



RESEARCH ARTICLE

FUNCTIONAL OUTCOME OF SCHATZKER TYPE VI TIBIAL CONDYLE FRACTURE TREATED BY ILIZAROV HYBRID EXTERNAL FIXATOR – A CLINICAL STUDY

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Abstract

Background: Treatment of Tibial Plateau Fracture, especially Schatzker type VI tibial condyle fractures is a fascinating therapeutic challenge, because of the complex fracture pattern in a bio-mechanically complex joint, wide range of associated soft tissue injuries and the poor functional outcomes with either conservative or surgical managements proposed until now. **Methods:** we prospectively evaluated the clinical and functional outcome of Schatzker type VI tibial condyle fracture treated by Ilizarov hybrid external fixator in a series of 20 patients. **Results:** According to IOWA knee evaluation, 8 patients had excellent results, 7 patients had good and 5 patients had fair results. The subjective, clinical and functional results were excellent in majority of the patients based on criteria of Honkonen and Jarvinen. **Conclusion:** Ilizarov hybrid external fixation offers a better alternative technique in the treatment of complex tibial plateau fractures especially type VI Schatzker. This technique involves less soft tissue dissection & immediate postoperative mobilization. Even though the radiological outcome was poor in most of the patients; the subjective, clinical and functional results were excellent in majority of the patients. The evaluation of secondary osteoarthritis requires further long term follow up studies.

KEYWORDS: Schatzker type VI, Tibial condyle, Ilizarov, Hybrid

INTRODUCTION

Tibial Plateau fractures (TPF) are estimated to comprise approximately 1% of all fractures¹. With the escalating rates of motor vehicle accidents, contact sports, industrialization and increased agricultural mechanization, the incidence of these fractures is also on the rise. TPF involve a major weight-bearing joint, and are often associated with concomitant injuries to blood vessels, nerves, capsule, collateral and cruciate ligaments as well as the menisci. The complex fracture patterns in a bio-mechanically complex joint, wide range of associated soft tissue injuries and the poor functional outcomes with either conservative or surgical managements proposed until now, make TPF a fascinating therapeutic challenge, especially Schatzker type VI tibial condyle fractures.

The principal aims & objectives of the study are:

1. To determine the demographic variations age and sex incidence, the mechanism of trauma, and associated soft tissue injury.
2. To evaluate the efficacy of Ilizarov hybrid external fixator in treating type VI Schatzker fracture of the tibial condyle.



3. Analysis of post operative complications
4. Clinical and functional outcome.

MATERIALS AND METHODS:

This is a hospital based prospective study evaluating the clinical and functional outcome of Schatzker type VI tibial condyle fracture treated by Ilizarov hybrid external fixator in a series of 20 patients. The study was conducted at our institution during the period between September 2010 to August 2012. Clearance was obtained from the hospital ethical committee.

During the period between September 2010 to August 2012, 20 patients with Schatzker type VI tibial condyle fracture were treated by Ilizarov hybrid external fixator and followed up to evaluate the results. All the required data was obtained from the patients during their stay in the hospital or during followup and from the hospital records, and recorded in the proforma.

Management:

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

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

- Schatzker type VI tibial condyle fracture confirmed
- Amount of articular surface widening
- Amount of articular surface depression

In highly comminuted fractures, CT scan with 3D reconstruction was done to know about the fracture fragments. MRI and arthroscopic studies were not done. Preoperative and postoperatively antibiotics were given for all patients.

Surgical procedure:

All surgeries were performed under either spinal anaesthesia or lumbar plexus block with Sciatic nerve block. Tourniquet was not used in any of the patients. Patient was positioned supine on the fracture table. Traction was given along the axis of the limb, fracture reduced by closed manipulation with the help of C arm. Condyles were fixed with 6 mm cannulated lag screws and olive wires. The cannulated screws were placed close to the articular surface so that the external fixation pins could subsequently be inserted inferior to the screws at a distance from the joint surface. The fracture at metaphysiodiaphyseal junction was stabilized by preassembled Ilizarov circular external ring fixator. Image intensifier views obtained in two planes assisted in the assessment of the reduction and in the placement of the cannulated screws. Extensile exposures, osteotomies of the tibial tuberosity, meniscal elevations, and other wide exposures of the joint surface were not used. Repairs of the ligaments and meniscectomies were not performed.

