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A Prospective Study of Titainium Elastic Nailing For Pediatric Tibial Shaft Fractures.

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I. INTRODUCTION:

Tibial shaft fractures are the third most common fracture in children with incidence of 15-20% of pediatric fractures. Most of the pediatric tibial shaft fractures were treated with Closed reduction and cast application. Surgical treatment is indicated in unstable fractures, failed closed reduction, open fractures, polytrauma patients, compartment syndrome or severe soft tissue injury and associated neurovascular injury. Excessive shortening, angulation, or malrotation after closed reduction cause failure of reduction at the fracture site, making operative intervention necessary[1].

Historically, external fixation and plate and screw fixation were the treatment option for tibial shaft fractures that required operative fixation. Reamed locking intramedullary nails may intrude with physeal growth plate, hence they were opted in skeletally mature patients while elastic stable intramedullary nailing was preferred in skeletally immature patients, which has low complication rate with high effectiveness.

Titanium elastic nails were load sharing devices which impart biomechanical stability with its prebend 'C' configuration that provides stable three-point fixation and acts as an internal splint. They act as internal splints that impart relative stability to the fracture allowing micromotion and thus promotes callus formation at the fracture site[2]. The advantages of elastic intramedullary nails include closed insertion, with preservation of fracture hematoma, minimal risk of fracture site infection, and physeal sparing entry point.

II. MATERIALS & METHODS:

A sample of 20 children with tibial shaft fractures who attended casualty of our tertiary care hospital in Tirupati, with in study period of one year were included in the study. Patients who were willing to participate were included in the study while patients with osteogenesis imperfecta, congenital pseudoarthrosis of the tibial or other skeletal dysplasias were excluded.

Patients were examined to determine demographic data, surgical indications, mechanism of injury, associated injuries, closed versus open fractures, time to weight-bearing, clinical and radiological union need for implant removal and complications of treatment. We evaluated preoperative and postoperative radiographs to determine fracture patterns, union rates, time to union (as defined by three bridging cortices), and final fracture alignment

The mechanism of injury was classified as Fall from height, Sports related injury and Motor vehicle accidents. Open fractures were classified according to Gustilo and Anderson classification.

Surgical technique

General anesthesia was given to all the patients. patient was placed supine position on a radiolucent table. A tourniquet is applied to the upper thigh, but is usually not inflated. The operative extremity is then prepared and draped free. Soft tissue debridement was prior to skeletal fixation. The titanium elastic nails (TEN) were used in all patients. Under fluoroscopy, the fracture site and proximal tibial physis are marked. The starting point for nail insertion is 1.5–2.0 cm distal to the physis, sufficiently posterior in the sagittal plane to avoid injury to the tibial tubercle apophysis. A longitudinal 2 cm incision is made on both the lateral and medial side of the tibia metaphysis just proximal to the desired bony entry point. Using a hemostat, the soft tissues are bluntly disected down to bone. Based on preoperative measurements, an appropriately sized implant is selected so that the nail diameter is 40% of the diameter of the narrowest portion of the medullary canal. A drill roughly 0.5 cm larger than the selected nail is then used to open the cortex at the nail entry site; angling the drill distally down the shaft facilitates nail entry. Prior to insertion, the nails are prebent by hand into a gentle ''C'' shape which helps achieve three-point fixation. When the nail reached far cortex, the inserter was rotated to direct the nail towards the medullary canal. The nail was advanced to the fracture site, once the nail reached the fracture site closed reduction was done and nail advanced distally. The nail position was checked under the image in both anteroposterior and lateral views. The lateral nail was inserted through similar exposure. Same size nails were used to avoid differential loading in opposite cortices that may lead to angular deformity. Both nails are then inserted through the entry holes and advanced to the level of the fracture site. Under fluoroscopic guidance, the fracture is reduced in both the coronal and sagittal planes, and the first nail is advanced past the fracture site. If proper intramedullary position of the nail distal to the fracture site is confirmed on anteroposterior and lateral views, then the second nail is tapped across the fracture site.

