A COMPARATIVE ANALYSIS OF ELEVATION OF DEPRESSED TIBIAL CONDYLE FRACTURE BY AUTOGENOUS BONE GRAFT AND HYDROXY APATITE CRYSTALS

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CERTIFICATE

This is to certify that the work entitled **"A COMPARATIVE ANALYSIS OF ELEVATION OF DEPRESSED TIBIAL CONDYLE FRACTURE BY AUTOGENOUS BONE GRAFT AND HYDROXY APATITE CRYSTALS"** which is being submitted for M.S. Orthopaedics, is a bonafide work of **Dr. R.Arokia Amalan**, Post Graduate Student at Department of Orthopaedics, Tirunelveli Medical College, Tirunelveli.

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He has completed the necessary period of stay in the Department and has fulfilled the conditions required for the submission of this thesis according to the University regulations. The study was undertaken by the candidate himself and the observations recorded have been periodically checked by us.

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This is to certify that the INSTITUTIONAL ETHICAL COMMITTEE OF TIRUNELVELI MEDICAL COLLEGE AND HOSPITAL, TIRUNELVELI– 11 has unanimously approved the dissertation titled entitled **"A COMPARATIVE ANALYSIS OF ELEVATION OF DEPRESSED TIBIAL CONDYLE FRACTURE BY AUTOGENOUS BONE GRAFT AND HYDROXY APATITE CRYSTALS"** by **Dr. R.Arokia Amalan**, MS Orthopaedics Post graduate student of Tirunelveli Medical College, Tirunelveli in its meeting held on 09.09.2008.

Tirunelveli,
09.09.2008

Sd/-
SECRETARY

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INTRODUCTION

With the introduction of high speed motor vehicles in this modern world, high energy trauma around the knee especially tibial plateau fractures are common. Tibial plateau fractures being intra articular often result in post traumatic knee stiffness and early osteoarthritis of knee joint if not managed properly.

Tibia is the major weight bearing bone of the leg. The proximal weight bearing surface of the tibia which forms the inferior articulating region of the knee joint is called the tibial plateau and any fracture involving this articular surface of tibia is included in tibial plateau fractures.

Proximal tibial articular fractures can be caused by motor vehicle accidents or bumper strike injuries. However, sport injuries, falls, and other less violent trauma frequently produce them, especially in elderly patients with osteopenia.

Tibial plateau fractures can be managed by operative or non-operative methods. Non-operative or conservative methods include cast immobilization, traction immobilization and cast bracing. Surgical methods include closed reduction and percutaneous internal fixation ,open reduction and internal fixation, arthroscopic assisted osteo synthesis and hybrid procedures including the use of external fixators.

Many investigators agree that there are five primary areas specific to the fracture that can ultimately determine the prognosis of these injuries:

- The degree of articular depression
- The extent of condylar separation
- Degree of diaphyseal-metaphyseal comminution
- The integrity of soft tissue envelope
- Metaphyseal-diaphyseal dissociation

Tibial plateau fractures itself or if not properly treated will result in a list of complications, which includes:

- Stiff knee
- Secondary osteoarthritis
- Malunion-Varus or valgus deformity
- Nonunion
- Infection

Hence, if rational treatment is to be instituted, the physician must have a sound knowledge of the personality of the injury and a clear understanding of the knee examination, have analyzed pertinent imaging studies, and be familiar with a variety of techniques for treating tibial plateau fractures. The challenge to the orthopaedic surgeon is to determine if treatment can be best be achieved by non-operative or surgical methods. It is well established that optimal knee function depends on a stable knee with a congruous and healthy articular surface that permits balanced load transmission across the joint.

REVIEW OF LITERATURE

Fracture of the tibial plateau, also known as the "fender fractures" were first described by Sir Astley Cooper.

Pioneering work on classifying these fractures was done by Clarke.H.Osmond in his work "fracture of tibia involving knee joint" which classified only lateral plateau fractures.

In 1956, Hohl and Luck proposed the classification of plateau fratures that included non-displaced, local depression, split depression and split fractures. One of the most comprehensive and acceptable classification was proposed by Schatzker.J. and which is in application and based on this in 1990 AO/ASIF published the comprehensive and complicated classification of these fractures.

Numerous scoring systems are used for post treatment evaluation of tibial plateau fractures like Hohl and Luck, Jensen and colleague, Duparc and Ficat. Rasmussen ,knee rating system of the Hospital for Special Surgery. In 1989 the knee society revised the HSS knee rating system to separate patient's overall functional ability from knee function alone.

Mitchell and Shepard in their studies on the effects of articular malredution on the outcome of articular fractures propounded that accurate reduction and stable fixation of intra-articular fragments are necessary for articular cartilage regeneration.

In the 1970s the AO group stressed the importance of anatomical reduction and rigid fixation of articular fractures.

Schatzker et al advocate that any degree of condylar spreading that results in widening of the tibial plateau or condylar depression should be operated as articular defects never fill in. In 1986, Lansinger and co-workers after 20 years of follow up study concluded that knee instability rather than amount of displacement, was the main indication for surgery.

In conclusion today the trend is of surgical treatment with two parameters serving as an absolute indication:

A) Instability in extension over 10 degree

B) Fragment displacement over 10mm.

Literature evidence of treatment of plateau fractures were mainly based upon the Schatzker type of fracture classification. Our study was confined to type II ,III,V and VI tibial condyle fractures.

Bone grafting for the void left after the elevation of the depressed articular surface is an important aspect of the treatment of types II, III,V and VI . Various substances have been studied as void filler. Autologous bone graft, demineralized cancellous allograft "croutons", hydroxy apatite are some of them. Use of fibular head as a replacement for large articular surface defects has had success in a limited series.

In our study we used both autologus bone graft and hydroxyl apatite crystal as 'Void Filler' in depressed tibial condyle fractures.

Hydroxy apatite:

It is also called as hydroxyl apatite. Hydroxy apatite is a naturally occurring mineral form of calcium apatite with the formula $Ca_5 (Po_4)_3 (OH)$, but is usually written $Ca_{10} (Po_4)_6 (OH)_2$ to denote that the crystal unit cell comprises two entities. Hydroxyl apatite is the hydroxyl end member of the complex apatite group. This $(OH)^-$ ion can be replaced by fluoride, chloride or carbonate, producing fluorapatite or chlorapatite. It crystallizes in the hexagonal crystal system. It has a specific gravity of 3.08 and is 5 on the mohs hardness scale. Pure hydroxyl apatite powder is white. Naturally occurring apatite's can however also have brown, yellow, or green colorations.

In this study we used G-Bone. This modified hydroxyl apatite granules and block are made of calcium hydroxyl apatite in highly crystalline form. The body absorbs it slowly. It is derived from bovine bone which has been sintered at a very high temperature of +500°C. This leaves only pure inorganic structure. It does not carry any risk of transmission of any disease because no organic matter survives such high temperature. It is available in the form of granules and blocks. The bone filler acts as a scaffold and encourage the rapid filling of the void by naturally forming bone provides an alternative to bone grafts. It will also become part of the bone structure and will reduce the healing time thus compared to situation, if no bone filler was used. Generally speaking dense hydroxyl apatite does not have the much strength to enable it to succeed in long term load. It should be supported by plating.

Fx. Huber et al (2005) treated 24 depressed tibial condyle fracture with hydroxyl apatite crystals as void filler. The results showed better functional outcome and less late collapse.

Schaller et al studied the clinical results using G-Bone in tibial condyle fracture as void filler and suggested that compressive strength, compressive stiffness and young modulus more than that of cancellous bone graft.

Franz-xaver et al treated 20 patients of tibial condyle fractures with G-Bone. This study expressed that the usage of G-Bone was an effective method in treating tibial compression fractures with large defect zone left after reduction.

Renuka Reddy et al evaluated radiological incorporation of G-Bone in tibial condyle factures. The conclusion of study stated that only partial incorporation of G-Bone even after 18-24 months. But there was no collapse of articular surface on weight bearing after 3 months of surgery. There was no complications like G-Bone disintegration or foreign body reaction.