In one patient miniarthrotomy was done to reduce the fracture and for bone grafting using G bone. No patient had arthroscopically assisted reduction. The alignment of the shaft with the condyles was evaluated with the aid of fluoroscopy. Open approaches were not used to reduce the shaft to the condyles, thereby minimizing any additional soft-tissue stripping of the proximal part of the tibia.



Post operatively all patients received intravenous antibiotics for five days (Ceftriaxone and Gentamycin). Sutures if any were removed on tenth day. Immediate non weight bearing mobilization was advised.

Check X rays were done postoperatively and the following features noted.

- Varus or valgus malalignment was measured
- Joint space was measured to provide a guide for future assessment of joint space narrowing

Follow-up:

The fixator remained in place until the fracture had healed clinically and radiographically: it was then removed in the outpatient clinic. The hybrid external fixator was removed after an average duration of 12.5 wks. Patients were followed up at an interval of 4 wks until fracture union and later, once in 3 months. At each follow up, the following points were made note of: Clinical features like Pain, Walking ability, Extensor lag, Range of flexion, Squatting, Pin tracts, Duck walking, stair climbing, Instability tests & thigh atrophy were evaluated.

Radiological features like Callus formation, maintenance of fracture reduction, widening and depression of the articular surface, varus or valgus deformity at knee (in weight bearing X-rays). Weight bearing was initiated once sound bony union was noted on the follow up x-rays.

At the latest follow up visit, all the patients had complete examination of the lower limb. Varus and valgus stress tests were done with the limb in extension and 30° of flexion. Anterior and posterior drawer tests were done to the patient lying supine; the range of movement was recorded with a goniometer. If the patient was able to squat, maximum flexion was measured in this position. The presence of pain, ability to walk, Jump, Squat, climb stairs, return to employment and ability to carry out routine activities was enquired upon.

The results were assessed as per the criteria of Honkonen and Jarvinen and also using IOWA knee evaluation.

OBSERVATIONS AND RESULTS:

The primary data obtained from the series of 20 patients who underwent surgery was statistically analyzed. The statistical methods employed and the results thus obtained are as follows:

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.

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

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.

In this series of cases, the average age of the patient was approximately 44.6 yrs. Males significantly outnumbered females [15:5]. Majority of the patients were aged between 31-45 yrs. In this series the vast majority of patients (14 cases 70%) had sustained fractures following RTA. Fifteen fractures were closed, and 5 fractures were open and all the open fractures were grade III according to Gustilo and Anderson's Classification. The hybrid external fixator was removed after an average duration of 12.5 wks. Most of the patients were followed up for a period of 23 months. The longest follow-up was 24 months and the shortest was 3 months. Average duration of follow-up 16.3 months. In most of the patients fracture united within 12 weeks.

Evaluation:

All patients were followed up regularly and evaluated using IOWA knee score and criteria of Honkonen and Jarvinen.

The Iowa knee score is a 100-point scale with which five categories of knee function are assessed according to numerical values assigned to the answers. The categories include functional activities such as walking, stair-climbing, and household chores (35 points); pain (35 points indicates no pain and 0 points, severe, continuous pain); gait (10 points); range of motion (10 points, with 1 point for each 15 degrees of movement); and absence of deformity, ligamentous laxity, locking of the joint, or contractures (10 points).

Criteria of Honkonen and Jarvinen includes subjective, clinical, functional as well as radiological assessment.

Pain:

One patient had severe pain, 2 had moderate and 5 patients had slight pain.

Walking ability:

Walking ability was normal in 9 patients and 7 patients had slight limp and 4 patients had severe limp.

**Range of flexion achieved:**

Maximum flexion achieved was 150° (2 patients) and minimum was 90° (4 patients) and 7 patients had a flexion of 135° . The average flexion achieved was 118.25° .

In the case series of J L Marsh et al², maximum flexion achieved was 150° , minimum flexion was 0° (ankylosis due to septic arthritis) and 4 patients had a flexion of 140° . The average flexion achieved was 124.5° .

One patient was unable to squatt and climb stairs. Jumping and duck walking were very difficult to assess especially in patients with other impairment of physical activity, but these activities were not important in grading the functional score. There were 5 excellent, 10 good, 3 fair results and only 2 patients had poor results.

