Original Article

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Outcome of Biological Plating of Extra-articular Proximal Tibia Fractures

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ABSTRACT

Introduction: The most prominent transformation in the treatment of fractures has been modified from intensive open reduction and internal fixation with absolute stability to the biological fixation with relative stability and secondary healing with callus formation, with priority on preservation of the vascularity of bone and soft tissue to improve fracture healing.

Aim: To evaluate the outcome of biological fixation of extra-articular proximal tibia fractures in adults using the locking compression plate.

Materials and Methods: The present prospective longitudinal study was conducted at Government Medical College and Hospital, Nagpur, which included 30 patients who had extra-articular proximal tibia fractures belonging to AO type 41A2 and 41A3 treated by proximal tibia lateral locking plate 4.5/5.0 mm. The patients were followed-up at two weeks, six weeks, three months, six months and one year. The fracture union, coronal, sagittal alignment was assessed radiologically at the end of follow-up. Functionally the outcome was evaluated using lower extremity functional score. Descriptive statistics were used for statistical analysis.

Results: Biological plating with locking compression plate has shown promising results both in terms of function and radiology. There was non-significant difference in lower extremity functional score between patients with malunion and normal alignment. Mean union time was 19.93 weeks with a standard deviation of 2.21 weeks. There was non-significant difference between the range of motion and fracture type (p-value 0.38) as well as that between Lower Extremity Functional Score (LEFS) and fracture type (p-value 0.0501). On functional evaluation of patients treated with biological plating, there was statistical significance in Knee Range of Motion (ROM) for the patients between malunion and normal alignment (p value 0.01).

Conclusion: The biological fixation using minimally invasive techniques is an effective method of stabilisation for extra-articular proximal tibia fracture, yielding good mechanical alignment and protecting soft tissues and blood supply, leading to higher union rates with good functional outcome.

Keywords: Fixation, Locking plate, Minimally invasive percutaneous plate osteosynthesis

INTRODUCTION

Metaphyseal proximal tibia fractures are common and constitute for 5-11 % of all tibial. Fractures [1]. These fractures are cumbersome, demanding and necessary to treat as proximal tibia plays a key role in weight-bearing. Due to high energy trauma involved there is complex, multi-fragmentary comminution, soft tissue injury and neurovascular injury. Though the problems of soft tissue and neurovascular injury were tackled by external fixator, it's use was largely limited due to complications of non-union, malunion and pin tract infections [2]. No agreement on optimal treatment has been reached as each modality has it's own indication and contraindication. In the era of aggressive internal fixation, infection and implant failure were common due to conventional plating. Though principles of anatomical reduction, rigid fixation was followed, preservation of soft tissue was unknowingly ignored. Following which AO (Arbeitsgemeinschaft fur Osteosynthesefragen) principles (1990) modified their principles that included functional reduction, stable fixation, preservation of blood supply and early active mobilisation. In the year 1997, Dr. Christian Krettek and Dr. Harald Tscherne introduced the concept of mini-incision surgery called minimally invasive percutaneous osteosynthesis [3].

This involved moving away from aggressive and rigid fixation and approaching towards indirect reduction, relative stability, minimal soft tissue stripping [3,4]. Intramedullary nail, though it was minimally invasive, but inefficient in proximal tibial fractures due to short proximal fragment and thus tendency for malalignment [5]. Farouk O et al., in 1999 showed that minimal invasive plating had better conservation of periosteal and medullary perfusion [6].

Locking compression plates revolutionised the world of fracture fixation. These plates and the minimally invasive operation tools are the main workhorses of the Minimally Invasive Percutaneous Plate Osteosynthesis (MIPPO) technique. This technique results in biological fracture healing preserving vascularity, fracture haematoma, minimising soft tissue injury, avoiding the need for bone grafting and relative stabilty. Therefore, MIPPO is also referred to as biological plating. Very little data is available in the literature regarding outcomes of extra-articular proximal tibia fractures by biological fixation. The objective of this study was to prospectively evaluate the functional and radiological outcome of metaphyseal proximal tibia fracture managed by locking compression plates following the principles of biological fixation.

MATERIALS AND METHODS

A proespective longitudinal observational study was done on 30 patients with proximal tibia fractures belonging to AO classification [1] type AO 41A2 and 41A3 were operated for internal fixation with 4.5 mm/5 mm proximal tibia lateral locking compression plate between August 2018 and September 2020 in Department of Orthopaedics in tertiary health care centre. Approval by the hospital Ethics Committee was sought (IEC-GMCHN/AP/2018/22).

Inclusion criteria: All patients aged 18-65 years, admitted in the study centre during the study time period with Gustillo Anderson grade 1 compound and closed fractures of proximal tibia belonging to AO type 41A2 and 41A3 sustained fracture within two weeks of surgery without neurovascular injury were included in the study after obtaining the written informed consent and preanaesthetic clearance for operative procedure in the study.

