

MANAGEMENT OF COMMINUTED FRACTURES OF LOWER EXTREMITY WITH MINIMALLY INVASIVE PLATE OSTEOSYNTHESIS

Kapil A. Pawar¹, Taufiq R. Panjwani², J. B. Panase³, Parag. K. Sancheti⁴

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ABSTRACT: Comminuted multi fragmentary periarticular fractures are always a challenge to manage even today. Results of conservative management and ORIF by traditional methods are associated with number of complications. This study evaluate the role of minimally invasive plate osteosynthesis in management of such fractures. Seventeen (17) multi fragmentary fractures of long bones of lower extremity (in 15 patients) were treated in the present prospective study using the technique of minimally invasive plate osteosynthesis (MIPO). There were 11 cases of supracondylar fracture femur, two intra articular, 3 cases of proximal tibial fractures, 2 cases of tibial shaft fractures and 1 cases of subtrochanteric fracture. Mean age of the patients was 45.6 years with 13 male and 2 female patients. Most fractures were caused by high velocity road traffic accidents. Average injury surgery interval was 8.64 days. Average operative time was 67.35 minutes. Average period of union was 19.17 weeks and average period for full weight bearing was 15 weeks. Average hospital stay was 18.41 days. All fractures went on to union. Incidence of complications was low. Range of motion at the proximal and distal joints was excellent. Overall 93.33% (16 of 17) cases had excellent to good results.

KEYWORDS: MIPO, Biological Fixation, Comminuted fractures, Blood supply.

INTRODUCTION: The goal of fracture treatment is to obtain union of fracture in the most anatomical position compatible with maximum functional return of the extremity.¹ In view of the technological development in the vehicles and ever increasing speed of the traffic orthopedic surgeons have to tackle more and higher velocity road traffic accidents with complex, multi fragmentary fractures.

The traditional school of thought concerning management of such fractures with anatomical rigid fixation has also yielded variably poor results.^{2,3,4,5,6} Conservative treatment of closed comminuted fractures with cast and later cast bracing have also met with problems like prolonged immobilization, deformity, shortening, angulations, joint stiffness etc.^{7,8,9,10,11,12,13} Dissatisfaction with these led to the development of newer techniques in open reduction and internal fixation.

Earlier mechanical considerations especially rigid anatomic mechanical stability with hair line reduction of fragments fascinated the surgeons and led to a situation in which many fragments of a broken bone were put together like doing "jigsaw" irrespective of soft tissue attachments. The post-operative radiograph, as the expression and documentation of achievement, was generally impressive and convincing, the application of implants however over-abundant and grandiose! Conventional plating techniques using this approach frequently lead to complications like non-union, delayed union, infection, implant failure and also the need for delayed bone grafting.^{2,3,4,5,6}

It has been rightly said in defining a fracture by Clay Ray Murray,¹⁴ as a "soft tissue injury complicated by a break in the bone". The most important single factor in the management of fracture is the treatment of the overlying soft tissues. Reduction and fracture fixation and the implant itself should not impinge unnecessarily on the biological environment.

ORIGINAL ARTICLE

The more extensively the bone has been fractured (is comminuted), the less the comminuted zone should be handled and approached.¹⁵ Spontaneous remodeling with the incorporation of individual fragments as seen in secondary healing is desirable.

Plate osteosynthesis is recognized as the treatment of choice for most articular, many metaphyseal and a few diaphyseal fractures.¹⁶ Biological plating techniques are those in which blood supply to the fractured fragment is preserved.¹⁷ Stress is laid on maintaining a precarious balance between devascularisation and mechanical perfection. Anatomy is important but physiology is equally important. Biological plating techniques have been referred to by many names—Biological Osteosynthesis, bridging plate osteosynthesis. (Heitemeyer and Hierholzer)¹⁸ and Minimally Invasive Plate Osteosynthesis. (M. I. P. O), (First coined by Christian Krettek.)¹⁷

AIMS AND OBJECTIVES:

- 1) To study and evaluate the results of fracture fixation using the Minimally Invasive Plate Osteosynthesis (MIPO) technique, with a limited operative exposure.
- 2) To compare the results of our study with previously published studies on MIPO technique.

TYPE OF STUDY: Prospective interventional study without control group.

REVIEW OF LITERATURE: Looking historically at the changes in treatment of fractures, three periods can be identified:¹⁶

- 1) The conservative period (approximate reduction and immobilization in traction or plaster cast)
- 2) The mechanical and operative period (exact anatomical reduction and stable even rigid internal fixation)
- 3) The biological and mechanical period (Stability with strict attention to the biological environment of the bone-circulation).

