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Original Research Article

A study of minimally invasive percutaneous plate osteosynthesis for tibial plateau fractures

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ABSTRACT

Background: Fractures of proximal tibia involve a major weight-bearing joint and are serious injuries, which, if not treated well, result in functional impairment. To preserve normal knee function one must strive to maintain joint congruity, preserve the normal mechanical axis, ensure joint stability and restore a full range of motion. This is a formidable task to accomplish, especially in the face of associated medical conditions of the patients.
Methods: In our study, 30 cases were selected. Selection of cases were done on the basis of X-rays. Schatzker type I, II, III, IV, V & VI included in study. Criteria for acceptable reduction 1) <5 mm of articular step; 2) <5 mm of articular depression. Each case is referred to one set of tibial plateau fracture, showing distribution of tibia plateau fractures that we treated with MIPPO. Clinical follow-up examination was performed at 4, 6, 10, 12 weeks and 3, 6 months. Clinico-radiological assessment was done at 3 month and grading was done. Patients were evaluated according to grading minimum 3 months after injury.
Results: Our study of 30 tibial plateau fractures confirms that the MIPPO technique is an excellent treatment modality in case of tibial plateau fractures. We observed these fractures mainly in age group of 30-40 years, which were involved in road traffic accident. Tibial plateau fractures seen in elder age group were mainly due to abnormal loading patterns on the leg. We have found oblique views very much informative especially for posterolateral or posteromedial displacement, articular depression which helps to plan the position and direction of screws to be used for fixation.
Conclusions: In view of the excellent results obtained with this technique, we advocate MIPPO over conventional open reduction and internal fixation technique for tibial plateau fracture fixation.

Keywords: Minimally invasive percutaneous plate osteosynthesis, Locking plate, Tibial plateau fractures

INTRODUCTION

According to Hohl, fractures of the tibial plateau make up 1% of all fractures in the elderly.[1] Published studies have shown that most injuries affect the lateral plateau (55% to 70%). Isolated injuries to the medial plateau occur in 10% to 23% of cases, whereas involvement of both plateaus, the so called bicondylar lesions, is found in 10% to 30% of reported series.

Since early 1980's with improvements in surgical techniques and implants, there has been an unmistakable trend towards surgical management of these injuries.[2] Despite a plethora of articles written since the middle of the twentieth century addressing the problems of classification and results of various treatments the optimal method of management remains controversial. The conventional technique of open reduction and internal fixation (ORIF) requires wide exposure,

extensive soft tissue stripping with subsequent risk of infection.[3] Our technique of minimally invasive percutaneous plate osteosynthesis (MIPPO) avoids all the above complications of ORIF yet allowing stable fixation and early mobilization.

Anatomy

The tibia is the major weight bearing bone of leg, with the fibula serving for muscle attachments and completing the ankle joint on lateral side. The proximal tibial shaft widens into lateral and medial tibial condyles. The bony articular surfaces of the tibia slope inferiorly approximate ten degrees from anterior to posterior hence an anteroposterior roentgenogram with the beam angled caudally ten to fifteen degrees will result in better views of tibial plateaus.[6] In between the plateau lies inter condylar eminence, which has medial and lateral tibial spines and areas for attachment for the menisci and cruciate ligaments.[4]

The tibial plateau is covered by hyaline cartilage approximately 3 mm thick on the medial plateau and 4 mm thick on the lateral plateau. The medial plateau is the larger and as is concave front to back as well as from side to side. The lateral plateau, is smaller higher than the medial plateau and is convex front to back as well as from side to side.[5]

When evaluating a lateral radiograph of proximal tibia, the clinician must remember the lateral plateau is higher than the medial plateau. This has importance when placing lateral to medial screw in this area. The hope is to avoid placing a screw in the medial plateau, only to find it has penetrated the joint because it is located inferior to the lateral joint line. The convexity of the lateral plateau also helps the surgeon to identify this region on a lateral image. The outer portion of each plateau is covered by fibro cartilaginous meniscus. The lateral meniscus covers a much larger portion of the articular surface than does the medial.

