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Dr. Ravikumar Rajappan
Additional Professor in
Orthopaedics, Department of
Orthopaedics, Govt. Medical
College, Kozhikode, Kerala,
India

Dr. Ravikumar V
Additional Professor in
Orthopaedics, Department of
Orthopaedics, Govt. Medical
College, Kozhikode, Kerala,
India

Dr. Suhail AP
Junior Resident in Orthopaedics,
Department of Orthopaedics,
Govt. Medical College,
Kozhikode, Kerala, India

Correspondence
Dr. Ravikumar V
Additional Professor in
Orthopaedics, Department of
Orthopaedics, Govt. Medical
College, Kozhikode, Kerala,
India

Functional outcome of tibial plateau fractures, Schatzker type V and VI treated surgically with plate osteosynthesis

Dr. Ravikumar Rajappan, Dr. Ravikumar V and Dr. Suhail AP

Abstract

Introduction: Tibial plateau fractures are serious injuries resulting frequently in functional impairment. For the more severe form of injury which results in comminuted tibial plateau fractures (Schatzker type V and VI) the ideal mode of treatment is always debatable. Aim of Management in tibial plateau fractures are anatomic reduction of the articular surface, restoration of axial alignment, and stable fixation which can be achieved very well by open reduction and internal fixation (ORIF), using a plate and screws.

Objective: To study the functional and radiological outcome of Tibial plateau fractures, Schatzker type 5 and 6 treated surgically with plate osteosynthesis.

Methods: 30 patients in the age group 18-60 were selected. Prospectively followed up clinically and radiologically for minimum one year. Functional assessment was done with Knee Society Score and Radiological evaluation done by Rasmussens score.

Results: Functional outcome as assessed by Knee Society Score had excellent to good results while the radiological outcome as assessed by Rasmussens criteria too had good results. The average duration for fracture union was 15.2 weeks. 18(60%) patients had at least 120degrees or above of flexion. The infection rate in this study was accounted as 16.6%. 6 patients out of the study group had varus or valgus deformity.

Conclusion: Open reduction and internal fixation by plate osteosynthesis of closed Tibial plateau fractures, Schatzker type V and VI has good functional and radiological outcome and is an effective method of treatment even with moderate soft tissue injury when adequate healing period is given which minimised postoperative complications such as infection.

Keywords: Tibial plateau fractures, Schatzker type V and VI, plate osteosynthesis, knee society scoring, Rasmussens criteria

Introduction

Management of fractures has been evolving continuously over several centuries. The quest has always been for treatment modalities that achieve the best possible functional outcome. The fact that such a pursuit continues till date reflects that such "ideal" treatment protocols remain to be defined in the management of fractures. This uncertainty exists more evidently in the management of intra-articular fractures, with the upper end of tibia being no exception.

Knee joint is an important joint as it is involved in varied functions like load bearing, walking, running, sitting etc. Knee joint is comprised of distal femur, proximal tibia & patella. Injuries of the knee must be treated properly to maintain a good knee function.

The tibial plateau refers to the flattened articular surface of the upper end of tibia. The fractures of the proximal tibia involving the articular surface are referred to as tibial plateau fractures (TPF). Fractures of the tibial plateau represent 1% of all fractures and approximately 8% of fractures occurring in the elderly [1, 2]. These are serious injuries resulting frequently in functional impairment.

The goals [3] in treating fractures of the tibial plateau are:

1. To restore the joint space
2. To restore the correct mechanical alignment of the limb
3. To achieve optimal healing of bone, tendon and ligaments and
4. To allow painless full range of motion of the knee.

The optimal treatment of tibial plateau fractures has been a source of controversy for a long time. They were managed both by non-operative and operative methods.

Numerous investigators report satisfactory results using either closed or open treatment methods, especially for the less severe type injuries that occur as a result of low energy. For the more severe form of injury which results in comminuted tibial plateau fractures (type V and VI) the ideal mode of treatment is always debatable. Conservative mode of management, Open reduction and internal fixation, closed reduction and percutaneous fixation, Hybrid external fixation has all been suggested [4].

Management aims in tibial plateau fractures are anatomic reduction of the articular surface, restoration of axial alignment, and stable fixation to prevent secondary displacement of the fracture fragments. This can be achieved very well by open reduction and internal fixation (ORIF), using a plate and screws through various approaches. Though this method is not without its own demerits like skin necrosis and infection, still this method is an excellent management technique by proper selection of patients, adequate preoperative soft tissue healing time and careful raising of skin flaps during surgery.

