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Original Article

Orthopaedics Section

Management of Extra-articular Proximal-third Tibia Fractures by Expert Tibia Nail and its Functional Outcome: A Longitudinal Cohort Study

FAISAL A SALEEM MOHAMMAD[1], SUMEET SHARAD PATIL[2], VIKRAM KUMAR[3], SOURAV MANDAL[4], PARAG SEVAKRAM BHELKE[5]

ABSTRACT

Introduction: Tibia, being anatomically placed subcutaneously throughout its length, is very prone to fractures. Incidence of extra-articular proximal tibia fractures accounts for 5-11% of all tibia shaft fractures. Among the various treatment modalities available, locked intramedullary nailing is a safe and adequate modality with fewer complications. Expert tibia nail is anatomically designed with multi-directional locking, which attains better angular stability and thereby allowing fixation of very proximal fractures.

Aim: To analyse and assess the functional and radiological outcome of expert tibia nailing used for treating extra-articular proximal-third tibia fractures.

Materials and Methods: A longitudinal cohort study was conducted for a duration of three years and five months, which included 31 patients. Standard descriptive statistical method was used to describe parameters. All these patients had extra-articular proximal-third tibia fractures and were managed with expert tibia nail. All patients underwent clinical and radiological evaluation based on the Klemm and Borner scoring system at a regular interval of six weeks, three months, six months, and at one year.

Results: The most common mode of injury was road traffic accidents (80.64%). Patients were in the age group of 26-63 years with an average mean of 41.80±9.7 years. The male to female ratio was 4.16:1, suggestive of male predominance. According to the Klemm and Borner scoring system, 71.42% of patients belonged to the excellent group, 17.85% were in good, 7.14% in fair and 3.57% in poor. Radiological union was achieved in an average period of 20.9±2.09 weeks.

Conclusion: In this study, scores obtained on the basis of Klemm and Borner scoring system, depicts that intramedullary expert tibia nailing is a good treatment modality for the management of extra-articular proximal-third tibia fractures, which provides good angular stability and adequate fixation resulting in early rehabilitation and union with excellent functional outcome and mere complications. It is also a safer treatment modality in case of compromised surrounding soft tissue.

Keywords: Klemm and borner score, Long bone injury, Structural anatomy

INTRODUCTION

Fracture of the tibia is a common long bone injury due to high energy trauma occurring secondary to motor vehicle accidents and fall from height with an annual incidence of 26 per 1,00,000 individuals [1]. Extra-articular proximal tibia fractures account for 5-11% of all tibia shaft fractures [2]. Due to the tibia's presence in subcutaneous location, its structural anatomy, and sparse anteromedial soft tissue coverage, the tibia is subjected to frequent injuries. It is also commonly associated with compound fractures than any other long bone in the body [3].

Various treatment modalities present for the management of tibia fractures include both conservative and surgical methods. The conservative method comprises of closed reduction and cast application, which commonly results in delayed union, malunion, and restricted range of motion at the ankle and knee joint [4]. To reduce the complications associated with conservative treatment, there is an increasing trend towards surgical management, which involves methods like open reduction and internal fixation with plates, Intramedullary Nailing (IMN), and external fixation, each having their own indications, advantages, and disadvantages [5-7].

The preferred surgical modality for such fractures is Intramedullary fixation, being less invasive, load sharing, preserves extra-osseous blood supply, and fracture haematoma [8-11]. With the advent of new modern implants like Expert Tibia Nail, an anatomically customised IMN system which allows multidirectional interlocking of nail below the tibia plateau, thereby facilitating the surgeon to address and fix very proximal tibia fractures [12]. Option of multidirectional locking and end caps, which blocks the most proximal oblique screw, helps attain absolute angular stability. Thus, expert tibia nailing system has led to significant advancement in the fixation of extra-articular proximal tibia fractures. The study aims to assess the functional and radiological outcome of expert tibia nailing technique in extra-articular proximal-third tibia fractures.

MATERIALS AND METHODS

A longitudinal cohort study was conducted at a tertiary care centre from August 2017 to December 2020 with a sample size of 31 patients after obtaining approval from Institutional Ethics Committee. Informed consents of patients were taken.

Inclusion criteria: The inclusion criteria for selecting patients in the study included skeletally mature patients ranging from 26-63 years with fractures classified as AO 41 A2/A3 [13], including both closed and compound fractures with grade 1 and 2 according to Gustilo-Anderson classification [14].

Exclusion criteria: Patients with intra-articular fracture, pathological and stress fracture, and those associated with ipsilateral limb fracture and neurovascular injury, and patients not willing or unfit for surgery were excluded from the study.

