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ORIGINAL ARTICLE

MINIMALLY INVASIVE PLATING OF HIGH ENERGY METAPHYSEAL PROXIMAL TIBIAL FRACTURES: OUR EXPERIENCE

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ABSTRACT: AIM: To study average clinical and radiological union time and range of motion at knee joint in case of proximal tibia fracture treated with Minimally Invasive Percutaneous Plate Osteosynthesis. **MATERIALS & METHODS:** 30 patients with proximal tibial fractures were treated surgically using the Minimally Invasive Percutaneous Plate Osteosynthesis technique between June 2011 and December 2013 with a 1 year follow-up. The fractures were classified using the AO and Schatzkar classifications (Figure 1). Closed and Compound fractures, both were included in the study. Patients were followed up on 14th post-operative day, 4 weeks, 6 weeks, and then monthly for 3 months and yearly later on. The functional outcome was evaluated using the Knee Society Score. **RESULTS:** Primary union was achieved by 29 of the 30 study subjects. The mean union time was 13.87 weeks. The rate and type of complication such as implant failure, wound gapping has not been observed. Acceptable range of movement with going back to activities of daily living was observed in our study. The mean Knee Society score was 88.7 at final follow-up visits, 26 patients achieved an excellent result, 2 a good result and 2 a fair result. There were 3 cases with infection, of which 2 healed uneventfully and one required implant removal after healing. Functional results were similar for primary and staged MIPO ($p = 0.109$). **CONCLUSION:** It could be hence inferred that MIPPO (Minimally Invasive Percutaneous Plate Osteosynthesis) or Biological plating preserves vascularity and hence has less complications, less union problems with early recovery in form of joint movement.

KEYWORDS: Proximal Tibia, Fracture, Minimally Invasive Plate Osteosynthesis, Knee Society Score.

INTRODUCTION: Among all the fractures in the body, tibia is the single largest bone that is commonly involved in injuries. Owing to the increase in vehicular accidents and industrial mishaps, high velocity trauma produces tibial fractures in increasing numbers. Fractures of the proximal tibia can be quite challenging to manage as they are difficult to reduce, align and stabilize and prone to develop wound complications and infections.[1]

Preservation of soft tissue, fracture hematoma and periosteal compression are the key to good results in proximal tibial fracture management. Intramedullary nails and Open reduction with compression plating have failed to give satisfactory results.[2]

Minimal Invasive Percutaneous Plate Osteosynthesis (MIPO) using a locking plate has become alternative technique for proximal tibial fractures. The preservation of periosteal blood supply allowed by MIPO offers a clear biological advantage over traditional plating, because it reduces iatrogenic damage to surrounding soft tissues.[3,4,5]

The purpose of this study was to assess the results and the efficacy of MIPO for closed and open fractures of the proximal tibia.

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MATERIAL & METHODS: Between June 2011 and January 2013, thirty patients with an closed and open fractures of the proximal tibia were treated using the MIPO technique at our institution; of these 30 patients, 28 were followed for over 1 year. There were 24 closed fractures and 6 were open injuries. There were 24 men and 6 women of overall mean age 36.26. years (range - 19 to 60 years). The mechanisms of injuries were; a vehicular accident in 26 and a fall from a substantial height in 4. Fifteen of the 30 had an associated injury or fracture. The institution approved the study, which was conducted in strict adherence with established guidelines for treatment of subjects, and written informed consent was obtained from each patient.

According to the AO Foundation and Orthopaedic Trauma Association (AO-OTA) classification, 3 patients were of type 41-A2, 12 were of type 41-A3, 1 were of type 41- B1, 2 patients were of type 41-B2, 6 were of type 41-C1, 3 were of type 41-C2 and 3 patients were of type 41-C3 (Table 1). According to Schatzkar classification 6 fractures were Type IV and 26 fractures were Type VI (Table 2). Open fractures were classified using the Gustilo-Anderson classification, and there were 6 patients with grade I.