In this study we are analyzing prospectively the functional and radiological outcome of open reduction and internal fixation of these high-energy injuries, which resulted in closed Schatzker type V, VI proximal tibia fractures using plate osteosynthesis.

Aim of Study

To study the functional and radiological outcome of Tibial plateau fractures, Schatzker type 5 and 6 treated surgically with plate osteosynthesis.

Materials and Methods

Study Design: Prospective study

Study setting: Department of Orthopaedics Govt Medical College, Kozhikode

Study population: Patients attending orthopaedic casualty and out-patient department at Govt. Medical College, Kozhikode

Inclusion criteria

1. Schatzker's type V and VI tibial plateau fractures.
2. Patients above 18 years and below 60 yrs.
3. Closed fractures

Exclusion Criteria

1. Schatzker's type I, II, III, IV tibial plateau fractures
2. Fractures treated conservatively and by other surgical methods
3. Age below 18 years
4. Those associated with other fractures of ipsilateral lower limb, pelvis or spine
5. All Compound fractures
6. Those associated with vascular injuries

Sample size: 30

Study period: August 2015 - August 2017

Source of data : During the period between August 2015 to August 2017, 30 patients with Schatzker type V or VI tibial plateau fracture were treated by plate osteosynthesis and followed up to evaluate the results. All the required data was obtained from the patients during their stay in the hospital or during follow up and recorded in the proforma.

Management

All cases of type V or VI Schatzker tibial plateau fractures on presentation to the emergency department were treated by initial resuscitation and temporary stabilization of fracture in plaster slab or by lower tibial skeletal traction and later treated by definitive surgery.

Plain X rays were taken in the antero-posterior and lateral views and the following points noted.

- Schatzker type V or VI tibial plateau fracture confirmed.
- Amount of articular surface widening
- Amount of articular surface depression

In highly communicated fractures, CT scan with 3D reconstruction was done to know about the fracture fragments. CT scan will provide images of the proximal tibia in several constructed planes. These images graphically demonstrate fracture lines and the direction and degree of fragment displacement and are used as a preoperative planning tool. The choice of surgical approach and placement of plates and screws is decided according to the CT scan evaluation and 3 column classification (Medial column, lateral column and posterior column).

Preoperative and postoperatively antibiotics were given for all patients

If there is extensive soft tissue injury, as indicated by soft tissue oedema or fracture blisters, surgery will be delayed. The limb will be elevated and immobilised in slab or with skeletal traction or by means of external fixation. Once the soft tissues become better, as evidenced by resolution of the oedema and the fracture blisters and appearance of skin wrinkles, the patient will be taken for surgery.

Surgical Technique

Anaesthesia, Patient Positioning and Tourniquet

Patients are operated under regional or general anaesthesia. They are placed in the supine position on the radiolucent table with a sand bag under the ipsilateral gluteal region for the anterolateral approach, which is removed while starting the medial approach. The sand bag is placed under the contralateral hip if a posteromedial approach is used. Tourniquet may or may not be used according to surgeon preference.

Approach

All the patients will undergo open reduction through an anterolateral approach, and/or a minimally invasive medial or an open posteromedial approach, and internal fixation with a lateral plate, and/or medial or posteromedial plate. Surgeries will be performed under fluoroscopic control to aid and assess the reduction.

Fracture reduction and fixation

As the first step, indirect fracture reduction, under image intensifier guidance, is achieved by longitudinal traction provided by the assistant. Percutaneously drilled Kirschner wires are then used as joysticks to fine-tune the reduction of individual fragments or to correct the tilt of articular fragments. The reduced fragments are then provisionally fixed with Kirschner wires. The Kirschner wires are later replaced with interfragmentary screws, either separately or through the plate. The articular reduction is further verified during open reduction by direct visualization through submeniscal arthrotomy. Articular surface depressions are also elevated under direct visualization through the submeniscal arthrotomy, supplemented by the image intensifier. The depressed fragment is elevated