Patients who were fulfilling inclusion criteria and suspected fracture were adequately stabilised, and relevant X-rays were done. Closed

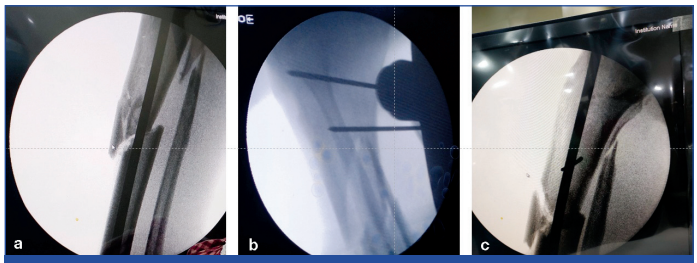
fractures with severe swelling were adequately splinted with an above-knee slab and were given oral proteolytic enzymes and limb elevation along with ice pack application. Surgery was done after the subsidence of swelling. Open fractures after thorough primary debridement were dressed daily and were given broad-spectrum Intravenous (i.v) antibiotics. Once the wound condition was favourable for interventions, then surgery was planned.

Surgical Technique

Under spinal anaesthesia, in supine position on a radiolucent table with the leg positioned in a semi-extended position in 20-30 degrees of flexion by putting a small bolster under the thigh, vertical patella tendon splitting approach was used.

In the anteroposterior view, the entry was taken in line with the lateral tubercle of the intercondylar eminence and in lateral view, the proximal entry point was taken at the tibia plateau's ventral edge to gain the maximum length of nail in the proximal fragment, under c-arm using curved bone awl. It is of utmost importance that the entry point is in the line of medullary canal is in order to place the nail adequately.

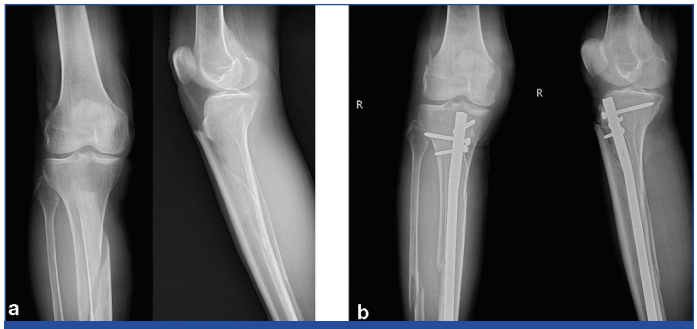
During the procedure, difficulties in reducing the fracture like apex anterior angulation of the proximal fragment and malalignments in coronal plane were encountered. To tackle the apex anterior angulation, the patient was placed in a semi-extended position, and blocking k-wires were placed in proximal fragment from medial to lateral cortex, anterior to fibula under fluoroscopy guidance [Table/Fig-1].



[Table/Fig-1]: a) Showing apex anterior angulation; b) Showing insertion of blocking k-wire; c) Showing the reduction achieved after blocking k-wire.

Similarly, one or two blocking k-wires were placed instead of poller screws in anteroposterior direction to counter coronal plane malalignments in such way that they neutralised the deforming forces during canal reaming and nail placement. Also, slight lateral entry was undertaken to avoid valgus malalignment. Same Anteroposterior blocking k-wires aided in preventing apex anterior angulation by applying downward directed force. Additional k-wires and AO reduction clamps were used for provisional fixation.

After appropriate alignment, guide-wire was passed anterior to the blocking k-wire, and reduction was achieved. Reaming was done over the guide-wire. After choosing the appropriate size nail, the whole assembly was passed over the guide-wire, followed by proximal and distal locking [Table/Fig-2,3]. At the end, all blocking k-wires were removed.



[Table/Fig-2]: a) Showing a preoperative radiograph of extra-articular proximal third tibia fracture; b) Postoperative radiograph showing adequate reduction and alignment with expert tibia nailing.

[Table/Fig-3]: Preoperative (a) and postoperative (b) radiographs of proximal third tibia fracture treated with expert tibia nailing.

On postoperative day 2 or 3, patients were mobilised and started with quadriceps strengthening exercises, knee and ankle mobilisation exercises, and non weight bearing-crutch walking. Initially, active knee flexion from 0 to 45 degrees was started and eventually was increased to 90 degrees, followed by passive range of motion exercises. Patients were discharged on day 5 after check dress. Patients with wound complication were discharged after adequate wound care and suture removal. After the completion of four weeks, patients were advised to start toe-touch weight bearing followed by partial weight-bearing from the sixth week with the help of walking aid and were shifted to full weight-bearing after eight weeks.

