tibia and in a posterior and medial direction, catching the medial tibial cortex.

SUTURING THE MENISCUS:

If the meniscus has been detached peripherally, it is sutured back to its coronary ligament. This procedure generally requires less soft tissue direction than injury open the lateral condylar fragment. This produce large cavity in the metaphysis, that must be filled with

bone. We usually take bone graft from iliac crest. After cavity in the tibia beneath the elevated fragments has been filled with cancellous bone pace the bone surgery using an inlay impaction. Then replace the lateral tibial condylar fragment surgery to back the articular fragments together.

APPROACH TO THE POSTEROLATERAL PLATEAU : BY EXTENSILE LATERAL APPROACH

In this situation, the fascial incision follows the insertion of the extensor muscles and continuous over the sub capital tibia. The peroneal nerve is exposed and the fibular neck is cut with an oscillating saw. This exposes the posterolateral plateau, as well as the lateral and posterior flare of the proximal tibia attachment. Iliotibial band, if reflected also reattached to the Gerdy's tubercle.

If central depression is the main deformity, remove an anterior cortical window with its proximal edge 1.3cm distal to the articular surface. Insert a small oesteotome (or) periosteal elevator into the cancellous subchondral bone and elevate it. Then the defect is filled with cancellous bone.

MEDIAL APPROACH:

This is done for medial tibial condyle fracture. Anterior (or) Antero medial incision is used. Technique similar to that described previously for the lateral tibial condyle is carried out.

MEDIAL EXTENSILE APPROACH:

This is applied for more complex fracture of the medial plateau. Take the anteromedial incision down to the bone and then detatch entire fascio periosteal layer from anterior to posterior, including the pestendons of the medial collateral ligament. Leave the medial meniscus in continuity with this layer and retract it out of the joint for exposing medial and posteromedial part of the proximal tibia. Fix the fascio periosteal layer back to the bone with a one layer running suture.

APPROACH TO COMPLEX TIBIAL PLATEAU FRACTURE:

Longitudinal mid line incision is used, beginning 3cm above the superior pole of the patella and extending distally just lateral to the crest of the tibia, enough to expose the proximal shaft. Expose the patella tendon. Sub periosteally dissect the soft tissues from the more

comminuted condyle, creating full thickness flaps. Make sub meniscal incision to expose the joint. Place a femoral destractor with pins in the distal femur and tibial shaft from medial to lateral to reduce the fracture by ligamentotaxis. Avoid varus and valgus angulation. Elevatic depressed fragments and support them with bone grafts. Use kirschner wires for temporary fixation. Then apply large fragment butterss plate to the tibial metaphysis and extend it down the tibial shaft for enough to securely stabilize the fractures. Orient the screws so that maximal fixation in achieved across the inter condyle fracture lines. If the buttress plate applied medially additional lateral fixation can be obtained by percutaneously placed cancellous screws directed from laterally to medially. One screw is placed at the apex of the metaphysis fracture. Poster lateral fragment is stabilised as described above.

Once the fracture is stabilised, suture the menicus to the coronary ligament. Close the capsule incision with interrupted sutures, and close the skin and subcutaneous tissue over drain. Place the limb in posterior plaster splint with the knee flexed 30 degrees.