with compacted cancellous bone beneath it and the resultant metaphyseal void is filled with autogenous cancellous or synthetic bone graft. After provisional reduction and fixation with Kirschner wires, open reduction is done. Medial column is fixed first usually. If the medial condyle is severely comminuted, then the lateral column is fixed first to maintain the length. The minimally invasive posteromedial approach utilizes a 1-inch longitudinal skin incision. The medial or the posteromedial fragment is exposed subperiosteally by elevating the pes anserinus with a periosteal elevator. After reducing the fragment, a small buttress plate is slid beneath the pes anserinus. Image intensifier is utilized to position the plate below the level of the joint line and the plate is then fixed to the bone with screws inserted through stab incisions. If the medial fragment is more posterior, the open posteromedial approach is used. The skin is incised 1 cm posterior to the posteromedial border of the proximal tibia, curving proximally along the line of tibia. The minimally invasive posteromedial approach utilizes a 1-inch longitudinal skin incision. The medial or the posteromedial fragment is exposed subperiosteally by elevating the pes anserinus with a periosteal elevator. After reducing the fragment, a small buttress plate is slid beneath the pes anserinus.



Fig 1: Type 6 Schatzker - Anterolateral incision



Fig 2: Posteromedial incision



Fig 3: Posteromedial and Anterolateral incisions



Fig 4: Posteromedial plate applied



Fig 5: After closure

The minimally invasive posteromedial approach utilizes a 1-inch longitudinal skin incision. The medial or the posteromedial fragment is exposed subperiosteally by elevating the pes anserinus with a periosteal elevator. After reducing the fragment, a small buttress plate is slid beneath the pes anserinus. Image intensifier is utilized to position the plate below the level of the joint line and the plate is then fixed to the bone with screws inserted through stab incisions. If the medial fragment is more posterior, the open posteromedial approach is used. The skin is incised 1 cm posterior to the posteromedial border of the proximal tibia, curving proximally along the line of the pes anserinus tendons. The saphenous vein and nerve are identified and retracted anteriorly. The deep fascia is incised to expose the pes anserinus tendons and the medial head of the gastrocnemius. The pes anserinus tendons are retracted anteriorly and the medial head of the gastrocnemius is gently retracted laterally to expose the posteromedial aspect of the proximal tibia. The fracture edges are exposed to aid in visualizing reduction. The posteromedial fragment is reduced and fixed provisionally with Kirschner wires under the guidance of the image intensifier. The fragment is then stabilized with a posteromedial plate. A proximal tibial buttress plate or locking proximal medial tibial plate may be used. For anterolateral approach, a curvilinear longitudinal incision is made starting from the lateral femoral epicondyle and passing over the Gerdy's tubercle and running parallel to the shin and 1 cm lateral to it. The iliotibial band is elevated from the Gerdy's tubercle and the underlying capsule. The tibialis anterior is elevated subperiosteally to expose the lateral surface of the lateral tibial condyle and shaft. A buttress plate or a lateral tibial head plate

or an anatomical lateral tibial locking plate is used to fix the lateral column. After fixation, the tourniquet is released and hemostasis is achieved. The surgical incisions are closed over a suction drain.

Postoperative protocol

Postoperatively, the knee is immobilized in slab. The data regarding the postoperative rehabilitation, antibiotic prophylaxis, and development of any complications are noted. Postoperative radiographs are reviewed to assess the adequacy of articular reduction, metaphyseal-diaphyseal reduction, and alignment. Non weight-bearing mobilization and quadriceps exercises, are started on the 10th postoperative day (POD). 1st post-operative wound inspection is done on 3rd post operative day. Suture removal is done on 10th post-operative day and the slab is removed and non-weight bearing mobilization and quadriceps exercises are started. Protected weight bearing ambulation is commenced after 12 weeks.

Follow up

Patients are called for review at 4 weeks, 8 weeks, 12 weeks, and at monthly intervals thereafter till bony union and maximal functional recovery, to assess the fracture healing and knee joint movements.

The outpatient records are reviewed to obtain data regarding pain, disability, wound healing, and range of movements of the knee. Follow-up radiographs are reviewed to note the time to union, any loss of articular reduction, fixation failure, or deformity. After clinical and radiological union, data regarding the functional recovery, such as walking ability, ability to climb and descend stairs, and activities of daily living are recorded. Return to pre-injury employment and ability to participate in sporting activities is also noted.

All the patients who satisfied the selection criteria are called for follow up at the end of the study period. Radiographs of the knee and leg in supine position are obtained in the antero-posterior (AP) and lateral planes to assess the articular congruity, the metaphyseal-diaphyseal alignment, and any evidence of new arthritic changes. The patients are questioned regarding functional recovery and their responses noted. The results are analyzed.