Only one patient had an extensor lag of 5° .

Residual deformity:

Fourteen patients had no residual deformity. A valgus angle $> 6^{\circ}$ and any varus angulation were considered significant. Only 2 patients had valgus deformity $> 6^{\circ}$ and 4 patients had a varus of 3° . Among 4 patients with varus deformity, 2 patients had their implant removed prematurely due to pin tract infection and the limb was immobilized using long leg cast which led to varus angulation. In other 2 patients, the fracture was thought to have healed by the time that the fixator was removed, but the shaft settled into 3° of varus before the fracture consolidated. In the case series presented by J L Marsh et al², 1 patient had a valgus angulation of 10° and 2 patients had a varus angulation of 8° .

Residual widening:

Residual widening of the articular surface (1-5 mm) was found 18 patients. But among these 18 patients, 6 patients had excellent result, 7 patients had good result, 5 patients had fair result according to IOWA knee evaluation and none of the patients had poor result. This finding supports the hypothesis of J L Marsh et al³, that the knee joint cartilage appears to be tolerant of both the injury and mild to moderate residual articular displacement.

Articular Depression:

Depression of articular surface of (3mm) was found in 7 patients and of (5 mm) in 1 patient. 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.

According to IOWA knee evaluation:

8 patients had excellent results, 7 patients had good and 5 patients had fair results.

According to criteria of Honkonen and Jarvinen;

Subjective evaluation: 13 patients had excellent results, 3 good and 4 fair results.

Clinically: 11 patients had excellent, 4 good and 5 fair results.

Functionally: 5 patients had excellent, 10 good and 3 fair and 2 poor results.

Poor results was not due to complications related to tibial condyle fracture but due to associated fracture both leg ipsilaterally in one patient and associated fracture of shaft of femur with fracture neck of femur of contralateral limb in 1 patient and fracture lateral condyle of ipsilateral femur with fracture patella in another patient.

**Radiologically:**

4 patients had – excellent, 9 good and 7 fair results.

There was a statistically significant association between subjective evaluation according to criteria of Honkonen and Jarvinen and IOWA knee score ($P \leq 0.0005$) and between clinical evaluation according to criteria of Honkonen and Jarvinen and IOWA knee score ($p=0.022$) and also between functional evaluation according to criteria of Honkonen and Jarvinen and IOWA knee score ($p=0.024$).

There was no statistically significant correlation between radiological evaluation according to criteria of Honkonen and Jarvinen and IOWA knee score ($p=0.410$).

DISCUSSION:

Management of intraarticular fractures has always been a matter of considerable ambiguity and confusion, with the proponents of conservative as well as surgical management techniques 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. But recently, there is a trend towards external fixation with minimally invasive internal fixation for treating complex fractures of Tibial Plateau especially type VI Schatzker fracture.

There are only few studies on management of complex tibial plateau fractures, and there are no studies reported so far pertaining to management of Schatzker type VI tibial condyle fracture exclusively.

Age and Sex incidence:

In this series of cases, the average age of the patient was approximately 44.6 yrs. Majority of the patients were aged between 31-45 yrs. The average age, as reported by Marsh JL et al², in their study of complex fractures of the tibial plateau was 43 years. Younger patients had better results than the aged ones, probably because of adequate bone stock and fewer incidence of pin tract infection. Males had a favourable outcome than females, although the difference was not statistically significant.

Most of the patients were from rural areas, occupied as manual labourers. A significant male preponderance (75%) was seen in this series as with studies of Marsh et al².

Mechanism of Injury:

In this series the vast majority of patients (14 cases 70%) had sustained fractures following RTA. Five patients had the fracture due to fall and one patient sustained type VI fracture due to an assault. Marsh JL et al², in their study of 20 cases, reported RTA as the cause in 13 cases. Patients with fractures due to RTA met with complications like severe soft tissue injury, edema, open fractures, polytrauma. Out of 5 open fractures, 3 were due to RTA. Only 1 patient with open fracture had an excellent result, 3 patients had a good result and 1 patient had a fair result.

Majority of patients had a left sided fracture (11 cases, 55%), although the difference was not statistically significant.