Three types of plates were used, (Table 3) Hockey Plate (anatomical pre-contoured locking plate), T-Plate and L-Plate. 10 plates were placed on the lateral side and 20 were placed on the medial side of the proximal tibia. Plate lengths were selected to obtain a minimum of three good bicortical screw purchases distal to the fracture. Great care was taken to handle soft tissue gently and to minimize soft tissue damage.

In most of the patients primary MIPO was done while in cases with inadequate soft tissue coverage, given the need for a brief operation due to general medical condition, and the presence of a severely contaminated wound, patients were treated by staged MIPO. Temporary external fixation was done with soft tissue procedure initially, and subsequent definitive treatment was performed with a locking plate using the MIPO technique.

PRE-OPERATIVE MANAGEMENT AND SURGERY: Temporary Immobilization was given in form of above knee plaster splint. After admission in ward; affected limb was kept on Bohler-Braun splint/ in straight limb with skeletal or skin traction. All routine blood investigations and medical and pre anesthetic checkups were carried out as necessary for surgery. Broad spectrum antibiotics were started for open injuries.

Average time from injury to surgery was 3-5 days. All surgeries were performed under regional anaesthesia. All surgeries were performed under tourniquet.

Attempt was made to keep incision minimum at the proximal side though enough to negotiate the plate (Figure 2). However this was not achieved at the cost of the difficulty of surgeons at the same time care was taken not to do over retraction. Distally either small incisions were made directly over the holes (either by clinical palpation or after confirmation under image intensifier) or a single incision to expose & hold plate was made (Figure 3).

After the incision, the subcutaneous tissue was cut in line of skin incision. In case of lateral approach, the origin of the tibialis anterior muscle was stripped off. The periosteal tube was not opened. Before the implant was slid, indirect reduction was achieved as far as possible mainly by longitudinal traction and manipulation under image intensifier. Sub muscular plane was created with help of soft tissue dissector or by plate. The plate was then slid across the fracture site under IITV image control in the sub muscular plane. After manipulation exact position of implant was achieved this was

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checked under image intensifier. Plate was fixed temporarily with the k wires and checked under image intensifier. Once position was acceptable, then plate was fixed with 6.5 mm cancellous screws proximally and distally by percutaneous cortical screws. Final fixation was checked under image intensifier. The incisions were closed and sterile dressing was applied.

POSTOPERATIVE CARE AND ASSESSMENT: Static quadriceps exercise and ankle mobilization was started as soon as patients' general condition and pain permitted, usually from second postoperative day. Non weight bearing walking was permitted with passive movements at the knee joint. After discharge, the patients were encouraged to perform straight leg-raising exercise and active flexion of their knees and ankles, from tolerable range of motion followed by gradual increase of range similar to unaffected limb. Partial weight bearing with crutches was started at approximately 4-6 weeks postoperatively, usually after signs of fracture union were seen. Routine follow-up radiographs were obtained at 4 weeks, 6 weeks and then monthly for 3 months (Figures 4 & 5) until solid continuous callus formation was observed; callus formation on 3/4 cortices and radiographic evidence of disappearing were considered fracture union signs. Knee and ankle ranges of motion, limb rotations and alignments, and signs of implant-associated complications like infection and failure were checked at all follow-up visits.

Final clinical outcomes were evaluated using Knee Society Score where an excellent result means 85-100; a good result means, 70-84; a fair result is, 60-69; and poor result is < 60. Complications were recorded as mal-alignment, non-union or infection, superficial or deep. The chi-square test and regression analysis were used to determine the natures of relations between final clinical outcomes, complications, and possible influencing factors, such as fracture pattern (AO-OTA), operative method (primary or staged MIPO), and type of implant used. The analysis was conducted and statistical significance was accepted for 'p' values <0.05.

RESULTS: Primary bony union was achieved by 29 (97%) of 30 patients at an overall average of 13.87 weeks (range, 9 to 20 weeks). There was 1 case of expectant non-union due to compound injury and initial soft tissue insult, requiring early implant removal (Table 4).