Outcome Measurement

Functional Outcome assessed by Knee Society Score

Radiological outcome by Rasmussen criteria

The knee objective score and functional scores are considered separately. They are graded as follows.

80-100	:	Excellent
70-79	:	Good
60-69	:	Fair
below 60	:	Poor

The Rasmussen radiological scores are graded as follows

18	:	Excellent
12-17	:	Good
6-11	:	Fair
<6	:	Poor

Results & Observations

The primary data obtained from the series of 30 patients who underwent surgery was statistically analyzed. The statistical methods employed and the results thus obtained are presented herewith.

Statistical methods employed

a) Descriptive statistics

This refers to measures of location and spread. The measure of location is expressed in the form of arithmetic mean (average), median or mode and the measure of spread is expressed as a range (minimum and maximum) or standard deviation.

b) Frequency distribution

It is an analysis to determine the number of variables or observations that fall into a predetermined category or group. It is useful in analyzing the incidence of a characteristic in different study groups.

c) Contingency co-efficient analysis (cross tabs procedure)

The cross tabs procedure is a method of organizing experimental data into two-way and multi-way tables that can then be subjected to a variety of tests and measures of association. The structure of the table and whether or not categories are ordered, determine what test or measure is to be used.

Chi-square test

It is a method to test the significance of difference between two proportions. The variables are divided into categories and the expected frequencies in each category are compared with the actual observed frequencies in that category and a Chi-square statistic is computed.

$$X^2 = \sum (O-E)^2 \div E$$

O = observed frequency

E = Expected frequency

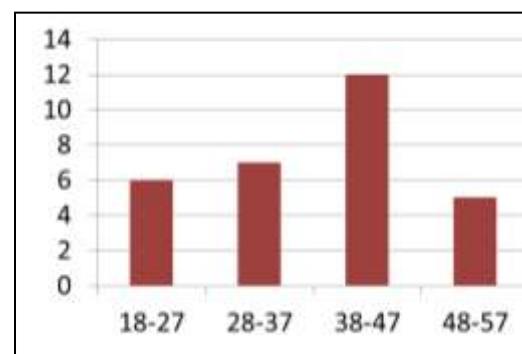
The 'P' (probability) value for that particular χ^2 statistic is calculated. A P value of < 0.05 is taken to be significant. A significant P value implies that the difference noted between the observed and expected frequencies is statistically significant and is not due to chance.

One way Anova

ANOVA is an acronym for 'analysis of variance'. The variability in the experimental values obtained in a study is due to intra-group and inter-group variations, in an ANOVA test these inter and intra-group variances are compared to determine whether the variability found in the results can be attributed to known differences between groups or not. One-way ANOVA is done if the experimental groups differ in terms of only one factor at a time.

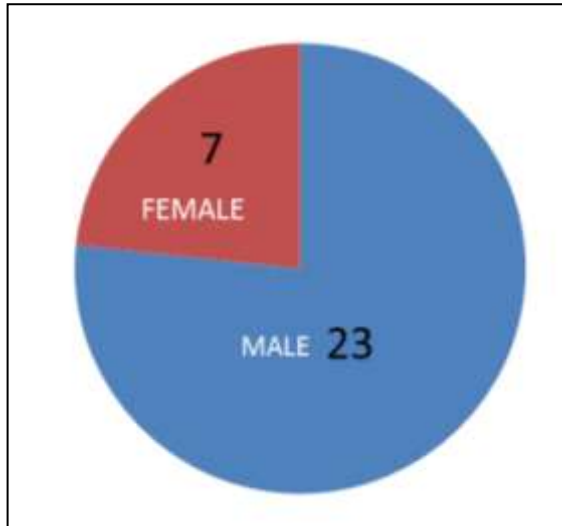
1 Age of incidence

Majority of the patients is in the age group 38-47 years. Youngest patient is 20 years old. Oldest is 56 years old.



Graph 1: Age Incidence

2 Sex



Graph 2: Sex Incidence

3. Side of affection

Of the 30 cases Right side was involved in 19 and Left side in 11

4. Mechanism of injury

Out of 30 patients 28 are affected by high velocity injuries like road traffic accidents or fall from height etc.

5. Time of presentation

93.3% (28 out of 30) of the patients presented on day 1 of the injury

6. Initial mode of immobilisation

Majority (80%) of the patient were immobilised in POP slab temporarily before definitive surgery. 20% cases were treated by skeletal traction

7. Associated injuries

2 patients had head injury, One had chest injury and 5 patients had other associated fractures

8. Co-morbidities

3 Patients had hypertension, 2 had Diabetes mellitus and one had coronary heart disease

9. Timing of surgery

53% (16 out of 30) of the patients were operated within 2 weeks of surgery. The average delay for definitive surgery was 12 days. There was a minimum delay of 6 days and maximum delay of 26 days.