Hussain et al treated 15 patients of Tibial compression fractures with G-Bone. He suggested that radiological appearance not co-linear with functional outcome and also emphasized that histopathological study was the ideal to conform the graft incorporation.

Andrew trenholm, Scott Landry et al conducted trial study with calcium phosphate cement and hydroxy apatite crystals in type II tibial condyle fractures. This comparative study showed that hydroxyl apatite crystals had higher initial stiffness than bone graft and transfer less stress to sub-chondral bone.

Simpson et al compared the functional outcome with injectable calcium phosphate cement versus bone graft. The conclusion of study showed more favorable anatomical results with injectable calcium phosphate than conventional treatment.

Cazev et al. treated 20 patients of displaced tibial condyle fractures with tri-calcium phosphate. The study showed early incorporation of tri-calcium phosphate than hydroxyl apatite crystals.

Touzard et al (1998), expressed good results with calcium triphosphate in depressed tibial condyle fractures.

Martin Divo et al, treated 24 patients of tibial condyle fractures with OSTIM-[nano crystalline hydroxyl apatite paste] and compared the functional outcome with bone graft.

Bi-phasic calcium phosphate and β-tri calcium phosphate are also used for filling the bony defect. These materials are brittle than hydroxyl apatite crystals. So these materials mainly used in non-weight bearing or low-load bearing areas. These materials are degraded earlier than hydroxyl apatite crystals.

The choice of the proper void filler depends largely upon the surgical priority to produce balance of the biological and mechanical properties required in the individual patient.

ANATOMY

Tibia is the major weight bearing bone of the leg. The Proximal weight bearing surface of the tibia which forms the inferior articulating region of the knee joint is called the tibia plateau.

The medial plateau is the larger of the two articular surfaces and is concave in both transverse planes. The lateral plateau is smaller and convex and lies slightly higher than the medical joint surface. A fibro cartilaginous meniscus covers both plateaus. The coronary ligaments serve to attach the menisci to plateaus and inter meniscal ligament serves to connect menisci anteriorly. The tibial spines are between the plateaus. The medial and lateral tibial spines serve as attachment points for the anterior and posterior cruciate ligament as well as menisci.

The tibia is a triangular shaped bone in cross section in this diaphysis. Proximally the tibial tuberosity is found antero – laterally about 3cm below the articular surface. This site serves as a point of attachment for the patellar tendon. Directly posterior to the patellar tendon is a richly vascularised fat pad. Further lateral on proximal tibia, gerdy's tubercle where ilio-tibial band inserts. The proximal tibio-fibular joint is located postero laterally on lateral tibial condyle. The fibular head acts as a buttress for the proximal lateral tibial condyle.

The stability of the tibial plateau depends upon three different osseous structures, the central portion consisting of the insertion of the cruciate ligaments, the medial and the lateral plateau.

Neurovascular structures are at risk with proximal tibial fracture. The common peroneal nerve courses around the neck of fibula distal to the proximal tibio-fibular joint. The trifurcation of the popliteal artery occurs posteromedially in the proximal Tibia. Neuro-vascular evaluation is mandatory in proximal tibia fractures.

The proximal medial tibial surface is devoid of muscle coverage, but serves as an attachment point for the pes tendons and medial collateral ligament. The anterior compartment musculatures attach to the lateral proximal tibia and must be carefully elevated while performing lateral approach to proximal tibia.

BIO-MECHANICS

The proximal tibial plateau fracture results from direct axial compression with added valgus or varus force. These fractures may occur with indirect shear force. The bio-mechanics of knee joint determines the fracture pattern in tibial condyle fracture.

Knee Joint is a modified hinge Joint. It allows both flexion and extension with rotary movements. During extension, the femoral condyle moves to internal rotation and thus is said to screw home and locked. While on flexion, the joint has to be unlocked by a reverse rotation and this is done by popliteus. The stability of the knee joint depends on bony components and ligamentous complex. The maintenance of articular congruity and ligamentous complex determine the functional outcome in tibial condyle fractures.

MECHANISM OF INJURY

Fractures of the plateau occur as a result of strong valgus or varus forces combined with axial loading. These can be due to either low energy or high energy trauma and the classic type called the "bumper fractures" which occurs in motor vehicle accidents involves the lateral plateau.

The direction, magnitude and location of the force as well as position of the knee at impact determine the fracture pattern, location and degree of displacement.

Lateral tibial plateau is more commonly involved in tibial plateau fractures. This involvement is due to anatomical axis at the knee joint which is normally 7 degree of valgus as well as to the predominance of injuries causing a lateral to medial directed force.

Patient factors such as age and bone quality also influence the fracture pattern. Older patients with osteoporotic bone are more likely to sustain depression type fracture because their sub-chondral bone is less likely to resist axially directed force. In constrast, younger patients with denser subcondral bone are more likely to sustain split type fracture and have associated ligamentous disruption. The intactness or disruption of medial collateral ligament also influences the fracture pattern in tibial condyle fracture.

CLASSIFICATION

Fracture of tibial condyle are classified according to fracture pattern, the degree of articular disparity, the presence or absence of comminution and whether they are open or closed. Each of these factors may have some bearing on the type of treatment to be selected and the ultimate prognosis.

In 1956, Hohl and Luck proposed the classification of plateau fractures that included non-displaced, local depression, split depression and split fractures. Then Moore sought to include some unusual fracture types involving plateau in coronal plane and proposed a new classification called fracture-dislocations of knee.

One of the most comprehensive and acceptable classification was proposed by Schatzker J. and which is in application and based on this in 1990 AO/ASIF published the comprehensive and complicated classification of these fractures. Numerous other classifications are also in vogue like Barr, Apley, Rasmussen each one having its advantages and disadvantages. Proper classification of these fractures plays a vital role in its management.

Schatzker's classification is taken into consideration in this study, which is described under these six types:

Type-I: Split fracture of lateral tibial plateau without articular depression

Type-II: Split depressed fracture of lateral tibial plateau

Type-III: Isolated depression of lateral plateau

Type-IV: Fracture of the medial plateau

Type-V: Bicondylar fracture with varying degrees of articular depression and displacement without metaphyseal-diaphyseal dissociation

Type-VI: Bicondylar fracture with metaphyseal-diaphyseal dissociation

INVESTIGATIONS

A minimum of two view- antero - posterior and lateral are mandatory in all tibial condyle fractures. Radiological evaluation should include oblique view. Because of the 10 – 15 degrees of posterior slope of tibial articular surface, 10 – 15 degrees caudally titled plateau view better delineate the articular step-off.

Traction view is virtual to assess the role of ligamentotaxis in reduction of fracture fragments. Stress view is needed to rule out ligamentous disruption.

CT Scanning is mandatory for treating tibial condyle fractures. CT Scanning with sagittal reconstruction has increased the diagnostic accuracy in tibial plateau fractures and is indicated in all cases with articular depression. The axial images are often most useful for determining the fracture configuration and planning for lag screw placement as well as surgical incision placement. CT scan helps to classify the fracture better especially where there is confusion between type I and type-II which is difficult to differentiate on routine radiographs.

MRI scanning is useful to ruleout ligamentous and meniscal injury.

Routine blood investigation is carried out for every patients and cardiac fitness for patients more than 35 year of age.

PRINCIPLES OF MANAGEMENT OF TIBIAL CONDYLE FRACTURES

There are a number of factors which play a dynamic role in determining the type of management, thereby influencing the prognosis. They include.

- The degree of articular depression
- The extent of condylar separation
- Degree of comminution
- Extent of soft tissue injury.
- Presence of multiple trauma.
- Degree of osteoporosis.
- Complex ipsilateral injuries.

So the objectives of treatment of tibial condyle fractures are,

1. to obtain and maintain anatomical reduction and rigid fixation.
2. to regain functional range of movement of knee joint.
3. to treat associated injuries.

METHODS OF TREATMENT

There are variety of options for treating depressed tibial condyle fractures. Tibial condyle fractures can be treated by non-operative and operative methods. The aim of treatment in tibial condyle fractures is to achieve a stable, well aligned mobile joint with minimal surface irregularities and with adequate soft tissue healing and the prevention of late degenerative changes.