OPERATIVE PICTURES

OPEN REDUCTION AND INTERNAL FIXATION

SKIN CONTUSION

SKIN INCISION

STEPS

1

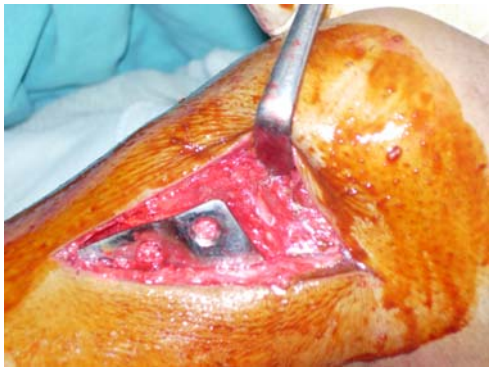
Exposing the fracture

2

Elevating the Depressed Fragment

3

4



Sliding the Plate

5

After Fixation

7

8

SKIN CLOSURE

PERCUTANEOUS TECHNIQUE

9

REDUCTION

10

K-WIRE FIXATION

11

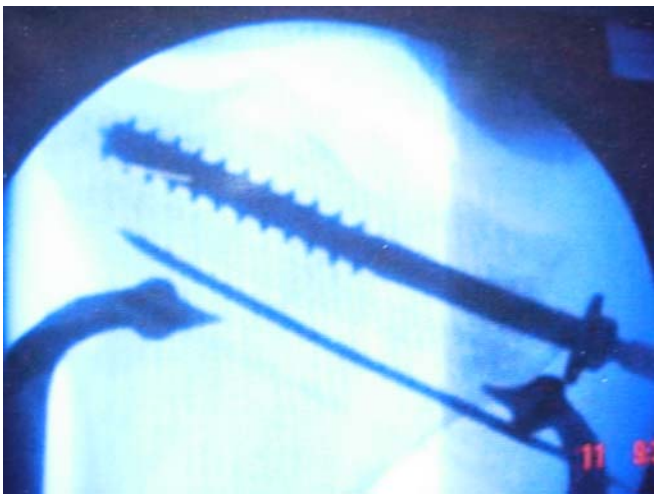


IMAGE INTENSIFIER VIEW

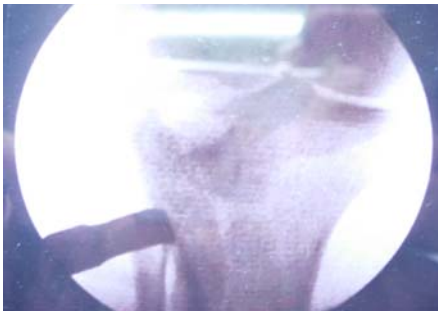
MINIMALLY INVASIVE PLATE OTEOSYNTHESIS

12

13

SKIN INCISION

14

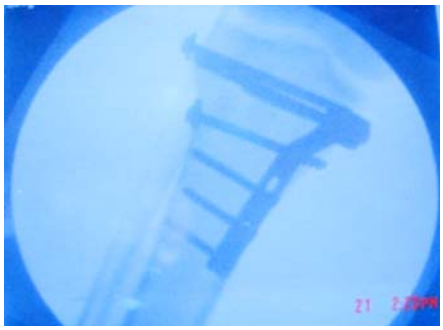


15

ELEVATING FRAGMENT WITH IMAGE

16

17



1-EXPOSURE OF FRACTURE

2-ELEVATION OF DEPRESSED FRAGMENT

3,4,5-PLATE FIXATION

7-PLATE FIXED WITH SCREWS

8-SKIN CLOSURE

9-REDUCTION WITH CLAMPS

10-K WIRE FIXATION

VIEW IN IMAGE INTENSIFIER

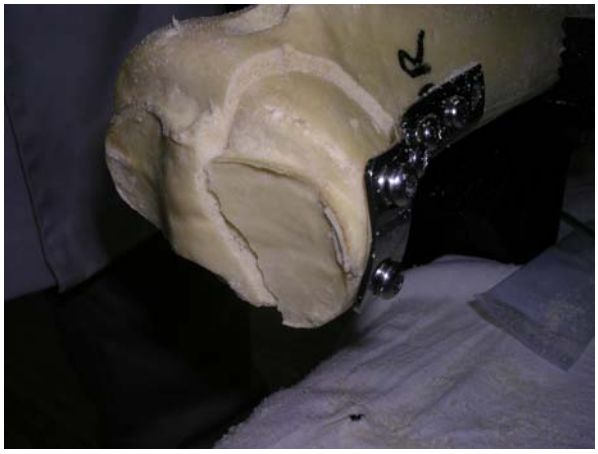
12,13-SKIN INCISION IN MIPO

14,15,16-ELEVATING BONE FRAGMENT WITH IMAGE

17-IMAGE AFTER PLATE FIXATION

EXPERIMENTAL MODEL

DEMONSTRATION



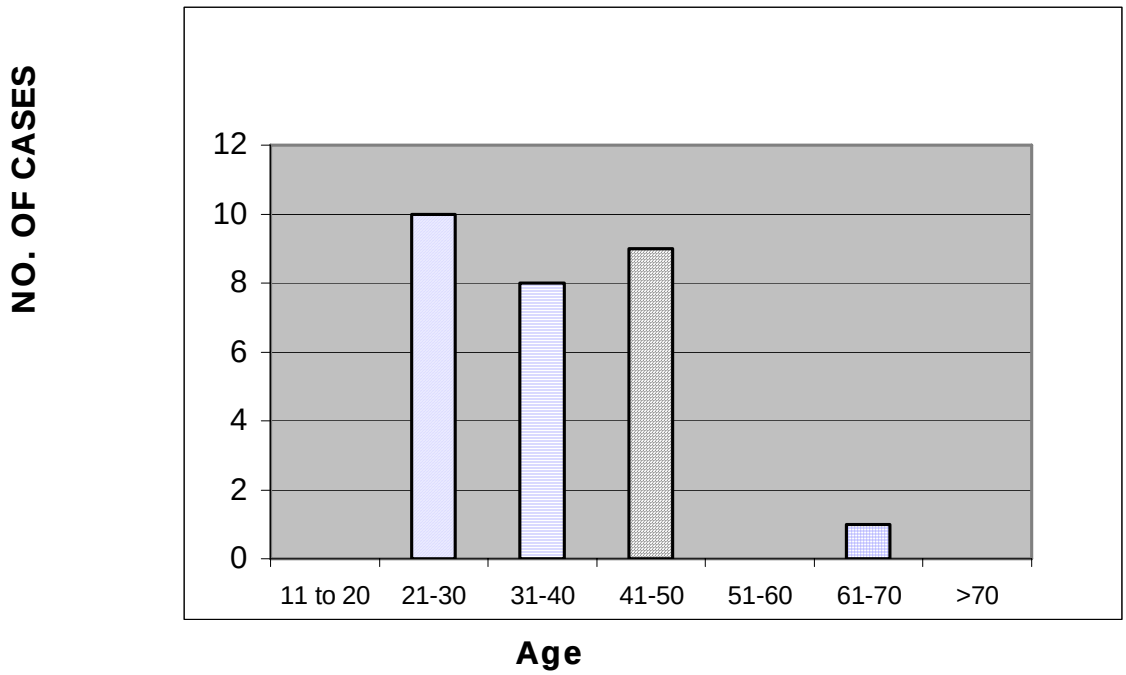
Materials and Methods

This is a prospective study consisting of 28 patients conducted at Department of Orthopaedic surgery, Government General hospital, Chennai – 3 during the period from May 2004 to March 2007. 6 patients were lost in their follow-up.

AGE INCIDENCE

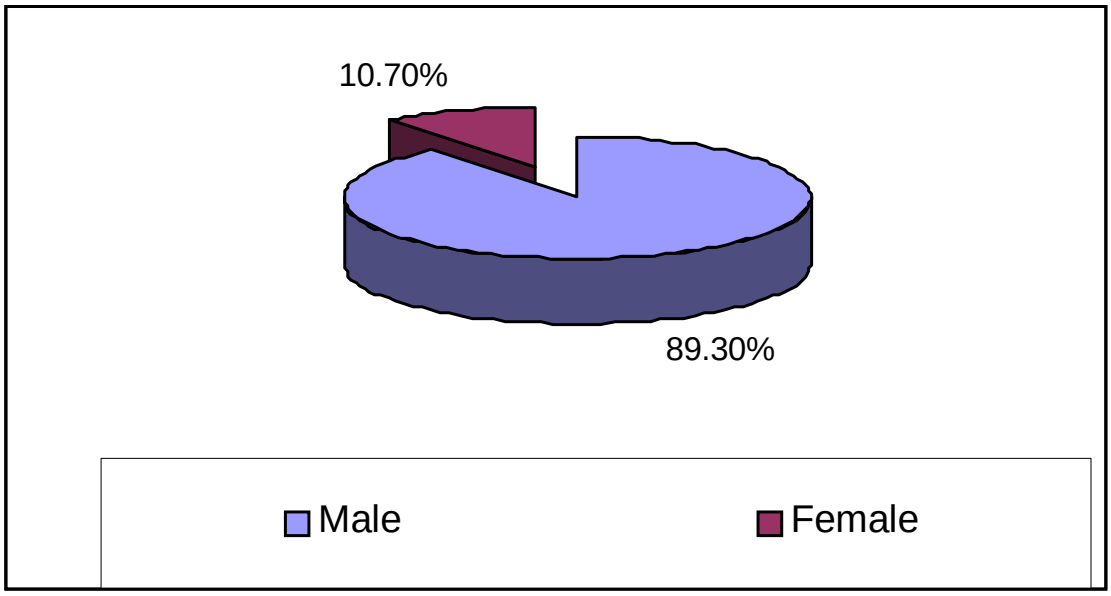
Age	No. of Patients	Percentage
21-30	10	35.7%
31-40	8	28.5%
41-50	9	32.17%
51-60	-	-
61-70	1	3.5%

The average age in our study population was 35.2 years with the range between 22 to 65 years.