10. Type of fracture

60% (18 out of 30) of the fractures were Schatzker classification type VI fractures.

Table 1: Schatzker Classification Type

Type	Frequency	Percent	Valid Percent	Cumulative Percent
Type V	12	40.0	40.0	40.0
Type VI	18	60.0	60.0	100.0
Total	30	100.0	100.0	

11. Surgical approach and single/dual plating

Majority of the patients (17 out of 30) underwent Single plating via either anterolateral or posteromedial approach and 13 patients were managed with dual plating technique with a combined approach

12. Fracture union

The average duration for fracture union was 15.2 weeks. The maximum duration for union was 30 weeks in one patient and minimum duration was 10 weeks in 3 patients. None of the patients had non-union.

13. Pain

12 patients (40%) had mild pain, 4 had moderate pain (13.3%) and 2 patients had severe pain (6.6%). Remaining 12 patients had no pain.

14. Flexion of knee joint

Maximum flexion achieved was 145 degrees (2 patients) and minimum was 60 degrees. Out of 30, 18(60%) patients had atleast 120degrees or above of flexion, 7 had atleast 90 degrees or above and in 3 patients flexion achieved was of atleast 60 degrees

15. Extensor lag

Table 2

Extension Lag	Frequency	Percent	Cum Percent
<10 Degree	1	3.3	3.3
10-20 Degree	2	6.6	10
>20 Degree	1	3.3	13.3
Nil	26	86.7	100
Total	30	100	

16. Deformity (varus/valgus)

Table 3

Alignment	Frequency	Percent	Cum Percent
5-10°	24	80	80
0-4°	4	13.3	93.3
11-15°	2	6.7	100
Total	30	100	

17. Infection

5 patients had post-operative infection. Out of these 5, 3 had superficial infections which responded to sensitive antibiotics according to pus culture and sensitivity. 2 had deep infections which was treated by wound debridement and antibiotic bead.

Table 4: Residual Widening Of Condyles

Widening	Frequency	Percent	Cum Percent
Nil	10	33.3	33.3
1-5	15	50	83.3
6-10	3	10	93.3
>10	2	6.7	100
Total	30	100	

Table 5: Residual Articular Depression

Depression	Frequency	Percent	Cum Percent
<5mm	4	13.3	13.3
6-10mm	2	6.6	20
Nil	24	80	100
Total	100	100	

Table 6: Knee Society Objective Score

Kss Score	Frequency	Percent
Excellent	19	63.33
GOOD	9	30
FAIR	2	6.67
POOR	0	0
	30	100

Table 7: Knee Society Functional Score

Kss Function Score	Frequency	Percent
Excellent	12	40
Good	13	43.3
Fair	3	10
Poor	2	6.7
Total	30	100

Table 8: Rasmussen’s Radiological Score

Radiological Score	Frequency	Percent
Excellent	9	30
Good	16	53.3
Fair	5	16.7
Poor	0	0
Total	30	100

