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Salvage fixation of proximal tibia non-union and mal-union with 95° angled blade plates

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Abstract

Introduction: Proximal tibia non-unions and mal-unions can present particular challenges in their management because of a short proximal segment, excessive misalignment and soft tissue compromise. Available options in the management should consider the biomechanical demand of that anatomical location. The aim of this study was to determine the long-term functional outcomes of patients treated with open reduction and internal fixation with 95° angled blade plate (ABP).

Materials and methods: Total of twenty nine patients with a proximal tibial non-union and mal-unions were retrospectively treated between September 2016 and March 2022. Eighteen (62%) were non-unions, and eleven (38%) were mal-unions. The male were 21 (72%) and female were 8 (18%); Right tibia in 16 patients, and left tibia in 13 patients. Among the non-unions twelve were originally closed fractures, and six were open fractures. While among the eleven mal-unions, Eight were varus deformity and three were valgus deformity. All cases were treated with a consistent approach of debridement, deformity correction, angled blade plate fixation, and with or without bone grafting. Only 5 patients who presented with non-union had bone graft.

Results: All the twenty nine patients' fixations healed within an average of 30 weeks, and alignment was within 5° of anatomic in all cases after follow up for a median 3.2 years (range 1.8 to 6.6). The average duration of union after surgery was 4.5 month (range 3 to 7.5 month). The outcome were 23 (79%) excellent; 4 (14%) good; 1 (3.5%) fair, and 1 (3.5%) poor result based clinical and radiological evaluations of pain, range of knee motion, limb length, fracture healing and overall satisfaction with daily living activities.

Conclusions: For clinical and biomechanical consideration, 95° ABP could be a very suitable implant in the management of metaphyseal non-union and mal-unions of the proximal tibia with high success rate.

Keywords: Proximal tibia; Nonunion; Malunion; Angled blade plate; Functional outcomes

1. Introduction

Tibial plateau fractures is caused either by high or low energy injuries, and are generally not uncommon. It is commonly classified by Schatzker into six types [1, 2].The proximal tibial region is notable for its rich vascular supply and a large cross-sectional area of metabolically active trabeculae, which has potential for reliable healing [3, 4]. Despite this, there have been reports of non-union rates between 0 and 3% in majority of studies on proximal tibia fractures [5, 6, 7, 8]. When non-unions developed, however, their management can be of great challenge due to tenuous soft tissues and a

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short articular segment. The principal methods of treatment for tibial plateau fractures often focuses more on maintaining normal knee alignment, reconstruction of articular bony congruity, and providing sufficient stability. The reasons for this have to do with poor regenerative ability of injured articular cartilage [9, 10, 11]. Early range of motion (ROM) exercises of the knee have great impact on the best functional outcome. Although plate fixation can achieve much support, operative complications including deep infection are common [12, 13, 14]. Various methods have been used to fix the proximal tibial osteotomy and nonunion until sufficient healing has occurred. The literature recommends use of minimal soft tissue dissection and reducing numbers of inserted plates [15]. Additionally, method of single laterally placed plate had achieved some supports [16, 17]. However, this situation may compromise stability and leads to the unwanted non-unions and mal-unions.

The purpose of this retrospective study was to report the clinical outcomes of patients treated with unilateral 95° angled blade plate (ABP) fixations for proximal tibial metaphyseal mal--unions and non-unions.

2. Materials and methods

Total of twenty nine patients with a proximal tibial nonunion and malunions were treated with angled blade plates between September 2016 and March 2022. Formal ethical approval was obtained prior to commencement of the study. The inclusion criteria includes: (1) Mal-union of proximal tibia fracture (2) Non-union of proximal tibia fracture (3) Previously operated proximal tibia fracture (4) Skeletally matured patients. The exclusion criteria were: (1) Infected mal-union or non-union of proximal tibia fracture (2) Associated knee ligament injury. The patients' median age was 35 years (range, 21–60). The male were 21 (72%) and female were 8 (18%); Right tibia in 16 patients, and left tibia in 13 patients. Among the twenty six patients, fracture was caused by road traffic accidents, while three was caused by a fall from height. Twenty four (83%) patients presented first time while five (17%) patients had previously been treated with single buttress plating laterally at other hospitals. Eighteen (62%) cases presented with non-unions, and eleven (38%) patients with mal-unions. Among the non-unions twelve were originally closed fractures, and six were open fractures. In eleven patients with mal-unions, eight were varus deformity and three were valgus deformity. The period from the injury to the surgery time was a median of 7 months (range 3–14). Table 1 summarised the various modes at which the 29 patients presented.