Type of fracture:

In the series of cases presented, 15 fractures were closed, and 5 fractures were open and all the open fractures were grade III according to Gustilo and Andersons Classification.

The type of fracture was not significantly influenced by age or sex of the patient. The patients with open fractures had an unfavourable result when compared to patients with closed fractures due to increased risk of infection, bone loss, fibrotic scar and stiff knee. A 28 yr old male patient, who had associated comminuted fracture of lateral condyle of ipsilateral femur and fracture patella, had severe restriction of knee flexion but on latest followup he regained flexion upto 105° after extensive physiotherapy.

Management of the fracture:

All patients were treated initially by resuscitation and temporary stabilization using Lower tibial skeletal traction. Definitive surgery was done using Ilizarov hybrid external fixation with without limited internal fixation. G bone was used in one patient for elevating the depressed articular surface.

75% (15) of the patients were operated within 2 weeks of injury. The average delay for definitive surgery was approximately 12 days. In the remaining 5 patients the limb was elevated along with lower tibial skeletal traction. The reason for the elevation was soft tissue swelling or blistering, or both. The patients who were operated late had poor results radiologically because of difficulty in achieving articular reduction, but functional results were good.

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 and external fixation devices. Primary repair may prolong the operative time and predispose to infection¹.

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.

The mean duration of hospital stay was 4.1 wks the duration of hospitalization in the study reported by Marsh JL et al averaged 27 days.

9 patients had associated fractures of other bones, like, fracture lower end of radius (2 patients) fracture both bone leg (1 patient), fracture shaft of femur with fracture neck of femur (1 patient) in the contralateral limb. One patient had fracture patella and fracture shaft of tibia in the contralateral limb. Three patients were associated with medical disorders like diabetes mellitus and hypertension. One patient had fracture lateral condyle of femur with fracture patella.

Patients with polytrauma had poor results due to associated fractures. A 30 yr old male with polytrauma had fracture neck of femur and fracture shaft of femur in the other limb and fracture neck of femur went in for non union. Eventhough the Schatzker type VI fracture in the other limb united well and had 135° of flexion in the knee joint, functionally he had poor result since he was not able to walk, jump, or climb stairs because of the non union fracture neck of femur.



The hybrid external fixator was removed after an average duration of 12.5 wks. In one patient implant was removed within 3 weeks due to severe pin tract infection. In one patient implant was removed after 28 weeks due to associated fracture both bone leg ipsilaterally.

Most of the patients were followed up for a period of 23 months. The longest followup was 24 months and the shortest was 3 months. Average duration of followup 16.3 months.

Union of fracture:

In most of the patients fracture united within 12 weeks. The maximum duration for union was 28 wks in 1 patient and minimum duration was 10 weeks in 2 patients. Average duration for fracture union was 13.25 weeks. None of the patients had non-union.

Pin tract infection:

Only 2 patients had severe pin tract infection which required implant removal and immobilization using POP cast and intravenous antibiotics (inj.cefotaxim). Four patients had minimal pin tract infection which was treated by local cleansing with antiseptic solution and oral antibiotics (ciprofloxacin), and 3 patients had a moderate pin tract infection, which required hospitalization and intravenous antibiotics (inj.cefotaxim) without removal of the implants. The patients with pin tract infection had unfavourable results and the association between pin tract infection and outcome of IOWA knee score was statistically significant ($P < 0.001764$).

In the case series presented by J L Marsh et al², 4 patients had superficial pin tract infection and 2 patients had septic arthritis. None of the patients in this series had septic arthritis.

Osteoarthritis:

Post-traumatic osteoarthritis was assessed on the most recent radiographs, made with the patient bearing weight, on the basis of narrowing of the joint space, subchondral sclerosis, subchondral cysts, and osteophytes. Grade 0 indicated no osteoarthrotic changes: grade I, small osteophytes or cysts without narrowing of the joint space: grade II, slight narrowing of the joint space with formation of osteophytes. Subchondral sclerosis, and cysts but no osseous collapse; and grade III, obliteration of the joint space due to marked narrowing as well as osseous collapse and severe subchondral sclerosis. Two patients had grade I and 1 patient each had grade II and grade III osteoarthritis².