Case Illustrations

CASE 1



Fig 6: Type VI Schatzker fracture



Fig 8: 3 months followup



Fig 9: 11 months followup



Fig 7: Immediate Post operative xray



Fig 10: Functional outcome flexion at 12 months followup



Fig 11: Extension at 12 months followup



Fig 12: Type VI fracture

Case 2

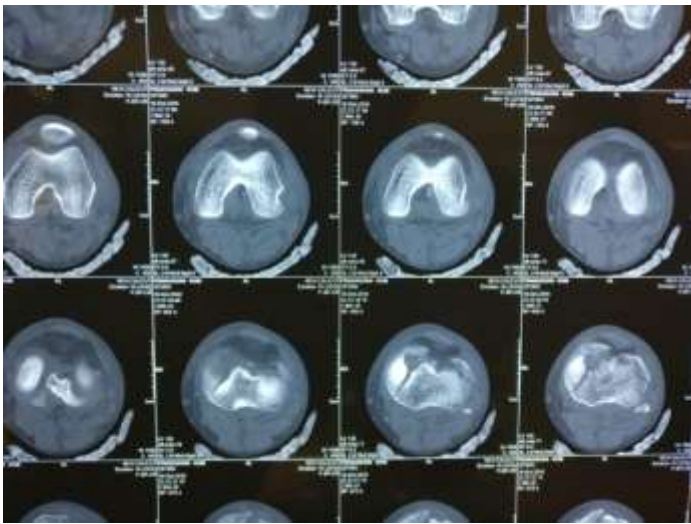


Fig 13: CT Scan showing the type of fracture

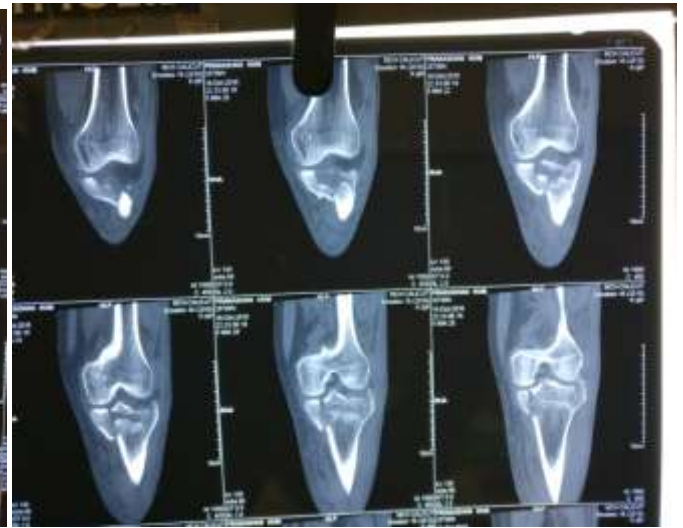


Fig 14: Immediate post operative X-ray



Fig 15: 6 months followup x-ray



Fig 16: 12 months followup xray



Fig 17: Flexion extension 12 months postop

Case 3

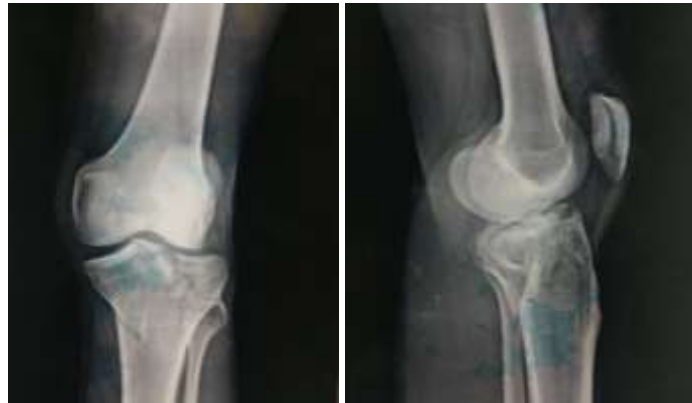


Fig 18: Type V Schatzker fracture



Fig 19: CT Scan



Fig 20: Immediate Post operative Xray



Fig 21: 3 Months followup X-ray



Fig 22: 6 months and 10 months postoperative X-ray



Fig 24: Type V Schatzker fracture



Fig 23: Functional Outcome after 11 months postoperative
CASE 4



Fig 25: CT Scan



Fig 26: 3 Months followup X-ray



Fig 27: 10 months Followup X-ray



Fig 28: Functional Outcome after 12 months followup

Discussion

Fractures of the tibial plateau have the potential to be devastating injuries especially when they have significant bony and soft tissue involvement along with knee instability and incongruity as in type V and VI injuries^[5].

Management of intraarticular fractures has always been a matter of considerable ambiguity and confusion, with the proponents of conservative as well as surgical management claiming superiority over the other. Management of Tibial plateau fractures is no exception in this scenario.

A review of the previous published articles reveals that a comparison of the contemporary studies is difficult mainly due to lack of well-defined criteria for selection of cases and the method of fixation. Even though there are a variety of treatment options like conservative methods, external fixation techniques, limited internal fixation plus external fixation, minimally invasive plate osteosynthesis and open reduction and plating, none of them has emerged as standard method of treatment. Each of these techniques has their own advantages and disadvantages. Considering all these facts we conducted a study on Functional and Radiological Outcome of Tibial Plateau Fractures, Schatzker Type V and VI Treated with Plate Osteosynthesis.

