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Outcome of regular nailing in fracture of proximal third tibial shaft

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Abstract
Proximal third extraarticular shaft of tibia fractures treated by open reduction and internal fixation (ORIF) with anatomical plates are reported to have soft tissue problems often. Plating by Minimally invasive percutaneous plate osteosynthesis technique (MIPPO) is often preferred instead. Load sharing nails are an equally good option considering the extremely soft tissue friendly characters and possibility of early weight bearing. But a major problem of malalignment has to be addressed. Common deformity seen are apex anterior and valgus deformity. But these can be tackled by certain modifications from the routine nailing techniques like better xray guided nail entry point, nailing in semi extended position, parapatellar approach and manoeuvres for attaining and holding reduction. The clinical outcome of reamed intramedullary standard interlocking nailing of closed proximal third tibia fractures in 34 patients using the above mentioned guidelines was studied using Johner and Wruh's criteria for outcome after a short term follow up of around 8 months. Majority of our patients belonged to a poor socioeconomic background and so expensive nails designed for proximal tibia fractures were not used. Instead our objective was to assess outcome using regularly used standard nails. More than 60 % cases had excellent outcome and > 20% had good outcome. 32 of the 34 cases had acceptable fracture union with no major complications. 2 cases had unacceptable malunion due to postoperative loss of reduction. Standard interlocking nailing when properly performed stands as an equally good cheap yet effective alternative for treatment of proximal third tibia fractures.

Keywords: Proximal tibia fracture, closed interlocking nail, malalignment, nailing techniques, reduction techniques.

1. Introduction

Tibial fractures are one of the most common fractures encountered in practise. In earlier days most were treated conservatively. Then came the advent of surgical fixation. Plate fixation and intramedullary nailing (IMN) became the mainstay in surgical fixation of tibia. Of all tibial fractures, extra-articular proximal tibial fractures account for 5–11% [14-16]. They usually result from high-energy injuries and are usually associated with severe soft tissue damage and complex bone comminution [14, 16]. Although various treatment options are available [17-22], there is no consensus regarding the optimal treatment for extra-articular proximal tibial fractures –particularly those with additional soft tissue damage. Conservative treatment is of secondary importance. Open reduction and fixation with load bearing plates is a common approach [23, 24] It permits a direct view of the fracture and anatomical reduction. However, a significant disadvantage of plate fixation is poor axial and varus stability [19, 25]. The angle-stable plate osteosynthesis construct provides greater rotational stability [25] But open reduction and plate fixation may be associated with an extensive soft tissue dissection which eventually may increase the risk of wound dehiscence and infection [14, 21, 26-28]. Minimally invasive plate osteosynthesis (MIPO) may overcome this, but reduction and proper alignment of the fracture is much more difficult, and rarely possible, compared to open procedures [17, 23, 26, 27]. Temporary or definitive external fracture fixation provides adequate stabilisation in extraarticular tibial fractures with extensive soft tissue injury in accordance with the damage control concept [14, 26, 30]. However, an external fixator for definitive treatment is considered uncomfortable for the patient and may pose the added risk of postoperative pin track infectionis and nonunion [14, 29]. Intramedullary nailing of extra-articular proximal fractures can be considered a feasible solution to avoid soft tissue complications [26, 31]. But high rates of malunion have been reported for nailing, which is debated [32-37]. The current study aims at improving the results by following certain methodologies to ensure better outcome in proximal tibial fracture nailing without using expensive nail modifications.

