IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 15, Issue 1 Ver. VI (Jan. 2016), PP 18-27
www.iosrjournals.org

Study of Surgical Management of Tibial Plateau Fractures – Functional and Radiological Evaluation

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Abstract:
Background: *Tremendous advance in mechanization and fastness in travel have been accompanied by steep increase in number and severity of fractures and those of tibial plateau are no exception.Knee being one of the major weight bearing joints of the body ,fractures around it will be of paramount importance.This study is to analyze the functional outcome of CRIF or ORIF with or without bone grafting in tibial plateau fractures in adults.*
Methods: *30 cases of tibial plateau fractures treated by various modalities were studied from August 2013 to December 2015 at our institution and followed for a minimum of 6 months.Fractures were evaluated using Modified Rasmussen's Clinical ,radiological grading system*
RESULTS: The selected patients were evaluated thoroughly and after the relevant investigations ,were taken for surgery.The fractures were classified as per the SCHATZKER'S types and operated accordingly with CRIF with percutaneous cannulated cancellous screws ,ORIF with buttress plate/ LCP with or without bone grafting.
Immobilisation of fractures continued for 3weeks by POP slab.Early range of motion was then started.Weight bearing upto 6 – 8 week was not allowed.The full weight bearing deferred until 12 weeks or complete fracture union.The knee range of motion was excellent to very good,gait and weight bearing after complete union was satisfactory.Knee stiffness in 3 cases,wound dehiscence and infection in 1case and non-union in none of the cases were noted.
Conclusion: *Functional outcome is better in operatively treated tibial plateau fractures in adults,because it gives excellent anatomical reduction and rigid fixation to restore articular congruity and early motion there by preventing knee stiffness.*
Keywords: *Tibial plateau fractures, Schatzker's classification , Open reduction and Internal fixation, Closed reduction and Internal fixation, Modified Rasmussen criteria.*

I. Introduction

In early days, treatments of fractures were guided by those people who set themselves up as healers. Some were good observers and passed it on to the later generation. The management of fractures thus began. Because of radiography it was possible to visualize the position of fractures, major changes in management took place and led to the fixation of fractures. Internal or external and later to rigid fixation of anatomically reduced fractures.

Tibial plateau fractures are one of the commonest intra-articular fractures. They result from indirect coronal or direct axial compressive forces. This makes about 1% of all fractures and 8% of the fractures in elderly. Most injuries affect lateral tibial condyle (55 to 70%) and isolated medial condyle fractures occur in 10 to 23% whereas the involvement of bicondylar lesions is found in 10 to 30% of the reported series [42].

These fractures encompass many and varied fracture configurations that involve medial, lateral or both plateaus with many degrees of articular depressions and displacements. Each fracture type has its own characteristic morphology and response to the treatment. It is essential to determine the force of injury since high-energy trauma is associated with considerable soft tissue and neurovascular damage. Apart from tibial plateau bony injury, meniscal tear and ligament injuries should also be assessed.

High velocity injury sustained in automobile disasters and increase in road traffic accidents as a whole is creating an ever-growing problem. Since man has taken to traveling at high speeds in the sitting position with the loading edge composed of flexed hind limbs, when the machine in which the subject is traveling stops suddenly, most of the impact is taken at first upon the patella, then the tibia and femur in varying proportions and at various positions. The stationary lower limb may be struck by a moving object; this is the common pedestrian injury, the so called "BUMPER FRACTURE", since the bumper of most vehicles being placed roughly at knee height.

Due to advancement, especially in orthopedic trauma a better understanding of biomechanics, quality of implants, principles of internal fixation, soft tissue care, antibiotics and asepsis have all contributed to the radical change. Thus we have advanced from the conservative approach to internal fixation in fractures as an acceptable mode of treatment. Nevertheless, tibial plateau fractures remain challenging because of their number, variety and complexity. Despite a plethora of articles, written in the past 50 years that have addressed the problems of classification and results of various treatments, the optimal method of management remains controversial [35].