Data Collection, Follow-up and Evaluation

Data related to demographics, mode of trauma, details of hospitalisation, operative time, postoperative rehabilitation, complications, clinical and functional outcomes were collected during hospital stay and follow-up visits in the OPD clinic. Patients were followed-up at regular intervals of six weeks, three months, six months, and one year in the outpatient department. Functional outcome was assessed based on modified Klemm and Borner scoring system [15]. Scoring was done by assessing the following factors such as pain, range of motions at knee and ankle, muscle atrophy, alignment and union on X-ray.

STATISTICAL ANALYSIS

Standard descriptive statistical method was used to describe parameters. Continuous variables were described using means, standard deviations, ranges, and tabulation was done accordingly.

RESULTS

The baseline data of the 31 patients with fresh extra-articular proximal-tibia fracture is depicted in [Table/Fig-4].

Parameter	Values
Age	
Range	26-63 years
Mean	41.80±9.7 years
Sex	
Male	25 (80.64%)
Female	6 (19.35%)
Mode of trauma	
Road traffic accidents	25 (80.64%)
Fall from height	6 (19.35%)
Type of injury	
Compound fractures	8 (25.80%)
Closed fractures	23 (74.20%)

[Table/Fig-4]: Baseline data of 31 patients.

It was seen that in the majority of the cases, road traffic accidents (80.64%) was the most common mode of injury, and the remaining were due to fall from height. All the patients belonged to the age group between 26 to 63 years, with the combined average age of 41.80±9.7 years. Males were more commonly affected than females with a male to female ratio of 4.16:1. Among these, 23 patients

were of closed fractures, and eight were compound fractures (five patients of grade 1 and three patients of grade 2). The interval from injury to surgery ranged between 3-8 days with a mean of 5.35±1.56 days. Average hospital stay in was found to be 5.87±3.11 days. Out of 31 patients, one patient died in the postoperative period reason being not related to surgery, and two patients were lost to follow-up. The average time duration required for surgery was 111.19±10.62 minutes. In postoperative period, knee range of motion more than 90° was achieved up to six weeks in 23 (82.14%) of patients. Full weight bearing was achieved by three months in 25 patients. Among the 28 patients who were followed-up till radiological union, the union was seen in 25 (89.28%) patients. The other three cases united later on by intervening with bone grafting and revision surgery which led to delayed weight bearing at six months. After primary surgery, all those who achieved radiological union were united within 18-25 weeks with an average time duration of 20.9±2.09 weeks. In closed fractures, union was achieved earlier at an average of 20.08±1.53 weeks compared to compound fractures where it was at an average of 23.88±1.45 weeks (p-value=0.00001).

Patients' functional outcome at each follow-up was assessed by using Klemm and Borner scoring system [Table/Fig-5,6]. At final follow-up after 12 months, outcome was excellent in 20 (71.42%), good in 5 (17.85%), fair in 2 (7.14%) and poor in 1 (3.57%). Acceptable alignment was seen in 22 (78.57%) patients (criteria for acceptability was considered with average coronal and sagittal plane deformity less than 5°). The remaining 6 (21.42%) patients had coronal plane deformity (four varus and two valgus) of more than 5° but did not had any effect clinically.

Functional outcome	Number of patients	Percentage
Excellent	20	71.42%
Good	5	17.85%
Fair	2	7.14%
Poor	1	3.57%
Total	28	100%

[Table/Fig-5]: Functional outcome on the basis of Klemm and Borner scoring system at 6 months of follow-up.

Follow-up period	6 weeks	3 months	6 months	12 months
Mean	9.3	11.07	14.43	15.04
SD	1.46	1.81	2.3	1.87

[Table/Fig-6]: Mean Functional score according to Klemm and Borner scoring system at consecutive follow-up.

The most common immediate complication in early postoperative was anterior knee pain, and mild to moderate restriction of movements was encountered in 8 cases (28.57%), which eventually resolved with physiotherapy. Other complications included surgical site infection with three superficial infections, which got cured by regular dressing and antibiotics, and one deep infection case, which was managed with debridement and antibiotic treatment. In the postoperative period, no cases of compartment syndrome or neurovascular complication were reported.

DISCUSSION

Despite the availability of various treatment modalities for the fixation of extra-articular proximal tibia fractures, it still poses an impending dilemma to orthopedic surgeons. It is quite tough to establish and individualise a particular treatment modality for proximal tibia fractures. Thus, each and every fracture has to be assessed individually and planned accordingly.

