

# Proximal tibial fractures with impending compartment syndrome managed by fasciotomy and internal fixation

## A retrospective analysis of 15 cases

Naveen Sharma, Varun Singh, Ashish Agrawal, Rakesh Bhargava

### ABSTRACT

**Background:** Proximal tibia fractures with compartment syndrome present a challenge for orthopedic surgeons. More often than not these patients are subjected to multiple surgeries and are complicated by infection osteomyelitis and poor rehabilitation. There is no consensus in the management of these fractures. Most common mode is to do early fasciotomy with external fixation, followed by second stage definitive fixation. We performed a retrospective study of proximal tibia fractures with impending compartment syndrome treated by single stage fasciotomy and internal fixation. Results in terms of early fracture union, minimum complications and early patient mobilization were very good.

**Materials and Methods:** Fifteen patients who were operated between July 2011 and June 2012 were selected for the study. All documents from their admission until the last followup in December 2013 were reviewed, data regarding complications collected and results were evaluated using Oxford Knee scoring system.

**Results:** At the final outcome, there was anatomical or near anatomical alignment with no postoperative problems with range of motion of near complete flexion (>120) in all patients within 3 months. 13 patients started full weight bearing walking at 3 months. Delayed union in two patients and skin necrosis in one patient was observed.

**Conclusions:** Since the results are encouraging and the rehabilitation time is much less when compared to conventional approaches, it is recommended using this protocol to perform early fasciotomy with the definitive internal fixation as single stage surgery to obtain excellent followup results and to reduce rehabilitation time, secondary trauma, expense of treatment and infection rate.

**Key words:** Compartment syndrome, fasciotomy, fixation, proximal tibial fractures, internal fixation

**Mesh terms:** Tibial fractures, compartment syndromes, fracture fixation, internal

### INTRODUCTION

Decision making in operative treatment of fractures of the proximal tibia associated with impending compartment syndrome has been difficult. The criteria for impending compartment syndrome are: Mild

to moderate increase in circumference of the leg, firm swelling on palpation, appearance of multiple fluid filled blisters, mild to moderate pain on stretching the tendons of muscles passing through the compartment involved and no vascular, sensory or motor deficit.<sup>1</sup> Various methods of treatment have been described, each with its own merits and demerits.<sup>2</sup> Common practice has been to perform the fasciotomy to treat the impending compartment syndrome and external fixator application followed by definitive fixation in the second stage.<sup>3,4</sup> Single staged fasciotomy with open reduction and plate fixation remains subject of controversy<sup>5,6</sup> Primary aim of the study was early management of impending compartment syndrome with concurrent definitive fracture fixation, secondary aim was to provide reduced hospital stay, less treatment cost, along with faster and better rehabilitation. Previously, similar patients were used to be managed with initial fasciotomy and temporary external fixation with subsequent definitive internal fixation at later stage, there are several reports from round the world regarding

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outcome of multi-staged surgeries, but same stage fixation in present study show better results in terms of reduced hospital stay, rehabilitation time and treatment cost and satisfaction level of the patients as well as of the surgeon significantly improved.

Research hypothesis was “Urgent fasciotomy with definitive internal fixation at same stage improves rehabilitation in patients presenting with proximal tibia fractures associated with impending compartment syndrome”, which was supported by the results of present study.

## MATERIALS AND METHODS

It is a retrospective analyses of 15 patients with proximal tibial fractures associated with impending compartment syndrome [Figure 1] who were operated via anterolateral approach buttress plating between July 2011 and June 2012. Preoperative radiographs in two planes were taken in all patients [Figure 2]. Computed tomography (CT) scan with three-dimensional reconstruction of CT scans were used for a better understanding of fracture configuration. Associated injuries and postoperative wound complications were recorded. Inclusion criteria for this study were: (1) Acute proximal tibia fractures with intra or extra-articular types. (2) Patients with impending compartment syndrome evident by firm to hard swelling around the knee and proximal tibia, fluid filled blisters on the skin and stretch pain were included in the study.<sup>1</sup> (3) Patients with no neurovascular deficit. (4) Open, Gustilo Anderson Grade 1 fractures

Exclusion criteria were (1) fracture with Gustilo Anderson Grade 2 and above.<sup>7</sup> (2) Established compartment syndrome with neuro-vascular deficit. (3) fractures with

posteromedial comminution. (4) Patients with less than 18 months of followup.