Conservative management:

1. Plaster cast
2. Skeletal traction
3. Functional cast bracing
4. Sequential combination of these methods.

Surgical management:

- Lag screw fixation
- T shaped and L shaped buttress plates
- Locking plates
- Tubular external fixator
- Illizarov ring fixator
- Arthroscopic assisted osteosynthesis
- Combination of these methods.

CONSERVATIVE MANAGEMENT

CAST IMMOBILIZATION:

Non – displaced, stable tibial condyle fractures can be treated by plaster immobilisation for a period of 10-12 weeks. Patient needs above knee cast for 6-8 weeks followed by functional bracing with partial weight bearing. Full weight bearing is allowed after radiological union of the fracture.Disadvantage of plaster immobilization is difficult to maintain the reduction and it needs prolonged immobilization. Post traumatic stiffness and post traumatic arthritis are more common with conservative management. Common peroneal nerve injury is one of the complication of improper bandaging.

SKELETAL TRACTION

This technique involves the use of Steinmann pin inserted in the tibial shaft below the fracture with associated skeletal traction. Patients are restricted to bed rest for 6 weeks, but are allowed active range of motion exercises for the knee. The major limitation of this form of treatment include inadequate reduction of the articular surface and ineffective limb alignment control. It also needs extended period of hospitalization and recumbency. Chances of pin tract infections are common.

SURGICAL MANAGEMENT

INTRODUCTION

During last century, surgical management of tibial condlye fractures has gained widespread acceptance as operative technique and the quality of implants have improved. The combination of properly designed implants, better understanding of the personality of the fracture, minimal soft tissue handling techniques, pre operative antibiotics have made surgical fixation safe and practical while treating the fractures.

The goals of operative treatment include,

- Restore articular congruity, joint stability and the original knee axis.
- Provide fracture stability allowing for early pain free movement of the knee and mobilization of the patient.
- Obtain full functional recovery as a long term goal.

Operative treatment is indicated in,

- Depressed tibial condyle fractures with fracture depression more than 10mm (>10mm)
- Instability in extension more than 10 degrees

PRE OPERATIVE PLANNING

Pre operative planning is mandatory and gives better results. It gives better idea to the surgeon about personality of the fracture and operative strategy. Good radiological evaluation is very important.

PRINCIPLES OF OPERATIVE TREATMENT

- Reconstruction of articular surface by direct or indirect means.
- Adequate buttressing of elevated articular fragment with bone graft (or) bone graft substitute.
- Preservation of soft tissue and meniscus.

SURGICAL EXPOSURE:

Exposure of tibial plateau can be gained through a variety of approaches. The planned surgical approach should provide adequate articular visualization combined with preservation of all vital structures and minimal soft tissue and osseous devitalisation. Skin incision for tibial condyle fractures should be longitudinal and as close to midline as possible. Because of majority of plateau fractures involve lateral compartment, a lateral parapateller incision with arthrotomy is often used. For medial fractures, either a medial parapatellar or postero medial approach is preferred. In bicondylar fractures, dual incision approach is more preferred than midline incision because it is more soft tissue friendly.Irrespective of the approaches, fracture visualization and fracture reduction are done through submeniscal arthrotomy.

REDUCTION TECHNIQUES:

Reduction of tibial plateau fractures can be attained by direct or indirect means. Direct reduction can be performed either open or semi open means. Indirect reduction uses the principle of ligamentotaxis with either femoral distractor or external fixator. Indirect technique is not successful in central depressed tibial plateau fractures. In these fractures, cortical window is made below the depression and elevated by bone tamps and punches. Following articular surface elevation, the void is filled either with autologous bone graft or bone graft substitute and should be adequately buttressed either with T-buttress plate or cancellous screws.

POST OPERATIVE PROTOCOL:

Post operatively, knee is placed in a posterior plaster splint. On 4^{th} post operative day, the splint is removed and physical therapy with quadriceps exercises and gentle active assisted exercises are begun. Crutch walking is begun but no weight bearing is permitted for 12-14 weeks. The fracture healing response is monitored by post operative radiographs once in every four week. Full weight bearing is allowed after radiological union of the fracture.

COMPLICATIONS

The complications following operative treatment for tibial condyle fractures are relatively less common because of better surgical technique and improved implants.

COMPLICATIONS OF FRACTURES:

1. Infection.
2. Post traumatic stiffness.
3. Malunion.
4. Post traumatic arthritis.
5. Associated vascular and nerve injuries.
6. Non union.

COMPLICATION OF OPERATIVE TREATMENT:

1. Incomplete reduction.
2. Incongruous reduction.
3. Unstable fixation.
4. Symptomatic hardware.
5. Infection.

The operative fixation does not always guarantee a favourable outcome. The surgeon must have a thorough understanding of local anatomy, mechanics of fracture fixation and patterns of fracture healing after internal fixation for obtaining consistently good results.

INFECTION:

The major drawback of operative fixation is infection. The incidence of infection is 3 – 38%. The incidence of infection is more common in open fractures and bicondylar fractures those who treated by dual incision. Pin tract infections are common with external fixator application. Even on persistent infection, every effort should be made to retain the implant, since stable infected fractures are easy to manage than unstable infected fractures. However, if the infection is severe, the implant has to be removed and fracture should be supported by external fixator or splinting.

KNEE STIFFNESS:

This is more common in conservatively treated cases. The knee joint is notorious for developing stiffness if it is immobilized too long. The main advantage of surgical fixation is that since the fracture fragments are stable after fixation, early rehabilitation exercises can be started at an earlier date.

PAINFUL HARDWARE:

The most common complication following operative treatment of tibial condyle fracture is symptomatic hardware. Patient presents with implant loosening or painful knee. Symptomatic hardware is one of the indications for removal of the implant after fracture union.

MALUNION:

This is relatively more common in conservatively treated cases because of difficulty in maintaining the alignment of fracture fragment . It also occurs in operative fixation due to inadequate reduction, loss of reduction and early incorporation of the bone graft. Results of patients with malunion and residual varus or valgus of greater than 10 degree have poor functional outcome.

POST TRAUMATIC ARTHRITIS:

It is one of the preventable complication it is more commonly occurring in conservatively treated cases. Post traumatic arthritis may result from initial chondral damage or may be related to residual joint incongruity. Preservation of joint congruity and meniscus reduce the incidence of post traumatic arthritis.

NONUNION:

The varying causes of nonunion are inadequate immobilization, improper fixation, implant failure, and the presence of underlying infection. Gross ostcoporosis of the bones is also an important cause for nonunion. Non union is more common in open fractures, bicondylar fractures and comminuted fractures. In a case of nonunion, open reduction and internal fixation with autologous bone grafting is the treatment of choice.

FUNCTIONAL OUTCOME

For evaluvating the functional outcome of fracture fixation, we used the revised HSS knee ranking score. This system took into account the following parameters.

Functional knee score

1. Walking

• unlimited	50
• > 10 blocks	40
• 5-10 blocks	30
• < 5 blocks	20
• house bound	10
• unable	0

2. Climbing staircase:

• normal up and down	50
• normal up down with rail	40
• up and down with rail	30
• up with rail unable down	15
• unable	0
Subtotal =	100 (max)

3. Deduction (minus):

- Single cane 5
- Two canes 10
- Crutches or walker 20

Total functional knee score= subtotal + deduction.

Evaluational knee score :

1. Pain

- None 50
- Mild or occasional 45
- Stairs only 40
- Walking and stairs 30
- Moderate occasional 20
- Continual 10
- Severe 0

2. Range of motion:

- 5 degree = 1 points 25

3 Stability (max. movement in any position)

anteroposterior

- < 5 mm 10
- 5-10 mm 5
- > 10 mm 0

Mediolateral

• < 5 degree	15
• 6 - 9 degree	10
• 10 - 14 degree	5
• > 15 degree	0
Subtotal =	100 (max)

4. Deduction (minus):

Flexion contracture

• 5 - 10 degree	2
• 10 - 15 degree	5
• 16 - 20 degree	10
• > degree	15

Extension lag

• < 10 degree	5
• 10-20 degree	10
• > 20 degree	15

Alignment

• 5-10 degree	0
• 0 - 4 degree	3 points for each degree
• 11-15 degree	3 points for each degree
• other	20
Total deduction =	50 (max)

Evaluational knee score = subtotal+total deduction

(If total is a minus number, score is 0)

Results are evaluated by working out percentage of obtained score out of total score.