Several techniques have been proposed for attaining proper alignment during the nailing of proximal tibia fractures. Stinner and Mir[1] in their review article has elaborated on them. But no studies have yet considered in a meticulous and systematic fashion the outcome of the procedures with respect to the manoeuvres attempted. Our study was particularly based on certain manoeuvres which were stringently followed in all the cases irrespective of the fracture pattern to gain statistical significance for the results. We used interlocking nailing in semi extended position (flexion of 15^{o}) with limb positioned in traction over a fracture table. Standard medial parapatellar approach was used. No expensive implant modification was practiced. Regular 316L SS intramedullary nails often used for mid diaphyseal fractures were used for nailing in all cases. Strict guidelines were followed to assess the entry point under image guidance. Reduction was preoperatively attempted with traction and gentle manipulation which was obtained in most cases. In three cases reduction was attained and maintained by percutaneously applied reduction clamps. No poller screws or reduction plates or distractors or schantz pin were used in any stages of the procedure for reducing or holding reduction.

2. Aim

To assess the outcome of standard intramedullary nailing in proximal third tibia extraarticular fractures done under image guidance following selected guidelines for nailing proposed by various authors

3. Materials and Methods

Prospective study of 34 patients with closed extraarticular proximal tibia fracture who underwent surgical fixation at Government Medical college, Calicut between January 2012 to November 2015. Among the 36 patients included in the study 2 patients were lost in follow up. Approval was obtained from the institutional ethical committee, and all patients provided informed consent. No patient refused to participate. The inclusion criteria was closed extra - articular proximal third tibia fractures where reduction was attained and maintained by closed methods preoperatively or using reduction clamps intraoperatively. Exclusion criteria were compound fractures, intra -articular fractures, paediatric fractures, pathological fractures and any other associated fractures other than ipsilateral fibula. The age distribution ranged from 19 to 61 years with the mean age of 39.12 years (Table 4). The mode of injury (Table 3) in patients was due to vehicle accidents in 22, fall from height in 8; fall on floor or stairs in 2 and assault in 2. Among the 34 patients included in our study there were 30 males and 4 females. The time of fixation varied from 6 hours to 10days post injury. All 34 patients were received in emergency room following which trauma series relevant x-rays including the affected legs with knee and ankle joints, antero - posterior and lateral views were taken. Initial management consisted of closed reduction and splinting. All the cases were performed following certain selected guidelines for nailing in proximal tibia by various authors as reviewed by Stinner and Mir [1].Routinely and cheaply available standard 316L SS interlocking tibial nails with proximal and distal dual uniplanar locking screws were used for all the cases. All patients who underwent intramedullary interlocking nail were operated under regional anaesthesia with patient supine on standard radiolucent table. The limb was positioned over a fracture table with traction. Medial parapatellar approach was used in all the patients (figure 1, 2). Reduction of fracture was achieved before starting the procedure by traction in semi extended position over a fracture table in most cases, except three cases were clamps were used in addition intraoperatively for reduction. Nail insertion point was determined under carm in true AP and Lateral views as per guidelines [5, 6]. *AP view*- just medial to lateral tibial spine (ensure correct rotation of tibia in image by fibular bisector line/ 'twin peak AP view' where sharpest profile of tibial spines seen) [5]. Care was taken to avoid medial entry to prevent valgus deformity (figure3,4).*Lateral view*-- just anterior to articular surface using "flat plateau lateral view"(align femoral condyles one behind the other and then adduct so that plateau of tibia aligned) [6]. Nailing was done in semi extended position [7] 15 deg flexion (to neutralise extensor pull) using fracture table and knee hinge (figure 1).

Fig 1: *Semiextended position for nailing over a fracture table*

Fig 2: *Medial parapatellar approach*

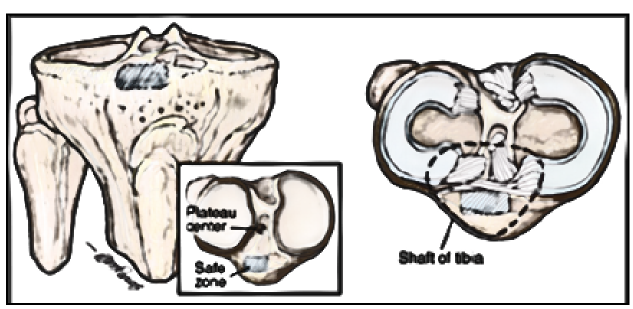

Fig 3: *Illustration showing safe zone for correct entry point in nailing in proximal fractures of tibia*