The first attempts at what is now called "Biological Plating" date back some 20 years (Boitzy and Weber), but it has gained popularity since the 1980's. The development of indirect reduction techniques (Mast et al, 1989), the development of wave plate (Brunner and Weber, 1981), and the bridging plate (Heitemeyer et al, 1935), brought about a basic change to fracture treatment.¹⁷

Brunner and Weber (1981) endorsed the use of plates that are shaped to form an elevated bridge over the fracture.^{17,19,20,21} These plates do not touch the bone surface in the critical area of bone injury. These plates were designed to span the fracture site with a plate fixed proximally and distally along the bone. Specifically the wave plate provided three theoretically advantages:

- 1) Decreasing vascular damage at the fracture site.
- 2) Allowing application of corticocancellous bone grafts.
- 3) Altering the load of plate to provide pure tension forces on the plate.

In 1989, Mast et al. published their technique for "indirect reduction". Indirect reduction techniques^{22,23} to be combined with open reduction and internal fixation have been developed to minimize damage to the blood supply.^{24,25,26,27}

Bone loss in the vicinity of plate has always been explained on the basis of Wolfe's law as a reaction of living bone to mechanical unloading of the plate bone segment (stress production).^{14,20} Using disulphide blue as a marker of viability, it was found that plates interfered with the blood supply to the cortex.

ORIGINAL ARTICLE

In 1997, O. Farouk et al²⁸ did a cadaver arterial injection study to analyze vascular supply to the femur and the effects of two surgical plating techniques on femoral vascularity.

In 1991, Heitemeyer U, Hierholzer G^{18,20} performed clinical and radiological follow-up of 29 comminuted fractures of the femoral shaft treated by bridging plate Osteosynthesis. Complete bone healing in 6 open fractures took 33 weeks and 15 closed fractures took 22 weeks.

In 1994, Gamier E, Ganz R²⁹ described a modified approach in internal fixation using plates. According to them, anatomical reduction of fragments in comminuted metaphyseal and diaphyseal fractures itself is no longer a goal. Important reduction aims are the correct length of the bone and axial and torsional alignment.³⁰

In 1997 Lungerhausen W, Ullrich P³¹ stressed the importance of soft tissue conditions and local blood circulation for bone reconstruction and healing of fractures. Additional soft tissue damage caused by operations must be avoided.

In 1997, K Wenda et al³² studied a surgical technique in which plate is inserted through the isolated proximal & distal incisions only behind vastus lateralis for comminuted and complex femoral fractures. This technique produced excellent bone healing. Out of seventeen fractures, 13 healed without complications and results were rated as excellent. Bone grafting was required in 3 out of 17 cases. Only one case of rotational mal alignment was reported. Implant used here was a condylar blade plate.

In a prospective study in 1997, Christian Krettek et al,³³ studied 14 cases of supracondylar or subtrochanteric fractures which were stabilised with a Dynamic Condylar Screw (DCS) using a Minimally Invasive Percutaneous Plate Osteosynthesis (MIPPO) technique. There were no infections and 12 of 13 cases healed without a second procedure. According to Neer score. 6 were excellent. 1 satisfactory and 3 unsatisfactory results.

Minimally Invasive Percutaneous Plate Osteosynthesis has also been tried for tibial metaphyseal fractures. In 1997, David L Helfet et al³⁴ described this for distal tibial fractures. Out of 20 patients, all the fractures healed without the need for second operation. No patient had deep infection. Time to full weight bearing averaged 10.7 weeks with excellent ankle motion.

In 1998, Weller S. et al³⁵ also emphasized the role of epiperiosteal percutaneous plate Osteosynthesis. They also described a new technique using a sliding tip and a manipulation handle for sliding the plate and making a tract in the soft tissues.

In 1998, M J Radziejowski et al³⁶ carried a prospective study of 22 proximal tibial fractures treated by percutaneous plating. Plating was delayed on an average of 7 days. The prebent Tibial head buttress plate (AO/ASIF) was inserted under the skin through a short transverse incision at the knee level. The plate was fixed by proximal and distal percutaneous screws. Union occurred within 12-24 weeks. Articular reduction and fracture alignment was satisfactory in all cases. Two superficial infections subsided after debridement and systemic antibiotics.