Both nails are advanced until the tips lie just proximal to the distal tibial physis. Fluoroscopy is again used to confirm proper fracture reduction as well as nail position. To minimize soft tissue irritation, the nails are backed out a few centimeters and cut along proximal tibial metaphysis. Care is taken not to bend the nails away from the bone to facilitate cutting, as we have found that this increases nail prominence and subsequent skin irritation. The two incisional wounds for nail entry are closed in a layered fashion, and the wounds are well padded with gauze. To protect our fixation and to minimize irritation at the nail entry site from knee motion, we immobilized our patients postoperatively, most commonly with a long leg cast. All children were initially nonweight-bearing, and were ambulated early with physical therapy on postoperative day 1. Most patients were discharged home on postoperative day 2 or 3. Partial weight bearing was started 4-6 weeks later when there was radiographic evidence of a bridging callus. Full weight bearing was started after clinical fracture union. Preoperative and postoperative radiographs were evaluated to determine fracture pattern, union rates, time to union and fracture alignment. The nails were routinely removed once fracture was united clinically and radiologically. The angular deformity was assessed on anteroposterior and lateral X-rays that were taken immediately after surgery and at the last follow-up. Knee range of motion (ROM), angular deformity, alignment, and signs of nail irritation were assessed in each follow-up. At the last follow-up, leg length discrepancies (LLD) between the injured and uninjured sides were assessed clinically as well as radiologically. Clinical outcomes were evaluated using modified Flynn criteria[3].

III. RESULTS:

Table 1: Data of the study sample.

Patient S no	Age	Gender	Side	Type of injury	Fracture pattern	Time to union in weeks	Angulation Coronal/ saggital	Complications
1.	8	M	R	Grade 1	Long oblique	7.9	0/2	None
2.	10	F	R	Closed	Spiral	8.9	2/3	None
3.	9	M	R	Closed	Spiral	17.2	0/0	None
4.	12	M	R	Grade 1	Short oblique	11.0	3/0	None
5.	13	M	L	Grade 1	Long oblique	9.7	4/0	None
6.	7	M	L	Grade 2	Spiral	8.7	0/0	None
7.	9	F	L	Closed	comminuted	9.9	2/3	None
8.	10	F	R	Grade 1	Transverse	10.7	3/0	Entry site irritation
9.	15	M	R	Closed	comminuted	12.7	0/0	None
10.	6	F	R	Grade 2	Short oblique	8.0	0/0	None
11.	8	M	L	Grade 1	Long oblique	9.9	3/2	Entry site irritation
12.	9	F	R	Grade 2	Long oblique	9.9	0/4	None
13.	10	M	R	Grade 3A	Short oblique	9.7	2/0	None
14.	11	M	L	Grade 2	Long oblique	11.4	0/0	None
15.	8	M	R	Grade	Transverse	7.4	4/2	None

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				3A				
16.	9	F	R	Closed	Short oblique	10.5	3/0	None
17.	10	M	R	Grade 1	Long oblique	9.6	0/0	None
18.	15	M	R	Grade 1	Long oblique	14.5	4/3	Superficial wound infection
19.	13	M	L	Grade 1	Short oblique	12.4	0/0	Entry site irritation
20.	7	M	L	Grade 2	Transverse	11.4	4/3	None

In our study we examined 20 patients of age ranging from 6 to 15 years with mean age of 9.9. 70% of the sample were boys (14) while 30% were girls (6). 65% of the fractures were right sided while 35% of them were left sided fractures.

Surgical modality was opted for the following indications like open fracture(16 cases), unstable fracture(3 cases), and inability to achieve stable initial reduction with closed treatment (1 case).

The most common mode of injury was motor vehicle accidents followed by sports related injuries and fall from height. 12 cases inflicted with motor vehicle accidents while 6 cases sustained sports related injuries and 2 cases had fall from height.

There were 16 midshaft, two proximal shaft, and two distal shaft fractures. Seven fractures had long oblique pattern while five cases were fractured in short oblique pattern. Three cases had spiral fractures while two cases had comminuted pattern and transverse pattern each. Two patients had concomitant fibula fractures.

All patients achieved clinical union at a mean of 10.5 weeks (6 to 16 weeks) and radiological union (evidence of tricortical bridging callus) at a mean of 8.4 weeks. The mean time to full weight bearing was 10.2 weeks (8 to 14 weeks). No case of a delayed union, malunion, and non-union were seen. All patients had their nail removed at an average of 24.2 weeks (range 20 to 30 weeks) after surgery.

The most common complication was irritation at the nail entry site seen in three patients followed by superficial wound infection in one patient, that healed with oral antibiotics and dressings.

At final follow-up, thirteen patients had an angulation of fewer than 5 degrees. The mean angulation was 2.75 in the sagittal plane and 3.2in the coronal plane. No procurvatum or recurvatum abornalities and no valgus or varus abnormalities were observed. No patients developed obvious rotational abnormalities, leg length discrepancies, or physeal arrests as a result of treatment. we observed no neurovascular injuries or compartment syndrome during our study.