Result will be considered as follows :

1. Excellent - > 80% score
2. Good - 60-79% score
3. Fair - 40 - 59% score
4. Poor - < 40% score

PREAMPLE

The tibial plateau fractures are one the most common fracture patterns occurring in lower limb injuries. These fractures affect the knee function and stability. A well aligned and stable joint is the prime goal of all treatment. Operative fixation is needed to restore and preserve the knee function.Following operative fixation anatomical restoration of articular surface, maintainence of the mechanical axis and restoration of ligamentous stability are achieved.

Articular incongruity more than 10mm and instability in extension more then 10 degree are absolute indications for surgery.

This study includes 20 patients all of whom were adults. Open fractures upto grade-II-Gustilo-Anderson,Schatzker's type II,III,V and VI with fracture depression more than 10mm were included.Open fractures more than grade II-Gustilo Anderson and fracture depression less than 10mm were excluded.

Articular congruity is the prime element for knee function. In this study, we used both bone graft and hydroxyl apatite crystals (G-Bone) as void filler in depressed tibial condyle fractures.

The outcome was analysed in the form of radiological union, graft incorporation, undue late collapse and functional outcome.

Based on our findings, we hereby submit '**A comparative analysis of elevation of depressed tibial condyle fracture by bone graft and hydroxyl apatite crystals.**

AIM OF STUDY

The aim of treatment in depressed tibial condyle fractures is attaining a well aligned and stable knee joint. These fractures are frequently treated improperly. The articular incongruity and associated instability can be reduced by articular elevation with either bone graft or bone graft substitute and providing adequate buttressing support.

The aim of the study is to evaluate the usage of hydroxyl apatite crystals (G-Bone) in depressed tibial condyle fractures and to compare and analyse the functional outcome with that of autologous bone grafting.

MATERIALS AND METHODS

The prospective study was carried out in the department of orthopedics, Tirunelveli Medical College Hospital from September 2007 to November 2009. In this study,

* adults between 20 and 60 years

*Schatzker's type II, III,V andVI tibial condyle fractures with fracture depression more than 10mm were included.

Open fractures (more than Grade II – Gustilo's), fracture depression less than 10mm and young patient less than 20 years were excluded.

All patients were analyzed using the following working sheet:

1. Personal details:

- Age
- Sex
- Occupation

2. Admission details:

- Date of injury
- Date of admission
- Mode of injury
- Side of injury
- Associated injuries
- Schatzker type
- Articular surface disparity

- Knee instability
- Neurovascular compromise
- Soft tissue condition
- Other complications

3 Management details:

Operative management:

- Date of operation
- Injury surgery interval
- Anesthesia used
- Mode of stabilization(procedure)
- Post operative complications

4. Follow-up details:

Within 3 months:

- Date of knee mobilization started
- Duration of knee brace given
- Date of weight bearing allowed
- Clinical union time
- Radiological union time
- Loss of reduction
- Non union
- Infection
- Implant loosening

After 3 months

- Knee society's revised HSS knee rating
- Hardware problem
- Stiff knee
- Other complications
- Patient satisfaction

Patient Details

Patients for the prospective study were selected immediately after their admission in the emergency department of the hospital.

Admission Details:

For the prospective study duration between the injury and first attendance in this hospital and treatment taken somewhere else were noted. In addition general condition of the patient like pallor, jaundice and other associated diseases like diabetes, tuberculosis, and hypertension were also attended.

Treatment Details :

All the patients irrespective of their age and fracture pattern were given intravenous fluids. Blood transfusion was based upon their hemoglobin status.

In compound fractures surgical debridement was done as early as possible followed by knee spanning external fixator whenever needed.

Routinely the lower limb was kept in above knee plaster slab or in lower tibial pin traction or in calcaneal pin traction with bohler braun splint.

Pre operative protocol includes radiological assessment using AP and lateral views, oblique view and CT scan was done for fracture classification, degree of fragment separation, location and amount of fragment depression.

CT scan help to classify the fractures better especially where there was confusion between type 1 and type 2 which was not so clear on routine radiographs. Oblique views were superior to AP views because in addition they provided with the location of the fracture whether anterior or posterior in the condyles. Routine blood investigation was carried out for every patients and cardiac fitness for patients more than 35 years of age.

PROCEDURE AND POST OPERATIVE PROTOCOL

All our patients were operated under regional anaesthesia in supine position on a standard operative table with tourniquet. All the cases were operated by antero-lateral approach.

For antero-lateral approach the following land marks are important, the joint line, gerdy's tubercle, tip of the fibula and lateral femoral condyle. With the knee in 30° flexion a slightly curved incision starting from lateral femoral epicondyle and ending between the fibular and gerdy's tubercle. The wound was extended either proximally or distally as needed. Reduction of Intraarticular fragments was confirmed by image intensifier and a sub-meniscal arthrotomy was done as needed. In type II,V&VI fractures lateral plateau was rotated laterally with it's soft tissue attachments. This allows for direct inspection of the joint impaction. The depressed articular fragments were elevated and directly reduced. In bicondylar fractures,inaddition to lateral tibial plateau fixation, the medial fragment was fixed with 6.5mm cancellous screws using lag screw principle.

In type III fractures, cortical window was made below the depressed condyle and the articular depression was elevated by periosteal elevator. Either autologus cancellous graft or hydroxyl apatite crystals were used to support the aritcular surface and fill the bone defect. The reduced articular fragments were temporarily fixed by multiple K-wires.T-buttress plate was then applied on the antero-lateral aspect of tibial condyle and secured with appropriate cancellous screws. Cortical screws of size 4.5mm were used to attach the plate to shaft of tibia.

POST OPERATIVE MANAGEMENT :

The limb was elevated and placed in posterior above knee slab.During the first post operative week, the splint was removed and physical therapy with quadriceps exercises and gentle active assisted exercises were started. If extensive suturing of the meniscus was done, the knee was kept immobilized for 3 weeks before active assisted exercises were started. Resting knee flexion should be avoided as flexion contractures may occur. Patients were maintained on non-weight bearing for 6 weeks. Partial weight bearing was allowed after 6 weeks. Full weight bearing was allowed after radiological evidence of fracture union preferably at 14 weeks of post operative period.

Follow up :

The prospective patients were followed up at 6 weeks, 12 weeks, 18 weeks, and 24 weeks postoperatively. Serial radiographs were taken and the ones especially used for assesment in the study were those taken at immediate postoperatively- for accuracy of reduction and stability, at 12 weeks- for maintenance of fracture reduction and fracture union, at 24 weeks- for assessing complete union.