Proximal tibia fractures were divided into the intra and extraarticular types, classification was done using AO system.<sup>8,9</sup> The operation notes were reviewed to note the time since injury to the surgery, the duration of the surgery, the type of anesthesia and the extent of blood loss. Surgical incisions employed, reduction techniques, use of bone grafts, implants used for fixation were recorded.

The limb elevation was provided with the help of Bohler-Braun splint. Serial clinical examinations were done to identify the signs of impending compartment syndrome. Patients were operated within 6 hours of appearance of symptoms.

Antibiotic prophylaxis (intravenous cefuroxime 1.5 g) was administered at the time of induction of anesthesia and it was continued twice daily by intravenous route for 5 days and then its oral regimen of 500 mg bid for 7 days more. It is our usual protocol to use this prophylaxis in cases where postoperative infection is suspected. In this study chances of infections were higher due to muscle ischemia because of impending compartment syndrome. Oxford Knee score was chosen for followup evaluation because it is an established and reliable tool to determine knee function and to help assess the impact that knee pain has had on patient’s daily life. This tool contains questions regarding clinical status of the knee. As our series included some of intraarticular knee fractures, it was prudent to use a tool that addresses the postoperative knee pain and its effects over the life style of patients as well as to assess the postoperative efficacy of the treatment provided.<sup>10</sup>



**Figure 1:** Clinical photograph of a patient presenting with impending compartment syndrome left leg showing tense swelling with shining skin and blisters



**Figure 2:** X-ray anteroposterior view (a) and lateral view (b) showing proximal tibial fracture

## Operative procedure

All the patients had undergone open reduction through anterolateral approach and internal fixation with buttress plate on the lateral aspect. We followed Musahl V *et al.*<sup>11</sup> (2009) technique. Surgeries were performed under fluoroscopic control and aseptic conditions. All patients were treated by the same team of surgeons (NS, VS, AA, RB) at single center.

A single curved incision served the purposes of compartment pressure release, good fracture reduction as well as buttress plate fixation [Figure 3]. Single lateral skin incision started from the postero-lateral aspect of the joint line continuing anteriorly in a curvilinear fashion about 1 cm lateral to the shin of tibia extending till mid shaft of tibia. Anterolateral compartment pressure was released by fasciotomy of intermuscular septum between anterior and lateral compartment and between lateral and superficial posterior compartments<sup>12,13</sup>.

As the first step, open fracture reduction under image intensifier guidance was achieved by longitudinal traction provided by the assistant. The reduced fragments were then provisionally fixed with Kirschner wires. The Kirschner wires were later replaced with interfragmentary screws, either separately or through the plate. The articular reduction was further verified during open reduction by direct visualization supplemented by the image intensifier. The tibialis anterior was elevated subperiosteally to expose the lateral surface of the lateral tibial condyle and shaft. A “hockey” buttress plate (Locking Compression Plate – Synthes, West Chester, PA, USA) was used to fix the lateral column. All the incision wounds were managed by primary closure to prevent the implant from being exposed to the external environment. Only one patient had skin necrosis and required secondary suturing.

## Postoperative protocol

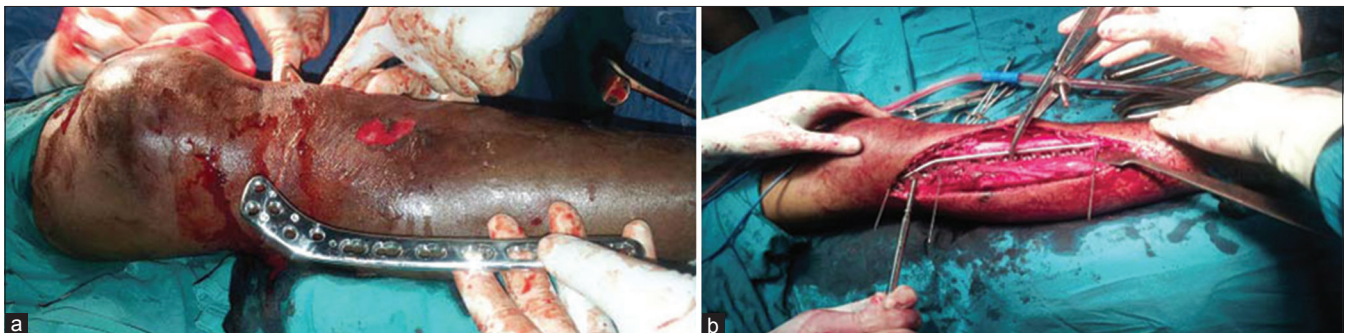
Static quadriceps exercises and nonweight bearing knee mobilization were started as soon as patient became pain-free. The posterior splint was given to all patients till

the suture removal (2 weeks). Patients were encouraged to do active assisted knee bending exercises after removal of the splint. Partial weight bearing started at 6 weeks and full weight bearing ambulation was commenced after 12 weeks. Patients were called for review at 6 weeks, 12 weeks, 6 months, 9 months, 12 months, 18 months and thereafter to assess their clinicoradiological and rehabilitation status.

