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Minimally invasive plate osteosynthesis versus open reduction and internal fixation in the management of tibial plateau fractures with locking compression plates

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Abstract
Knee is a major weight bearing joint of the lower limb consequently any fractures involving the proximal tibia will compromise the knee function and stability. Understanding the injury patterns, better implants, and the concept of early surgical fixation and early mobilization of knee joint are need. The aim of the study was to analyse the functional outcome of locking compression plate for tibial plateau fractures done minimally invasive versus open reduction techniques. This was a prospective observational study conducted in srinivasa medical college and yenepoya medical college hospital, Mangalore. In this study, 45 patients with tibial plateau fractures who presented between October 2017 to October 2020 were studied. 38 cases were treated with minimally invasive technique through standard lateral approach and 7 cases with Open Reduction and Internal Fixation with locking compression plates. Minimally invasive percutaneous osteosynthesis and open reduction techniques compared and found to be good union, more movement and lesser complication in former technique. More than the types, early surgery and closed treatment held the key to good results. The emphasis is now shifting from perfect reduction and rigid fixation to biological means of fixation by minimally invasive approaches with using of locking compression plate.

Keywords: union, tibial plateau locking compression plate, minimally invasive percutaneous osteosynthesis, open reduction internal fixation

Introduction
Knee is a major weight bearing joint of the lower limb consequently any fractures involving the proximal tibia will definitely compromise the knee function and stability. Though difficult, the aim of treatment of these fractures is to bring back and conserve normal knee function by anatomical restoration of joint surfaces, maintaining of mechanical axis and restoring ligamentous stability. Understanding the injury patterns, better implants, and the concept of early surgical fixation and early mobilization of knee joint all have convincingly bettered the functional outcome of these injuries to a great degree knee function and stability. They account for 8% of fractures in the elderly [1]. Tibial plateau fractures are frequently caused by high energy trauma and 1 to 3% of these fractures are open injuries, often associated with other complications [1]. Isolated injuries to lateral condyle occur in 70%, 15% involve medial condyle and 15% are bicondylar [1].

Proximal tibial plateau fractures when operated with extensive dissection for the purpose of reduction, it resulted is delayed union and infection. This forms the cause of evolving an in between approach, [Minimally invasive approach] [2] which not only reduces stiffness but is also biological. The locking screw technology was initiated by Carl Hansmann [Hamburg 1886] [3] and improved by Paul Reinhold [Paris 1931].

But now Locked plate technology has become the latest innovation, which is widely used in managing complex tibial plateau fractures. With the advent of newer implants and minimally invasive techniques, complex tibial plateau fractures which were once considered difficult to treat, are now having successful outcomes.

Materials and Methods

This was a prospective observational study conducted in srinivasa medical college and yenepoya medical college hospital, Mangalore. In this study, 45 patients with tibial plateau fractures who presented between October 2017 to October 2020 were studied. Patients with more than 18 years of both sexes were included into the study. Patients admitted with road traffic accidents, were resuscitated and once they were hemodynamically stable, were clinically examined and assessed for associated injuries. Clinically the knee joint was evaluated for degree of soft tissue injury, vascular compromise, presence of compartment syndrome, any obvious ligamentous instability. Radiological examination of the knee joint was done. X rays of the knee involved knee joint were taken, Antero Posterior and Lateral views, whenever necessary oblique views were obtained. Traction X rays were taken if the fracture patterns were not clear on the initial radiographs Schatzker classification of tibial plateau fractures was used to classify fractures in this study. The fractures were initially stabilized with either above knee slabs or calcaneal pin traction. CT SCAN of the knee joint was done in select cases with excessive articular communition and depression to assess the fracture characteristics. MRI of knee was not done routinely.

Inclusion criteria

The following cases were included in our study

1. Closed Schatzker type III tibial plateau fractures.
2. Closed Schatzker type IV tibial plateau fractures.
3. Closed Schatzker type V tibial plateau fractures.
4. Closed Schatzker type VI tibial plateau fractures.

Exclusion criteria

1. Open fractures
2. Fractures with compartment syndrome
3. Fractures with vascular compromise
4. Schatzker type I, II tibial plateau fractures

38 cases were treated with minimally invasive technique through standard lateral approach and 7 cases with Open Reduction and Internal Fixation. These cases were taken for surgery from minimum of 2 days to maximum of 8 days after the injury. For all cases a minimally invasive approach was preferred, open reduction was done only for fractures where it was felt that accurate reduction was not possible through a minimally invasive technique, the primary reason for which being delay in taking up of cases for surgery.