Complications:

4 patients had minimal pin tract infection which was treated by local cleansing with antiseptic solution and oral antibiotics, and 3 patients had a moderate pin tract infection, which required hospitalization and intravenous antibiotics without removal of the implants. Two patients had severe pin tract infection, especially in the proximally placed tension wires, for which implant removal was done and immobilization was given using POP cast until fracture union and intravenous antibiotics (inj.cefotaxim). None of the patients developed septic arthritis of the knee.

In the case series of 16 cases of Schatzker type VI fracture presented by J L Marsh et al², 4 patients had superficial pin tract infection which subsided by oral antibiotics and 2 patients had septic arthritis which required arthrotomy. None of patients in this series had septic arthritis.

Murphy et al⁴ reported that one intrarticular infection developed after the treatment of five fractures of the tibial plateau, and Weiner et al⁵, noted 2 instances of septic arthritis after the treatment of 45 fractures of the proximal tibia.



Rasmussen⁶ reported 5 cases of superficial infection and 1 case of deep infection in series of patients.

Mallik et al⁷ found infection complicating 4 of 5 bicondylar fractures that were treated with plates.

LIMITATIONS:

- Sample size is small and there is no control group.
 - A potential disadvantage of indirect reduction and external fixation is decreased accuracy of reduction of the articular surface compared with that obtained with open reduction. Reduction of articular surface was not assisted by other techniques like arthroscopy
 - The evaluation of secondary osteoarthritis requires long term follow up studies.
- plateau fractures.⁷

Figure 1: Pre-operative X-ray



Figure 2: Post-operative X-ray



Figure 3: Immediate post-operative mobilization



Figure 4: After Implant Removal



Figure 5: Full extension at 2 yrs follow-up



Figure 6: Full flexion at 2 yrs follow-up



Table 1: Age Incidence

Age [yrs]	Number of patients	Percent
16-30	5	25.0%
31-45	8	40.0%
46+	7	35.0%
Total	20	100.0%