Meniscotibial ligaments attach the meniscus to the periphery of the tibial plateau. These structures are crucial to identify when performing a sub meniscal exposure to visualize the articular surface of the plateau. They can be carefully incised in a horizontal fashion to elevate the meniscus. This structure must be carefully repaired to avoid producing on iatrogenic peripheral meniscal detachment. The medial articular surface and subcondylar medial plateau region is much stronger than lateral plateau counterpart. Because of this, lateral plateau fractures are much more common and encompass a broader spectrum of low energy fracture patterns. Medial plateau fractures therefore occur as a result of a much higher energy mechanism, and thus have a wider variety of associated injuries such as ligamentous disruptions, peroneal nerve injuries, compartment syndromes or popliteal artery damage.[6]

The management of tibial plateau fractures has always held a particular interest for orthopaedic surgeons. Surgical stabilization of fractures and early mobilization of the patient provides best clinical outcome. Most of the controversy resides in the treatment techniques regarding the choice of implants, as the indication for surgery is fairly clear. These areas of controversy would seem to be an excellent target for prospective clinical research. In addition, the factors that lead to good versus poor outcomes often depend on treatment techniques than other factors, which can be controlled. For these reasons, new treatment techniques may need to continue to be evaluated in case series and cohort studies. Therefore, we conducted this study for evaluation of functional outcome of MIPPO in the surgical management of tibial plateau fractures.

METHODS

A prospective study conducted in department of orthopaedic surgery, Grant Medical College and Sir JJ Group of hospital, Mumbai from 2014-2015. All patients attending the orthopaedic department with tibial plateau fracture who met the inclusion criteria were counselled regarding the disease and the study and those willingly consenting to participate in the study were selected. Informed and written consent was obtained from all patients with consent form approved by the Institutional ethical committee. A total of 30 subjects were consecutively recruited for the study.

Inclusion criteria

Intra-articular fracture Schatzker type I, II, III, IV, V & VI included in study. Age above19 years and less than 60 years, fibula fracture may/may not be associated, patients who were medically fit for surgery.

Exclusion criteria

Pathological fracture, all open fracture, associated compartment syndrome or vascular injury, polytrauma, extra-articular fracture.

All the selected patients underwent routine investigations, was clinically evaluated in detail regarding the mode of injury and treatment taken prior to admission. A detailed examination was done to assess any deformity, associated injuries was noted, if any.

Standard antero-posterior and lateral roentgenographic views of the knee and leg including ankle and upper tibia was taken. Patients were subjected to all relevant preoperative investigations and were taken up for surgery as soon as he/she was fit for anaesthesia.

Surgery was performed under anaesthesia with MIPPO method.

Clinical follow-up examination was performed at 4 weeks, 6 weeks, 10 weeks, 3 months, 6 months and 1 year. All patients were assessed clinically and radiographically with following terms such as tenderness at fracture site, abnormal mobility, infection, pain on movement of knee and ankle joints and antero-posterior and lateral radiographs of the leg for union of fracture.

On admission all patients were addressed for:

1) Skin condition
2) Deformity
3) Instability
4) Any other associated injuries
5) Fracture morphology

24 patients were operated within 2 days of injury and 6 Patients were operated after 10 days of injury because of oedema and bad skin condition. Till then limb elevation, magnesium sulphate dressings, immobilization in slab was given.

Reduction

1) Esmarch bandage tied starting from toes to above knee.
2) More pressure given in area of upper end tibia Reduction checked under c- arm.
3) If required gentle tapping with hammer done on medial or lateral condyle depending upon fracture configuration. Pelvic clamps also can be used to hold the reduction.

Criteria for acceptable reduction

1) <5 mm of articular step
2) <5 mm of articular depression

Fixation

Under image intensifier control, a transverse incision, about 1.5 inches long is made, bone deep, about 1 cm distal to the joint line. A broad periosteum elevator is introduced to strip the periosteum downwards and anteriorly towards the shin, distal to the tuberosity.

Through transverse incision, a T/L plate is slid subperiosteally along the track made by the periosteum elevator. The reduction again is confirmed on image intensifier.