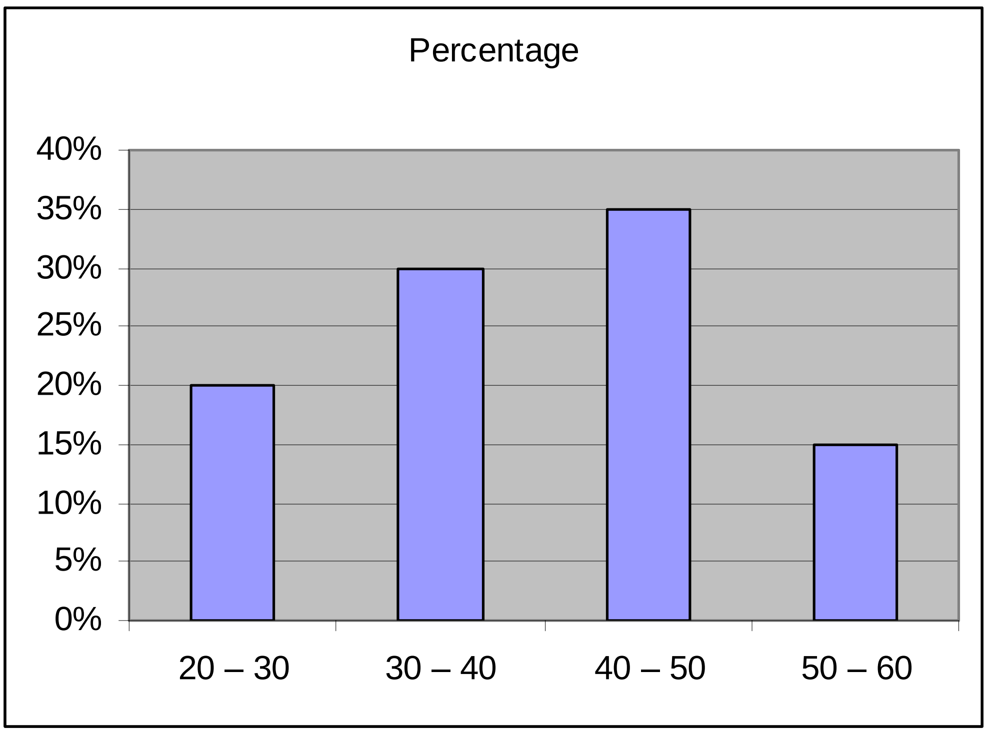
Patients were evaluated according to knee society's revised HSS knee rating score into excellent, good, fair or poor depending upon the variables. The patient's satisfaction was also taken into consideration.

OBSERVATIONS

This study comprised of 20 patients, who were admitted in the department of orthopedics Tirunelveli Medical College Hospital. The following are the observation and the result complied at the end of the study.

Table – 1

Age Distribution



Youngest patient in our study was of 20 years and oldest was of 59 years.

Table – 2

Sex distribution

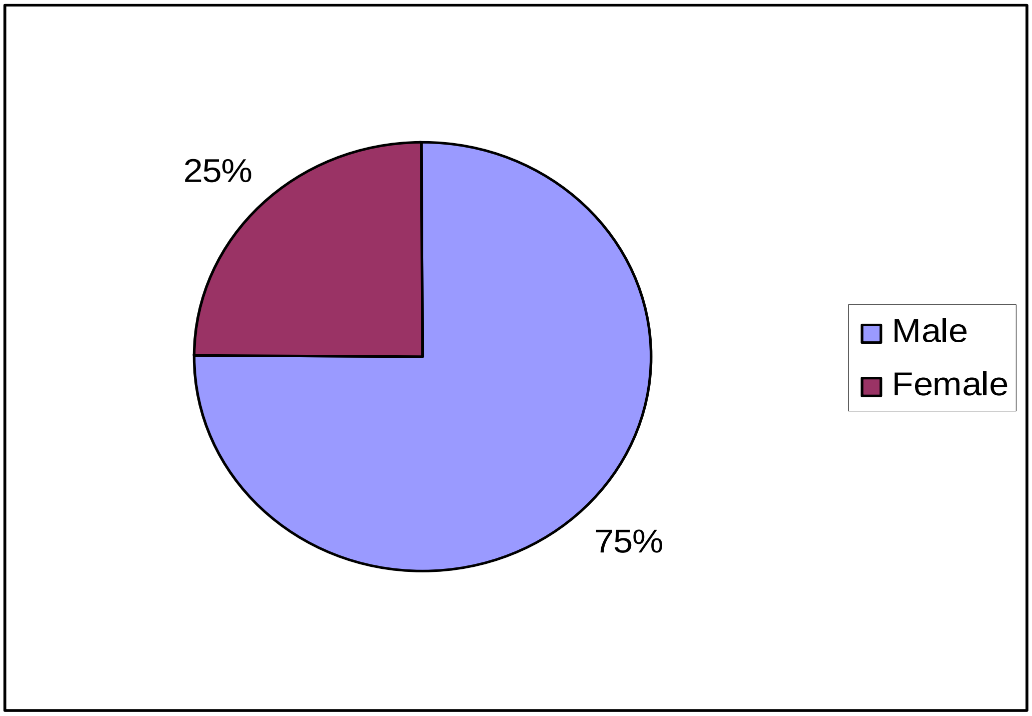


Table – 3

Mode of injury

Mode of injury	No. of cases	Percentage
Road traffic accidents	14	70%
Fall from height	4	20%
Fall of heavy objects	2	10%

Most common mode of injury is RTA.

Table – 4

Side of injury

Side	No. of cases	Percentage
Right	8	40%
Left	12	60%
Bilateral	-	-

Table – 5

Type of fracture

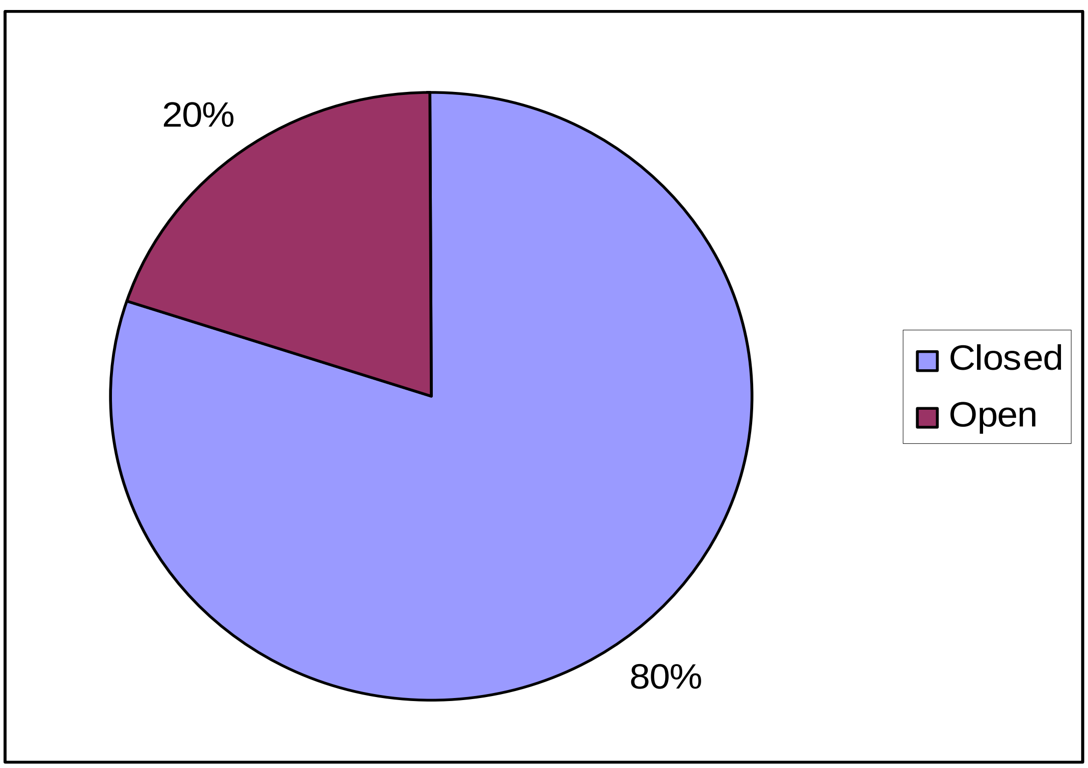


Table – 6

Schatzker type

Types	No. of cases	Percentage
II	6	30%
III	6	30%
V	2	10%
VI	6	30%

Table – 7

Associated injuries

Associated injury	Same side	Opposite side
Fracture shaft of femur	2	0
Fracture patella	2	0
Upper limb injury	3	2
Other lower limb injuries	4	2
Fracture fibula	12	0

Table -8

Mode of fracture stabilization (in % for each type)

Type	No. case	Bone graft	Hydroxy apatite blocks (G-Bone)	Implant used
II	6	3	3	butress plate
III	6	3	3	butress plate/ cancellous screw
V	2	1	1	butress plate
VI	6	3	3	butress plate

Table – 9

ROM commencement time

(ROM – range of motion)