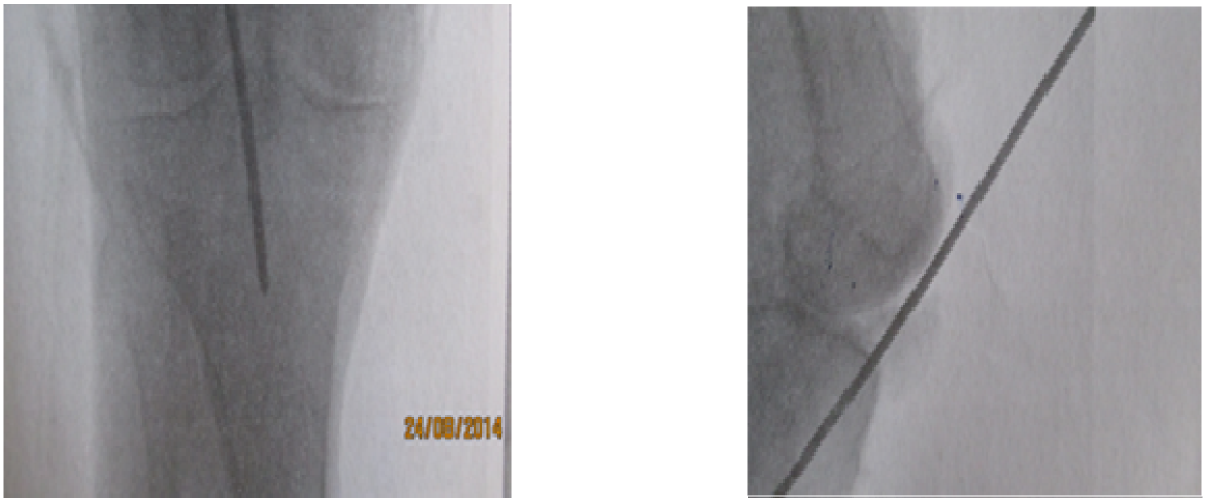

Fig 4: *Intraoperative image of the entry point in AP and Lateral views*

The approach was medial to patellar tendon (1 to 2cm retinaculum may be cut to assist in patellar subluxation). Trochlear groove was used as guide for reeming and nailing. The trajectory was ensured with imaging. It was always made sure that the fracture was reduced before reeming. Surrounding tissues and articular surfaces were protected. Clamp assisted reduction was sought after when needed. Percutaneous clamps were applied through stab incisions [8] in three cases. They were used to hold apex anterior deformity. Nail insertion and locking was done as routinely perfomed for tibial nailing.

None of the patients were operated under tourniquet control. Postoperative radiographic evaluation was done with standard antero -posterior and lateral view of the tibia with knee and ankle joint. Passive range of movements of knee and ankle joint along with static quadriceps strengthening exercises were started on the next day of surgery. Active knee ROM exercises was encouraged from second week onwards. All patients were given 3 to 5 days of broadspectrum intravenous antibiotics. Wound inspection was done on second, fifth, seventh post -operative day. Suture removal was done on 11 th post-operative day. Patients were soon initiated and maintained on non weight bearing ambulation for three weeks. This was followed by partial weight bearing from fourth week onwards. Once clinical and radiographic signs of healing were seen full weight bearing was allowed. Radiographic evaluation was done at regular intervals to detect possible loss of reduction and to assess fracture healing. Secondary surgeries with bone grafting was performed in four patients treated as delayed unions for failure of progression of healing. Patients were followed up for clinical and radiological evaluation using Johner and Wruh's [37] criteria at 6weeks, 3 months, 6 months and 8 months. Radiological bone healing was assessed according to Hammer *et al.* (table1) radiological assessment of callus formation [2] the collected data was transferred and analyzed using Statistical Package for Social Sciences (SPSS) version 11.0. The variables to be analyzed included demographic information (age, gender etc), pain, mobility, gait, deformity assessment and callus formation. Duration for union was calculated in weeks and patients were labeled as union, delayed union or non-union. The variables were presented using simple descriptive statistics using mean and standard deviations for quantitative data like age.