II. Materials And Methods

This is a study of surgical management of tibial plateau fractures conducted in the department of orthopedics at GOVERNMENT GENERAL HOSPITAL,VIJAYAWADA between August 2013 to DECEMBER 2015. Clearance was obtained from hospital ethical committee.

During this period 30 patients were treated for tibial plateau fractures in which all patients were treated by internal fixation, out of which, 10 with Percutaneous cancellous screw fixation method, 9 with ORIF with buttress plate, 7 with ORIF with buttress plate and bone grafting and 4 with Locking compression plate.

All the required data was collected from the patients during their stay in the hospital, during follow up at regular intervals and from the medical records.

The Inclusion Criteria

1) Patient who has been diagnosed as Closed, Unstable tibial plateau fracture
2) Age group of 20–70 years of both sexes.

The Exclusion criteria

1) Skeletally immature individuals.
2) Open fractures of tibial plateau.
3) Fractures associated with knee dislocation.
4) Patients with associated ipsilateral femur, tibia and foot fractures.

- All patients are selected on the basis of history, clinical examination and radiography.
- The Schatzker's classification was used to classify these fractures. The patients were followed up for an average period of 6 months.
- Fractures will be defined as unstable if any of the following are present:
  Depression > 4mm
  Displacement >10mm
  Instability >10 ^{o}
- All cases will be treated with open reduction and internal fixation.
- Fixation can be done by Cannulated cancellous screw fixation, AO type T or L-plate, Locking Compression Plate.
- Follow up and assessment will be performed using modified Rasmussen's Clinical and Radiological criteria.

III. Management:

The patients were first seen in the casualty. The history was taken followed by general and local examination of the patient. Concerned specialists undertook appropriate management of the associated injuries. Intensive care was given to those patients who presented with shock and immediate resuscitative measures were taken. Once the patient's general condition was fit, relevant X-rays were taken and the degree of instability graded. The patients were taken for surgery at the earliest possible time depending on their medical condition, skin condition and the amount of swelling. All surgeries were done under C-arm image intensifier control. Fractures were fixed either with percutaneous technique or by open reduction and internal fixation. The fixation devices consisted of T Buttress plate, L Buttress plates, 4.5 mm Cortical screws and 6.5 mm Cannulated and Non-cannulated Cancellous screws.

Bone grafts, Bone graft substitutes were used in depressed and comminuted fractures. The source of bone graft was ipsilateral iliac crest.

IV. Postoperative Protocol :

Postoperatively patients were immobilized with an above knee posterior slab or a compression bandage for 3 weeks. The sutures were removed on the 12th postoperative day. Antibiotics were given till suture removal by 5 days of intravenous and 7 days of oral. The patients were advised static quadriceps exercises for initial 3 weeks followed by passive range of motion with protected knee brace and non-weight bearing crutch walking up to 6 weeks. After 6 weeks knee mobilization and weight bearing crutch walking was advocated. An immediate postoperative X-ray was also done, later on repeated at 6 weeks, 3 months and 6 months.

V. Follow Up Protocol :

The First follow up was done at 2 weeks, during which the surgical scar was inspected and range of movements noted. The Second follow up done at 6 weeks during which an X-ray was taken to look for signs of fracture union and loss of reduction if any. The Third follow up was done at 3 months during which one more X-ray was done and a clinical evaluation of union done. Based on the clinical and radiological signs of union patients were allowed partial weight bearing and gradually progressed to full weight bearing. The patients were then followed up at 6 months, during which time the anatomic and functional evaluation was done using the modified Rasmussen clinical and radiological criteria.