NO. OF CASES
12
10
8
6
4
2
0
11 to 20
21-30
31-40
41-50
51-60
61-70
>70
Age

SEX RATIO

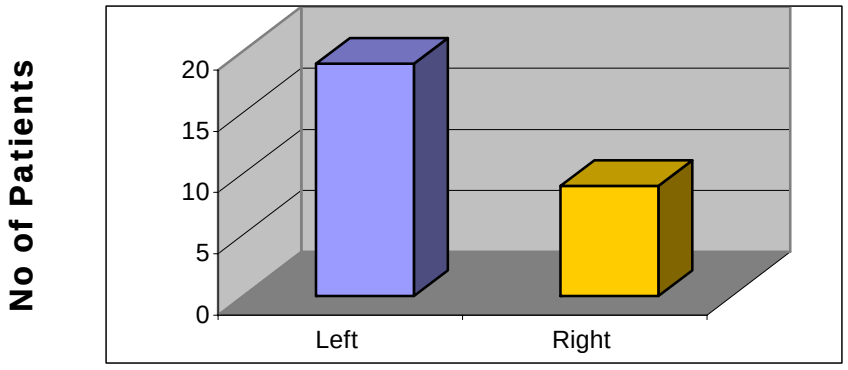
Sex	No of Patients	Percentage
Male	25	89.3%
Female	3	10.7%



Males are in preponderance when compared to females with the ratio of 3.1 : 1

SIDE INVOLVED

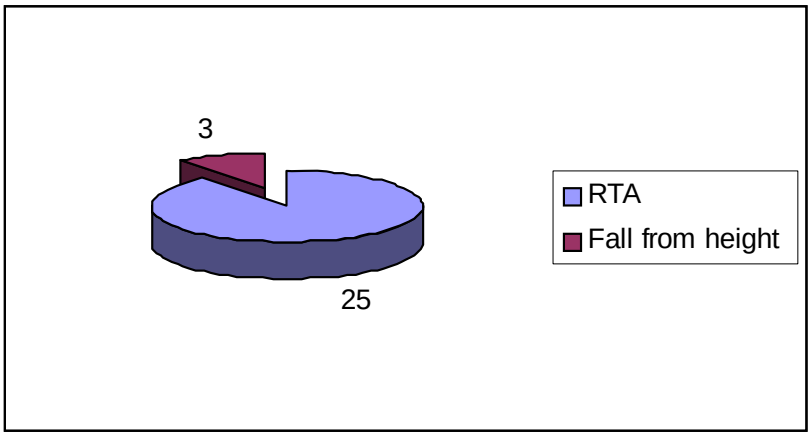
Side	Number of Patients	Percentage
Left	19	67.9%
Right	9	32.1%



Left side involvement is commonly seen in our study group.

MODE OF INJURY

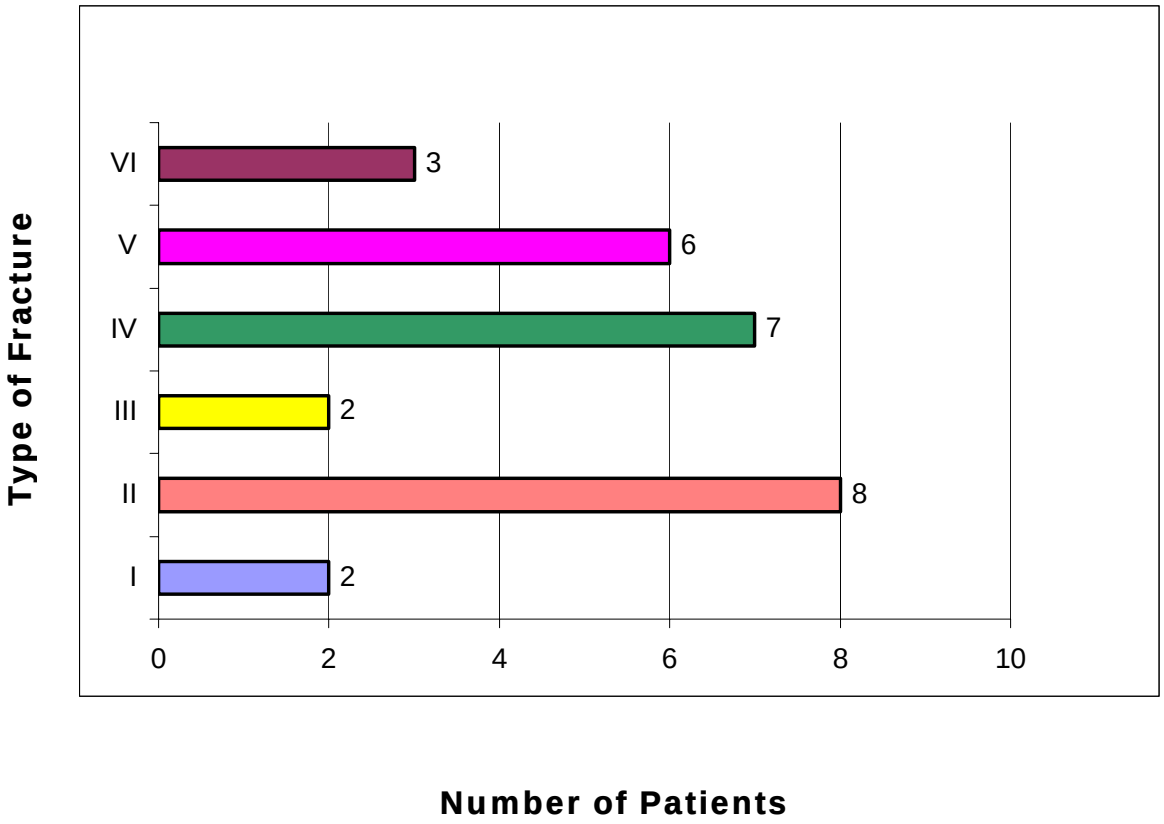
Mode of Injury	No of Patients	Percentage
RTA	25	89.2%
Fall from height	3	10.8%



Road traffic accidents was the major cause for injury in our study group.