Graph 1: Age incidence

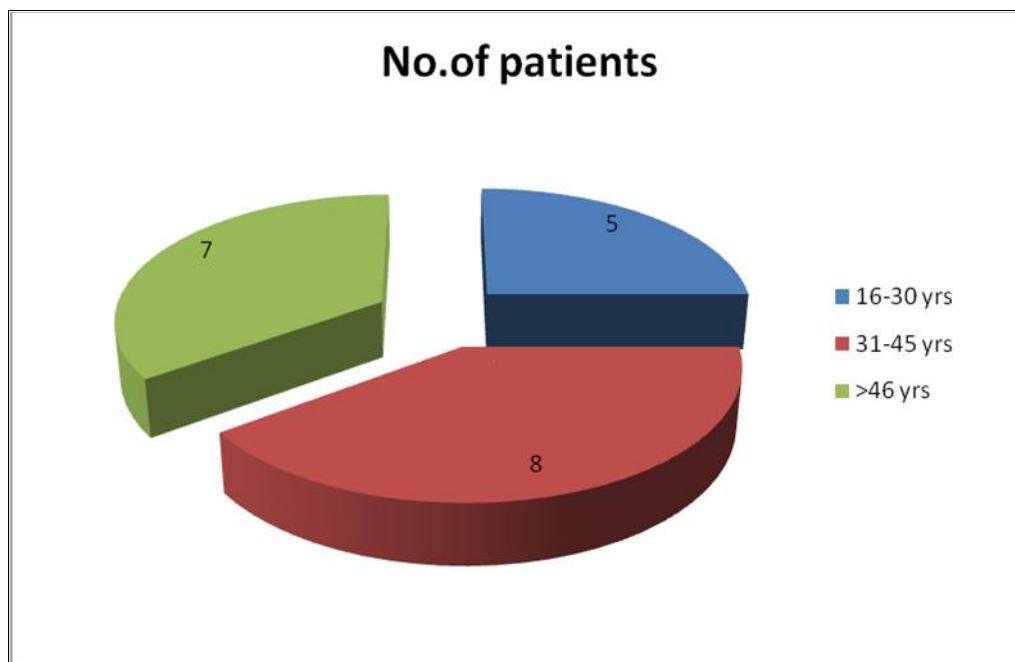




Table 2: Sex Incidence

Sex	Number of patients	Percent
Males	15	75.0%
Females	5	25.0%
Total	20	100.0%

Graph 2: Sex incidence

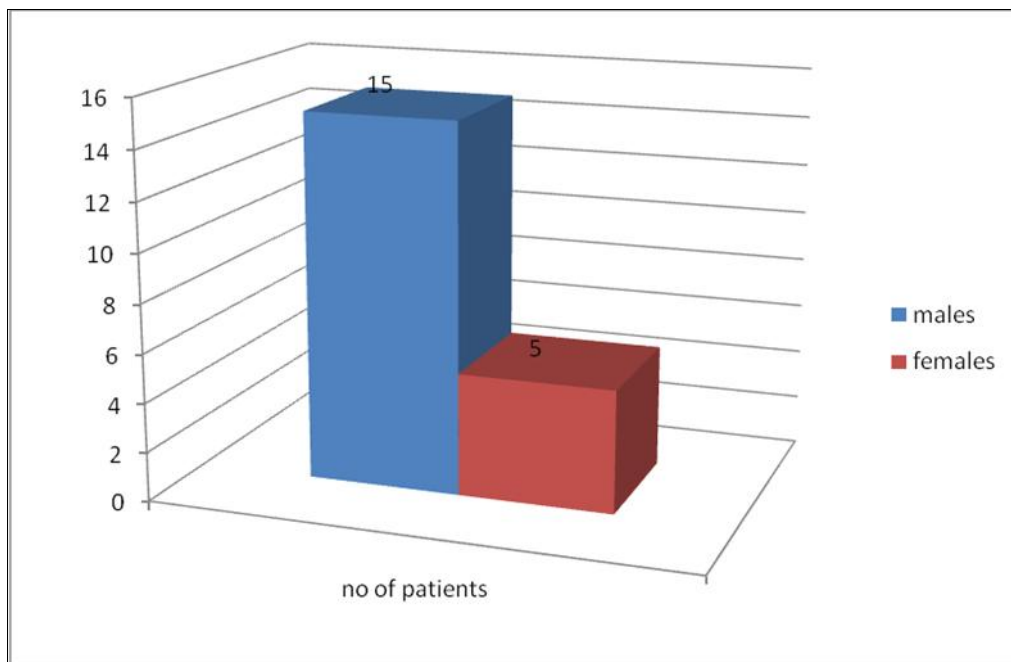




Table 3: Mechanism of trauma

Mech. of injury	Number of patients	Percent
RTA	14	70.0%
fall	5	25.0%
assault	1	5.0%
Total	20	100.0%