Figure1.Picture showing Anterolateral approach

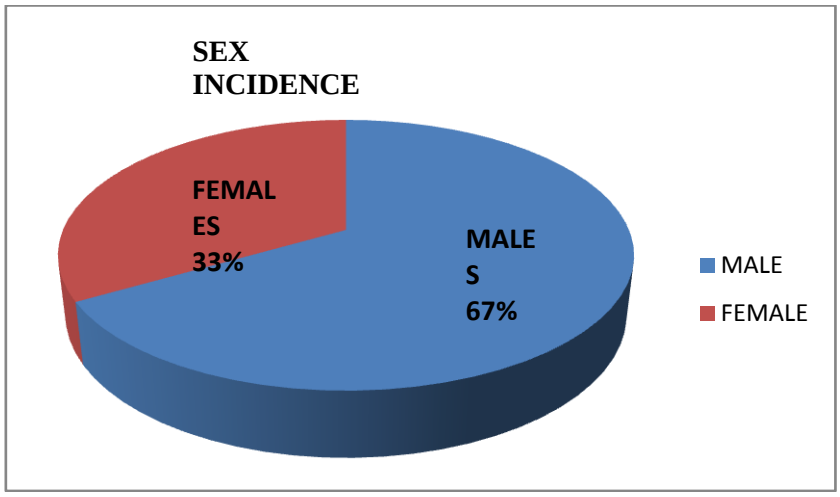
Figure2. Fixation with Locking compression plate

Sex Incidence:

In this study 66.6% were male patients and 33.4% patients were female patients. Highly significant association of this study with male patients.

Table 1: Frequency of Sex incidence

SEX OF THE PATIENT	NO OF PATIENTS	PERCENTAGE
MALE	20	66.6%
FEMALE	10	33.3%
TOTAL	30	100%

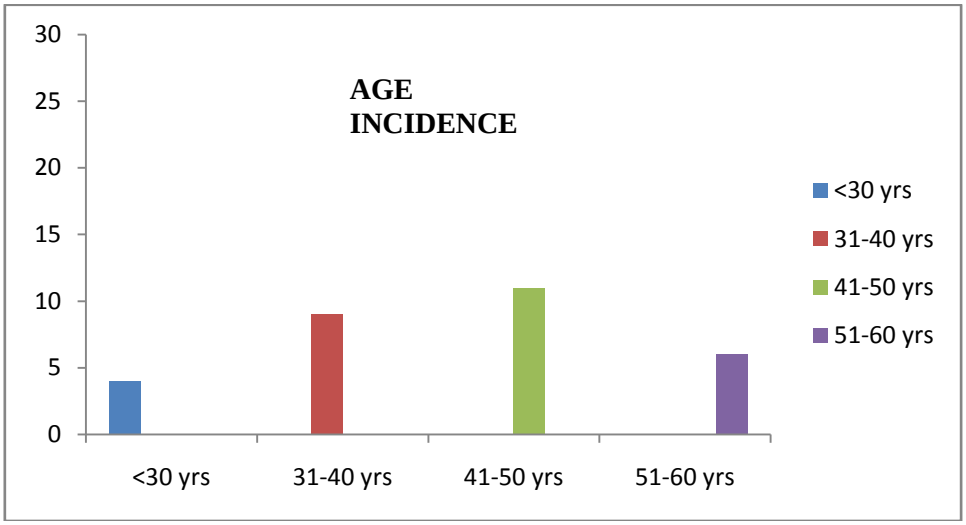


Age Incidence:

In this study 66.6% were in the 3rd and 4th decade. Highly significant association fracture in the 3rd and 4th decades.