All the fractures united solidly (figure 5,6,7) with mean union time of 19.5 weeks ranging from 14 to 32 weeks. 2 cases had unacceptable malunion due to loss of postoperative reduction Since they were not severely hampered functionally, they were reluctant on further corrective surgeries. Clinical and radiological outcome using Johner and Wruh's [37] showed that in our study majority of patients had ended in excellent and good results. Patients who underwent nailing shows a good regain of range of movements in both knee and ankle with mean knee flexion range of 104.71degree (figure 9). There was ankle and subtalar stiffness in 8 patients but noone had knee fixed flexion deformities Extensor lag was noted in 8 patients after 3 months follow up and they regained power after quadriceps strengthening exercises. In our series 6 of the patients with comminuted fractures had limb length discrepancy ranging from 8 mm to 1.2 cm which was insignificant. Except for the 2 malunited cases, no note of significant limping gait was appreciated in any of the patients at the end of follow up. No significant malalignment as expected in terms of valgus or apex anterior deformity was noticed in the rest 30 cases. Among the 30 cases no patients had varus or valgus malalignment amounting more than 5 ^{o}. Sagittal plane malalignment (Apex anterior to be precise) in 4 patients and rotational malalignment in 6 patients was measured to be in range of 6-10^{o}. No patient had fixation for associated fibula fracture...Table 3,4 shows the descriptive characteristics of the samples at baseline. According to Johner-Wruhs' criteria[37] (table2) for outcome evaluation, a total of 22 patients (64.7%) were excellent, 8(23.5%) were good, 2 (5.8%) were fair, and 2(5.8%) had poor results. Accordingly, there were 30 patients (88.2%) characterized as either excellent or good in functional recovery. For radiological assessment of union (Table 1), 66% patients had bridging callus at fracture site on 3 months. At 6 months, union was achieved in 82%. At 8 months 35.3% patients had massive bone trabeculae crossing fracture and fracture line was barely discernible and 64.7% had homogenous bone (Figure 11).4 patients who had delayed union (union not achieved by 6 months as per Hammer *et al.* criteria) were subjected for open bone grafting and continued weight bearing at 3 months and later achieved union. No cases were subjected for dynamization of locking nails to enhance union for fear of instability at fracture site. No patients had non-union. Mean duration of union was 19.59 ± 5.712 weeks. (table4). 5 patients who developed superficial surgical site infection responded to meticulous wound care and sensitive antibiotics. Comorbidities did not have statistically significant influence on the treatment outcomes.

Fig 5: *Immediate postop lateral view left knee, 56 year old male*

Fig 6: *Immediate postop AP view left knee*

Fig 7: *AP and Lateral view left knee 8 months postop*

Fig 8: *Standing AP view showing normal alignment of left limb compared to right*

Fig 9: *Full ROM of left knee at 8 months postop*

Table 1: Hammer *et al.* classification of fracture healing

Grade	Callus Formation	Fracture Line	Stage Of Union
1	Homogeneous bone structure	Obliterated	Achieved
2	Massive bone trabeculae crossing fracture line	Barely discernible	Achieved
3	Apparent Bridging of fracture line	Discernible	Uncertain
4	Trace No bridging of fracture line	Distinct	Not achieved
5	No callus formation	Distinct	Not achieved