MATERIAL AND METHODS: This is prospective study of patients with multifragmentary comminuted fractures of long bones of lower extremity namely femur & tibia were studied. Cases were treated in Sancheti Institute of Orthopaedic & Rehabilitation between the period of March 2004 to March 2006. The method used for fracture fixation was Minimally Invasive Plate Osteosynthesis (MIPO) using two small incisions proximal and distal to the fracture site without opening fracture site. Implants used were plates and screws of different shapes made up of 316L stainless steel. LC-DCP or Titanium implants were not used. Duration of follow up ranged from 3 months to 8 months.

Inclusion Criteria:

1. Fractures selected in this study were restricted to major bones of lower extremity with comminuted segments (multi fragmentary). Fractures in all regions-subtrochanteric femur, shaft femur, supracondylar femur, Fractures of upper tibial metaphysis, tibia shaft or pilon fracture. Articular fractures were also included.
2. All fractures were acute.
3. Closed fractures and open fractures Gustilo Anderson Grade 1, Gr. II, Gr. III were included in the series. Fractures with neurovascular injuries were excluded from this study.

Exclusion Criteria:

1. This study does not include pathological fractures or any fractures in the children.

Following Protocol was observed for Patients on Arrival: Administration of first aid on reception of patient in the casualty department. Thorough examination of the patient to rule out other system injuries followed by assessment of fractures in all extremities. Careful assessment of injured limb was done as regards neurovascular status. Primary immobilization of the involved limb was done in a Thomas splint or slab support or upper tibial pin traction over Bohler's frame was done. Thorough examination of the soft tissues around the fracture site was made & noted on paper to be compared later. All fractures were assessed radiologically by anteroposterior and true lateral X-rays taken of involved limb.

Fractures were then treated depending on their personality and location. Multi fragmentary fractures of tibial diaphysis or upper end tibial fractures-temporary slab support with elevation was given. For fractures of the femur-upper tibial pin traction given over a Bohler's frame. Strict limb elevation was given with additional chymotrypsin/trypsin or serratiopeptidase tablet for decreasing the swelling and overall inflammatory response.

Compound/open injuries (Gr. I, Gr. II) were taken for debridement, if necessary, under anaesthesia, at the earliest possible. Broad spectrum antibiotics were started for such patients. Temporary stabilization as described earlier was continued till the wound heals and there is no sign of any active infection. Grade III compound wounds were treated additionally with external fixators till the wound heals up. Many of the patients had other bony or soft tissue injury on the same side or contralateral side and these were treated appropriately.

IMPLANTS AND TREATMENT PROTOCOL: For subtrochanteric comminuted fracture, 95 degree Dynamic condylar screw with short barrel plate assembly was used. For supracondylar fractures, 95 degree dynamic condylar screw with short barrel plate assembly or a long cobra locking plate. For tibial fractures, L or T buttress plates or Narrow DCP's or hockey stick plates. Plate sizes were variable but long plates with 10 to 16 holes were required. 6.5mm cancellous screws used in metaphyseal bone and 4.5mm cortical hexagonal screws in cortical bone. All implants were made up of 316L stainless steel.

For fractures of the Femur, operative procedure was planned as early as possible when the patient was haemodynamically stable and any other life threatening injury is tackled with and also when the implants necessary were obtained.

Standard lateral approach was taken depending on the fracture site sub trochanteric or supracondylar, appropriate incision was taken so as to aid placement of the guide wire for placement

ORIGINAL ARTICLE

of the dynamic hip screw/dynamic condylar screw. The incision was limited to only 3-4cm so that the area for placement of guide wire is seen.

For supracondylar fractures, the entry point for the definitive guide wire is decided based on the femorotibial wire and patellofemoral wire as references and 2cm proximal to the knee joint line at the junction of anterior 1/3rd and posterior 2/3rd of the longest anteroposterior diameter of the lateral condyle. Anteroposterior and lateral C arm images were then taken to check the position of guide wire. Triple reamer with the prefixed length passed over the guide wire and rimming done. Tapping was done and selected DHS or DCS was inserted into the channel with a wrench. The iliotibial band was then incised spread an additional 2-3cm longitudinally to facilitate plate insertion. An appropriate side plate as determined preoperatively, was then selected. The DCS/DHS plate was inserted through a skin and iliotibial tract incision beneath vastus lateralis muscle while inserting the barrel is pointing laterally.

The side plate is now rotated so that the barrel can be slide over the condylar/hip screw. The condylar screw/hip screw and its attached fragment, proximal/distal were fixed to shaft fragment indirectly and non-anatomically. The plate was then fixed percutaneously and trans-muscularly with three or four diverging cortical screws (4.5mm). Limb length, rotation and axes were determined using clinical and fluoroscopic techniques.