Table 2: Frequency of Age incidence

AGE OF THE PATIENT	FREQUENCY	PERCENTAGE
<30	4	13.4%
31-40	9	30%
41-50	11	36.6%
51-60	6	20%
TOTAL	30	100%



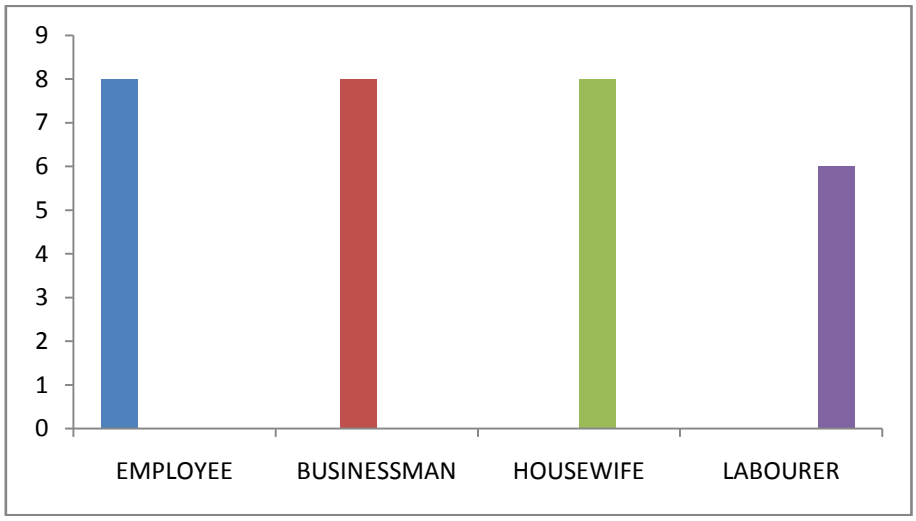
Incidence In Occupation:

The high incidence of fracture is seen in occupation involved in more mobility like businessmen and employee which is around 53.4%.

Table 3: Frequency of Occupational incidence

OCCUPATION	NO. OF CASES	PERCENTAGE
EMPLOYEE	8	26.7%
BUSINESSMAN	8	26.7%
HOUSEWIFE	8	26.7%

LABOURER	6	20%
TOTAL	30	100%



Mode Of Injury:

In this study mode of injury is highly associated with road traffic accident which accounts for about 56.6%.

Table 4: Frequency of mode of Injury

MODE OF INJURY	FREQUENCY	PERCENTAGE
RTA	17	56.6%
FALL FROM HEIGHT	7	23.4%
FALL FROM LEVEL SURFACE	6	20%
TOTAL	30	100%

Side Of Injury:

In this study 63.4% of the patients sustained injury on the left side and 36.6% on the right side. In our study, there was left sided predominance, compared to the right side.

Table 5: Frequency of Side of injury

SIDE OF INJURY	FREQUENCY	PERCENTAGE
RIGHT	11	36.6%
LEFT	19	63.4%
TOTAL	30	100%

Type Of Fractures Schatzker's Classification:

In our study, the majority of the fractures were found to be of type II fracture types i.e. Cleavage combined with Depression fractures

Table 6: Frequency of Type of Fracture

SCHATZKER TYPE OF FRACTURE	NO. OF CASES	PERCENTAGE
TYPE I	5	16.6%
TYPE II	9	30%
TYPE III	7	23.4%
TYPE IV	1	3.4%
TYPE V	3	10%
TYPE VI	5	16.6%
TOTAL	30	100%

Methods of Treatment:

10 cases were managed with Percutaneous cannulated screws, 9 were managed with Buttress plate , 7 by Buttress plate along with Bone graft and 4 cases with Locking plate**.**

Table 7 : Frequency of Methods of Treatment

METHODS OF TREATMENT	NO. OF CASES	PERCENTAGE
PCCS	10	33.3%
ORIF with BP	9	30%
ORIF with BP + BG	7	23.3%

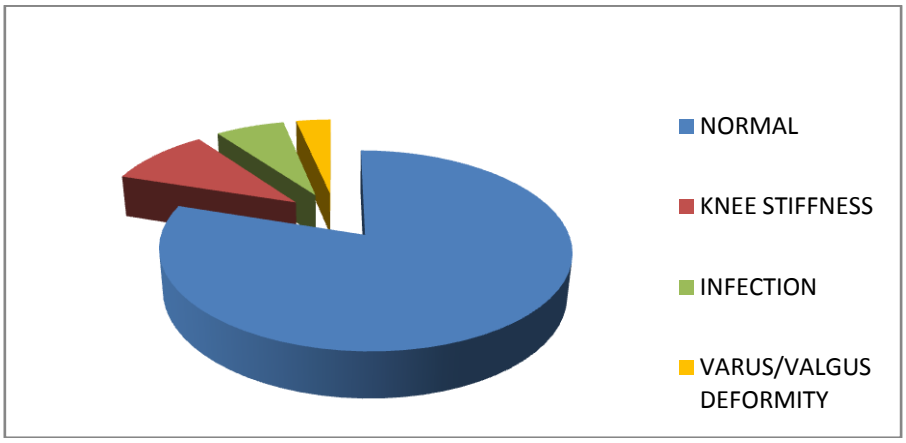
ORIF with LCP	4	13.4%
TOTAL	30	100%

VI. Complications

All fractures united within expected time, not a single nonunion was noted in our series. The cases with wound infection also had stiffness of the knee joint.