Proximal tibia fractures are associated with high-velocity injuries leading to severe soft tissue compromise. In such case, conventional method of open reduction and plating is associated with complications like infection, flap necrosis, varus collapse and knee stiffness [16]. Other modalities like percutaneous plating methods (MIPO) or IMN fixation for extra-articular proximal tibia fractures are being largely recommended. The IMN fixation gives an added benefit of being a load-sharing device that allows early weight-bearing. Though they are associated with difficult reduction of proximal fragment leading to apex anterior, valgus or varus malalignment and anterior displacement of the proximal fragment [8,17-20]. Hence, conventional nails has been replaced by expert tibia nail which is anatomically designed and the multidirectional interlocking screws provides better axial and angular stability to the proximal fragments.

Various previously published studies shed light on the various factors contributing to the sagittal and coronal plane deformities when IMN nailing was used to fix proximal tibia fractures. Factors associated with sagittal plane deformities includes the pull of the patellar tendon [8,18,19] and the muscles of the anterior compartment [17], lack of a posterior cortex [17], the "wedge effect" of the bent nail in the distal fragment [20], and a distal starting point for nail insertion [18]. Similarly, there are some factors which come into play and leading to coronal plane deformities which includes an inappropriate entry point mainly a more medial entry, inserting nail with the tip directed laterally [8,17,18], and the various forces acting due to the pull of muscles of lateral compartment [17]. Following are the studies with their outcomes in terms of malalignment, factors contributing to malunion, and various technical modifications undertaken to prevent the malalignment.

Freedman EL and Johnson EE carried out a radiographic evaluation of 133 tibia fractures treated with IMN fixation and reported that 7 (58%) of the 12 proximal tibia fractures were malaligned, compared with an overall rate of 12% in the whole cohort [17]. To avoid the coronal plane deformities, they suggested practicing a slight lateral entry point.

Similarly a data shared by Lang GJ et al., reported that 27 of 32 proximal tibia fractures (84%) had an angulation of 5° or more in the frontal or sagittal plane, which were treated by conventional interlock nails and suggested that coronal plane deformities could be prevented by avoiding medial entry point and directing nail laterally [8]. In contrast, sagittal plane deformities were avoided by inserting the nail as possible as parallel to the anterior cortex to minimise the extent of anterior angulation.

Tornetta P and Collins E described the use of the semi-extended position of the knee for IMN of fractures of the proximal tibia to avoid sagittal plane deformities [19]. The knee was positioned in 15 degrees of flexion during the procedure. Immediate postoperative assessment for alignment was carried out in 30 patients with fractures of the proximal-third of tibia treated with intramedullary nails, found that five patients treated without using the semi-extended knee position had an average flexion deformity of 8 degrees (range 5 to 15 degrees). The remaining 25 patients were treated using the technique described, and it was found that only two patients had malalignment.

Buehler KC et al., described a lateral starting point for nail insertion to avoid the valgus malalignment [18]. In order to prevent sagittal plane deformities, they suggested that the entry point should be as proximal as possible and use of femoral distractor was done to nullify the deforming forces of the patellar tendon. In this study, they practiced nailing in hyperflexion with the use of prototype outrigger handles which helped to insert the nail parallel to the anterior cortex of proximal fragment in a sagittal plane. Interlocking was carried out in full extension which helped to fix the fracture in the position of optimal fracture reduction. In this study, 14 patients were operated on by using these techniques and reported that one patient had malalignment and the other one landed up in non union for which revision surgery was carried out.

Hansen M et al., in a study of 181 patients with tibia fracture treated with ETN, found that clinical union was seen in 12.4 weeks after

the surgery, and the time for radiological union was 18.2 weeks post surgery [21]. He reported that the chances of valgus, varus malalignment of greater than 5 degrees in any plane on radiographic was 4.3% for shaft fracture, 1.5% for intra-articular fracture fractures distally, and 1.3% for intra-articular fracture proximally.

Zhu DC et al., conducted a study of 31 patients, which undergone expert tibia nailing and found that union was achieved in all cases at 17.6±2.5 weeks [22]. The duration of surgery was 84.5±17.3 minutes and the time required to achieve union was 8.4±2.1 weeks. 90% of patients show good to excellent results according to Johner-Wruhs' criteria.