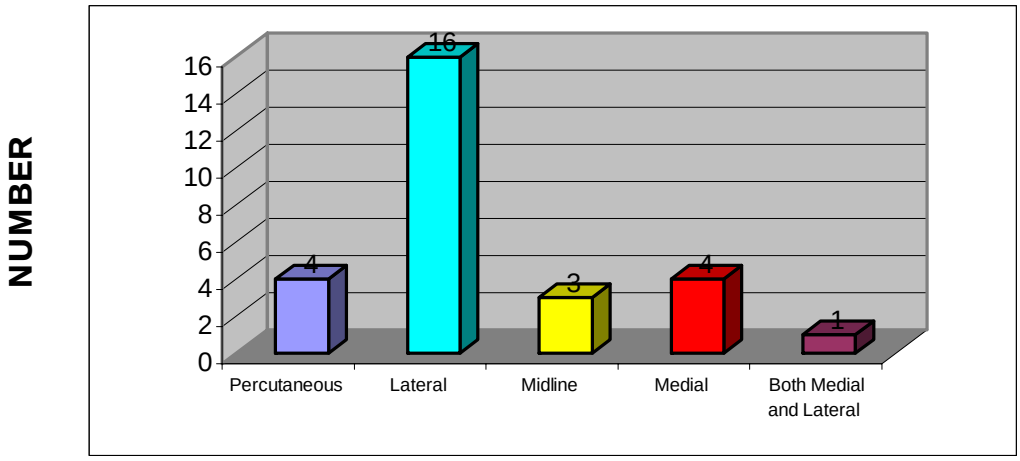
SCHATZKERS # TYPE DISTRIBUTION

Type of Fracture	No. of Cases	Percentage
I	2	7.2%
II	8	28.5%
III	2	7.2%
IV	7	25%
V	6	21.4%
VI	3	10.7%



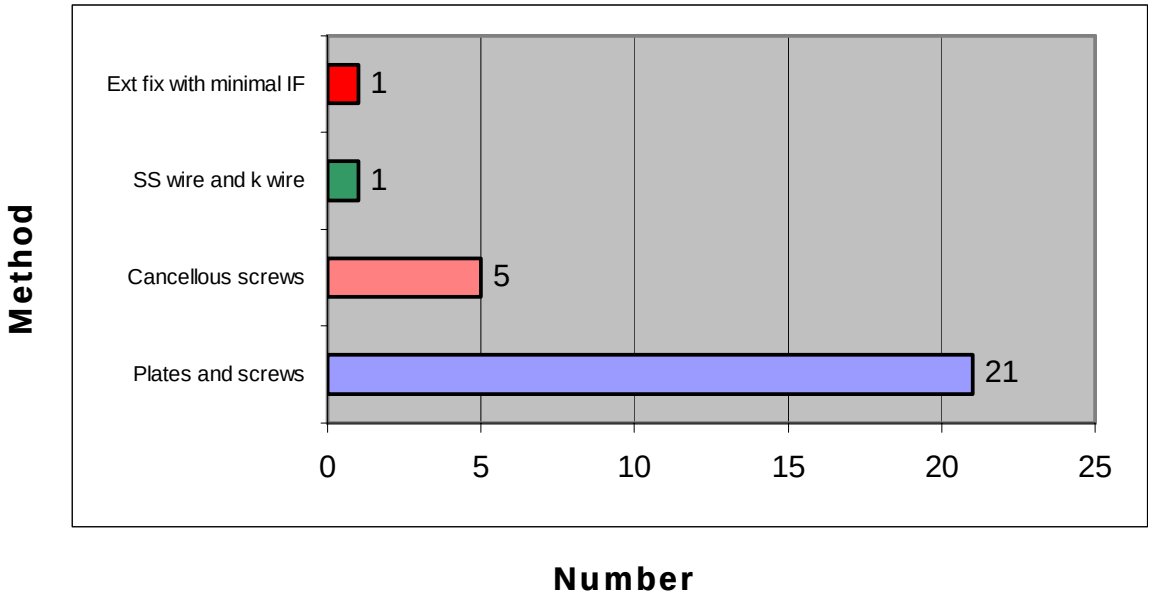
SURGICAL APPROACH USED

Approach	Number	Percentage
Percutaneous	4	14.3%
Lateral	16	57.1%
Midline	3	10.8%
Medial	4	14.3%
Both Medial and Lateral	1	3.5%



DIFFERENT MODALITIES OF TREATMENT FOR DIFFERENT TYPES OF FRACTIONS OF TIBIAL PLATEAU

Fixation done	No. of Patients	Percentage
Plates and screws	21	75.1%
Cancellous screws	5	17.8%
SS wire and k wire	1	3.5%
Ext fix with minimal IF	1	3.5%