Table 8 : Frequency of Complications

COMPLICATION	NO. OF CASES	PERCENTAGE
KNEE STIFFNESS	3	10%
VARUS/VALGUS DEFORMITY	1	3.4%
INFECTION,WOUND DEHISCENCE	2	6.8%
NORMAL	24	79.8%
TOTAL	30	100%



Associated Ligamentous Injuries :

MCL injury was the most commonly associated ligament injury in our series followed by ACL, LCL.

Table 9 : Associated Ligament injury

ASSO. LIGAMENT INJURY	NO. OF CASES	PERCENTAGE
MCL	3	10%
LCL	1	3.3%
ACL	2	6.7%
TOTAL	6	20%

All the ligamentous injuries were managed conservatively by a Brace. The patient's function and outcome were good even without addressing these injuries.

Pain	Points
None	6
Occasional	5
Stabbing pain in certain positions	3
Constant pain after activity	1
Significant rest pain	–3
Walking capacity	
Normal walking capacity for age	6
Walking outdoors (>1 h)	5
Walking outdoors (15 min–1 h)	3
Walking outdoors (<15 min)	1
Walking indoors only	0
Wheelchair/bedridden	–3
Knee extension	
Normal	4
Lack of extension (<10°)	2
Lack of extension (>10°)	0
Lack of extension (>20°)	–2
Total range of motion	
Full	6
At least 120°	5
At least 90°	3
At least 60°	1
<60°	–3
Stability	
Normal stability in extension and 20° flexion	6
Abnormal stability in 20° flexion	4
Instability in extension (<10°)	2
Instability in extension (>10°)	0
Power of quadriceps	
Grade 5	2
Grade 3–4	1
Grade <3	2
Maximum score	30
Excellent	28–30
Good	24–27
Fair	20–23
Poor	<20

Fig.3 Modified Rasmussen Criteria for Clinical Assessment

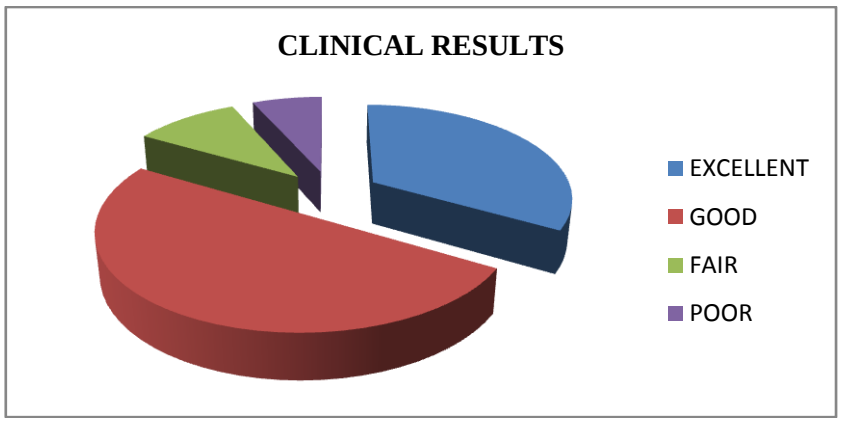
Articular depression	Points
None	3
<5 mm	2
6–10 mm	1
>10 mm	0
Condylar widening	
None	3
<5 mm	2
6–10 mm	1
>10 mm	0
Varus/valgus angulation	
None	3
<10°	2
10–20°	1
>20°	0
Osteoarthritis	
None/no progress	1
Progression by 1 grade	0
Progression by >1 grade	-1
Maximum score	
Excellent	9–10
Good	7–8
Fair	5–6
Poor	<5

Fig 4.Modified Rasmussen Radiological Assessment

Clinical Evaluation: The mean Rasmussen Functional score at final follow up was 25.062 (range 15-30)**.** Out of 30 cases treated with surgical procedure, 10 cases gave excellent result, 15 cases came out with good result, fair in 3 cases and 2 cases had poor result, mainly due to the severity of the injury and infections.