At the outpatient surgical department, range of knee motion was a median of 110° (range, 70°–135°). Those limbs with non-unions demonstrated painless instability on physical examination while those with mal-unions revealed various degrees of varus (8) and valgus (3) deformities. All patients had plain anteroposterior and lateral radiographs views of the knee that confirmed fracture non-union, and varus/valgus angulation of the proximal tibia (Figures 1 & 5A). The degree of angulation was measured both with goniometer and on individual patients radiographs. Leg lengths were also measured, and a discrepancy of not more than 3cm was found among the 3 patients with mal-union. Patients were admitted and optimised for surgery with investigations that include complete blood cell (CBC), C-reactive protein (CRP), erythrocyte sedimentation rate (ESR). Infection was ruled out and any case with latent infection was treated with external fixation and was excluded from this study. Investigative parameters of all the 29 cases in our study were within normal range. No particular statistical test was employed for outcome measures because there were no available detailed clinical evaluations to match the individual knee society function and knee scores. In this regards, outcome measures at follow up were based on clinical and radiological findings developed to give patients postoperative outcome assessment (Table 2).

Table 1 Different patients features at presentation

	Cause of the initial Injury		**Nature of presentation**		**Complications at presentation**	
Number (%)	RTA 26 (90%)	Fall from Height 3 (10%)	First time 24 (83%)	Had previous buttress plate 5(17%)	Non-Union 18 (62%) {Closed 12, Open 6}	Mal-union 11(38%) {Varus 8, Valgus 3}

Table 2 Patient assessment score at follow up

Scores	Criteria
Excellent	Fracture healed, Full knee ROM (up to 135° flexion), no pain, equal limb length, normal daily activities
Good	Fracture healed, Knee ROM 0-120°, equal limb length, near normal activities
Fair	Fracture healed, Knee ROM 0-90°, limb length discrepancy <3cm, impaired daily activities
Poor	Fracture healed or not healed, stiff knee (<50° flexion), limb discrepancy >3cm, grossly impaired daily activities

2.1. Surgical Technique

Spinal anaesthesia given in each instances, and the patient was positioned supine with a sand bag beneath the buttock of the operated leg for better operation site accessibility and deformity correction. To minimise blood loss and for a better surgical exposure, a pneumatic tourniquet was applied on the ipsilateral upper thigh. The area was cleaned, and draped free. An extensile longitudinal incision cantered I cm lateral to the tibial crest was done to expose the proximal tibial metaphyseal non-unions and mal-unions. For the distal exposure, a longitudinal incision 1 cm lateral to the tibial crest is made. The exception to this exposure approach is in those cases involving severe angular deformity in which a longitudinal incision was directed along the convex side of the limb. After skin and subcutaneous incision, the periosteum on the sub-articular part of the proximal tibia was elevated (Figure 2A). In non-unions, fracture site debridement, excision of fibrous tissues, and proper intramedullary curetting were done before appropriate fracture reduction and hardware application. In mal-united fracture with excessive angulation that requires corrective procedure, an oblique osteotomy was started distally at the level of the tibial tuberosity on the lateral or medial side that ended at the far cortex at the inter-condylar area; it was opened with the inter-condylar area acting as a hinge. Depending on the need, cancellous bone graft was harvested from the iliac crest and was placed in and around the non-union site. Proximal fibulectomy was done to enable tibial deformity correction after osteotomy. The correction of the deformity was controlled by the use of Kirschner wires as markers for rotational and angular position under C arm guidance. The 95° ABP chisel was used to create passage just above the tibia tuberosity from one side to the other (figure 2B). In the presence of an angular deformity, the implant was placed in every instance on the convex side to function as a tension band. A 95° ABP 65mm blade length with 5 holes was used to fix the osteotomy after checking with the image intensifier (figure 2C & 2D). The wound was closed in layers without use of drain in most cases (figure 3).