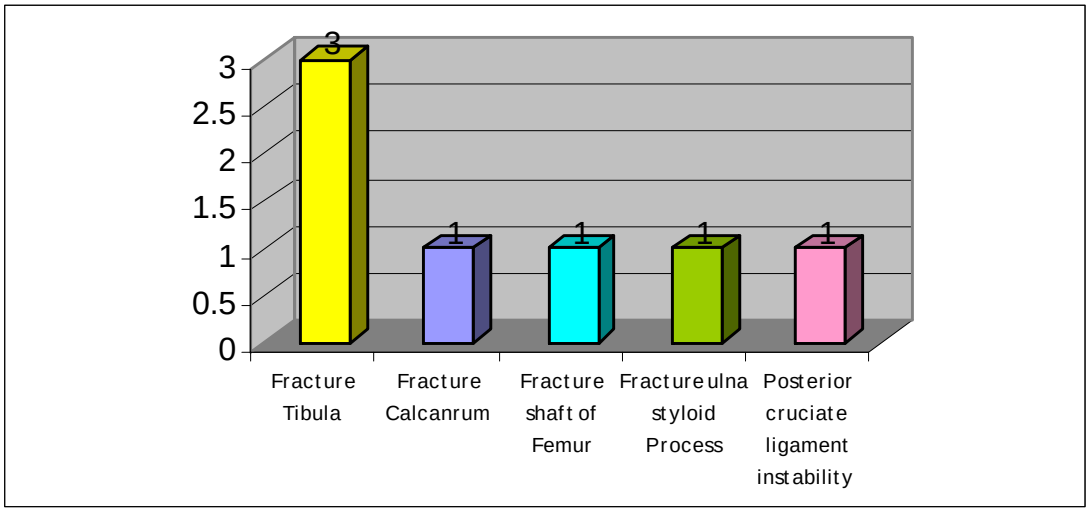


ASSOCIATED FRACTURES:

The following injuries were associated with Tibial plateau fractures in our series:

a. one case associated with ipsilateral calcaneal fracture and ulna styloid process fracture treated conservatively
b. one patient had contralateral fracture shaft of femur treated with interlocking nailing
c. three had fracture neck of fibula treated conservatively
d. one of our patient had posterior cruciate ligament instability,which we are planning to work out in his future visits.

Associated Injury	Number	Percentage
Fracture fibula	3	10.7%
Fracture Calcaneum	1	3.5%
Fracture shaft of Femur	1	3.5%
Fracture ulna styloid Process	1	3.5%
Posterior cruciate ligament instability	1	3.5%



-BONE GRAFTING:

We have done bone grafting in 7 cases. This includes 5 type II fractures, 1 type III fracture, 1 type VI fracture.

POST-OP PROTOCOL

The patients ware nursed in post operative ward. Drain removal done after 48 hours. At 3-4 day, if the wound is sealing satisfactory, the splint is removed.

Physical therapy with quadriceps exercise and gentle active motion begun. Then, crutch walking is began, but no weight bearing is permitted for 12 weeks.

If extensive suturing of the meniscus has been done, inmobilisation for approximately 3 weeks is required before motion exercises are permitted.

FOLLOW – UP:

Suture removal done on 10-12 day post of. The patients were renewed regularly at month interval for first 3 months, then at 6 months, 1 year and periodically there after for every 6 months. At the end of the study patients were called been for review. Patients were assessed clinically using the modified tibia and luck grading. X-ray of the knee taken and compared with initial x-ray for signs of implant failure, screw pull out and union.

The duration of follow up at the end of 3 months of this study ranged from 26 months with an average of 9.4 months.

ILLUSTRATIVE CASES

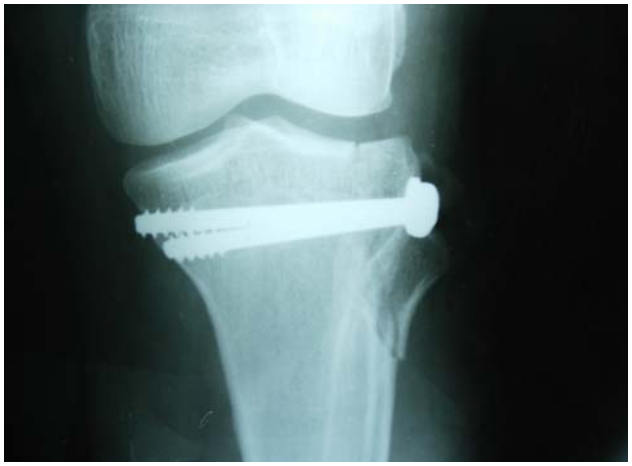
CASE 1:

This 36 year old male , suffered RTA 6 months back leading to Type I Schatzkers tibial plateau fracture for which he was treated with percutaneous cannulated cancellous screw fixation. Fracture united and his result was excellent.

PRE-OP

INTRA-OP

POST OP



FUNCTIONAL RESULTS:

SIX MONTHS FOLLOW-UP

KNEE FLEXION

KNEE EXTENSION

SQUATTING

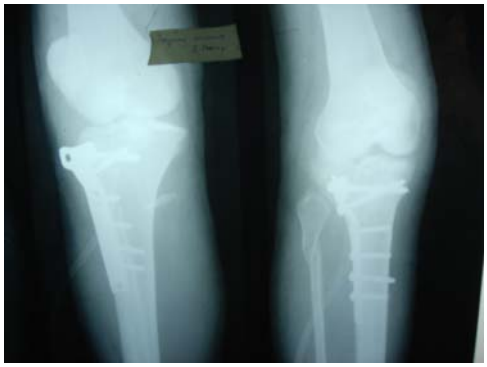
STANDING

CASE 2:

This 43 years old male patient suffered RTA 8 months back and he was treated with buttress plating and bone grafting for Type II Schatzkers Tibial plateau fracture. Fractured healed satisfactorily except for his valgus of < 5 degrees. His result was good.

PRE-OP

POST-OP



8 months follow up

FUNCTIONAL RESULTS:

8 MONTHS FOLLOW UP

KNEE FLEXION

KNEE EXTENSION

STANDING

CASE -3

This 36 year old male patient 1 year back ,after RTA had Type V Tibial plateau fracture ,for which he was treated with buttress plates and cancellous screws. His result was good.

PRE-OP

POST- OP

1 YEAR FOLLOW UP

FLEXION

STANDING

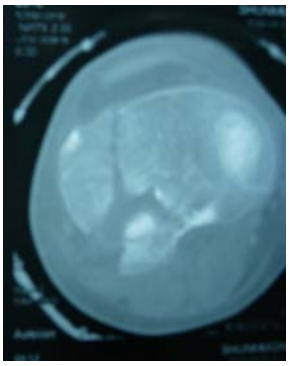
EXTENSION

CASE 4:

This 36 year old male after RTA had Schatzkers type V tibial plateau fracture which we treated with buttress plates and cancellous screws. The fracture healed well and his result was good.