Exclusion criteria: All patients with compound fractures of Gustillo Anderson grade 2 and grade 3, pathological fractures, patient aged

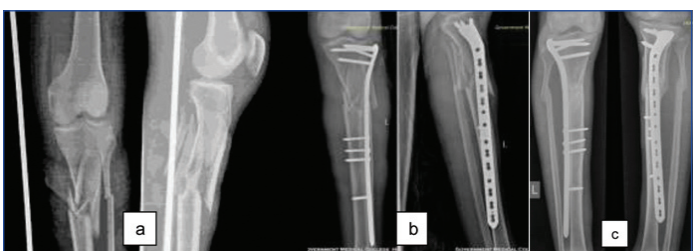
less than 18 years and more than 65 years and those with severe co-morbidities like psychiatric illness, cardiovascular diseases, cognitive disorders, were excluded from the study.

Sample size constituted: It constituted all patients sufficing the inclusion criteria, hence 30 in number, 19 male patients and 11 female patients. A thorough history and clinical examination was done for each patient. Other associated injuries like head, chest, spine, any other extremity and abdomen were noted. Plain radiographs of the involved limb with adjoining joint were taken in anteroposterior and lateral views.

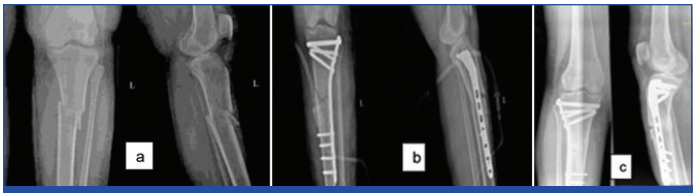
Study Procedure

The patients were operated in supine position (under general or regional anaesthesia) on a radiolucent table, with a sandbag underneath the ipsilateral hip joint with pneumatic tourniquet over the proximal thigh. Under all aseptic precautions, a curvilinear incision (s-shaped) was made over the proximal tibia on the lateral side. The skin incision was approximately 5-6 cm in length. The fascia of the ilio-tibial band was divided longitudinally parallel to its fibres starting at the gerdy's tubercle. Dissection was extended distally through the fascia of tibialis anterior muscle. The submuscular tunnel was made with a periosteal elevator. Indirect reduction was achieved with axial traction and/or application of reduction clamps or distractor. To achieve reduction at the fracture site, a reduction clamp percutaneously was applied to correct coronal and sagittal plane alignment. All was confirmed under fluoroscopic guidance (High Frequency 50Khz Microprocessor controlled portable C-arm machine). Internal fixation with a proximal tibia lateral locking compression plate 4.5 mm/5 mm was achieved. Principles of bridging plate fixation were followed [3,4]. Fracture reduction was obtained before the screw placement. Cortical screws flushed the plate to the bone. Locking screws were fixed distally and proximally. A submuscular drain was inserted and closure done in layers.

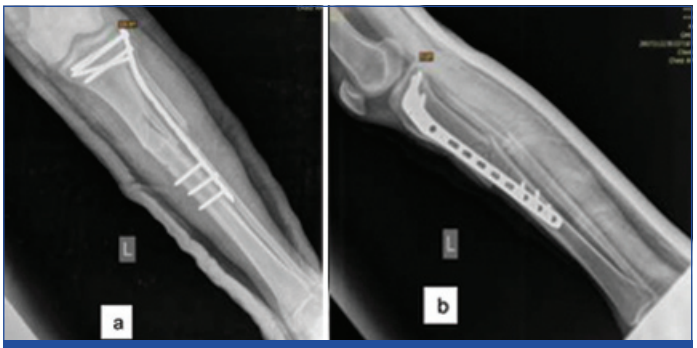
Passive range of motion exercises of the knee was started on the first postoperative day. All patients were mobilised with toe-touch weight-bearing immediately in the postoperative period and partial weight-bearing with crutches at six weeks. Active and active-assisted range of motion was started once swelling subsided. Quadriceps strengthening exercises were commenced after two weeks. Full weight-bearing was restricted until clinical and radiological signs of the union were evident. The patients were followed-up at two weeks, six weeks, three months, six months and one year [Table/Fig-1,2]. Antero-posterior (AP and lateral radiographs were obtained postoperatively and followed-up till the end of one year. In the AP view, varus/valgus deformity was measured by measuring the angle between the lines drawn perpendicular to the proximal and distal tibial articular surfaces. In lateral view, the procurvatum/recurvatum was measured similarly and 8 degrees of the posterior slope was subtracted [7]. The measurement of angles was done using Dicom software (Radiant DICOM viewer 4.0.1) [Table/Fig-3]. Fracture healing was considered as callus formation in two orthogonal planes. Non-union was defined if three consecutive months' X-rays did not show progressive healing. Malunion was defined as more than 5 degrees of angulation in the coronal plane, 10 degrees of angulation in the sagittal plane and more than 10 degrees of rotation. Rotation, limb length and range of motion was assessed clinically using a standard goniometer.