The outpatient records were reviewed to obtain data regarding pain, disability, wound healing and range of movements of the knee. Radiographs during the immediate postoperative and subsequent followup period were reviewed for all patients to note the time to union, any loss of articular reduction, fixation failure or deformity<sup>14</sup> [Figure 4]. All the patients who satisfied the selection criteria were called for a followup. Radiographs of the knee and leg in the supine position were obtained in the anteroposterior (AP) and lateral planes to assess the articular congruity, the metaphyseal-diaphyseal alignment and any evidence of new arthritic changes.<sup>15</sup> The patients were also questioned regarding functional recovery and their responses noted. The results were analyzed according to the Oxford Knee score criteria [Figure 5], in which the patients were questioned regarding the degree of pain in the knee during the past week, distance that they can walk, any difficulty in toilet activities, any difficulty in getting in and out of a car or bus, getting up from the floor or chair, any limp, ability to kneel and getup, any night pains, ability to do household chores or activities of daily living, climbing up and getting down the stairs and household shopping.

All patients had a similar postoperative regimen and were followed up at regular intervals for at least 18 months. During the followup period, fracture healing time and postoperative complications were recorded. Knee function evaluation was performed at 6, 12 and 18 months according to Oxford Knee score.<sup>16</sup>

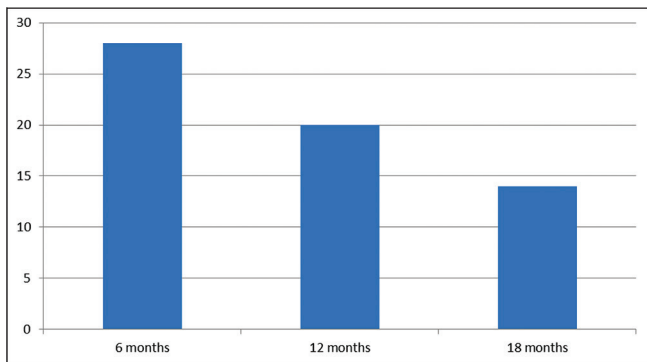
Bony union was defined radiographically as 3 cortical unions atleast in AP and lateral views during the followup period.<sup>17</sup>



**Figure 3:** Intraoperative clinical photographs during fasciotomy showing (a) buttress plate measurement (b) open reduction of fracture and buttress plate fixation



**Figure 4:** X-ray anteroposterior and lateral views (a) immediate postoperative x-rays showing lateral plate *in situ* (b) 6 months followup x-rays (c) one year followup x-rays showing union with implant *in situ*



**Figure 5:** Bar diagram showing mean Oxford knee scores

**RESULTS**

9 males, 6 females (Fifteen patients) with proximal tibia fractures [Table 1] were included in the study. All the injuries were a result of road traffic accidents. The mean age of patients was 40 years (range 22-61 years). The mean hospital stay was 14 days (range 12-20 days). Minimum duration of followup was 18 months (range: 18-24 months). There were concomitant injuries in 6 patients [Table 2]. All fifteen patients underwent emergency surgery as soon as they presented with or started developing features of impending compartment syndrome. The mean duration of the surgery was 95 min (range 56 min–120 min). The average blood loss was 250 ml (range 200 ml - 350 ml). The average union time was 12 weeks (range 8-20 weeks). Around 120° knee flexion was achieved in all patients in 3 months [Figure 6]. None of the patients had deep infection. Skin necrosis occurred in only one patient due to oblique placement of the plate that caused the persisting pressure on the distal

**Table 1: Classification of cases (AO/OTA classification system)**

| Type of fracture (AO classification)                 | Number of cases | Percentage |
|--|-----------------|------------|
| 41-A3 (extraarticular, metaphyseal multifragmentary) | 4               | 26.66      |
| 41-B1 (pure split)                                   | 1               | 6.6        |
| 41-B3 (split depression)                             | 3               | 20         |
| 41-C1 (simple metaphyseal)                           | 2               | 13.33      |
| 41-C2 (simple metaphyseal multifragmentary)          | 4               | 26.66      |
| 41-C3 (multifragmentary)                             | 1               | 6.6        |