In the present study, it was found that these fractures were four times more commonly found in males than females, with patients belonging to a mean age of 41.8 years, which is comparable to the study conducted by Zhu DC et al., [22]. The aim of the study was to study the functional outcome of the modality as mentioned above of treatment. In the majority of cases, the mode of trauma was road traffic accidents followed by fall from height highly suggestive of high-velocity injury. The average time duration required for a surgical procedure was 111.19 minutes. Zhu DC et al., in there study achieved union at 17 weeks which is comparable to present study [22]. During the study, it came to the notice that union was achieved relatively earlier in closed fractures than compound fractures. Among these 28 patients, three patients' union was delayed, which was achieved by doing bone grafting later on. The probable cause of such a prolonged union was due to malalignment and inappropriate implant fixation, which was later corrected during the revision surgery by doing exchange nailing and bone grafting to expedite the healing process. At 12 months of follow-up, the functional outcome of the patients was assessed based on Klemm KW and Borner MA scoring system [15], and according to which out of 28 patients, outcome were excellent in 20 (71.42%), good in 5 (17.85%), fair in 2 (7.14%) and poor in 1 (3.57%) which are almost comparable to a study conducted by Tijoriwala P et al., [3]. In this study comparision of functional outcome at six weeks and 12 months was done, and found significant difference [Table/Fig-7].

Follow-up period	6 weeks	12 months	p-value
Mean	9.3	15.04	<0.00001
SD	1.46	1.87	

[Table/Fig-7]: Comparison of functional outcome at 6 weeks and 12 months [3]. (p-value calculated by paired t-test)

In present study, semi-extended position of knee was used, to avoid extension of proximal fragment. The rationale of this method is that it eliminates the pull of quadriceps on proximal fragment and allows anterior placement of the nail. After appropriate proximal and distal interlocking of a nail, the blocking k-wires were removed, and no loss of reduction was seen, which is attributed to the use of snuggly fit nail. Even after using these technical, it was noted coronal pane deformities in 6 (21.42%) patients, which was because of wide canal in osteoporotic patients, comminution and inappropriate entry point, reaming and placement of undersized nail. However, these coronal plane deformities were not clinically significant. The incidence of occurring coronal plane deformities is almost similar to the study conducted by Nork SE et al., [11].

The present study malunion rates are much lower compared to the above-mentioned studies [9,18,19,22], which used conventional nails, in contrast to which expert tibia nail allows multidirectional locking options providing better angular stability and also secondary to various modifications made to the techniques of reduction and nailing. The study has shown that nailing is a good option in case of compromised soft tissue status. Nailing has an added advantage in terms of less blood loss, fewer chances of infection, shorter hospital stay, early mobilisation, and rehabilitation. It came to notice that nailing is quite associated with acceptable degree of malalignments with good functional outcome and minimal complications. Thus, making expert tibia nailing an effective modality of treatment for extra-atricular proximal-third tibia fractures.

Limitation(s)

Due to poor socio-economic status of patients in our government setup and non-availability of expert tibia nail through government schemes, small number of cases were performed. Limited period of follow-up as well as comparative analysis with other treatment modalities was necessary to establish the effectiveness of expert tibia nailing in proximal-third tibia fractures was not done. To establish the role of expert tibia nail for treating simple intra-articular fracture also requires further study to find out its efficacy.

CONCLUSION(S)

From the study, conducted and the results obtained, the functional outcome after treating extra-articular proximal tibia fractures with expert tibia interlock nailing in the majority of the cases is good to excellent. The study concluded that a multidirectional interlocking system and anatomically designed expert tibia nail confers angular stability and provides better hold of fragment in three planes and, thereby allowing the surgeons to address the high proximal tibia fractures. The study has shown that nailing is a good option in case of compromised soft tissue status. Nailing has an added advantage in terms of less blood loss, fewer chances of infection, shorter hospital stay, early mobilisation, and rehabilitation. It came to notice that nailing is quite associated with acceptable degree of malalignments with good functional outcome and minimal complications. Thus, making expert tibia nailing an effective modality of treatment for extra-articular proximal-third tibia fractures.

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PARTICULARS OF CONTRIBUTORS:
1. Professor, Department of Orthopaedics, Government Medical College and Hospital, Nagpur, Maharashtra, India.
2. Assistant Professor, Department of Orthopaedics, Government Medical College and Hospital, Nagpur, Maharashtra, India.
3. Senior Resident, Department of Orthopaedics, Government Medical College and Hospital, Nagpur, Maharashtra, India.
4. Assistant Professor, Department of Orthopaedics, Government Medical College and Hospital, Nagpur, Maharashtra, India.
5. Assistant Professor, Department of Orthopaedics, Government Medical College and Hospital, Nagpur, Maharashtra, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Sumeet Sharad Patil,
Flat No. 302, Plot No. 443, Brahma Appartment, Near Chaukani Maidan,
Hanuman Nagar, Nagpur, Maharashtra, India.
E-mail: sumpatil92@gmail.com

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