PRE-OP

CT PICTURE



POST- OP

FUNCTIONAL RESULTS:

KNEE FLEXION

KNEE EXTENSION

Squatting

Standing

CASE 5:

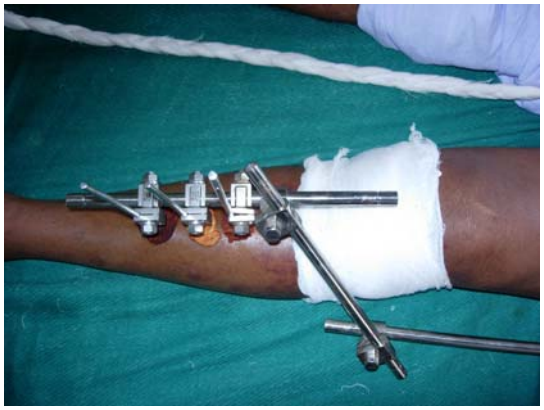
This 40 year old male patient suffered RTA 4 months back. He was treated with external fixation with percutaneous cancellous screws. His fracture healed well. He has knee stiffness and his result was fair.

PRE-OP

CT- PICTURE

POST-OP

IMMEDIATE POST-OP



COMPLICATIONS

HEALING AFTER SUPERFICIAL INFECTION

VALGUS

knee stiffness

OBSERVATION

- Most common age group involved in our study is 21 – 50 years with an average of 35.2 years.
- Male preponderance is seen (89.3%).
- Left side involvement is seen more commonly (67.9%)
- RTA being the most common mode of injury seen (89.2%)
- Type II, IV & V Fracture Pattern contributes mainly (75%)
- Plates and screws (21 cases) is commonly used for surgical fixation in our study
- Results were good to excellent in (71.14%)
- The average period of follow up is 9.4 months in our study.

RESULTS

In this study, we have analysed the functional results of surgically treated tibial plateau fractures done in 28 patients in Government General Hospital ,Chennai during the period from May 2004 to October 2006.The average follow up was 9.4 months (3 months to 26 months).

All patients were evaluated clinically and radiologically at various follow up periods. All the patients were analysed using Modified Hohl and Luck functional evaluation method.

In our study 3 patients(10.7%) showed excellent results, 17 patients(60.7%)showed good results, 5 patients(17.8%) showed fair results and 3 patients(10.7%) showed poor results.

In 5 patients treated with open or closed reduction and cancellous screw fixation, 1 had excellent results, 3 had good results, 1 had fair results.

In 21 patients in open reduction and plating group, 3 had excellent , 13 had good,4 had fair and 1 had poor results.

One patient treated with external fixation with limited internal fixation had fair result.

Table 36-3. Modified Hohl and Luck Evaluation Method

Grade	Lack of Extension (degrees)	Range of Movement (degrees)	Valgus or Varus Instablity (degrees)	Walking Distance (m)	Pain*
Excellent (all of the following)	0	≥120	<5	>3000	None
Good (not more than one of the following)	>0	<90	>5	<1000	Mild on activity
Fair (not more than two of the following)	≥10	<75	>5	<100	Moderate on activity or intermittent at rest
Poor	All results worse than fair				

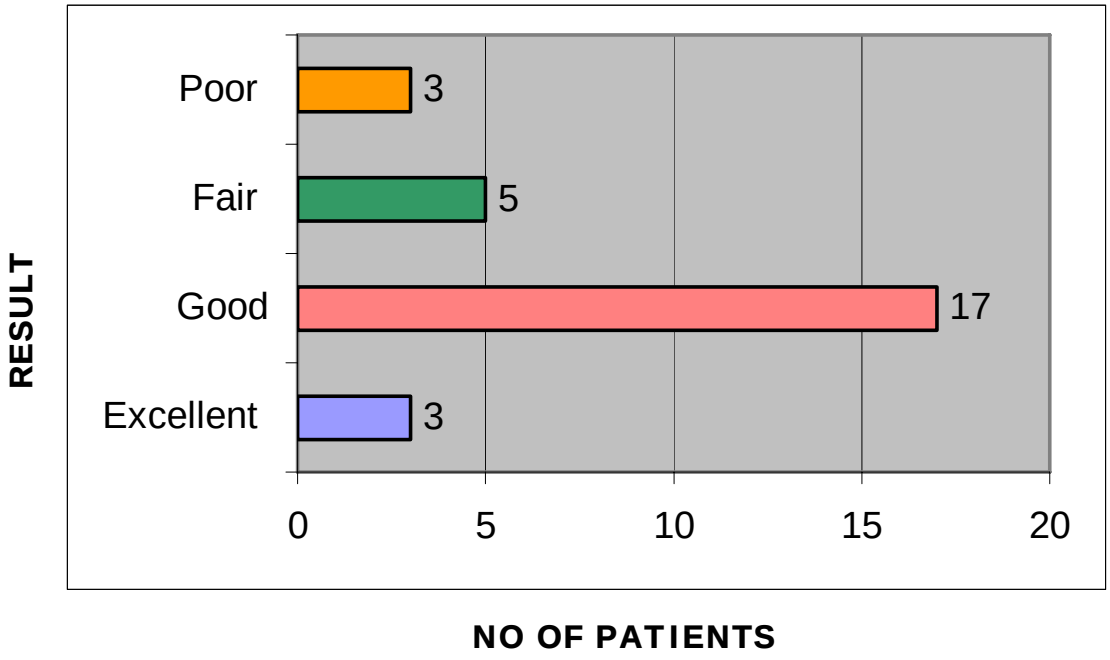
* The grade cannot be higher than for pain.
(Modified from Jensen et al., [92] with permission)

-Based on the Modified Hohl and Luck functional evaluation method ,

the results were divided into excellent, good, fair and poor.

At the end of the study, the results are

Result	Number of Patients	Percentage
Excellent	3	10.7%
Good	17	60.7%
fair	5	17.8%
poor	3	10.7%



OVERALL RESULTS OF TREATMENT OF TIBIAL PLATEAU

Type	Total No.	Excellent	Good	Fair	Poor
I	2	1	1	-	-
II	8	1	6	-	1
III	2	-	1	1	-
IV	7	1	6	-	-
V	6	-	2	2	2
VI	3	-	2	1	-
Total	28	3	17	5	3

Excellent and good results were seen in the simple fracture patterns and more number of fair and poor results were seen in the complex fracture patterns.