Table 2: *Johner Wru's criteria for clinical and radiological outcome*

	Excellent (left = right)	Good	Fair	Poor
Non-union, osteomyelitis, amputation	None	None	None	Yes
Neurovascular disturbances	None	Minimal	Moderate	Severe
Deformity				
Varus/valgus, °	None	2–5	6–10	>10
Anteversion/recurvation, °	0–5	6–10	11–20	>20
Rotation, °	0–5	6–10	11–20	>20
Shortening, mm	0–5	6–10	11–20	>20
Mobility, %				
Knee	Normal	>80	>75	<75
Ankle	Normal	>75	>50	<50
Subtalar joint	>75	>50	<50	
Pain	None	Occasional	Moderate	Severe
Gait	Normal	Normal	Insignificant limp	Significant limp
Strenuous activities	Possible	Limited	Severely limited	Impossible

Table 3: *Demographic analysis*

		Frequency	Percent
Category	Excellent	22	64.7
	Good	8	23.5
	Fair	4	11.8
	Total	34	100.0
Sex	Male	30	88.2
	Female	4	11.8
	Total	34	100.0
Mode	Road traffic accident	22	64.7
	Fall from height	2	5.9
	Domestic fall	8	23.5
	Assault	2	5.9
	Total	34	100.0
Comorbidities	DM	6	17.6
	HTN	2	5.9
	Nil	26	76.5
	Total	34	100.0
Addictions	Smoking	10	29.4
	Non smoking	24	70.6
	Total	34	100.0
Comminution	Nil	20	58.8
	Mild	8	23.5
	Moderate	4	11.8
	severe	2	5.9
	Total	34	100.0
Injury -Surgery Interval	Within 48 hours	26	76.5
	2-7 days	6	17.6
	>7days	2	5.9
	Total	34	100.0
Polytrauma	Nil	30	88.2
	yes	4	11.8
	Total	34	100.0

Table 4: *Patient character analysis*

	N	**Minimum**	**Maximum**	**Mean**	**sd**
Age in years	34	19	61	39.12	10.804
Hospital stay in days	34	5	15	6.76	3.133
Weeks for fracture union(grade1,2)(*fig 11*)	34	14	32	19.59	5.712
Range of knee motion in degree	34	80	120	104.71	10.528

Fig 10: *Common deformities encountered in proximal tibial nailing.* (ref: Wheeless CR III: IM nailing of proximal tibial fractures,in Wheeless' Textbook Orthopaedics. Availableat http://www.wheelessonline.com/ortho/im_nailing_of_proximal_tibial_fractures.)

4. Discussion

Proximal tibial extraarticular fractures have presented a treatment challenge for orthopedic surgeons. Soft tissue concerns with open plating techniques resulted in the increased use of either percutaneous plating methods or intramedullary nailing fixation, which has an added benefit of being load-sharing device to allow early weight bearing. Malalignment was common with early nailing techniques and implant designs as demonstrated by several series published during 1990s [3, 4]. In a radiographic analysis of 133 tibia fractures treated with IMN fixation, Freedman and Johnson [3] reported that 7(58%) of the 12 proximal tibia fracture were malaligned, compared with an overall rate of 12% in the whole cohort. This experience was shared by Lang *et al*. too [4]. Bhandari *et al*. evaluated the outcome of surgical techniques in the management of extra-articular proximal third tibial fractures with regard to rates of nonunion, malunion, infection, compartment syndrome, and implant failure [2]. Although the analysis of three prospective and 14 retrospective case series yielded rather weak evidence, higher rates of malunion were noted for intramedullary nails, while infection rates were significantly lower. The malunion rates in our series are much lower compared to the above mentioned series.

Compared to plates or external fixators, common deformity seen are *apex anterior* and *valgus* deformity due to the complex pull by extensor over the proximal segment along with the pull from hamstring and ITB. Spaciousness of the canal in the proximal region also contribute. Extraarticular proximal tibia fractures which were treated with plate osteosynthesis especially after high energy injuries had encountered higher complication rates, because of which many surgeons preferred intramedullary interlocking nailing technique to minimise surgical insult to the fracture and adjacent soft tissue. However proximal tibia fractures can be difficult to control with intramedullary devices.