On final assessment, two patients were having union in a position of minimal deviation from anatomical alignment. 4 patients had union in Varus while the same number of patients had a union in Valgus. No mal-alignment or angulation of more than 10° occurred in any planes. However, because these extents were negligible and did not influence knee joint function, no correction was needed. The other patients showed neutral alignment. Functional results were excellent in 26(86.67%) patients, good in 2(6.67%) and fair in 2(6.67%). Mean Knee Society score at final follow-up was 88.7 (range - 75 to 95).

Functional outcome was not related to fracture pattern ($p = 0.092$), operative method ($p = 0.109$) or type of implant used ($p = 0.074$).

Post-operative infection occurred in 3 (10%) cases; superficial infection in 2 (6.67%) and deep infection in 1 (3.33%). Two cases of infection occurred in open grade I and 1 in a closed fracture. Closed fractures showed a lower infection rate (3.33%) than open fractures (33.3%) ($p = 0.019$).

In this study, there were four patients (13.33%) with restriction of knee range of movement, of which, one had pre op restricted range of movement due to broken DFN for supracondylar femur fracture on same side; and one had myositis ossification at compound femur fracture on same side. One patient had ipsilateral AO/OTA 33 C2 type supracondylar intercondylar fracture femur (Table 5).

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DISCUSSION: Among all the fractures in the body, tibia is the single largest bone that is commonly involved in injuries. Owing to the increase in vehicular accidents and industrial mishaps, high velocity trauma produces tibial fractures in increasing numbers. By its location and by being subcutaneous in most of its length tibia fractures tend to be open very commonly. Due to its precarious blood supply and scanty soft tissue coverage, Orthopaedic Surgeons around the world have been fighting infections and union problems.

Fractures of the proximal tibia can be quite challenging to manage as they difficult to reduce, align and stabilize and prone to develop wound complications and infections. As these fractures involve a major weight bearing joint, they result in functional impairment frequently. To preserve normal knee function, it is essentially important to maintain joint congruity, preserve the normal mechanical axis, ensure joint stability and restore full range of motion especially in Indian culture where squatting and sitting cross legged is a must as a routine activity.[6] This is a formidable task to accomplish, in the presence of compromised soft tissues especially in open fractures, variable bone quality and associated medical conditions of the patients.

There is a considerable debate regarding the best method for treating proximal tibial fractures.[7]

In the past close reduction and casting followed by functional bracing were the prime modalities for treating the open and close tibial fractures. Frequent soakage in the cast, inaccessibility of dressing, breakage of cast, knee and ankle stiffness and high chances of delayed and non-unions produced discouraging results leading to a wave of new experiments to treat these fractures effectively. Discouraged by close reduction and cast application a trend began to treat fractures by application of external fixator in the tibia. Its use has also been documented in management of both closed and minor open fractures. Immediate stabilization has produced good short term results in wound healing but gradually complications like pin tract infection, fixator frame failure, malunion, non-union, compartment syndrome, chronic osteomyelitis, joint stiffness and necessity of secondary procedures etc. diverted many of the treating surgeons to find some other methods of fixation that would reduce these complications.[7,8,9]

Indirect reduction was introduced in the 1988 by Mast et al. and others. It was an attempt to decrease surgical dissection by ligamentotaxis, blind repositioning of fragments, reduction aids such as the distracter and other methods to maintain soft tissue integrity and preserve bony perfusion. Additionally, plates were redesigned to limit contact with the underlying bone and further preserve bony vascularity.[10]

In the 1990s, Krettek et al. popularized MINIMALLY INVASIVE PERCUTANEOUS PLATE OSTEOSYNTHESIS TECHNIQUES using conventional implants placed through small incisions and sub muscular (subcutaneous) tunnels.[11] As part of the continued development of BIOLOGICALLY FRIENDLY PLATING, and to facilitate MINIMALLY INVASIVE PLATING TECHNIQUES, the use of plates that allow screws to lock into the plate to create a fixed angle construct is gaining popularity nowadays.[12]