[Table/Fig-1]: (a) Plain radiographs of proximal tibia anteroposterior and lateral view showing AO type 41A3 fracture; (b) Immediate postoperative plain radiographs AP and lateral view of proximal tibia fracture AO type 41A3 treated with lateral tibia locking compression plate 4.5 mm; (c) Follow-up plain radiographs AP and lateral view at 21 weeks showing radiological union.



[Table/Fig-2]: (a) Plain radiographs showing proximal tibia fracture AO type 41A2 anteroposterior and lateral view. (b) Immediate postoperative plain radiographs A.P. and lateral view of proximal tibia fracture AO type 41A2 treated with lateral tibia locking compression plate 4.5mm.(c) Follow-up plain radiographs A.P. and lateral view at 18 weeks showing radiological union.



[Table/Fig-3]: (a)Plain radiographs of operated proximal tibia with lateral tibia locking plate Anteroposterior view showing valgus (Coronal plane alignment) of 10 degrees on DICOM software.(b Plain radiographs of operated proximal tibia with lateral tibia locking plate. Lateral view showing recurvatum (Sagittal plane alignment) angle of 7 degrees on DICOM software.

Functional outcome was assessed by LEFS with maximum points being 80 and minimum points being 0 points at the end of follow-up [8].

STATISTICAL ANALYSIS

The results were assessed using mean, Standard deviation, Student's t-test, pearsons correlation coefficient. A p-value of less than 0.05 was considered significant. The results were entered in MS Excel spreadsheets, and statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 16.0.

RESULTS

Present study comprised of a total of 30 patients. Out of which were 19 were male and 11 were female. The mean age was 42±11.15 years (range 24-65 years).

The most common mode of injury was road traffic accident (23 patients) followed by domestic fall (7 patients). Mean follow-up period was 34 weeks. A total of 17 were AO type 41A2 and 13 were AO type 41A3. Mean surgical delay was 5.4±2.31 days (range 2-8 days). Mean surgical time was 54.56±5.84 minutes. Mean range of motion attained at the end of follow-up was 126.93±4.50 degrees. LEFS at the end of follow-up was 61.86±4.20. Mean union time was 19.93±2.21 weeks [Table/Fig-4].

There was no statistically significant difference between fracture type and range of motion (p=0.38). Also, there was no statistical difference between fracture type and lower extremity functional score (p=0.0501). There was no statistically significant difference between fracture type and union time (p=0.63).

Pearson correlation coefficient for range of motion with advancing age was 0.01 positive weak correlation. Pearson correlation coefficient for LEFS with advancing age was 0.03 negative weak correlation. Malunion in coronal plane was observed in five patients (range from 9 degrees varus to 10 degrees valgus). Malunion in sagittal plane was observed in four patients (range from 15 degrees procurvatum to 12 degrees recurvatum). Malunion in both the planes was observed in three patients [Table/Fig-5].

Data analysis (Mean±SD)	Fracture type 41A2	Fracture type 41A3	Total
Age (years)	44.29±11.06	39±10.95445	42±11.15
Surgical delay (days)	5.41±2.47	5.38±2.18	5.4±2.31
Surgical time (minutes)	53.41±5.81	56.07±5.75	54.56±5.84
Range of motion (degrees)	127.58±4.12	126.07±4.99	126.93±4.50
LEFS	63.23±3.40	60.07±4.60	61.86±4.20
Union time (weeks)	19.76±2.33	20.15±2.11	19.93±2.21

[Table/Fig-4]: Demographic data and outcome for each fracture subtype.
LEFS: Lower extremity functional scale; n=17 in fracture 41A2 and n=13 in fracture 41A3

Alignment	Deformity	Frequency (n)
Coronal plane	≤5° Varus	15
	>5° Varus	3
	≤5° Valgus	10
	>5° Valgus	2
Sagittal plane	≤10° Procurvatum	13
	>10° Procurvatum	2
	≤10° Recurvatum	13
	>10° Recurvatum	2

[Table/Fig-5]: Radiological evaluation of patients treated with biological plating.

Rotational malunion was observed in two patients averaging 13 degrees. Shortening was observed in two patients averaging 1 cm and both observed in AO type 41A3 patients [Table/Fig-6].

Clinical parameteres	Measurements	Frequency (n)
Rotational alignment	≤10°	28
	>10°	2
Shortening	≥1 cm	2

[Table/Fig-6]: Clinical parameters.

There was a significant difference in knee range of motion between patients with malunion (p-value=0.01) and normal alignment. There was no significant difference in lower extremity functional score between patients with malunion (p=0.12) and normal alignment [Table/Fig-7].