Graph 3: Mechanism of trauma

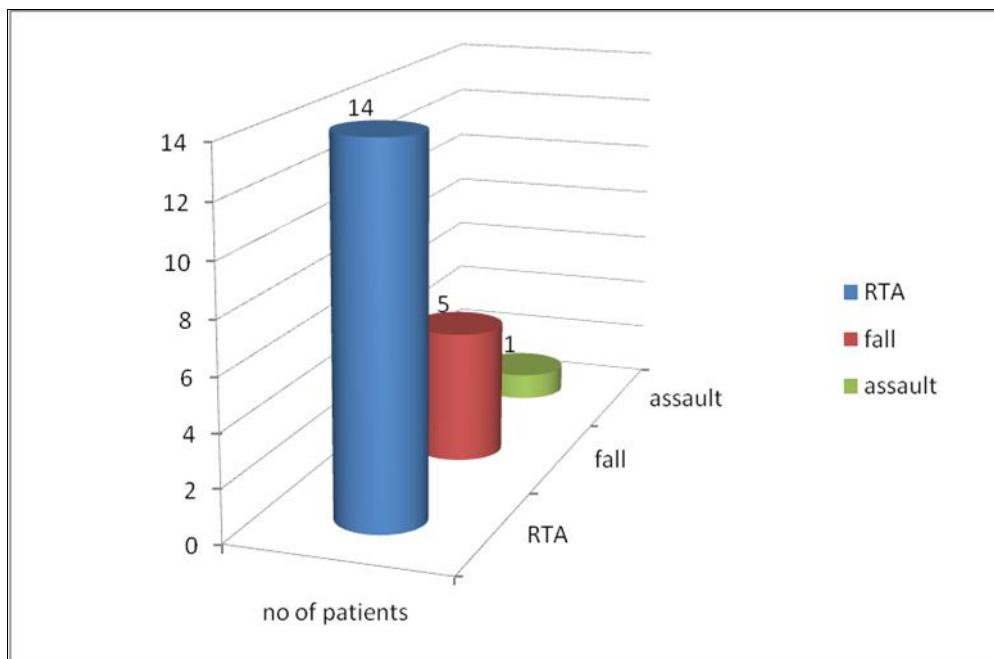




Table 4: Union of fracture in wks

Union (wks)	Number of patients	Percent
10	2	10.0%
11	1	5.0%
12	12	60.0%
14	1	5.0%
16	3	15.0%
28	1	5.0%
Total	20	100.0%

Graph 4: Fracture union [wks]

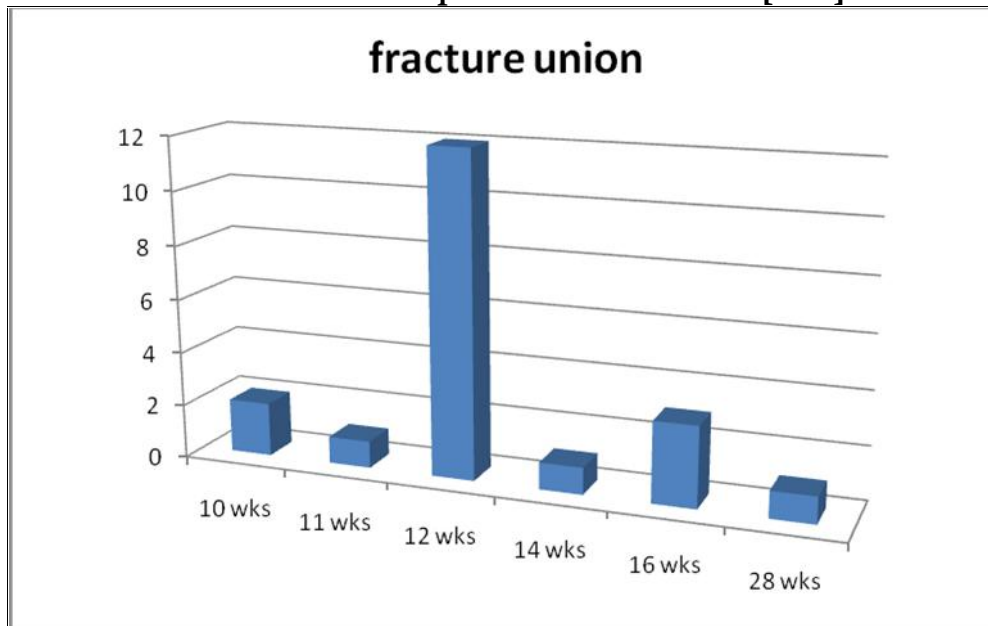
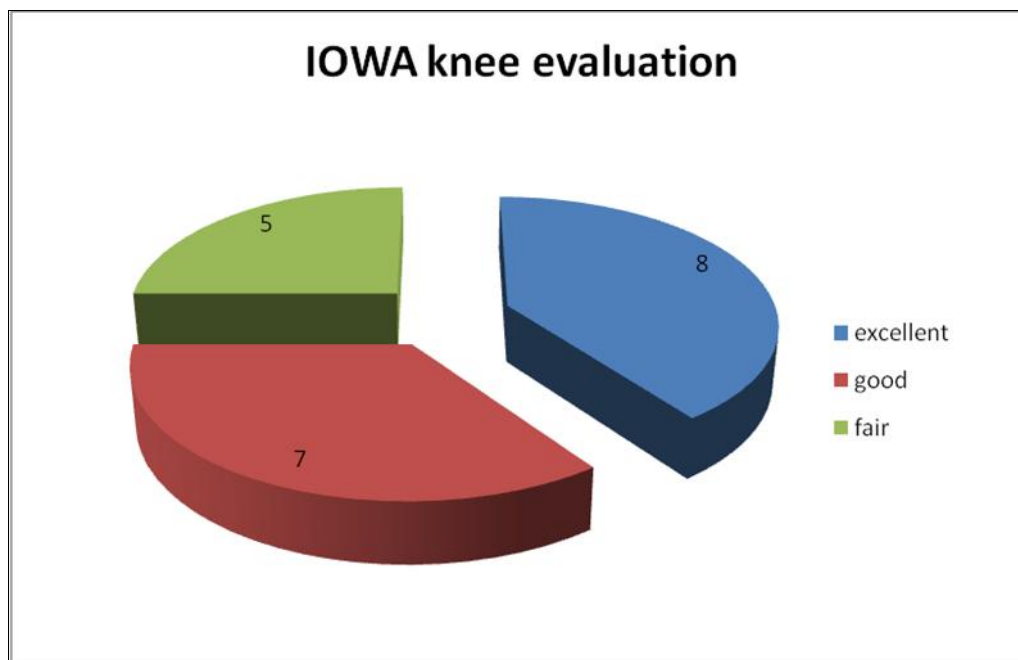