Several different surgical approaches have been described for PROXIMAL TIBIAL fractures (medial, lateral and combined) depending on the location of the fracture. Combined extensive approaches, in particular, are associated with high complication rates, possibly due to compromised soft tissue perfusion and/ or extensive soft tissue stripping from bone fragments. A review of the recent literature demonstrates a trend towards increasingly limited open reduction and internal fixation, often in association with some form of external stabilization. Minimally invasive techniques have also

been described for intra-articular fractures (metaphyseal and diaphyseometaphyseal) of the proximal tibia. These techniques avoid the long incisions and extensive soft tissue stripping associated with conventional techniques and are best used with shorter, lower profile plates.[13,14]

Keeping in mind the daily routine activities of Indian patients and their requirements of sitting cross legged and squatting, we chose rigid criteria for final assessment. Beside this, other factors which are considered are the time of union, movement of knee joint, alignment of fragments, pain, and infection at fracture site.

We choose this study to reinforce the minimally invasive technique and to compare it with the existing national and international literature. We undertook a study of 30 cases of comminuted distal end tibia fracture treated by minimally invasive percutaneous plate osteosynthesis and compared it with studies from P.A.Coleet.al., C. Krettek et.al., Raiyurkar et.al.[15,16,17]

Commonality was in age like young patients being more affected with male sex preponderance. All injuries in pilot as well as reference studies comprised mostly of high energy injury.

Union problem with this technique were negligible. The rate and type of complication such as implant failure, wound gapping has not been observed. Acceptable range of movement with going back to activities of daily living was observed in our study. In cases of polytrauma, fracture fixation of difficult comminuted fracture with MIPPO technique had less surgical trauma, less blood loss, and faster union as it does not interfere with fracture healing biology.

It could be hence inferred that MIPPO (Minimally Invasive Percutaneous Plate Osteosynthesis) or Biological plating preserves vascularity and hence has less complications, less union problems with early recovery in form of joint movement.

"MIPPO is certainly a big step forward, but in my opinion it will only reach its full potential when we are able to achieve closed, simple, and indirect reduction with a technology that is available to everybody." Stephan M. Perren, Davos.[18]

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TYPE	NO. OF FRACTURES	PERCENTAGE (%)
A1	00	00
A2	03	10
A3	12	40
B1	01	03
B2	02	07
B3	00	00
C1	06	20
C2	03	10
C3	03	10
TOTAL	**30**	**100**

TABLE 1: ACCORDING TO AO CLASSIFICATION 41

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TYPE	NO. OF FRACTURE	PERCENTAGE (%)
I	00	00
II	00	03
III	00	00
IV	06	20
V	00	00
VI	24	80
TOTAL	**30**	**100**

TABLE 2: ACCORDING TO SCHATZKER CLASSIFICATION

TYPE	4 HOLE	5 HOLE	6 HOLE	7 HOLE	8 HOLE	9 HOLE	10 HOLE	>10 HOLE	TOTAL
HOCKEY PLATE	2	2	2	4	2	3	3	3	21
T PLATE	0	2	0	2	1	1	0	0	06
L PLATE	1	0	1	0	0	1	0	0	03
TOTAL	**03**	**05**	**03**	**06**	**03**	**05**	**03**	**03**	**30**

TABLE 3: TYPE OF IMPLANT

TIME	NO. OF PATIENTS	PERCENTAGE (%)
<15 weeks	20	66.67
15 – 20 weeks	9	30
>20 weeks	0	00
TOTAL	**29**	**96.67**

TABLE 4: FRACTURE UNION

COMPLICATIONS		NO. OF PATIENTS
Restriction of movement		04
Upper leg pain		02
Infection	Superficial	02
	Deep	01
Total		**09**