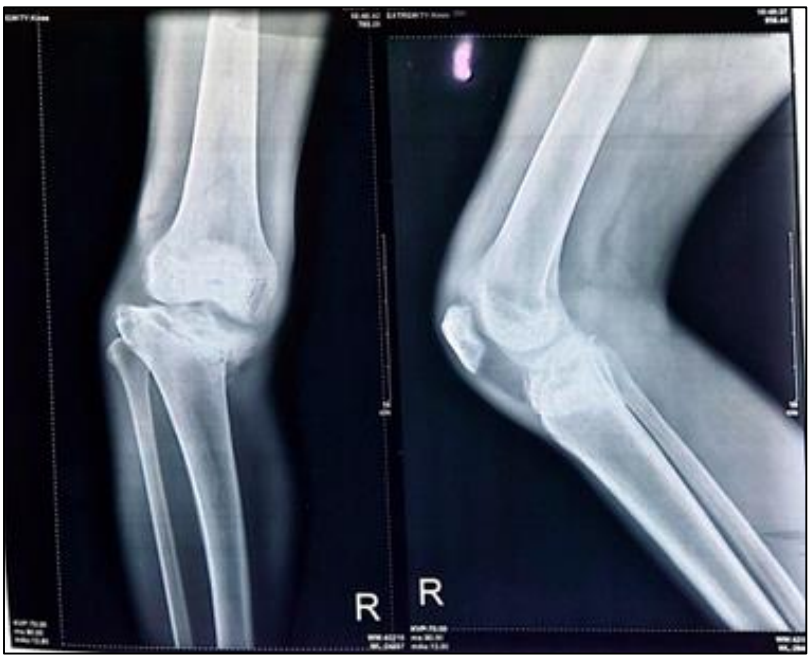

Figure 1 Preoperative image of 30yr old man who presented 3 months post injury

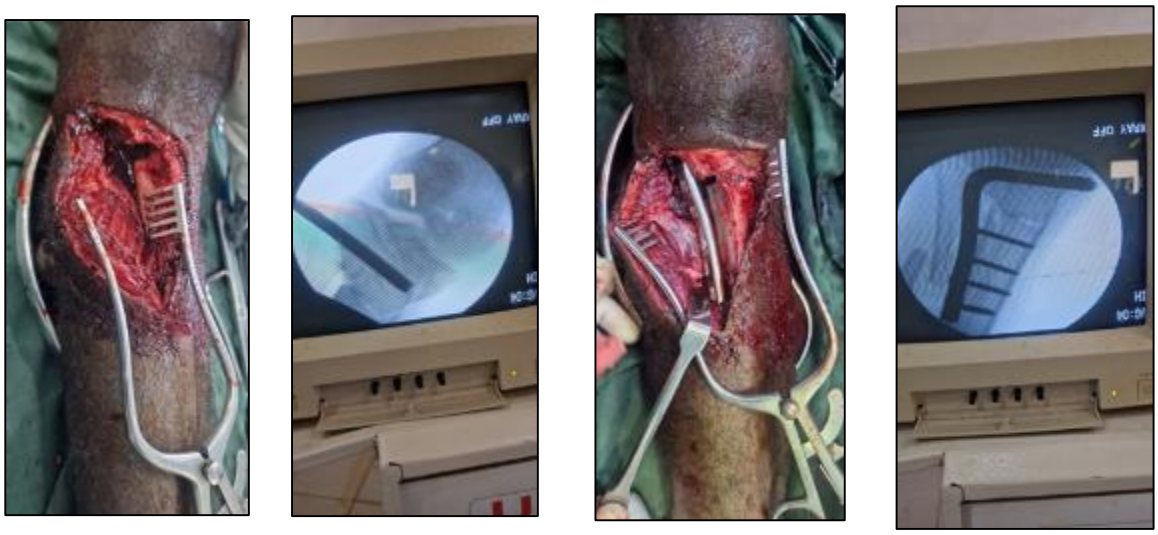

Figure 2A Figure 2B Figure 2C Figure 2D

Figure 2 Intraoperative detail of a high tibial osteotomy for a 30 year old male patient

Figure 3 Immediate postoperative wound and Xray (Antero-posterior and Lateral)

Figure 4 The postoperative patient during follow up (at 2 years)