AO=Arbeitsgemeinschaft fur osteosynthesefragen, OTA=Orthopaedic trauma association

**Table 2: Concomitant injuries**

| Injuries                                  | Number of cases | Percentage |
|---|-----------------|------------|
| Ipsilateral fracture of both bone forearm | 3               | 20         |
| Ipsilateral colle’s fracture              | 2               | 13.33      |
| Ipsilateral fracture shaft humerus        | 1               | 6.66       |

end of the suture line and required secondary suturing. None of the patients showed new osteoarthritic changes when compared with the contralateral knee at the final followup. Two patients had articular step off of >2 mm [Table 3]. There was no varus/valgus instability at the final followup.

Functional outcome of patients was graded by the Oxford Knee score (12–60 score criteria) at 6, 12 and 18 months,<sup>18</sup> which showed encouraging results.

**DISCUSSION**

The pathophysiology of compartment syndrome involves an insult to normal local tissue homeostasis that results in increased tissue pressure, decreased capillary blood flow



**Figure 6:** Clinical photograph showing postoperative knee flexion at 3 months followup

**Table 3: Complications**

| Complications                        | Number of cases | Percentage |
|--------------------------------------|-----------------|------------|
| Skin necrosis                        | 1               | 6.66       |
| Followup reduction altered 2 mm/more | 2               | 13.33      |
| Delayed union (>3 months)            | 2               | 13.33      |

and local tissue necrosis caused by oxygen deprivation. Significant muscle necrosis can occur if pressure remains high (>30 mmHg) for >8 h, higher pressures can cause necrosis in lesser time as well.<sup>19</sup> Impending compartment syndrome is a clinical condition in which the pressure has started to get raised, but not to the extent from where diagnosis of full fledged compartment syndrome can be made, e.g. no vascular deficit, no sensory deficit (no paresthesia, no hypesthesia), no motor deficit, no severe pain which is out of proportion to the trauma, no woody hard swelling, and no severe pain on passive stretch.

All of the above signs are specific for compartment syndrome diagnosis, apart from it the clinical signs which we used for the diagnosis of impending compartment syndrome are mild to moderate increase in circumference of the leg, firm swelling on palpation, appearance of multiple blisters, mild to moderate pain on stretching the tendons of muscles passing through the compartment involved.

Significant controversy exists regarding appropriate compartmental pressures for performing fasciotomies, serial clinical examinations are necessary to decide about urgent fasciotomy regardless of pressure monitoring is done or not. Recent studies have shown, however, that pressure measurements are erroneous in as many as 30% of patients and should not be used as the primary determinant for or against fasciotomy.<sup>19</sup> Diagnosis criteria for acute compartment syndrome includes hard swelling, severe pain with passive motion, weakness of muscles, pain out of proportion to that expected with the injury, hypoesthesia

and paresthesia. We kept all such patients in our exclusion criteria and patients in our inclusion criteria did not have any neuro-vascular deficit at all and no significant passive or rest pain.<sup>19</sup>