Age and sex incidence

In this series of cases, the average age of the patient was approximately 39.44 years. Majority of the patients were aged between 38-47 years. Mean age as reported by Yong Zhang *et al.*^[6] in their study was 37.7 and by Ebrahim Ghayem Hassankhani *et al.*^[7] was 35 and by G. Thiruvengita Prasad *et al.*^[8] was 40 years. Thus we can conclude that the younger section of our community is more likely to sustain these fractures.

In our study, the male female ratio was almost 4:1. Out of the total 30 patients studied, 23 (76.6%) patients were male and rest 7 (23.6%) patients were females. Study by G. Thiruvengita Prasad *et al.*^[8] had 33 (82.5%) male patients and 7 (17.5%) female patients and in a series of 22 cases there were 16 men and 6 women in a study by Ebrahim Ghayem Hassan Khani *et al.*^[7]. This indicates that since men are involved more in outdoor activities than females they are more likely to sustain these fractures.

Mode of Injury

In this series the vast majority of patients (28 out of 30 cases) had sustained fracture following high energy trauma like road traffic accidents or fall from height etc. Only 2 patients sustained this fracture from a low energy trauma like a simple fall. Yonzz Hang e al⁶ had 89.9% cases sustained by road traffic accidents and the remaining due to other causes. In the study by G.

Thiruvengita Prasad *et al.*^[8] all of his cases (100%) had sustained this fractures due to road traffic accidents.

Majority of patients had a right sided fracture (19 out of 30).

Management of the fracture

All patients were immobilised initially by either in plaster (26 out of 30) or by temporary stabilization using lower tibial skeletal traction (4 out of 30).

In this series, in majority (16 out of 30) of patients the surgery was done in the 2nd week. 10 patients had surgery in the 3rd week and the remaining 3 and 1 underwent surgery in the 1st and 4th week respectively. In a case series study by cong-fengluo *et al.*^[9], the mean injury- surgery interval was 8.5 days while study by T. Gosling *et al.*^[10] showed average delay before surgery of 7.5 days. The patients who were operated late had poor results radiologically because of difficulty in achieving articular reduction, but functional results were fair to good.

Out of 30, 18 were Schatzker type VI and 12 Schatzker type V. So our study points common occurrence of type VI than type V.

Though there is widespread evidence that knee ligament injuries associated with tibial plateau fractures must be repaired, primary repair is not always indicated. Primary repairs, ligament augmentation and reconstruction are difficult because of the presence of a fracture and associated internal fixation devices. Primary repair may prolong the operative time and predispose to infection. The menisci were not routinely visualized in this series. And no meniscal or ligamentous injuries were treated operatively. None of our patients appeared to have symptoms related to residual abnormalities of meniscal injuries. Any meniscal injuries were not severe enough in relation to the osseous injury to be clinically important or probably they healed during the treatment of the fracture.

3 patients had associated upper limb fractures like 1 with ipsilateral shaft of humerus fracture, 1 with ipsilateral distal end radius fracture and other with contralateral distal radius fracture. 1 patient had associated head injury and another with chest injury. 4 patients had contusions or lacerations of the other extremities. Five patients were associated with some medical disorders like diabetes mellitus, hypertension etc.

In this series, most of the patients (17 out of 30) underwent Single plating via either anterolateral or posteromedial approach and 13 patients were managed with dual plating technique with a combined anterolateral and posteromedial approach.

The mean duration of hospital stay was 3.5 weeks.

Most of the patients were followed up for a period of at least 12 months. The longest followup was 18 months and the shortest was 8 months. Average duration of follow up is 13 months.

Fracture Union

In our study the average duration for fracture union was 15.2 weeks. The maximum duration for union was 30 weeks in one patient and minimum duration was 10 weeks in 3 patients. None of the patients had non union. Yong Zhang *et al.* [6] reported mean duration of union 14.1 weeks in their study. Cong-fengluo *et al.* [59] found mean union time to be 13.1 weeks while Ebrahim Ghayem Hassan Khani *et al.* [7] recorded an average of 15 weeks for radiological union. In a case series by James P Stannard *et al.* [11] he found a mean union time of 15.6 weeks. So time for fracture union was more or less similar to other studies in the literature.