Table 5: IOWA knee evaluation

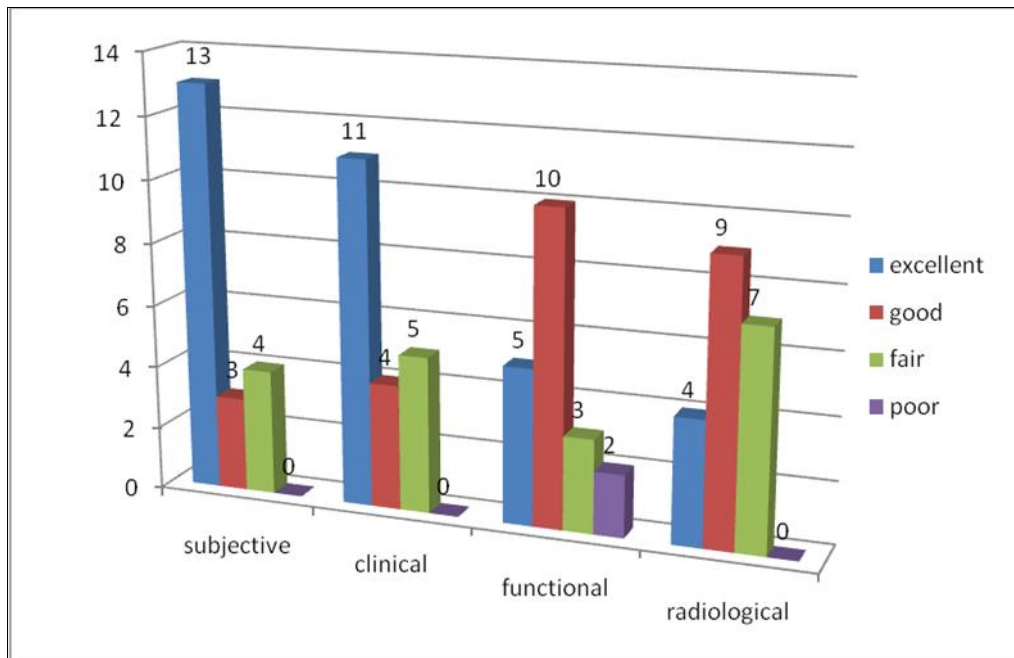
IOWA knee evaluation	Number of patients	Percent
Excellent [score 90-100]	8	40.0%
Good [80-89]	7	35.0%
Fair [70-79]	5	25.0%
Total	20	100.0%

Graph 5: IOWA knee evaluation





Graph-6: Criteria of Honkonen and jarvinen

**CONCLUSION:**

The following conclusions can be derived from the study presented herein.

- In the treatment of complex tibial plateau fractures especially type VI Schatzker. Ilizarov hybrid external fixation offers a better alternative technique.
- This technique involves less soft tissue dissection which avoids extensive fibrosis and joint stiffness.
- Immediate postoperative mobilization is the most significant advantage of this technique which provides very good results clinically as well as functionally.
- The knee joint cartilage appears to be tolerant of both the injury and mild to moderate residual articular displacement.
- 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.
- Eventhough the radiological outcome was poor in most of the patients; the subjective, clinical and functional results were excellent in majority of the patients.
- Although the number of patients was small and there was no concurrent control group, these results appear to be far superior with those obtained after more extensive approaches for open reduction and internal fixation.



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