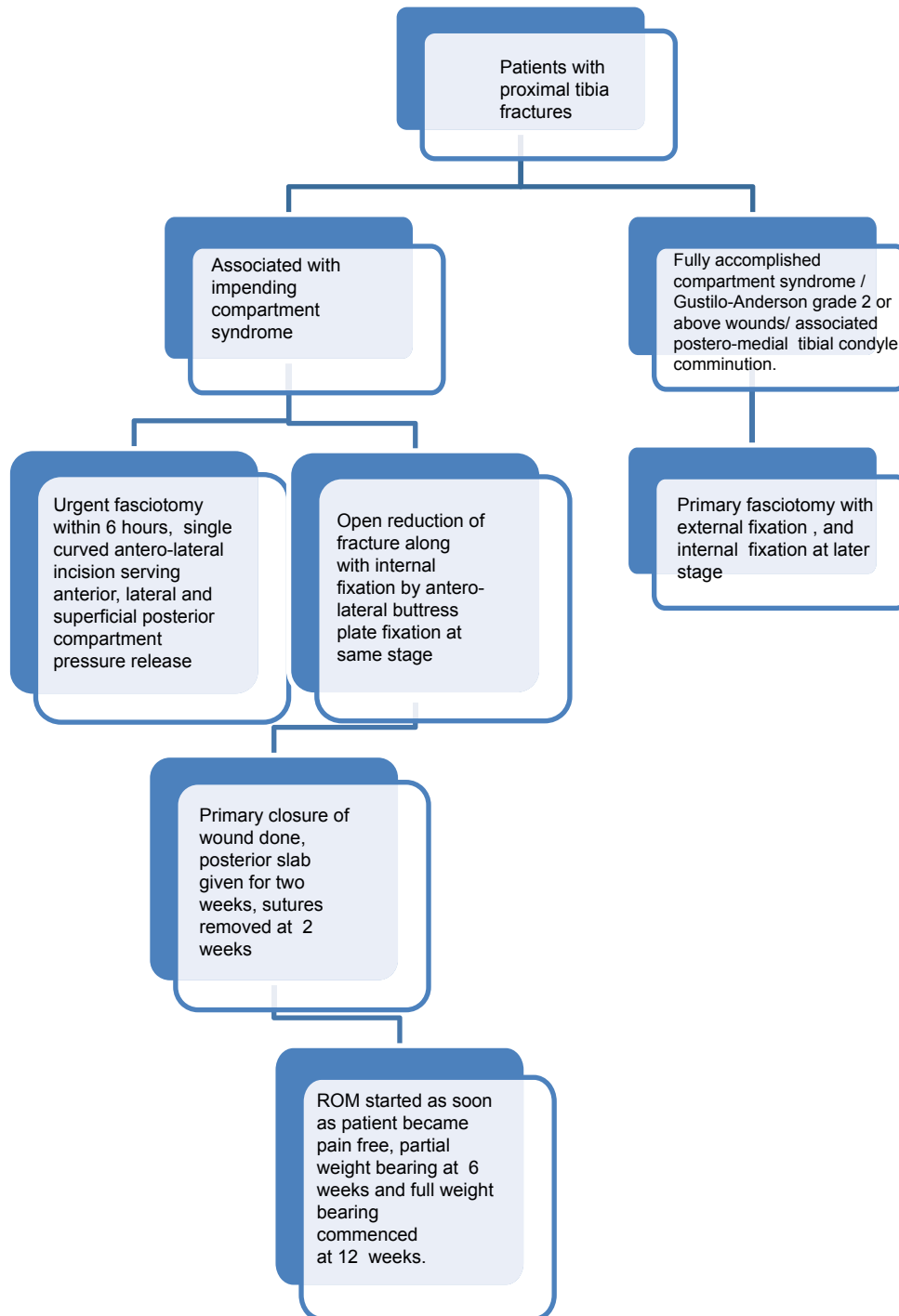
The goals of operative treatment were to relieve compartmental pressure and its clinical symptoms, to achieve anatomical fracture reduction and articular surface congruity and also to provide stable fixation to allow for early knee joint range of movement [Figure 7]. Usually in cases of established compartment syndrome it is essential to ensure deep posterior compartment fascia release, but the cases in the present series had impending compartment syndrome, symptoms were milder and intra compartmental pressure symptoms got relieved by anterior, lateral and superficial posterior compartment fascia release.

While there are several studies present in scientific literature discussing about two staged management of proximal tibia fractures with poor skin condition and compartment syndrome, there are very few about the single staged internal fixation of such fractures with impending compartment syndrome. On comparing the results of present study with the previous studies in literature, complications in present study have been considerably less.

Gunasekaran Kumar *et al.* in 2011 performed an extensive review of literature regarding internal and external fixations of proximal tibia fractures and concluded that if stable internal fixation is possible and local soft tissue status permits then internal fixation is carried out, they recognized that circular external fixator has a higher risk of significant problems with pin-site infection if the wires are intraarticular, i.e. within 12 mm to 15 mm of the knee joint. Plate fixation had significant benefits in terms of decreased number of outpatient visits, avoidance of pin-site problems and the morbidity.<sup>20</sup>

In support of results of present study another series by G Thiruvengita Prasad *et al.* in 2013 after studying 46 tibial plateau fractures Schatzker type V and VI with poor soft tissue conditions concluded that plate fixation of severe bicondylar tibial plateau fractures is an excellent treatment option as it provides rigid fixation and allows early knee mobilization. Careful soft tissue handling and employing minimal invasive techniques minimizes soft tissue complications.<sup>21</sup>

There are reports of development of compartment syndrome in tibial plateau fractures following treatment with external fixators,<sup>22</sup> whereas in the present study there was no incidence of postoperative compartment syndrome or any other soft tissue complication owing to plate fixation,



**Figure 7:** Treatment approach flowchart

except for one patient who developed small pressure skin necrosis at lower end of plate.