Operative procedure

For minimally invasive percutaneous plate osteosynthesis [3, 4]. Under appropriate anaesthesia the patients were taken up for surgery. In all the patients locking compression plate were applied through a minimally invasive approach without opening the fracture site. 2 small incisions were done, one at the level of the head of the fibula at the lateral tibial plateau for introducing the locking plate after achieving anatomical reduction by closed method. Another distal small incision was done on the lateral part of shin of tibia spanning the fracture site to put distal locking screws.

Operative procedure for Open Reduction and Internal Fixation

Under tourniquet control, an 'L' shaped incision was made beginning at the level just above the head of the fibula on the lateral tibial plateau, it was carried down to the shin of tibia and inferiorly or a lateral parapatellar incision was used[5]. Arthrotomy was done to expose the joint and visualize articular reduction. In the former approach sub meniscal ligaments were cut to expose the articular surface [6]. The entire fracture was exposed, and reduced. The plating technique is the same for rest of the procedure. These patients were immobilised in an above knee slab postoperatively.

Bone grafting

Autologous iliac crest bone grafting was done in four cases. These cases had depression of the articular surface which was elevated intraoperatively and the resultant gap was filled with bone graft [7, 8].

Implant used

In all the patients a stainless steel hockey stick shaped locking compression plate with combi holes was used. For two patients in whom a posteromedial plate was needed, we used a T shaped locking compression plate. For the condyles a 6.5 mm cancellous locking screws and for the shaft 4.5 mm cortical locking screws were used.

Post-operative protocol and rehabilitation

All patients were started on broad spectrum intravenous antibiotics started preoperatively continued for four days postoperatively. Suction drain was removed 48 hrs after surgery. Emphasis was laid on starting early range of motion and static quadriceps exercises as Rasmussen [9] considered 6 weeks to be the upper limit of knee mobilization for restoring normal range of movements. Exercises were started on the second post-operative day as per patient tolerance. Gentle hip and ankle mobilization exercises were initiated. Continuous passive motion was advised for select cases. Non weight bearing mobilization was started on the second postoperative day.

Follow up

All patients were reviewed at 4 weeks, 8 weeks and 12 or 14 weeks and once in two months thereafter. Functional outcome was measured using Bostman knee score [10] and radiological outcome using Rasmussen radiological assessment [9] uniformly for all the patients at 6 months follow up.

Results

The group varied from 22 to 55 years with the mean age of 36.6 years Incidence of fracture was observed maximum between 31 to 40 years of age. 87% of the study population were male and 13% were female patients. 51% of the cases were right side and 49% showed left side involvement. All the patients had road traffic accident. In the study population Type III and Type V fractures were more common (28.8%), Type IV fractures were less common (17.7%) and Type VI fractures occurred in 24.4%.

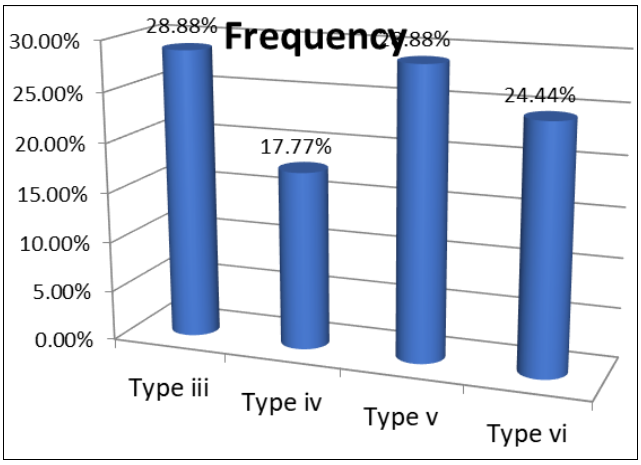

Fig 1: Bar diagram showing different types of fractures and their frequency in the study population.

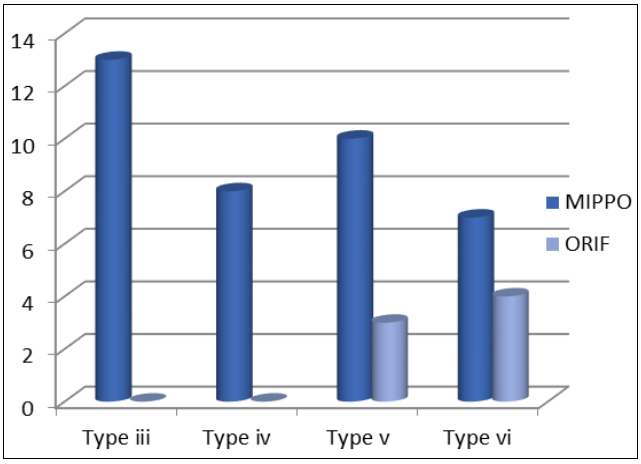

Fig 2: Bar diagram showing the type of operative technique done in different types of fractures.