COMPLICATIONS

In our study , the following complications were noted.

1) Superficial wound infection:

2 of our patients had superficial wound infection. It required pus culture and sensitivity. With appropriate antibiotics the wounds healed by secondary intention.

2) Knee stiffness:

6 patients had knee stiffness to varying degree. All are treated with wax bath and mobilization exercises.

3) Valgus deformity:

one patient had valgus deformity (< 5 degrees) of his knee which was asymptomatic.

4) Varus deformity:

One patient has varus deformity,which the patient is not worried of, and he has to be followed in future for secondary arthritis.

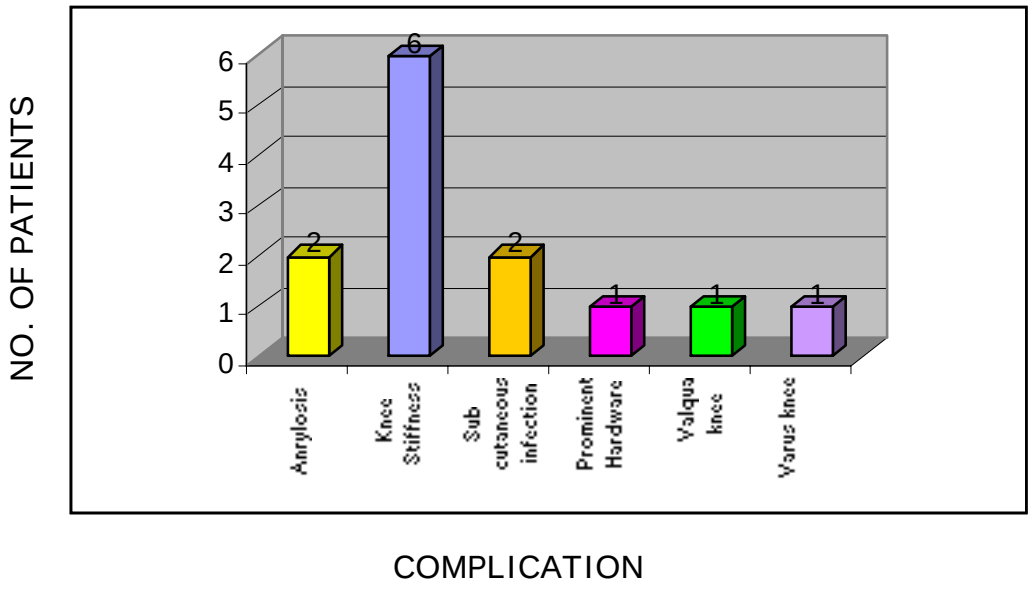
5) Prominent hard ware:

One patient had prominent hard ware(k-wire) which was removed at his 10th follow up month.

6)Ankylosis:

Two patients had ankylosis of knee joint. We are planning to do arthrodesis for one patient and the other patient is not willing for further treatment.

COMPLICATIONS	NO. OF PATIENTS	PERCENTAGE
Ankylosis	2	7.5%
Knee Stiffness	6	21.6%
Sub cutaneous infection	2	7.1%
Prominent Hardware	1	3.5%
Valgus knee	1	3.5%
Varus knee	1	3.5



DISCUSSION

The spectrum of injuries to the tibial plateau is variable that no single method of treatment has proven uniformly successful. Numerouos authors have reported satisfactory results using non operative and surgical methods of treatment.

Shrestha et al..[23] from the B and B hospital, Kathmandu University teaching hospital, Gwarku, Lalitpur analysed the outcome of treatment methods of tibial plateau fractures in 81 knees done between 1997-2002.

Since the materials and methods used for the analysis were similar to our study, this study was choosen for the comparision of our results.

Champman[7] – says schatzkers classification of tibial plateau fractures is currently the most widely used and was the first to make the distinction between medial and lateral plateau fractures.

Oxford[19]**,** pointed out that Schatzkers classification has been the mainstay of radiographic categorization of tibial plateau fractures.

Browner et al[6] quotes that most widely used and accepted classification of tibial plateau fracture in North America is that proposed by Schatzker, it addresses the regional idiosyncrasis of tibial plateau fracture.

Since world wide many authors are following Schatzkers classification, we applied the same in our study.

In ***Shrestha et al***[23] study, the average age of the patients was 37 years compared to 35.2 years in our study group.

The incidence is more common in males (62) compared to 18 females with the ratio of 3.4:1.

In our study group too males are larger in number with the ratio of 3.1:1.

Fracture type seen in ***Shrestha et al***[23] study were 56% isolated lateral plateau fractures, 25% were bicondylar, 19% were isolated medial condyle fractures.

In our study we had 35.7% lateral plateau fractures, 25% medial condyle fractures and 21.4% bicondylar fractures. The pattern of fracture in our series is comparable with the ***shrestha et al***[23] study.

Road traffic accident (RTA) 89.2% was the main mode of injury in our study group and injury due to fall from height contributes the rest with 10.8%.

This is similar to the study done by ***Hohl and larsen***[13] (900) cases, ***Chaix et al***[8]***, Lansinger et al*** (260) cases.

In ***Shrestha et al*** study, 54% had excellent results. In our study 10.7% had excellent results, 60.7% had good results, 17.8% had fair results and 10.7% had poor result.

Since our study is only have mean follow up of 9.4 months compared to Shrestha et al study which has 4 years analysis, further long term follow up is needed to have a definite conclusion.

Pre op planning is an important part of management.

In ***Shrestha et al*** study group,

X-ray of the knee antero posterior and lateral views are taken routinely. In displaced fractures traction X-rays are taken, which allows better visualization of comminuted fragements. Computed tomography and MRI were taken only in high energy fracture patterns.

Although MRI may reveal detail better than CT, it does not demonstrate fracture and it may not be widely available on an acute basis in most institutions.

We followed the same discipline in our study.

Bunker has suggested that the resultant metaphyseal defect should be filled with graft material, to prevent collapse of the articular fragment. Types I,IV,V, do not need graft. Graft was taken from the iliac crest.