Infection

5 of our patients had infection. That accounts for 16.6% of the study group. Of these 3 patients had superficial infection which was managed with proper antibiotics according to pus culture and sensitivity and regular dressing. 1 patient needed wound debridement for control of infection and 1 in addition to all these needed antibiotic bead placement. In the study of high energy proximal tibial fractures by dual plate fixation by Ebrahim Ghayem Hassan Khani *et al.* [7], 2 out of 22 patients had infection. Yong Zhang *et al.* [6] reported superficial infection in 4 patients in buttress plate group and 2 patients in combination group and deep infection in 2 & in 1 patients in buttress plate group and combination group respectively. In a series of 29 patients studied by Steven N. Shah, M.D and Madhav A. Karunakar [12] in 2007, they reported overall infection rate of 17 % with deep infection being 13%. Deep infection rate of 8.4 % was reported in a study of 83 patients treated with dual plating by Barei *et al.* [13].

Evaluation

All patients were followed up regularly and evaluated using Knee Society Score for assessing clinical and functional outcome and by Rasmussen's score for radiological outcome.

Pain

2 patients had severe pain, 4 had moderate pain and 12 patients had mild or occasional pain

Range of Movements

Maximum flexion achieved was 145 degrees (2 patients) and minimum was 60 degrees. Out of 30, 18(60%) patients had at least 120 degrees or above of flexion, 7 had at least 90 degrees or above and in 3 patients flexion achieved was of at least 60 degrees. 4 patients had extensor lag out of which 2 had 20 degrees, 1 cases with 10 degrees lag and the other 5 degrees. The flexion contracture was recorded in 2 patients both with 10 degrees of deformity. The average flexion achieved was 114.6 degrees. Yong zhang *et al.* [6] showed mean range of motion to be 121.2 degrees while Yunfeng Yao, *et al.* [14] reported the average range of motion in their study as 115 degrees.

Stability

21 patients had anteroposterior movement of less than 5 mm, 7 patients with movement between 5-10mm and 2 cases had more than 10mm movement.

19 patients had mediolateral movement of less than 5 degrees, 8 had movement between 6-9 degrees, 2 cases with an instability of 10-14 degrees and 1 with more than 15 degrees.

Residual Deformity

24 patients had no residual deformity. A valgus angle of more

than 10 degrees and any varus angle is considered significant. 2 patients had a valgus deformity of more than 10 degrees and 4 cases had a varus of 3 degrees. Study by Yu *et al* reported 3 cases of varus deformity, 2 cases of valgus deformity.

Residual Widening

Residual widening of the articular surface (1-5mm) was seen in 15 patients. 3 patients had widening between 6-10mm while 2 had more than 10mm widening and 10 cases had no widening.

Depression

In our study, depression of articular surface less than 5 mm was seen in 4 patients and between 6-10 in 2 patients. A study was conducted by PJ Struben to describe the moulding of the tibial plateau in response to flexion and extension of knee. He concludes that early movement (following TPF) consisting of flexion and extension but avoiding rotation, varus or valgus, encourages the joint surfaces to mould to their original shape.

Knee Society Score

Objective scoring: 19 patients had excellent, 9 cases had good 2 patients had fair scores.

Functional Scoring: 12 patients had excellent, 13 cases good, 3 patients fair and 2 cases with poor results.

Radiological Outcomes

Evaluated by Rasmussen's radiological assessment.

9 patients had excellent, 16 patients with good and 5 cases had fair scores.

There was no statistically significant correlation between radiological evaluation according to Rasmussen's criteria and objective Knee Society Scoring ($p=0.772$), and between Rasmussen's criteria and functional Knee Society Scoring. ($p=0.902$).

It is also worth mentioning that type 5 schatzker type have slightly good KSS objective and functional scores compared to type 6 schatzker and the correlation between them is significant ($p=0.036$) and there is no statistically significant association between Schatzker type and radiological outcome.

According to our study it is noted that there is also no statistically significant association between type of plating (Single/Dual) and functional Knee Society Score ($p=0.232$), and between type of plating and radiological outcomes ($p=0.627$)

Conclusion

The following conclusions can be derived from our study:

- Open reduction and internal fixation by plate osteosynthesis of closed Tibial plateau fractures, Schatzker type V and VI is an effective method of treatment even with moderate soft tissue injury when adequate healing period is given.
- This technique can achieve articular reduction and restore the maximal joint stability and congruity, which are essential for articular cartilage regeneration.
- The radiological outcome was good which correlates with the articular reduction and stability of fracture fixation achieved by this technique.
- This technique also proved to give us excellent to good functional outcome.
- Schatzker type 5 fracture have slightly improved functional outcome compared to type 6 fracture.
- Superficial infection is the commonly encountered complication in these fractures postoperatively, but by proper and careful handling of the tissue envelope, this complication was minimised.

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