For tibial fractures, the operative interventions were postponed for 7 to 10 days. This delay was necessary for the edema to settle and also the occult soft tissue injury, if any; get manifested. This also gives time for the microcirculation to the skin of the leg to recoup and thus prevents any healing problems for incision later.

Proximally the incision is an inverted L or S shaped incision on either side of the patellar tendon depending on site of plate application. Distal incision of about 3-4cm is also taken just beyond the fracture site. A subcutaneous tunnel is then created between the two incisions and along the medial or lateral aspects of tibia.

On occasion this is unnecessary and the plate can be advanced directly beneath the soft tissues without making a tunnel. The position and length of the plate is the adjusted and confirmed using X-ray control. Proximally the metaphyseal part is fixed to the plate using two/three 6.5mm cancellous screws while distally four/ five 4.5mm cortical screws are passed through the limited incision.

Post-operatively, for femoral fractures Thomas splint support was given. Tibial fractures were given posterior above knee plaster splint given with ankle in neutral position and elevated over a Bohler - Braun frame. Suction drains can be removed when drainage is less than 20cc/hour generally within the first 24 to 48 hours.

Static quadriceps and hamstring exercises were begun on 2nd postoperative day. Depending on condition of wound. Patient was usually discharged by the 14th-16th day. After 3 weeks, crutch walking was started with strict warning not to bear weight and asked to attend the OPD every 2 weeks initially for supervised progressive weight bearing which was decided according to the radiological union. Full weight bearing depended on clinical and radiological picture.

At each follow-up of the patient was assessed as regards clinoradiological union, pain at fracture site, range of movement at knee ankle, deformity, muscle strength, shortening, and integrity of operative scar.

In polytrauma patients, the postoperative treatment was adapted to treat the associated injuries. For each fracture type, the long term results were evaluated by Neer's Rating System, which

ORIGINAL ARTICLE

was modified from the original used for evaluation of functional outcome after supracondylar fractures.

OBSERVATIONS AND RESULTS: 15 patients with 17 multi fragmentary comminuted fractures of long bones of lower extremity were studied. In this study, the youngest case was a 25 year male; the oldest was a 72 year old male. Overall mean age was 45.6 years. Most of the patients involved in high velocity accidents were in the 31 to 40 year age group. There were only 2 female patients. 100% of the fractures were sustained due to RTA resulting from high velocity trauma.

Seven (41.17%) of 17 fractures studied were simple while 10 (58.83%) were open fractures. There were four (4) compound grade III B injuries, two(2) compound Grade III A, two (2) compound grade II, and one compound grade I injury based on Gustilo-Anderson system.

Fracture Subtype	Number of cases
Distal Femur A3	6
Distal Femur C2	5
Tibia fibula Proximal A3	3
Tibia fibula Diaphysis C1	1
Tibia fibula Diaphysis C3	1
Femur diaphysis (sub trochanteric) C1	1

Table 1: Distribution of cases according to fracture subtype

There were two cases of intraarticular fracture of supracondylar femur. There were 5cases of tibial fractures and 11cases of supracondylar fracture femur. There was a single case of subtrochanteric femur fracture with intertrochanteric fracture which was treated with sliding DHS.

Five (5) patients had associated injury resulting from trauma. Medical illness were seen in two cases. Average injury surgery interval was 8.64 days. Thus 47% cases were operated in the period 9 to 14 days post injury. Average operative time was 67.35 minutes.

Healing of the fracture occurred with formation of callus, thus pattern similar to secondary healing was seen. 94.4% of cases united within 23 weeks. Average period for union was 19.17 weeks. Only one case of supracondylar femur showed delayed union with union attained at 26 weeks. Average time taken for full weight bearing was 15weeks. 76% of cases achieved full weight bearing by 18 weeks. Average period of hospital stay was 18.41 days (range: 8-31 days).

Complications	Number of Cases (n=17)	%
Infection	1	6.66
Delayed Union	1	6.66
Deformity	2	13.33
Shortening	1	6.66
Joint Stiffness	0	-
Non Union	0	-
Implant	0	-

Table 2: Complications

There was a single case of superficial infection in fracture shaft tibia which was treated with antibiotics and adequate debridement. Infection did not warrant removal of implant until union was

ORIGINAL ARTICLE

achieved. There was one case of significant shortening of 2.0cm. Delayed union was seen in the case of fracture shaft tibia due to associated superficial infection.