Void filler	Types	No. of cases	Average time (in days)
Bone graft	II	3	7
	III	3	4
	V	1	12
	VI	3	12
G-Bone	II	3	7
	III	3	4
	V	1	12
	VI	3	12

Table – 10

Union Time (in weeks)

Types	Bone graft	Hydroxy apatite blocks (G-Bone)
II	12	No radiological incorporation at 3 ,6 months and 2 years follow up.
III	10.8	
V	12	
VI	12	

Table – 11

Weight bearing Time

Types	Bone graft	Hydroxy apatite blocks (G-Bone)
II	14	12
III	12	12
V	14	12
VI	14	12

Table – 12

Post management complication

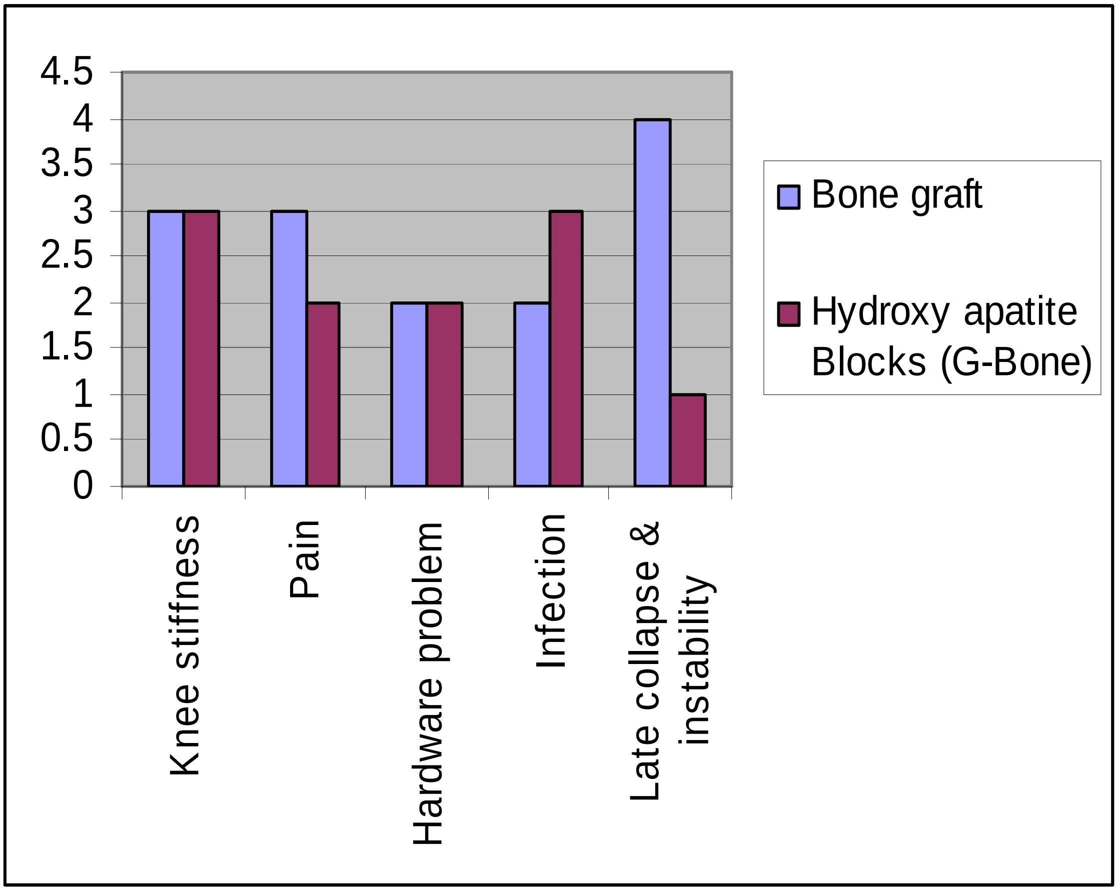


Table – 13

Final evaluation based on Schatzker type (in %)

Void filler	Type	Excellent	Good	Fair	Poor
Bone graft	II	84%	12%	2%	2%
	III	90%	8%	2%	-
	V	83%	12%	3%	2%
	VI	79%	17%	2%	2%
G-Bone	II	86%	12%	2%	-
	III	93%	7%	-	-
	V	84%	10%	2%	2%
	VI	80%	16%	2%	2%

Table – 14

Final evaluation based on management modality (in %)

Void filler	Type	Excellent	Good	Fair	Poor
Bone graft	II	87%	11%	2%	1%
	III	89%	10%	1%	-
	V	83%	14%	2%	1%
	VI	80%	15%	3%	2%
G-Bone	II	86%	12%	1%	1%
	III	93%	6%	1%	-
	V	84%	12%	2%	2%
	VI	82%	12%	4%	2%

DISCUSSION

The aim study is to evaluate the usage of hydroxyl apatite crystals(G-Bone) in adult tibial condyle fractures with depression (Schatzker's typeII & typeIII) and to compare and analyses the functional outcome with that of autologous bone grafting.

We selected 20 cases of adult tibial condyle fractures, during September 2007 to November 2009. All the cases had more than 10mm of depression and belonged to Schatzker's type II, III,V&VI. We had 6 cases of schatzker's type II , 6 cases of type III,2 cases of type V and 6 cases of type VI that were randomly divided into two groups, one treated with G-Bone and the other with autologous bone grafting.

The youngest patient in our series was 20 yrs and the eldest was 59 years with the average being 40 yrs.

We had 15 male cases and 5 female cases with a ratio of 3:1 male preponderence. Of the 20 cases, 4 cases had compound fractures, 2 with Gustilo- Andersons Grade II and 2 with grade I injury.

The common mode of injury in our study was road traffic accident(RTA) and the others being fall from height and fall of heavy objects.

In our study we had 12 cases involving the left side and 8 cases involving the right side.

In our study the associated injuries varied from 2 cases of ipsilateral femur fractures & 2 cases of ipsilateral patellar fractures. There were 3 ipsilatral upper limb injuries and 2 contralateral upper limb injuries

The lower limb injuries included 2 cases of ipsilateral malleolar fracture , one contra lateral malleolar fracture, One each case of ipsilateral and contra lateral metatarsal fractures and one case of ipsilateral femoral condyle fracture.

Associated fracture of the ipsilateral extremity makes the treatment of tibial plateau fractures much more complex and the results are less predictable. According to Schatzker.J et.al(1979) the generally acceptable principle was rigid fixation of all the associated fracture in order to start early rehabilitation. All associated fractures were treated surgically except for the metatarsal fractures.

Sarminento et.al(1979) in a study of 106 fractures concluded that the condition of fibula determine the angulatory behaviour of the tibial condyle fractures. Hence all tibial condyle fractures with loss of fibular buttressing were supplemented with buttress plating in our study.

All the cases were evaluated with antero posterior and lateral view radiography of the tibial condyle .10- 15 degree caudally tilted plateau view was needed to delineate the articular step off due to 10-15 degree posterior slop of tibial articular surface.

CT Scanning was mandatory in all cases as it indicates the amount of tibial plateau depression, the articular comminution and the fracture pattern.

Routine blood investigations were carried out for all patients along with cardiac evaluation for those above 35 years of age.

All cases were operated by antero-lateral approach. In type II,V&VI fractures, the depressed articular fragment was elevated and supplemented either with autogenous bone graft or hydroxyl apatite crystals. The reduced fracture was fixed with buttress plate and cancellous screws.

In the type III fractures, a cortical window was created and the depressed plateau was elevated and supplemented with autologous bone graft(or) hydroxyl apatite crystals. The articular congruity was evaluated under image intensification. The fracture was fixed with cancellous screws after achieving anatomical reduction. In all patients with type III fractures above the age of 45 , a buttress plate was added with the cancellous screws.

All the case of type II&III were commenced on range of motion at the end of first post operative week. For type V&VI and open fractures,ROM exercises were started at the end of second week.

All cases were radiologically evaluated at 4 weeks interval for fracture union and graft incorporation.

In the group with autologous bone graft radiological evidence of union was seen at 11 weeks in type III fractures and after 12 weeks in type II,V&VI fractures. No evidence of incorporation of G-Bone was seen even at 2 years followup.