The clinical benefits of ILN influenced surgeons to device better strategies by implant design modifications and newer surgical techniques. Blocking or poller screw [9-11] are used to minimise canal diameter in metaphyseal wide region ie decrease effective size of canal when needed. They are believed to provide added stability to the construct.They are preferred and retained in cases of osteoporosis or comminution. They are always placed in the concave side of deformity ----so lateral or posterior to nail usually, ideally before reeming. No poller screws were used in any of our cases...Since all the cases were closed fractures, plate assisted reduction [12] was not performed. They are indicated ideally as a temporary measure in open fracture or maybe used in closed when other reduction manoeuvres fail. Universal distractor [13] can be used when necessary in attaining reduction, but were not used since traction was applied using fracture table in our series. Those cases where reduction was not obtained preoperatively by closed methods or using reduction clamps intraoperatively were excluded from the study to avoid confounding. Our study was particularly aimed at assessing the feasibility of cheap regularly used intramedullary nails in proximal fractures because majority of our patients belonged to low socioeconomic status. So no implant modifications namely multiplanar proximal locking (expert nail) or angular stable locking screws or Herzog bend modifications were used in any of the cases. Inorder to ensure that there is no early loss of reduction the patients were allowed only delayed weight bearing.

5. Conclusions

The good results shown in the study proves that ordinary interlocking nailing should be considered as an equally good option in extraarticular proximal tibia fractures especially in those patients who do not afford expensive advanced nails designed for proximal tibia fractures and those patients with poor status of soft tissue. This study shows that nailing techniques and reduction techniques play an equal role compared to implant design modification in the overall outcome. The delay in full weight bearing is justifiable in this context since no patient had significant deformities or movement retrictions at the end of follow up. Given that there is no clear consensus on acceptable alignment in these fractures, the minor malalignments in the majority study cases may very well not be clinically significant and would be considered by some to be acceptable; especially when the patients are functionally not impaired. There were no serious complications noted in the study groups except for delayed union in 4 cases, malunion in 2 cases and superficial infections in 5 cases. Those four cases which went for delayed union were treated with open bone grafting and continued weight bearing. Dynamization was not considered since it was believed to increase the instability at the fracture site. The major limitation of the study is the smaller number of cases and the limited period of follow up.

Table 5: *showing union status with duration post surgery (refer table 1 for grading of fracture union)*

Grades of callus formation	1st post operative day		3 months		6 months		8 months	
	N	%	N	%	N	%	N	%
Grade 1 (Union acheived)	0	0	0	0	10	29.4	12	35.3
Grade 2 (Union acheived)	0	0	0	0	20	58.8	22	64.7
Grade 3 (Union uncertain)	0	0	20	58.8	4	11.8	0	0
Grade 4 (Union not acheived)	0	0	8	23.5	0	0	0	0
Grade 5 (Union not acheived)	34	100	6	17.6	0	0	0	0
Total	34	100	34	100	34	100	34	100

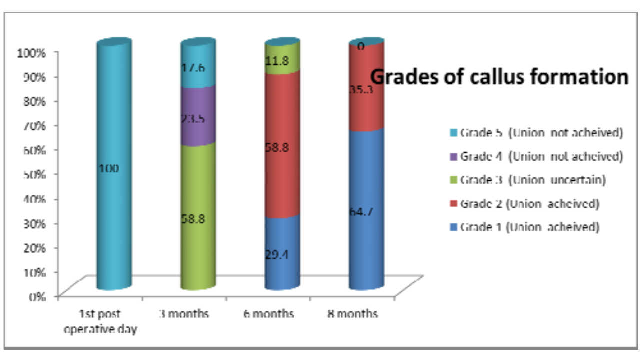

Fig 11: *Bar diagram showing grades of callous formation*

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