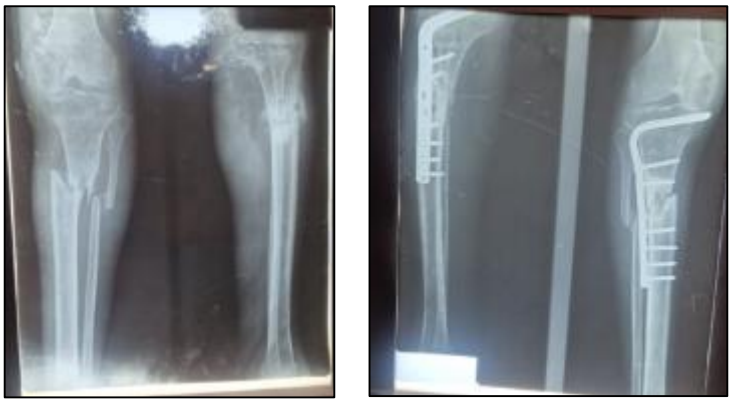

Figure 5A Figure 5B

Figure 5 Immediate preoperative (5A) and postoperative (5B) radiograph of a 52 year old male patient who presented with non-union of proximal left Tibia

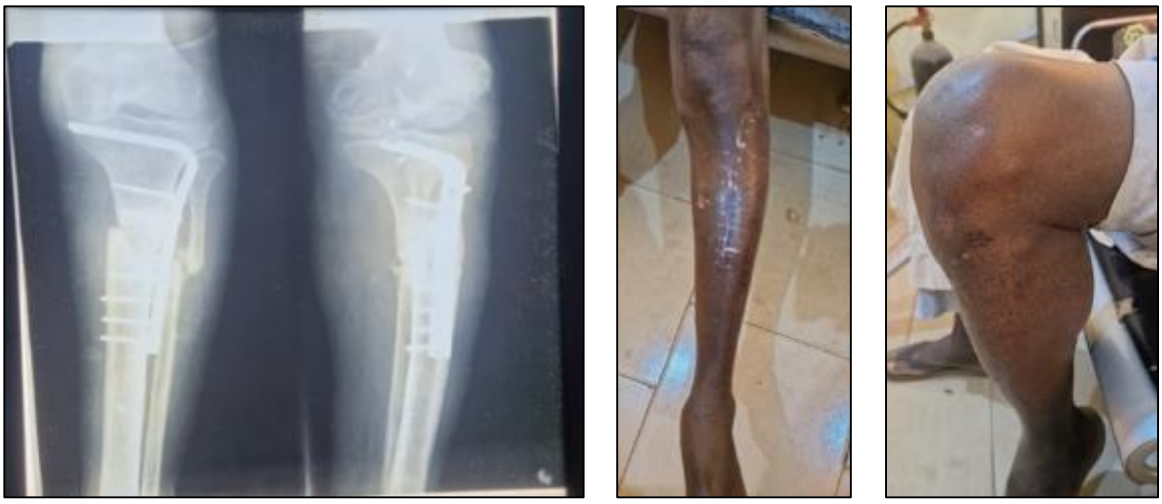

Figure 6 While on follow up @2 years postoperatively

Postoperatively, and after having radiograph (Figure 3 and figure 5B) the patient was permitted to mobilize the proximal and distal joints. Following wound healing; the patient was permitted to ambulate non-weight bearing using a pair of axillary crutches. This was continued for a minimum of 6 weeks postoperatively. Progressive weight-bearing was commenced during the subsequent 6 weeks based on evidence of on-going radiographic healing, At the final follow-up appointment, all the patients were evaluated as to subjective symptoms of pain, fracture site movement, weakness, dysfunction, or other symptoms that they may have experienced as being associated with their limb. The limbs were objectively assessed for limb length, joint range of motion, clinical signs of fracture union, and associated soft tissue status. Evidence of non-union at the fracture site was radiographically confirmed through assessment of persistent fracture site lucency and reactive bone with sclerosis.