Full weight bearing was allowed after evidence of radiological union among the bone graft group and at 12 weeks in the hydroxyl apatite group irrespective of the radiological incorporation.

All patients were evaluated at the end of 3 months duration using knee Society's revised HSS knee rating score and the results were expressed in percentage based both on schatzker's type & management modality. Excellent results were seen in 84% of bone graft group & 86% of G-Bone group among type II fractures , 90% in bone graft & 93% in G-Bone in type III fracture,83% in bone graft& 84% in G-Bone in type V and79% in bone graft&80% in type VI according to Schatzker's type.

Functional outcome was excellent in 87% & 86% of type II fractures treated with bone graft & G-Bone respectively. In type III fracture, the results were excellent in 89% of bone graft group & 93% of the G bone group. In bicondylar fractures [type V &VI], excellent functional results were seen in 83% of bone graft group& 84% of G-Bone group among type V fractures and80% in bone graft & 82% in G-Bone among type VI fractures.

Post operative complications included knee stiffness 3 cases in each group. Pain of varying severity over the knee region was present in 3 cases of bone graft and 2 cases of G-Bone.

Hardware problem was noticed in 2 cases of each group. Patient was relieved of symptoms after removal of hardware at the end of 18 months.

Infection was present in 2 cases of bone graft group and 3 cases of G-Bone group of the 3 cases, 2 were compound grade II fractures at presentation. All infected cases were effieciently treated with appropriate antibiotics. In one case treated with G-Bone infection was not controlled and infection subsided one year after the implant removal.

Late collapse of tibial plateau was seen only in type III&VI tibial condyle fractures, 4 cases that were treated with autologous bone graft and in one case treated with G-Bone.

No vascular (or) neurological complication was noted.

In our study compared to autologous bone graft group ,the intra operative duration was reduced and graft related complications were nullified in the hydroxyl apatite group. The incidence of late collapse of the tibial plateau was also significantly reduced in the G-Bone group.

CONCLUSION

In the present study assessing the functional outcome of tibial plateau fractures, we reached the following conclusion:

1. Tibial plateau fractures commonly occur in men around the 4th decade due to road traffic accidents.
2. Conventional radiographs are not sufficient for proper classification of these fractures. Routine CT scan should be done for proper classification of these fractures and to define the articular surface incongruity.
3. Proper Schatzker classification of tibial plateau fractures is essential as is influence the plan of management.
4. Fracture stabilization by rigid internal fixation results in early functional recovery and low incidence of stiffness.Perfect anatomical reduction is the key to this which can be achieved either by open reduction or closed reduction with the aid of image intensifier and sub-meniscal arthrotomy.
5. While fixing the depressed tibial condyle fractures (Schatzker's type II,III,V&VI), elevation of articular surface and maintaining the congruity of articular surface is the most essential step which determines the outcome of the fixation. For this traditionally autologus bone graft has been used for filling the metaphyseal

defects. However using autologus bone graft has following disadvantages.

1) Chances of late collapse of articular surface because of early incorporation of bone graft.
2) Presence of donor site morbidity.

The usage of G-Bone has following advantages;

1) Less operative time
2) No additional graft site morbidity
3) No need of prolonged anaesthesia
4) The mechanical strength of the G-Bone is more than that of autologus bone graft. Hence G-Bone allows the patient for early weight bearing without complications like late collapse and loss of fixation
5) G-Bone is biocompatible and non-immuogenic .

Even is the absence of radiological incorporation of G-Bone, it prevents late collapse of articular surface with its inherent mechanical strength and at the same time it avoids donor site morbidity. Eventhough autologous bone graft is being used traditionally as a void filler in tibial condyle fractures, G-Bone offers a better viable alternative to autologous bone graft.