One of the proximal screw hole in filled with a 6.5 mm cannulated screw, passed across the fracture. This screw is used as a hinge to rotate the plate as required for accurate placement.

The distal-most screw (4.5 mm cortical) is inserted by making a small stab incision under image intensifier control followed subsequently by other screws. A similar sized plate is used as a template to aid in malting the stab incisions. The primary transverse incision allows for the placements of two subchondral 6.5 mm screws and the proximal-most metaphysical 4.5 mm screw, while the distal incision is made over the last but second screw hole, allows for the placement of distal three screws by pinching and moving the skin proximally and distally.

In joint depression fractures the incision is made slightly oblique so as to allow the elevation of the depressed fragment and for providing space for inserting bone grafts.

Bone grafts, if required are taken up from iliac crest. Skin incision closed with mattress sutures using ethilon. Dressing applied. Above knee plaster of Paris slab applied with knee in 15 degree of flexion.

Figure 1: X-ray right knee AP view and lateral view preoperative and postoperative.

Figure 2: Intraoperative plate sliding subperiosteally and after screw locking.

Follow up

A) First follow up - 4 weeks

   1. Radiological assessment.
   2. Continue knee range of movements and active quadriceps exercises.

B) Second follow up - 6 weeks

   Partial weight bearing with the help of crutches. Gradually increased to full weight bearing.

C) Third follow up - 8 weeks

   Clinico-radiological assessment. 50% weight bearing started increased to 75% after 15 days.

D) After 3 month

   Clinico-radiological assessment. Usually fracture unites sufficiently.

   Full weight bearing walk.

RESULTS

Our study of 30 tibial plateau fractures confirms that the MIPPO technique is an excellent treatment modality in case of tibial plateau fractures. The population of tibial plateau fracture in our study is comparable to other studies. We observed these fractures mainly in age group of 30-40 years, which were involved in road traffic accident. Tibial plateau fractures seen in elder age group were mainly due to abnormal loading patterns on the leg, for example due to fall from height. Majority of our cases were due to indirect injuries. In case of direct injury pattern soft tissue injury observed was more and we had to wait longer time before taking patient for surgery. We evaluated all fractures clinically for soft tissue damage. We also found associated injuries in some patients. Seventeen patients had upper end fibula fracture, two of supracondylar fracture femur, one of ankle fracture, one of calcaneal fracture. We took four x-rays for all patients-anteroposterior, lateral, external oblique and internal oblique. We have found oblique views very much informative especially for posterolateral or posteromedial displacement, articular depression which helps to plan the position and direction of screws to be used for fixation. We classified all fractures according to Schatzker's system, which we have found best. Since it gives idea about both, mechanism of injury and guideline for further treatment plan. Further it is simple with less inter-observer variation. With increasing type of Schatzker there is also increase in force of injury, complexity of fracture and increase in soft tissue injury. We found and agree with Schatzker et al that elderly patients were more with depressed fractures than younger who had split fractures. 24 patients we operated within two days of injury, for others we had to wait even for 10-15 days for oedema to subside, soft tissue injury to heal and skin condition to improve. Even after 15 days, open reduction internal fixation would not have been possible due to skin condition, therefore we opted for MIPPO. Till then we immobilized these fractures with above knee slab. We agree that patient should be operated as soon as possible.

We operated all of them under Spinal Anaesthesia. We selected patients according to Schatzker type and articular step or depression present. We found elderly patients more with depressed fractures than younger who had split fracture. We selected patients according to Bennett and Browne that more than 5 mm joint depression or displacement and of more than 5 degree of axial malalignment as indication for surgery.

Table 1: Age distribution (n=30).

Age (years)	Number of patients (%)
20-29	9 (30.00)
30-39	14 (46.66)
40-49	5 (16.66)
50-59	2 (6.66)
Total	30 (100)

Amongst age distribution, maximum patients (46.66%) being in the age group of 30-39 years. The mean (SD) for age was 35 years.

Table 2: Sex distribution (n=30).

Sex	Group I (%)
Male	21 (70.00)
Female	9 (30.00)
Total	30 (100)

Table 3: Mode of trauma to patients.