The time of union varied from minimum of 12 weeks to a maximum of 24 weeks with the average being 15.9 weeks. Associated injuries included one person having a splenic injury, another 2 having fracture shaft of Femur and one person having fracture neck of femur. The follow up period ranged from a minimum of 4 months to a maximum of 24 months. Average being 18.9 months.

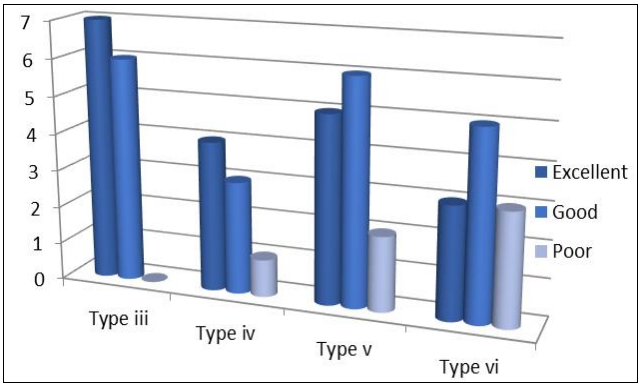

Fig 3: Functional outcome in tibial plateau fractures in study population.

Table 1: Functional outcome in tibial plateau fractures in study population.

	No of cases	Percentage
Excellent	19	42.22
Good	20	44.44
Poor	6	13.33

Case distribution according to radiological outcome

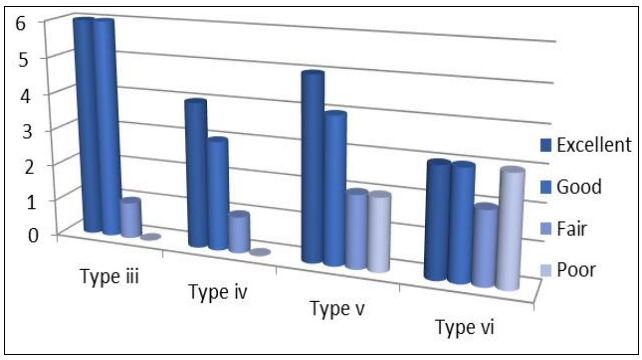

Fig 4: Bar diagram showing radiological outcome in different types of fractures.