Table 11 : Clinical Assessment

CLINICAL RESULT	NO. OF CASES	PERCENTAGE
EXCELLENT	10	33.3%
GOOD	15	50%
FAIR	3	10%
POOR	2	6.7%
TOTAL	30	100%

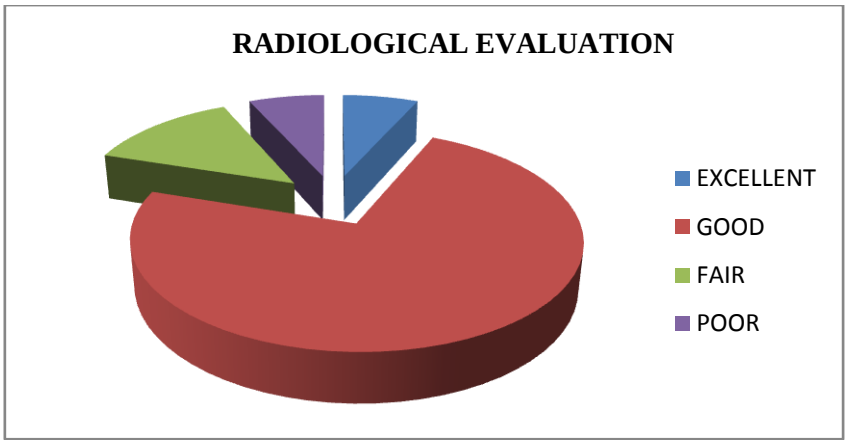


Radiological Evaluation:

The mean Rasmussen Radiological score at final followup was 7.68 (range 0-9). Out of 30 cases treated with surgical procedure, 2 cases gave excellent result, 22 cases came out with good result, fair in 4 cases and 2 cases had poor result**.**

Table 12 : Radiological Assessment

RADIOLOGICAL EVALUATION	NO. OF CASES	PERCENTAGE
EXCELLENT	2	6.7%
GOOD	22	73.2%
FAIR	4	13.4%
POOR	2	6.7%
TOTAL	30	100%



RASMUSSEN'S GRADING

CRITERIA	EXCELLENT	GOOD	FAIR	POOR
Pain evaluation	13	9	8	0
Walking capacity	13	12	3	2
Extension lag	14	12	3	1
Range of movement	15	8	4	3
Stability	20	10	0	0
FUNCTIONAL RESULTS	**10**	**15**	**3**	**2**
RADIOLOGICAL RESULTS	**2**	**22**	**4**	**2**

- It was also noted that Clinical results had no significant association with follow up Radiographs (Chi square test, p value = 0.176**)**

Fig.5 Preoperative Radiograph showing Type II fracture

Fig.6 Immediate Postop X-ray

Fig 7.At 6 months follow up

Fig.8 clinical pictures showing (a) flexion (b) extension (c) sitting cross legged at follow up