In our study design , 7 patients were treated with bone graft harvested from iliac crest. Mostly type II fractures were supplemented with bone grafts inour study population. This is comparable to the ***Shrestha et al*** study

No universal agreement exists on the articular depression that can be accepted varying from 4mm to 10mm. At our centre we consider articular depression of more than 5mm for surgical intervention.

In ***Shrestha et al***[23] series early range of motion was began following internal fixation. Weight bearing was permitted only 12 weeks post operatively or after the fracture has united clinically and radiologically. Radiological union was considered only after healing of cortices in both views.

In our series also full weight bearing is done only after 12 weeks, which is comparable with the above study.

At every follow up, we review the patients both clinically and radiologically and by modified Hohl and Luck grading scale as done in the shrestha et al study.

The two cases of superficial wound infection seen in our series is comparable with the Shrestha et all study.

We also had one patient with prominent hard ware, 2 cases of ankylosis knee, one varus and valgus knee deformity which were also reported in the above study .

No cases of peroneal nerve palsy, deep infection or compartment syndrome seen in our study group.

Long term post traumatic arthritis is a matter of concern in most cases of type III-VI. One case of post traumatic arthritis is reported in ***Shrestha et al*** group. . We are yet to have long term follow up to analyse the incidence of arthritis in our series.

Non union is rare after low energy energy fracture pattern owing to the predominance of cancellous bone and its rich blood supply. It is most commonly seen in type VI and it is never reported in both the study population.

COMPARATIVE RESULTS

	MMC Study	Shrestha et al study
Average Age Group	35.2 years	37 years
Sex ratio / M:F	3.1 : 1	3.4:1
Most common side	Left	Right
Most Common Mode of Injury	RTA	RTA
Most Common # Pattern	Lateral Plateau	Lateral Plateau
Most Common Fixation	Buttress Plates	Cancellous Screws
Results Excellent to good	71.14%	80%

CONCLUSION

The surgical management of Tibial plateau fracture is a difficult and challenging task. The techniques demand considerable skill and mature judgement on the part of the on the part of the surgeon.

Delayed institution of proper management of fractures of proximal tibia gives poorer functional outcome. Hence proper evaluation of fracture pattern and early institution of appropriate management yields good results. Bone grafting to supplement the fixation methods in depressed fracture patterns is useful in restoring the articular congruity and early rehabilitation of patient.

CT and MRI have a definite role in studying the correct personality of complex fracture patterns and deciding the appropriate treatment method .

Rehabilitation and physiotherapy should be timely instructed for effective functional outcome of treatment methods.

As this is only a short term study, further follow up and evaluation is essential to come out with a definitive conclusion

PROFORMA

CASE NUMBER:

Name : DOI :

AGE : DOA :

SEX : DOS :

I.P. NO. : DOD :

ADDRESS :

HISTORY :

X-RAYS / CT FINDINGS:

DIAGNOSIS:

SURGERY :

ANAESTHESIA:

APPROACH :

IMPLANTS USED:

TABLE 36-3. MODIFIED HOHL AND LUCK EVALUATION METHOD

Grade	Lack of Extension (degrees)	Range of Movement (degrees)	Valgus or Varus Instablity (degrees)	Walking Distance (m)	Pain*
Excellent (all of the following)	0	≥120	<5	>3000	None
Good (not more than one of the following)	>0	<90	>5	<1000	Mild on activity
Fair (not more than two of the following)	≥10	<75	>5	<100	Moderate on activity or intermittent at rest
Poor	All results worse than fair				

* The grade cannot be higher than for pain.
(Modified from Jensen et al., [92] with permission)

S.No.	NAME	Age	Sex	IP. No.	DOS	Mode of Injury	Side	Fract Typ
1.	ELANGO	28	M	732472	24/8/04	RTA	L	TYPE
2.	KOLLAPURI	48	M	732594	26/8/04	RTA	R	TYPE
3.	NANDAKUMAR	22	M	722360	13/5/05	RTA	R	TYPE
4.	KANNIAPPAN	50	M	728495	15/6/05	RTA	R	TYPE
5.	VEERA	23	M	730409	20/6/05	RTA	L	TYPE
6.	DASAN	65	M	732455	2/7/05	RTA	L	TYPE
7.	KAMARAJ	30	M	735070	13/7/05	RTA	L	TYPE
8.	CHANDRA BABU	42	M	784170	27/06/05	RTA	R	TYPE
9.	NARAYANA BABU	35	M	784264	10/07/05	RTA	L	TYPE
10.	PRABAKAR	42	M	781435	20/08/05	RTA	L	TYPE
11.	VALARMATHI	23	F	784312	27/08/05	RTA	L	TYPE
12.	VADIVEL	36	F	786952	7/11/05	RTA	R	TYPE
13.	SELVAM	49	M	788148	2/3/06	RTA	L	TYPE
14.	JEYARAJ MANICK	43	M	778668	16/2/06	RTA	L	TYPE
15.	SRINIVASAN	36	M	802216	10/4/06	RTA	R	TYPE
16.	ABDUL MUNAF	32	M	803274	25/6/06	RTA	L	TYPE
17.	RAJASEKAR	25	M	810617	28/5/06	RTA	L	TYPE
18.	RAMACHANDRAN	42	M	817426	21/6/06	RTA	L	TYPE
19.	JANAKI	40	F	814128	29/5/06	RTA	L	TYPE

20.	GUNASEKAR	40	M	818022	3/7/06	RTA	L	TYP
21.	DHAVAMANI	40	M	803269	8/6/06	RTA	L	TYP
22.	JOSEPH	47	M	808577	26/6/06	RTA	L	TYP
23.	SHANMUGAM	36	M	857291	28/6/06	RTA	R	TYP
24.	ARULRAJ	25	M	822887	23/5/06	RTA	L	TYP
25.	GANESAN	22	M	826892		RTA	R	TYPI
26.	MURUGAN	42	M	831688		RTA	L	TYP
27.	GOPAL	24	M	831898		RTA	L	TYPI
28.	SAKTHI	27	M	837420		RTA	R	TYP

BP – Buttress plate
PC – Percutnaeous
CS – Cancellous Screws
BG – Bone Grafting
RTA – Road Traffic
Ext. Fix – External Fixation
MIPO – Minimally invasive Percutaneous Osteosynthesis
- Fracture