Table 2: Radiological outcome in tibial plateau fractures

	No of cases	Percentage
Excellent	18	40
Good	16	35.55
Fair	6	13.33
Poor	5	11.11

Comparison between operative techniques

Table 3: According to time of union

	MIPPO	ORIF	Overall
Average time for union (wks)	14.73	22.28	15.9

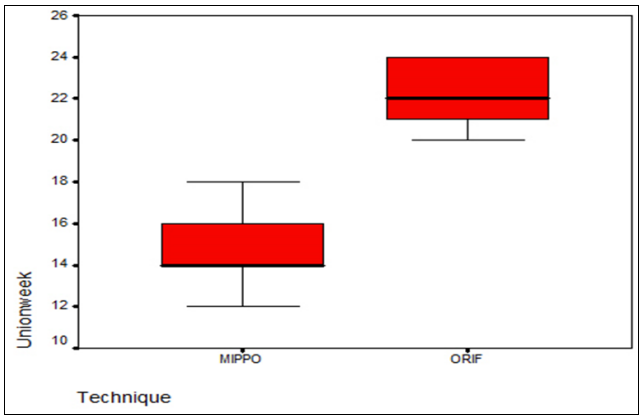

Fig 5: Plot diagram showing difference in union time between MIPPO and ORIF

Table 4: According to functional outcome

	MIPPO	ORIF	Overall
Average score	24.73	14.85	24.46

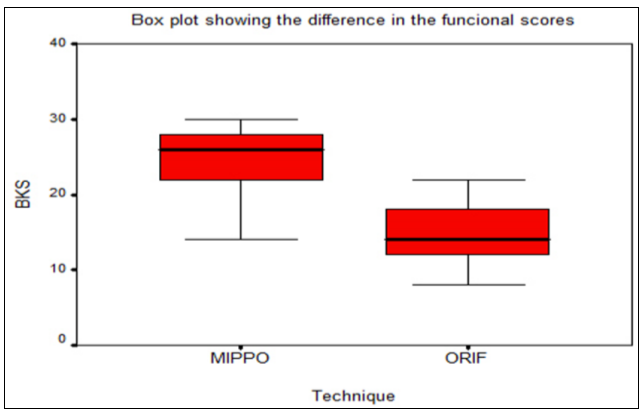

Fig 6: Box plot showing the difference in the functional scores

Table 5: According to post op knee movements

	MIPPO	ORIF	Average
Average range of motion (degrees)	120.52	92.85	116.22

Range of movement in the post-operative period

Table 6: Comparison of functional outcome between MIPPO and ORIF

	MIPPO	ORIF
Excellent	19 (100%)	0
Good	18(90%)	2(10%)
Poor	1(16.66%)	5(83.33%)

Table 7: Comparison of radiological outcome between MIPPO and ORIF

	MIPPO	ORIF
Excellent	18(100%)	0
Good	15(93.75%)	1(6.25%)
Fair	4(66.6%)	2(33.33%)
Poor	1(20%)	4(80%)

Maximum Rasmussen radiological assessment score was 18 and the minimum was 6, with an average of 12.

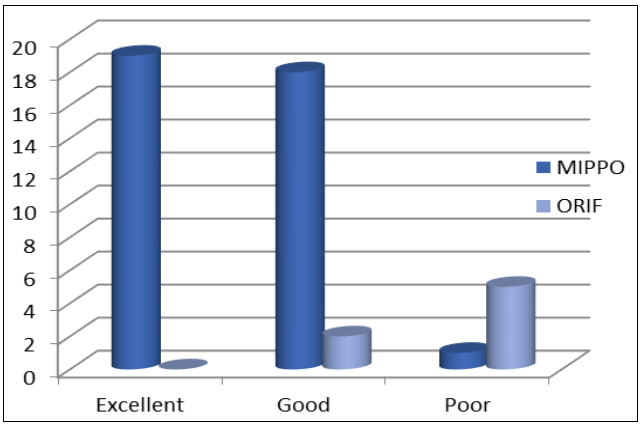

Fig 7: Comparison of functional outcome between MIPPO and ORIF

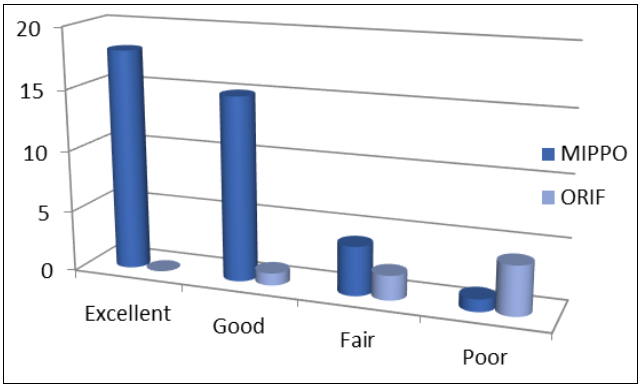

Fig 8: Comparison of radiological outcome between MIPPO and ORIF

Complications

Infection: 3 case developed wound infection, of which 2 were superficial infection controlled by appropriate antibiotics and regular dressings. One case developed wound necrosis which needed regular dressings and debridement and healed by secondary intention.

Knee stiffness: 4 patients developed knee stiffness with the range of motion being less than 90 degrees. They were advised active and assisted range of motion exercises for knee joint.

Malunion: In one case where there was more than 20 degrees of varus angulation.

Limb length discrepancy: Shortening of around 1 cm was observed in one case, which had associated fractures of femur.

Discussion

This prospective study was done on 45 patients with tibial plateau fractures gives us an insight into the epidemiological pattern of these injuries. In our series the patients were predominantly in the fourth decade followed by the third decade. Most of our patients were males, females were less. There was no preference to the side involved share equal percentage of these cases. There was an associated injuries in our series ranging from fracture shaft of femur, fracture neck of femur to splenic injuries giving testimonial to the high velocity of these injuries.