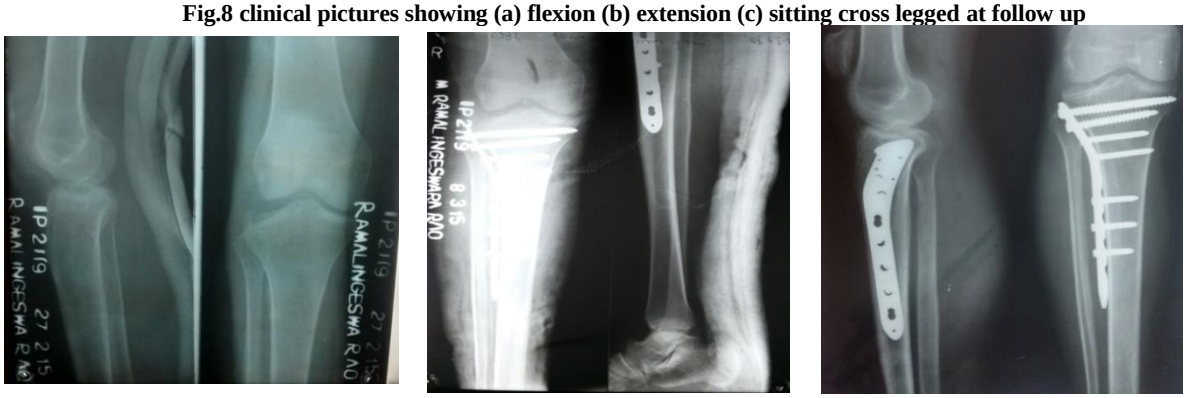


Fig 9.(a) Preop X-ray showing Type III fracture(b) Immediate post op (c) At 6 months follow up

Fig 10.Clinical pictures showing (a) flexion (b) Extension (c) sitting cross legged at 6 months follow up

Fig 11. a) Preop X-ray showing Type IV fracture(b) Immediate post op (c) At 6 months follow up

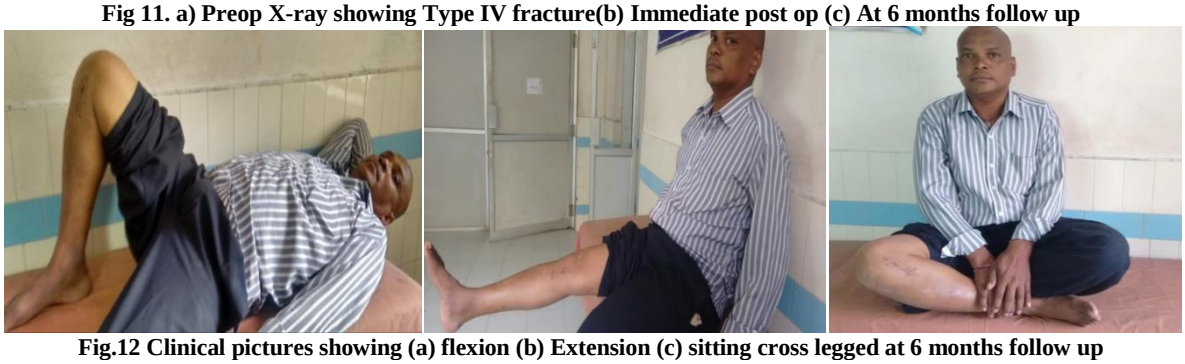


Fig.12 Clinical pictures showing (a) flexion (b) Extension (c) sitting cross legged at 6 months follow up

VII. Discussion

Aim of study is to assess functional outcome in operatively treated tibial plateau fractures in 30 cases. The analysis of the results were made in terms of - age of the patient, sex distribution, occupation, mode of injury, side of fracture, analysis of the types, modalities of treatment, complications, associated injuries and the functional outcome.

Tibial plateau fractures are more commonly seen in the active productive age group (**31-50 years**) due to high-energy trauma. Closed treatment of these injuries has had little success in reducing depressed or displaced fracture fragments, this necessitates open treatment in most displaced and unstable fractures. It is extremely important to do a stable fragment fixation and in order to regain the complete range of motion.

In our series majority of the patients were **Males** . This can be attributed to more involvement in RTA. The significance of tibial plateau fracture-related sex distribution was not available to comment on them.

Occupationally tibial plateau fractures were seen in people with high level of activity, movement and travel. It is most commonly seen with people with **high mobility** like businessmen (26.7%), employees (26.7%), and labourers (20%).In our study, there was **Left** sided predominance, compared to the right side with left side 63.4% and right side 36.6%.In our study, the majority of the fractures were found to be of **type II** i.e. Cleavage combined with Depression fractures account for about 30%. Type IV was least with 3.4%.