3. Results

All the twenty nine patients' fixations healed within an average of 30 weeks, and alignment was within 5° of anatomic in all cases after the average duration of union after surgery was 4.5 month (range 3 to 7.5 month). The outcomes were classified as Excellent, good, fair and poor based on clinical and radiographic assessment (Table 2). Twenty three patients (79%) had excellent outcome and were subjectively satisfied with their result and had returned to their normal activities; 4 (14%) had good results, while 1 (3.5%) had fair and 1(3.5%) poor results (Table 3). Figures 4 and 6 showed both radiographs and clinical photographs of two different patients on follow up with fracture unions and satisfactory range of knee motion. Among those 3 patients with preoperative limb-length discrepancy of 3cm or less had the leg lengths all corrected. The follow up was for a median 3.2 years (range 1.8 to 6.6). At 2-year follow-up, one patient, a 43

year old male presented with prominent hardware on the lateral side close to the knee. Although the fracture perfectly healed, the implant was subsequently removed uneventfully. Two other patients developed knee stiffness with less than 50° of flexion because of poor rehabilitation compliance, but later both patients had good functional outcome following extensive and consistent physiotherapy.

Table 3 Outcomes at 2 year follow up

	Excellent	**Good**	**Fair**	**Poor**
Number (%)	23 (79%)	4 (14%)	1 (3.5%)	1 (3.5%)

4. Discussion

Our study indicated use of 95° ABP for fixation method of proximal tibial nonunions and malunions to be effective as 83% of our patients had excellent outcome going by the absence of pains, fracture union, sufficient knee range of motion and satisfactory activities of daily livings. The secure fixation is crucial to healing of the complicated fractures and maintenance of alignment while allowing early rehabilitation of the knee and optimizes the outcome of this procedure. It can be observed that our study did not make a reference to a particular outcome measure score like knee society function and knee scores. These scores require accurate and detailed preoperative assessment of certain clinical parameters that provide the basis for postoperative comparison. However, in our study, there was loss of some patients preoperative knee evaluation data that could make a viable postoperative outcome for comparison as in other study [18]. However, despite these shortcomings, the postoperative assessment scores by clinical and radiological parameters at the follow up time gave adequate and reliable information to validate our operative treatment performance.

A study by C.C Wu [19], employed similar method of fixation by use of blade plates for the nonunions and malunion of proximal tibia fracture. They reported of an angled blade plates inserted on the medial aspect of the tibia which provided enough stability until the fracture healed. They noticed that for medial compartment involvement use of laterally single buttress plating is unsuitable for the fixation of complex tibial plateau fractures. Another study by Carpenter and Jupiter [20] used a blade plate laterally in seven patients with proximal tibial nonunions, and reported a union success rate of 88%, with subsequent overall regain of full ambulation in only 75% of patients.

Plate fixation of proximal tibia fracture and osteotomy has been found to be biomechanically superior, J. M. Hartford et al [21], made use of buttress plate to compare its superiority over use of staples for such fixations. However the use of 95° ABP confers more biomechanical advantage over the use of buttress plates particularly in the settings of fracture complications like nonunions and malunions [18, 22].

During follow up, most of our patients had excellent to good outcomes with few presenting with knee joints stiffness that improved on extensive postoperative rehabilitaons. Meanwhile, in other study as reported by Lonner et al. [23] used variety of treatment methods including ORIF, external fixation, cast treatment, and arthroplasty to fix proximal tibial non-unions. Although they were able to achieve bone union, there was a high rate of knee stiffness, chronic pain, and functional limitation. In some instances, the use of Ilizarov techniques for the complicated proximal tibia fractures has also been reported [24]. intramedullary nails as a device were also used as a treatment option for proximal tibia nonunions in three cases as reported by McLaren and Blokker [25] with disappointing postoperative complications that included chronic knee pains and residual deformity.

5. Conclusion

In conclusion, the use of 95 ABP to treat complicated proximal tibia fractures with nonunions and mauinons showed favorable outcomes in majority of our patients particularly in respect to fracture union, knee joint mobility, absence of implant failures and overall return of normal patients functions. The long term follow up for our patients helped revealed few patients that developed fewer treatable complications especially the knee stiffness that resolved from extensive physiotherapy management.

Compliance with ethical standards

Disclosure of conflict of interest

There is no conflict associated with this study.

Statement of ethical approval

This research was conducted as an observatory study following surgical management of the patients who were the subjects. Appropriate ethical approval was obtained from the relevant ethical board before the commencement of this study.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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