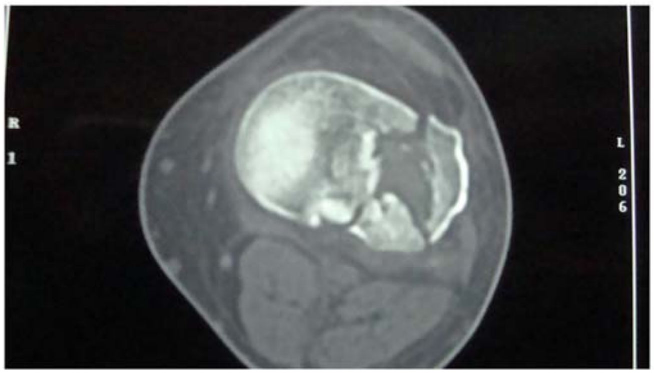
INCISION

Implants

G - Bone

CASE 1

Pre OP X-Ray

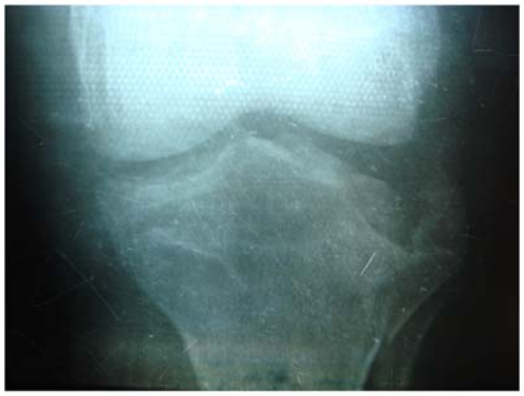


Cortical window

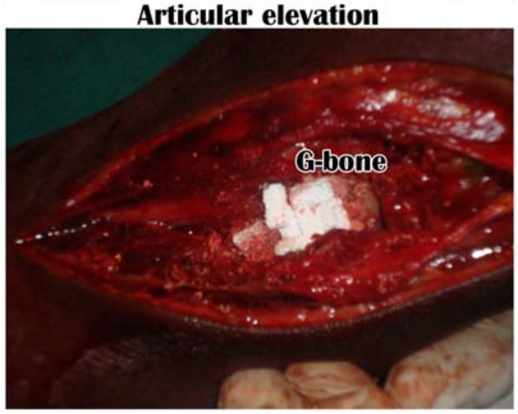
Post OP X-Ray

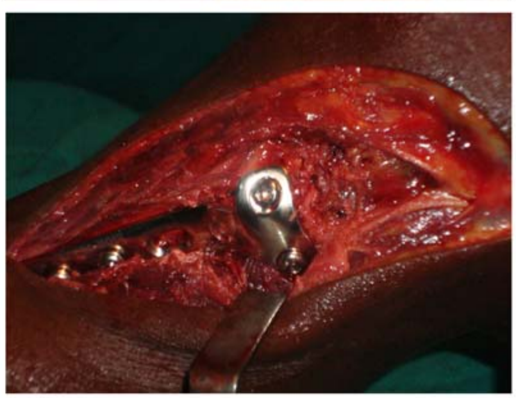
CASE 2

Pre OP X-Ray



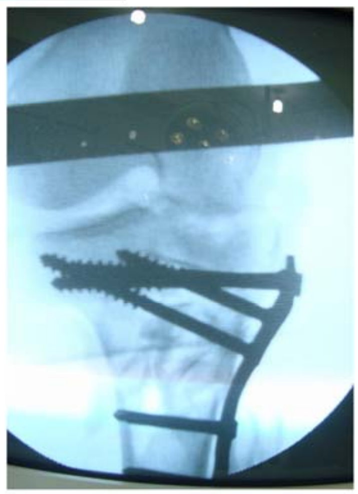
Articular elevation





CASE 3

Pre OP



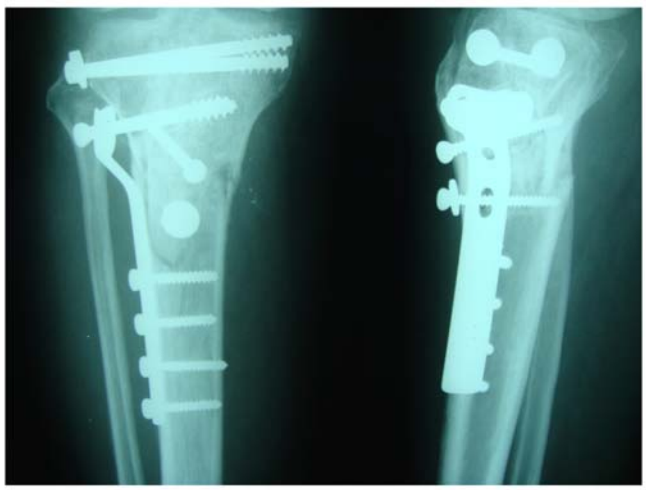
C-arm picture

Post OP

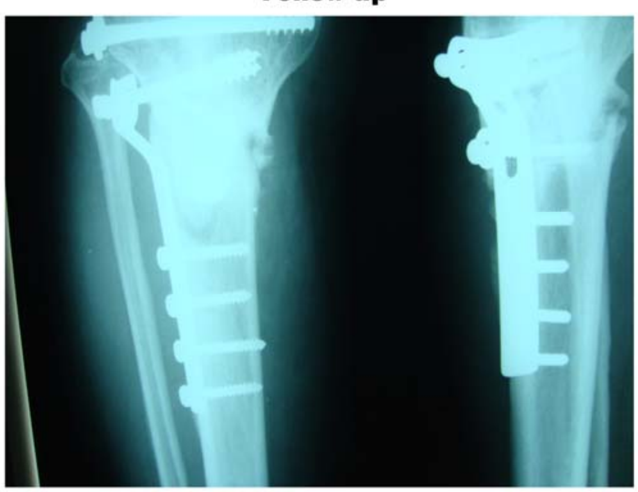
CASE 4

Pre OP

Post OP



Follow up



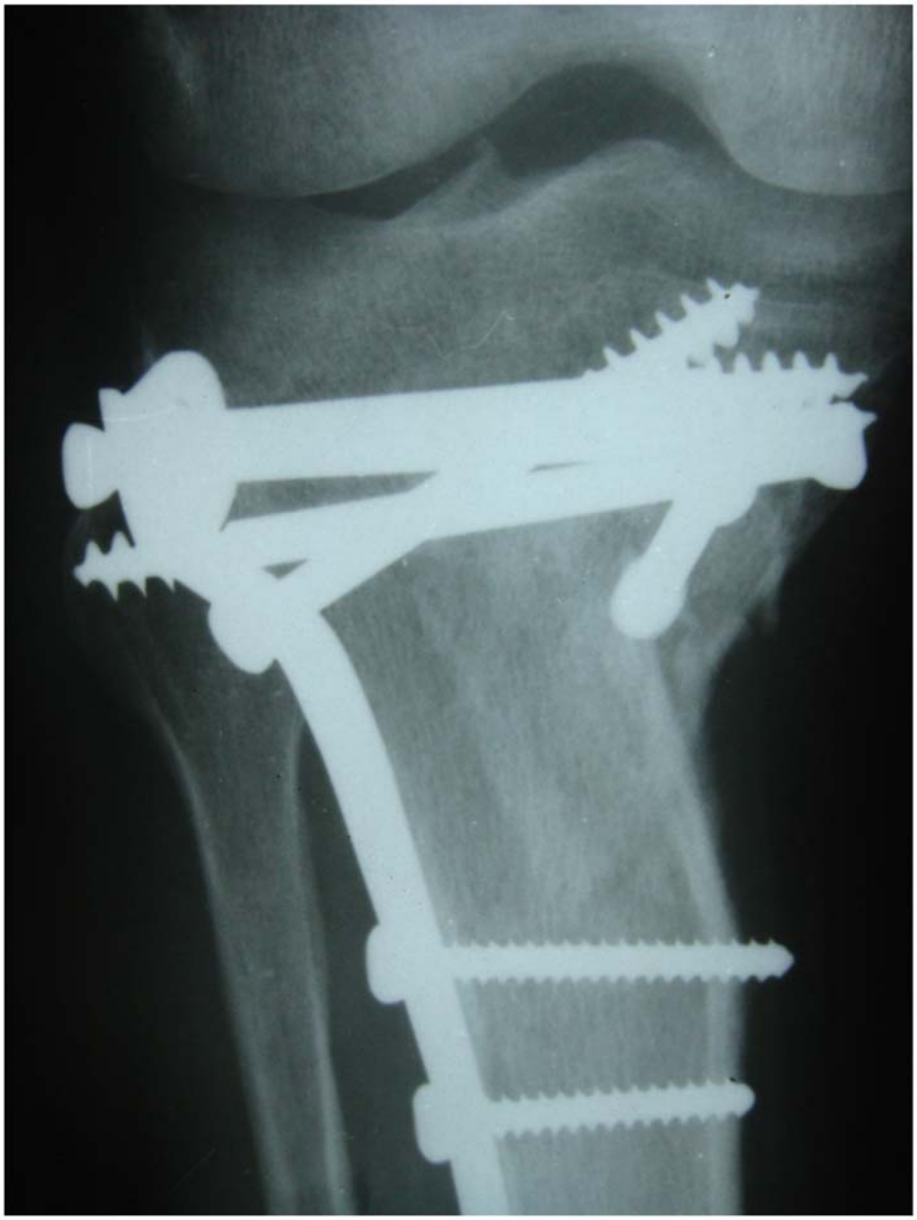
CASE 5

Pre OP

Post OP

COMPLICATION

Late Collapse in Bone graft



MASTER CHART

S.No	Age/ Sex	Mode of Injury	Schatzker Type	Type O/c	Side	Associated Injuries	Vold filler	Mode of Fixation	Rom in Days	Union Time in weeks	Wt. bearing time in weeks	COMPLICATIONS	Knee Society score function
1	24/m	RTA	II	C	L	NIL	G-bone	butress plate	7	-	12	nil	87%
2	43/m	RTA	III	C	L	# Shaft of Femur	G-bone	cancellous screw	4	-	12	pain/stiffness	89%
3	52/m	FALL HEIGHT	III	C	L	# Colles / # clavicle (L)	Bone graft	butress plate	5	11	12	late collapse	90%
4	21/m	RTA	II	C	R	NIL	Bone graft	butress plate	6	12	14	nil	83%
5	47/m	RTA	V	O	R	NIL	G- bone	butress plate	12	-	12	infection	79%
6	54/m	RTA	III	C	L	NIL	Bone graft	butress plate	4	11.2	12	late collapse	88%
7	59/m	RTA	VI	C	L	NIL	Bone graft	butress plate	12	12	14	hardware problem	81%
8	33/m	RTA	VI	C	R	Fracture Shaft of Femur (R)	G- bone	butress plate	12	-	12	pain/ stiffness	78%
9	38/m	RTA	II	C	L	NIL	Bone graft	butress plate	7	12	13	nil	89%
10	41/m	RTA	VI	C	L	NIL	Bone graft	butress plate	13	12	14	late collapse	81%
11	27/m	FALL OBJECT	III	O	R	NIL	G- bone	cancellous screw	4	-	12	infection	82%
12	32/m	FALL HEIGHT	II	C	R	NIL	G- bone	butress plate	5	-	12	Pain / stiffness	90%
13	49/m	RTA	VI	C	L	# Patella (L)	G- bone	butress plate	13	-	12	pain/stiffness	81%
14	42/m	FALL OBJECT	VI	O	L	NIL	G- bone	butress plate	14	-	12	infection	74%
15	35/m	RTA	III	C	L	# Bi- malleolar / metatarsal #(R)	Bone graft	cancellouns screw	4	11	12	pain/stiffness	91%
16	28/m	RTA	V	C	R	NIL	Bone graft	butress plate	14	12	14	nil	80%
17	42/m	FALL HEIGHT	II	C	R	NIL	Bone graft	butress plate	7	12	12	nil	86%
18	37/m	RTA	VI	O	L	# Patella (L)	Bone graft	butress plate	14	12	14	hardware problem	73%
19	31/m	FALL HEIGHT	II	C	L	# Clavice (R)	G- bone	butress plate	5	-	12	late collapse	87%
20	48/m	RTA	III	C	R	(L) # medial malleolus	G- bone	butress plate	4	-	12	nil	89%