Egol KA in 2005 studied 53 patients with 57 high energy tibia plateau fractures, according to their postoperative results, complications included 3 (5%) deep wound infections, 2 (4%) nonunions and 2 patients (4%) with significant knee stiffness (<90 degrees). Nine patients (16%)

underwent additional surgery after definitive skeletal stabilization related to their injury.<sup>23</sup>

In an another series in 2005 M Thimmegowda studied complex tibial plateau fractures of sixteen patients who were treated by closed reduction fixation of articular fragments by screws and application of unilateral external fixator. The average duration of external fixation was 13 weeks. Pin

tract infections were encountered in 32% of patients with this procedure. Knee stiffness and pin-tract infection rate were major drawbacks.<sup>24</sup>

On comparing the results in present study, patients were started range of motion exercises at 2-3 weeks, partial weight bearing at 6 weeks and full weight bearing at 12 weeks, no patient had knee joint stiffness, none of the patients required second surgery, there was no deep tissue infection, no drawback of pin tract infection was encountered, none of the patients had nonunion, while only 2 patients had delayed union (>3 months). There was no financial burden of secondary definitive surgery on the patient, hospital stay and followup visits reduced considerably as compared with the initial external fixation and secondary definitive fixation at the later stage.<sup>20</sup>

A recent multicenter prospective study conducted by the Canadian Orthopedic Trauma Society reported that a circular external fixator yielded similar clinical outcomes as with normal external fixator but with fewer complications.<sup>25</sup> However, insufficient fracture reduction due to poor visualization and superficial or pin tract infections concerns many orthopedic surgeons.

Less invasive stabilization system (Synthes, West Chester, PA, USA) fixation offers the advantages of indirect fracture reduction, percutaneous sub-muscular implant placement, and fixed angle structure. Several studies have reported encouraging results with this technique.<sup>26</sup> Gosling *et al.* evaluated the less invasive stabilization system used alone to treat 69 bicondylar tibial plateau fractures.<sup>6</sup>

Poor condition of soft tissue in impending compartment syndrome patients has been an area of concern while treating such cases. Postoperative complications including skin necrosis are due to poor soft tissue coverage.

This single stage surgery protocol improves the rehabilitation time significantly ultimately reducing hospital stay. It avoids complications of temporary external fixator application followed by definitive fixation at later stage, e.g. pin tract infection, osteomyelitis or deep soft tissue infection, with advances in surgical technique, a deep infection rate has already been reported to have reduced to 4.7%.<sup>27</sup> No infection was encountered in the current study, which is better than previous reports.

Gentle handling of the soft tissues with less traumatic protocol of single staged surgery helped reduce soft tissue complications and infection rate.<sup>21</sup> All patients in the current study were managed with urgent surgery, fasciotomy by minimal possible effective incision which

also helped in open reduction of fracture and internal fixation.

Eighteen months results of 15 patients are satisfactory with a low complication rate and are encouraging towards the use of new approach in the management of proximal tibial fractures with impending compartment syndrome.

## LIMITATIONS OF STUDY

We did not perform pressure monitoring because clinical evaluation served our purpose very well. Recent studies have shown, however, that pressure measurements are erroneous in as many as 30% of patients and should not be used as the primary determinant for or against fasciotomy. Significant controversy exists regarding appropriate compartmental pressures for performing fasciotomies, serial clinical examinations are necessary to decide about urgent fasciotomy regardless of pressure monitoring.<sup>19</sup> Additionally our patients did not have rest pain and were pain free on immobilization with a posterior splint.

Small sample size is another limitation of the study. In addition, because of the difficulty of quantifying the degree of soft tissue damage in impending compartment syndrome, the effect of soft tissue damage on the outcome of this type of fracture was not evaluated. More studies with bigger sample sizes are required to come to a definite conclusion.

## CONCLUSION

This study showed that treating proximal tibia fractures presenting with impending compartment syndrome by urgent fasciotomy and lateral buttress plate fixation at same stage gave satisfactory clinical and radiological outcomes. This treatment approach has the benefits of avoiding repeated soft tissue trauma of secondary surgeries, reduced hospital stay, early rehabilitation and less health care expenditure.

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