Functional parameters	Alignment	Mean
Knee ROM	Malunion	121.4°±3.714
	Normal	128.04°±3.81
Lower extremity functional score	Malunion	58.8°±4.14
	Normal	62.48°±4.02

[Table/Fig-7]: Functional evaluation of patients treated with biological plating.
*There was statistical significance in Knee Range of Motion for the patients between malunion and normal alignment (p-value 0.01)
*There was no significant difference in Lower Extremity Functional Score (LEFS) for the patients between malunion and normal alignment. (p-value 0.12)

With regards to the complication, one patient had implant prominence with the removal of implants done after the radiological union was achieved. One patient had a deep infection treated by debridement and culture-sensitive intravenous antibiotics. One patient had superficial infections treated by oral antibiotics. No complication of non-union and heterotopic ossification was seen.

DISCUSSION

Metaphyseal proximal tibial fractures are difficult to treat due to associated complications. Also, considerable data is lacking due to limited number of studies exclusively on extra-articular metaphyseal tibia fractures. The present study highlights the outcome of such fractures radiologically and clinically. Open reduction and internal fixation was common through all these years with very little emphasis on soft-tissue preservation and vascularity. With the advent of minimally invasive operations, vascularity and soft tissue are maintained, thereby improving rates of fracture healing with reduced incidence of infection and non-union anchored by various studies [9-11]. These all constitute features of biological fixation with preservation of biology of bone and stable mechanical fixation. Intramedullary nails though are minimally invasive but had complications of sagittal and coronal malalignment. Proponents of intramedullary nail cited various techniques of fixation which includes a higher entry point multi-directional locking system nail design, use of poller (blocking screws), early mobilisation and weight bearing [12-15]. The indications of external fixator have become limited due to emerging minimal invasive systems and applies only to compound fractures. In the present study, the authors used a lateral locking plate for fixation. Laterally applied plate provides rigid fixation, are biomechanically stable and assists in reduction due to pre-contoured design. With no need of medial buttressing as cited by various studies [16,17]. While some studies believe that a medial buttressing is essential to withstand varus load and a must for comminuted proximal tibia fractures [18]. Locking plates provides fixed-angle construct in comminuted fractures and osteoporotic bones, reduces the loss of fixation.

Malalignment caused in proximal tibia fractures are usually due to muscular forces of the patellar tendon resulting in procurvatum deformity and valgus deformity due to pes anserine tendons. These deformities can be easily reduced indirectly with the use of minimally invasive instruments and fluoroscopy [19]. Bhandari M et al., in his study observed reduced rates of malunion in locking plate group and higher rates in the intramedullary group [20].

Lindvall E et al., in his comparative study also cited results of malunion associated with nailing group [21]. A significant difference in knee range of motion between patients with malunion and normal alignment was observed in this study. We believe that the lateral locking plate is inefficient in cases of severe medial comminution and demands medial fixation as well having buttress effect. Infection was common in the era of open reduction and internal fixation. Biological plating drastically reduced the rates of infection. However, the studies are lacking in the infection rate in closed fractures treated by biological plating. With many studies involving compound fractures, the rate of infection was significantly higher [20].

However, in both the studies, the difference between the groups were not statistically significant. In this study, rate of infection was mere 6.66 per cent with the reason being the exclusion of compound fractures. Phisitkul P et al., reported a 22% rate of infection in patients involving high energy proximal tibia fractures treated by less invasive stabilisation system [11].

Hardware prominence is common in plate fixation due to its high-profile design. This was supplemented by various designs involving the proximal tibia plate [21,22]. The hardware prominence can be reduced by curvilinear skin incision, covering the plate with meticulous ilio-tibial band closure and use of cortical screws in construct to flush the plate to the bone. The removal of locking plates can become difficult due to cold welding of locking screws. Implant prominence is a major problem in the plating group as compared to the interlocking nail group supported by the literature [21-23]. In present study, there was one case of implant prominence.

Non-union is uncommon in proximal tibia unless it is a compound fracture. Due to vascular supply maintained because of biological fixation non-union is avoided [19,22-24]. In present study, no case of non-union was observed. Knee stiffness is an uncommon complication as fractures are extra-articular. Early rehabilitation avoids such complication. In the present study, no such complication was observed. Polytrauma especially in the same limb trauma may be a predictor in the outcome of proximal tibia fractures.

Limitation(s)

Small sample size, absence of comparative group, inter-observer variation and short-term follow-up for complications were the limitations of this study.

CONCLUSION(S)

Biological fixation of metaphyseal tibial fractures belonging to AO type 41A2 and 41A3 with locking compression plates has shown promising results. The present study also concluded that this technique reduces Malalignment, infection rates and gives optimum stability, better functional outcome.

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