TABLE 5: COMPLICATIONS

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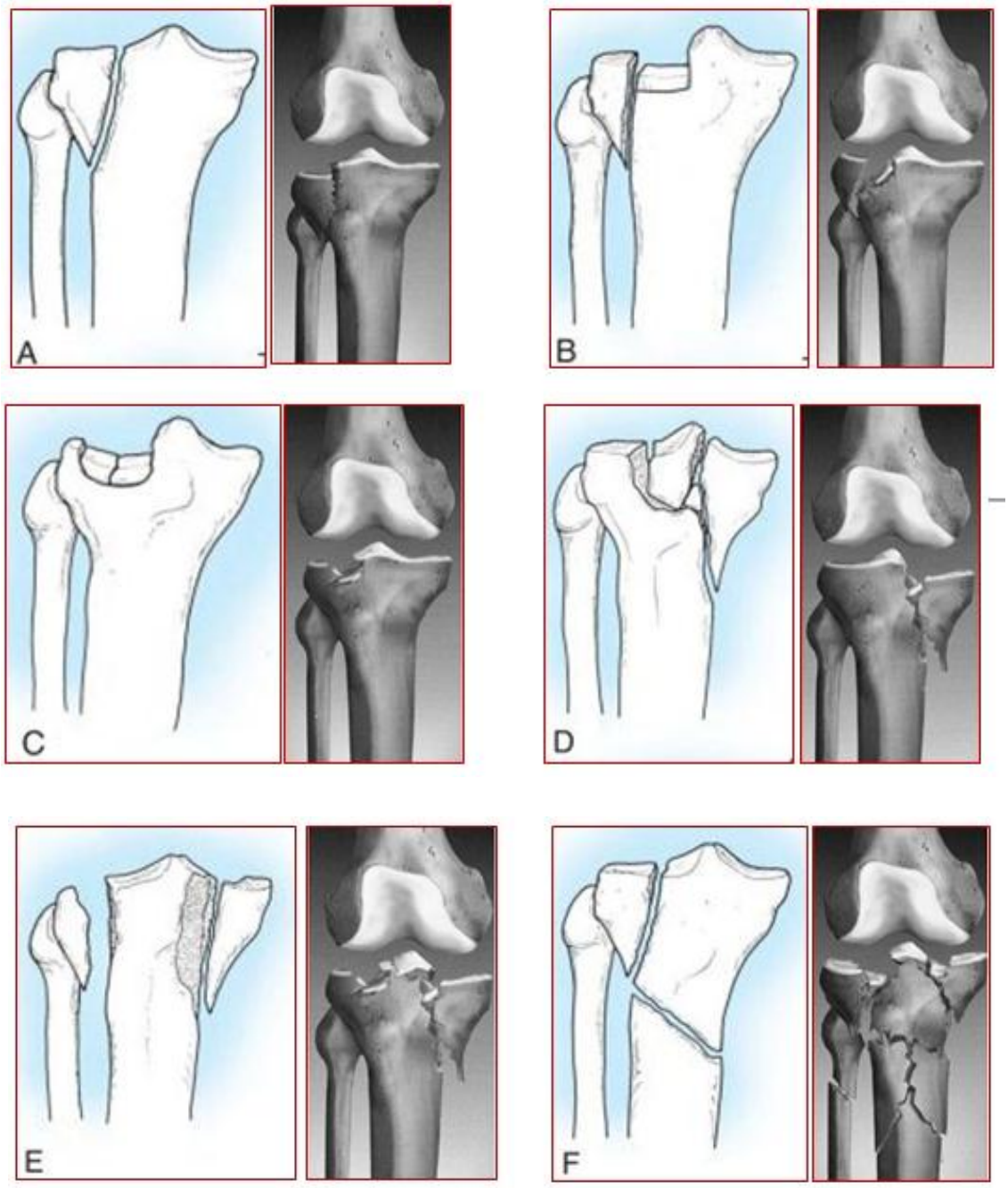

Fig. 1: Schatzker Classification

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Fig. 2a: Proximal Incision

Fig. 2b: Sliding of Plate

Fig. 3: Distal Incisions

Fig. 4: Using the T Plate

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Fig. 5: Using the Hockey Plate

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