Average waiting period for surgery was 4 days. There is significant association between lag period and functional outcome (p0.0001) with cases operated early having better functional outcomes. In our series all the patients were operated using MIPPO technique except seven of these patients who presented late and ended up with open reduction and internal fixation. Late cases which underwent open reduction internal fixation in an attempt to achieve joint congruity went in for complications like knee stiffness, wound necrosis and poor functional outcomes. But there was no significant association between the operative technique and complications. In cases operated by minimally invasive technique blood loss was minimal varying from 30 to 50 ml, whereas in open reduction methods tourniquet time varied 1 to 1½ hours and the average blood loss was around 150 to 200ml which reiterates the advantages of minimally invasive approach over open reduction. Most of the good range of movements came from minimally invasive methods. However two cases of MIPPO had poor range of movements, first taken up for surgery after one week and the other where there was a secondary loss of reduction needing prolonged immobilization. During the follow up period which ranged from four months to twenty four months average being 18.9 months, the cases were assessed for functional outcome using Bostman knee score which took cognition of the activities of daily living with clinical findings like pain, effusion, instability, range of movements and we had 19 excellent, 20 good and six poor cases. The patients in whom Minimally Invasive Plate Osteosynthesis was used showed better results when compared to Open Reduction Internal Fixation with the average functional score being 24.7 in the earlier and 14.85 in the latter.

Thus cases operated by minimally invasive techniques have better functional Outcomes compared to those treated by open reduction (p0.0001) proven by both Mann Whitney test and chi square tests. All the patients [4] with poor results belonged to the Open Reduction Internal Fixation group, one case was a polytrauma patient with multiple injuries to femoral shaft and neck. Second case was a gentleman taken up for surgery after one week with excessive articular communition and depression. The third case developed postoperative wound necrosis treated with debridement and regular saline dressings. Patients were radiologically assessed using

Rasmussen scoring system and we had 18 excellent, 16 good, 6 fair and 5 poor outcomes with an average Rasmussen score being 13.7,which is comparable to results obtained by Mathur *et al.* [11] (average score 15.3). With respect to the analysis of radiological outcome there is no association of it with the operative technique. And reiterating the fact that radiological outcomes do not alter the functional outcomes, it has been found that there is no association between the two. Though Schatzker type 6 is supposed to be prognostically bad compared to type 5, there was no significant association between the type of fracture and functional outcomes. More than the types, early surgery and closed treatment held the key to good results. In spite of the often feared complication of non-union in locking compression plates, in our study all the cases ended in bony union.

Statistical analysis has proved that there is significant difference in duration of fracture union between minimally invasive groups and open reduction groups with the former showing union earliest (p value 0.0001). Malunion occurred in a one case which had poor functional outcome primarily due to poor patient compliance. In a series by Mathur *et al.* [11] on 27 operatively treated tibial plateau fractures, functional outcome was analyzed using Rasmussen scoring and they obtained 37% excellent and 51.85% good results with only 3 patients having unacceptable results. Whereas in our study the average functional score was 24.7 (range 8- 30) with 42.22% having excellent, 44.44% having good and with rest having poor functional outcomes. The mean Rasmussen's radiological score at final follow up was 15.33 (range, 10-18), in our study the average radiological score was 13.7 (range 6-18), they had also observed clinical evaluation did not correlate with the follow up radiograph as the same in our study. Though Mathur *et al.* [11] in their series had used the open reduction techniques advocated be AO/ASIF, from our results we see that minimally invasive methods also achieve equally good results.

In another study by Kienast *et al.* [12] on the use of unilateral lateral locking plates in bicondylar tibial plateau fractures in twenty six patients, he achieved 65% good, 23% moderate and 11% poor results, which is comparable to our study. The average postoperative knee movements in our study were 116.22 degrees with four patients having movements less than ninety degrees similar to Kienast *et al.* In our series the infection rate was less. Superficial wound infection in two cases and wound necrosis in another. All of them were settled by regular dressings and antibiotics. Historically the rate of infection following dual incision techniques for tibial plateau fractures has been high sometimes going up to 50% in some studies [7, 13], but in our study the rate of infection was only less than 10% in which two cases were superficial infections. As far as the complications are concerned they do not alter the functional and radiological outcomes. Our study confines to a group of 45 patients followed up for a mean period of 18.9 months.

Conclusion

Early stable fixations of the unicondylar and bicondylar fractures of tibial plateau by biological methods using locking compression plates achieve acceptable results. The minimally invasive approach is a boon in the treatment of such complex fractures as it achieves early union, good functional outcome and minimal complication.

The emphasis is now shifting from perfect reduction and rigid fixation to biological means of fixation by minimally invasive approaches. To achieve the above goals we need an implant which provides stability at the same time respects biology, for which locking compression plate is the answer and early surgical intervention provides good results.

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