Mode of trauma	Patients (%)
Road traffic accident	12 (40.00)
Fall from height	7 (23.33)
Fall at home	5 (16.66)
Assault	1 (03.33)
Sport related injury	5 (16.66)

Table 4: Morphology of fractures Schatzker type.

Type	Patients (%)
1	5 (16.66)
2	7 (23.33)
3	3 (10.00)
4	11 (36.66)
5	2 (06.66)
6	2 (06.66)

Table 5: Different intra and post-operative variables.

Variables	Values (%)
Mean±SD operating time (min)	102.14±8.15
Mean±SD time of union (weeks)	18.43 ± 2.04
Knee pain	3 (10.00)
Articular step and depression	2 (06.66)
Deformity	2 (06.66)
Knee movements restriction	2 (06.66)
Instability	3 (10.00)

The mean operating time was 102.14 minutes. Mean union time in was 18.43 weeks.

Post operatively, we evaluated the patients with the help of following evaluation system. Anatomical (radiological) and Functional (clinical).

Table 6: Evaluation of results (anatomical).

Points	4	3	2	1
1. Deformity	No	<5	5-10	>10
2. Articular step	<3	3-5	5-10	>10
3. Articular depression	<3	3-5	5-10	>10

Maximum points: 12

Table 7: Evaluation of results (clinical).

Points	4	3	2	1
1. Knee movement-flexion	Full	90-120	30-90	<30
2. Stability	Good	Grade 1 laxity	Grade 2 laxity	Grade 3 laxity
3. Pain	No	With exercise	With walking	Continuous

Maximum points: 12

Table 8: Grading of results.

Grade	Poor	Fair	Good	Excellent
Points	1-6	7-12	13-18	19-24

Evaluation of results according to grading. Using the above grading system, the results of our study were as follows.

Table 9: Evaluation of results

Grading	Number of cases	Percentage (%)
Excellent	26	86.66
Good	3	10.00
Fair	1	03.34
Poor	0	0

DISCUSSION

In our study, after evaluating results, treatment of tibial plateau fractures requires following considerations. We evaluated each fracture radiologically for displacement of fragments and preoperatively decided about type of plate and number of screws. This preoperative planning helped us a lot while operating in theatre. We classified the fractures according to Schatzker's classification.[7] Patients with tibial spine and tibial tuberosity avulsion fractures are not included in this study as they require classic O. R. I. F. We initially assessed ligamentous instability under anaesthesia. We found one in type I, two in type II, three in type IV, one in type V and three in type VI associated ligamentous injuries. We agree with Rasmussen that ligamentous injuries occur in 10%-33% of tibial plateau fractures.[8] All ligament injuries treated conservatively. We agree with Schatzker et al that younger patients mainly get split fractures (type I, IV) and elderly patients, joint depression type of fractures (type II, III, V, VI).[12] We found type I and type IV fractures in age group of 20 to 40 years. Out of 5 type I, 4 patients (80%) were between 20 to 40 years and all type IV patients, that is 11 patients, below 40 years. This is because of dense cancellous bone and high energy injury in young patients which develops split type of fracture. We found 2 patients with type VI patients were above 40 years and both type V patients also above 40 years. Also 4 out of 7 type II fractures were above 40 years. This is due to associated osteoporosis which leads to communited and depression type of fractures. We agree with Hohl et al, that males are more prone to get tibial condylar fractures because they are mainly involved in road traffic accidents or occupational accidents.[13] We found 21 males (70%) and 9 females (30%) in our study of 30 patients. We used esmarch bandage to help in reduction, which we found very helpful to decrease displacement. Large pelvic clamps also used sometimes to held the reduction. C-arm used for assessing the reduction and we found it very convenient and accurate.[14] Our aim during surgery was to get anatomical reduction. Only in 2 patients (13.33%), there was articular step of 5 to 10 mm left. Those patients were operated after 2 weeks because of poor skin condition. We still got a good range of motion at 6 weeks.