In this series we studied 30 cases of tibial plateau fractures treated only by surgical methods. Different authors use different criteria for the surgical management of these fractures. Seppo E, Honkonen conducted 130 tibial plateau fractures taking into consideration the following for the surgical management: -

Condylar widening of > 5mm

Lateral condyle step off > 3mm

All medial condylar fractures

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

In our series we have not formulated any criteria as to particular method of fixation for particular type of fracture. So each case was individualized and treated accordingly as it needed. Most of the type I, some type II were treated with Percutaneous cancellous screw fixation. The split fracture, of>3mm displacement was treated by ORIF. Bone grafting was included along with ORIF with **Buttress plate/LCP** and screws in type II, III, IV, V and VI wherever necessary.

The major problem faced by us during the study was **Knee stiffness** and **Infection**, hence immobilization was more in these patients for stiffness. The infection might be attributed to nosocomial infection.

Inspite of all the associated Ligament injuries and Complications, we were able to achieve 33.4% excellent result, 50% good result (overall 83.4% acceptable results). In addition we have 10% fair and 6.6% poor results.These results are comparable and on par with other documented standard studies.

STUDY	SATISFACTORY RESULTS
Rambold, 1992	93%
Seppo E, 1993	86%
Joseph Schatzker, 1986	86%
Our Study, 2013	**83.4%**

Probably, if we were less invasive at surgery, still more rigid in fixation and further aggressive in physiotherapy, we would not even have had these complications (stiffness & infection) and at the same time would have achieved the best results.

VIII. Conclusion

To manage different types of tibial plateau fractures depends on good clinical judgment. The surgeon must have sound knowledge of the personality of the injury and a clear understanding of the knee examination, imaging studies and must be familiar with variety of techniques available at present for treating tibial plateau fractures.

The conclusions of these studies are:

1) Displaced condylar fractures of tibial plateau those belonging to Schatzker's type I , the treatment of choice is Closed reduction internal fixation/Open reduction internal fixation with Cannulated cancellous screws. Results are excellent to good by this method.
2) The main aim of surgical treatment include accurate reconstruction of the articular surface with elevation of the depressed bone fragment, bone grafting, stable fragment fixation allowing early range of movement.
3) Schatzker's typeII, III managed operatively with ORIF with Buttress plate and bone grafting gives good to fair results.
4) In Schatzker's type IV fractures which were managed by ORIF and Buttress plating had fair to good results.
5) In high velocity injuries belonging to Schatzker V and VI which were managed with Buttress plate/LCP , number of good to fair results were seen. This is mainly due to adequate reconstruction of the articular surface during operative period and prevention of collapse of reconstructed articular surface.
6) Complication seen in our series are knee stiffness, infection and wound dehiscence and valgus or varus deformities these complications are mainly seen in high energy injuries (Schatzker's type V,VI).
7) Retrospectively it was found that high velocity injuries (type V – VI) have poor outcome than low velocity injuries (type I-IV)[38].
8) It was also noted that Clinical results had no significant association with follow up Radiographs.

IX. Summary

This is a study of surgical management of tibial plateau fractures involving 30 patients and followed up over 18 months. In our series all patients were treated operatively out of which 10 were managed by CRIF with Percutaneous cannulated cancellous screws, 7 patients were managed by ORIF with Buttress plate and Bone grafting , 9 patients were managed by ORIF with Buttress plate and 4 with LCP. Patients were followed up for a minimum period of 6 months. Functional evaluation of the knee was done, based on Rasmussen clinical and radiological criteria.

Our series concludes that closed reduction and internal fixation with Percutaneous cannulated screws is the treatment of choice for displaced fractures belonging to Schatzker type I . Schatzker's type II, III fractures have good results when managed operatively with ORIF with buttress plate and bone grafting. Schatzker's type V and VI managed by ORIF with Buttress plate/ LCP and bone grafting provides perfect anatomical reconstruction of the articular surface, stable fixation and early mobilization and has good results.

There were minimal to moderate complications seen in operatively managed patients and high velocity injuries patients. Surgical reconstruction of the articular surfaces reduced the incidence of osteoarthitis. It would be preferable to do follow up for longer period to know the exact incidence of posttraumatic osteoarthritis and other late complications.

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