Long term final results were rated using points system for pain, function, work ability, joint movement, radiological and gross appearance. The rating was correlated to AO classification. 93.33% (16 of 17 cases) thus showed good to excellent results.

DISCUSSION: In the present study, 15 cases with 17 multi fragmentary, long bone fractures of the lower extremity were studied and fixed with plates and screws using the minimally invasive plate osteosynthesis technique. There were 11 cases of supracondylar fracture femur, 5 of fractures of tibia and a single case of subtrochanteric fracture.

Seven (7 fractures out of 17) were close fractures, while 10 were open fractures. Proper selection of cases for MIPO with regards to the grade of soft tissue injury is a must. Even with prophylactic antibiotics and adequate debridement, there is always risk of post-operative infection when treating open injuries by internal fixation. Plating should not be resorted in highly compromised soft tissue environment.

Series Name	Period for Union (in weeks)
Present series	19.17 weeks
C. Krettek ³³	16.3 weeks
M. J. Radziejowski ³⁶	20.4 weeks
C. Krettek ³⁷	18 weeks

Table 3: Comparison of Union periods with previous studies

In the present series, average time for full weight bearing was 15 weeks. Full weight bearing was allowed only when bridging callus was seen crossing across the fracture site and when tenderness over the fracture site disappeared. Full weight bearing had to be delayed in 4 cases with ipsilateral other bone fracture.

Study Series	Infection rate
Present Series	7%
D. Helfet et al ³⁴	5%
M. J. Radziejowski et al ³⁶	9%
C. Krettek ^{33,37}	0%

Table 4: Comparison of Incidence of infection as compared to other series

There was one case of fracture tibia with valgus deformity of 10° was noted and attributed to early weight bearing. A significant shortening of 2.0cm was observed in one case. There were two cases of delayed union of supracondylar fracture femur.

In a study by Christian Krettek et al³⁷ complications included 3cases of angular malalignment greater than 150, 1case of shortening greater than 20mm, and 4cases with a varus/valgus angulation. There was one case of wound infection.

In the study by M. J. Radziejowski et al³⁶ there were two cases of superficial infection which subsided after debridement.

ORIGINAL ARTICLE

EVALUATION OF FINAL RESULTS: According to the Neer's criteria, excellent to good results were obtained in 93.33% (16 cases), while 6.66% (1 case) showed fair results. Broadly, good functional results were obtained in patients who had simple and extra articular fractures. There was no direct correlation between age of patient and final outcome in this series. All fractures went on to unite.

Christian Krettek et al³³ reported 6 excellent, 1 satisfactory and 3 unsatisfactory results in their study of 10 femoral fractures.

David Helfet et al³⁴ in their study of distal fractures of tibia had no loss of fixation or evidence of hardware failure. There were isolated cases of delayed union, superficial cellulitis, deformity. All 20 cases showed union.

Series	Excellent	Good	Satisfactory	Unsatisfactory	Total cases
Present	11	3	1	0	15
C. Krettek ³³	6	0	1	3	10
D. Helfet ³⁴	12	2	3	3	20
C. Krettek ³⁷	9	2	4	3	18
C. Krettek ³⁸	4	0	2	2	8

Table 5: Comparison of results between studies using Neer's criteria

CONCLUSION: Minimally invasive plate osteosynthesis (MIPO) is one such method in which a percutaneously inserted plate is fixed at a distance proximal and distal to the fracture (Comminuted area) through minimum exposure.¹⁷ The results of this study compare favourably with those of other series of osteosynthesis using MIPO. However, the surgical technique is complex and requires a relatively long learning curve. However, it has good results which are reproducible with low complication.

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AUTHORS:

1. Kapil A. Pawar
2. Taufiq R. Panjwani
3. J. B. Panase
4. Parag. K. Sancheti

PARTICULARS OF CONTRIBUTORS:

1. Assistant Professor, Department of Orthopaedics, Seth G. S. Medical College and K. E. M. Hospital.
2. Resident, Department of Orthopaedics, Seth G. S. Medical College and K. E. M. Hospital.
3. Consultant Surgeon, Sancheti Institute of Orthopaedics & Rehabilitation, Pune.

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4. Chairman, Department of Orthopaedics, Sancheti Institute of Orthopaedics & Rehabilitation, Pune.

NAME ADDRESS EMAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Taufiq R. Panjwani,
Department of Orthopaedics,
6th Floor, Multy Storey Blog,
K. E. M. Hospital, Parel,
Mumbai-12.
E-mail: taufiqpanjwani@gmail.com

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