According to Mills et al, anatomic reduction of the metaphysis is not necessary to get good functional outcome.[9] Instead early range of motion should be started after giving adequate, stability and alignment with fixation. We also agree Shatzker et al that early motion is necessary in order to obtain good result.[16] Stiffness is usually the result of immobilization. In surgically treated patient mobilization should begin within 5 to 7 days.[10] This, however, should not be carried out at the expense of the reduction or at the expense of wound healing. If any doubt exists as to the stability of fixation, then mobilization should begin either in traction and be continued in a cast brace or begin in a cast brace from the start of motion post operatively. We also found that, mechanism of injury determines the type of fracture. In case of simple falls, mainly type I or type II fractures were found commonly. In case of motorcycle accidents, mainly type IV fracture pattern found. In case of dashboard type of injury and fall from height, type V and type VI found commonly. We operated 24 out of 30 patients within 2 days of injury. For 6 patients, we had to wait up to two weeks for oedema to subside, soft tissue injury to heal skin condition to improve. For 2 weeks we treated those patients with limb elevation in slab. We also recommend the use of temporary knee spanning external fixator in such conditions. We used iliac crest bone graft whenever required. We used it in 19 of 30 patients (69.230/0), all of them were of joint depression type. We put the bone graft through same incision after elevating the depressed fragment with periosteum elevator. Alternative to bone grafting, tricalcium phosphate paste can be used to avoid donor site morbidity.[11] We have not used intra-operatively arthroscopic evaluations for the reduction or to repair any meniscal injury. According to series of Lobenhoffer and Schulze, arthroscopic reduction had no advantage over reduction under fluoroscopic control.[12] None of our patients had problems with wound healing or infection. Only two patients developed superficial skin infection, which settled with dressing. This can be attributed to a smaller incision and exposure and hence a shorter surgical and tourniquet time. Out of 26 patients had excellent results. Average hospital stay was 5.5 days and this resulted in reduced expense to the patient.

The principles of MIPPO have been elaborately elucidated by Sirkin et al.[13] They have advocated the use of longer plates (for improved mechanical leverage) and fewer screws (to avoid unnecessary bone and soft tissue damage). In fact, filling off each and every hole can weaken the bone and it may refracture on implant removal.[14] Lag screws are preferably inserted through the plate to avoid excess soft tissue stripping.[15] By this technique, the plate becomes a load bearing implant till callus appears. These plates require only 2 or 3 bicortical holds in distal fragment to achieve stability. We started immediate active and passive knee range of motion exercises on 5th day. In few cases where preoperative swelling or skin conditions was bad, we delayed it for two weeks. We agree with Bailey et al that early range of motion exercises is necessary in order to obtain good results.[11,16]

We also found that after achieving anatomic reduction, the lateral radiograph shows the lateral plateau higher than the medial plateau, as we found in normal lateral radiograph.

Considering the benefits of minimal soft tissue striping, anatomical reduction of articular surfaces, minimal infection and excellent functional results, we recommend the MIPPO over ORIF for all tibial condylar fractures.

CONCLUSION

In our prospective study of 30 cases of tibial plateau fractures treated with minimally invasive percutaneous plate osteosynthesis, following conclusions we have drawn.

1. Peak age group for tibial plateau fractures is 30-40 years, which are mainly involved in road traffic accidents.
2. Vehicular accidents giving rise to indirect trauma due to abnormal loading is the main mechanism of injury.
3. Younger patients have more chances of split fractures while older patients have more chances of depression fractures of tibial condyle. Comminution was more common in older age group because of osteoporosis.
4. Soft tissue injuries are commonly seen in high energy pattern of Schatzker type, especially those having direct injury.
5. Tight Esmarch bandage used for exsanguination helps in reduction.
6. Evaluation of reduction under arthroscopy does not have any significant advantage over fluoroscopic control.
7. No incidence of wound complications. This can be attributed to the smaller incision, shorter surgical and tourniquet time.
8. Early knee mobilization is very important to get good outcome.
9. Reduced hospital stay and expense to the patient.

Finally, we conclude with, in view of the excellent results obtained with this technique, we advocate MIPPO over conventional open reduction and internal fixation technique for tibial condylar and plateau fracture fixation.

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