Table 2 : Final outcome according to modified Flynn's criteria

	Excellent	Satisfactory	Poor
Leg length Discrepancy	<1cm	<2cm	>2 cm
Malalignment	$<5^0$	5^0- 10^0	$>10^0$
pain	absent	absent	present
complications	None	minor	major
Results(n=20)	12	8	0

The final outcome was analysed Titanium Elastic Nailing outcome scoring system by Flynn.et al.

We found 12 patients had excellent results, eight patients had satisfactory results. No poor results were observed in our study. Satisfactory results were due to either irritation at the nail entry site or surgical site infection. All patients had a full range of motion at knee and ankle joint.

IV. DISCUSSION:

Tibial shaft fractures are the third most common fractures in children, after fractures of the femur and forearm. Closed reduction and casting standard treatment for closed type of pediatric tibial shaft fractures. Non operative treatment requires prolonged immobilization and regular follow up which is difficult in children. Operative treatment must be opted in children whenever indicated like unstable fractures, failed closed reduction, open fractures, polytrauma patients, compartment syndrome or severe soft tissue injury and associated neurovascular injury.

In our study 70% of the sample were boys while 30% were girls. In the study done by Byanjankar et al, 14 were boys while 8 were girls. Right sided fractures were more common in their study as in conconrdance with our study.

The most common mechanism of injury observed by them was fall from height followed by motor vehicle accidents and sports related injury unlike our study. Tibial mid shaft fractures outnumbered in both of the studies.

Historically, Pediatric tibial shaft fractures were surgically managed with external fixation which may pose risk of non union, malunion and pintrack infections[4]. The lack soft tissue coverage at the site of external fixation over tibial is the culprit for increased complication rate and decreased effectiveness.

Reamed intramedullary nails can pose risk of damage to growth plate in skeletally immature patients. Hence, Titanium elastic nails were preferred in children to achieve biomechanical stability from the divergent ‘‘C’’ configuration which creates six points of fixation and allows the construct to act as an internal splint[5]. Elastic intramedullary nail provides stable and elastic fixation that allow micromotion at fracture site when the load is applied. This facilitates bridging callus formation and early union. Both nails should be of equal diameter otherwise this may lead to an angular deformity due to differential loading of opposite cortices. The advantages of elastic intramedullary nailing include immediate fracture stabilization, minimal soft tissue disruption, lower infection and refracture rates, early mobilization and more rapid return to daily function than conservative treatment with immobilization alone.

Kubiak et al. retrospectively compared flexible nailing with external fixation for treating the pediatric tibia fractures. They found that the union time was significantly shorter in ESIN group (seven weeks) compared to the external fixation group (eighteen weeks).

Early weight bearing is an important factor in promoting union. Onta PR et al. prospectively studied 18 children with tibial shaft fracture. The time of fracture healing was 13.3 weeks and the average time for full weight bearing was 8.8 weeks[7].In our study, all patients achieved clinical union at a mean of 10.5 weeks (6 to 16 weeks) and radiological union (evidence of tricortical bridging callus) at a mean of 8.4 weeks. The mean time to full weight bearing was 10.2 weeks (8 to 14 weeks).

Several studies have described irritation at the nail entry site as the most common complication following the use of TENs in the femur, ranging in incidence from 7 to 40%[6]. W.N.Shankar et al reported similar results in the tibia, where 26% of their study subjects complained of pain over the proximal insertion sites. 15% of our study sample had irritation at nail entry site.

Byanjankar et al, reported eighteen patients had an angulation of fewer than 5 degrees, four patients had angulation of 5-10 degrees and none of the patients had an angulation of more than 10 degrees from their study.

W.N.Shankar et al, found 12 excellent results, six satisfactory results, and one poor result according to Flynn’s criteria. Satisfactory results were due to either irritation at the nail entry site or need for repeat manipulation. The poor result was due to the full-thickness skin necrosis that occurred between cast changes in one patient following treatment with TENs. Although the area of necrosis was well away from the nail entry sites, and we believe more the result of casting rather than TENs, the patient did require a free flap.

Byanjankar et al, observed 82% (18 patients) of study sample had excellent results, 18% (4 patients) satisfactory results while no patients had poor results with Flynn’s criteria. Ahmed et al. reported 75% excellent and 25% satisfactory with no poor results. The better functional outcome may be due to early fracture union leading to an early return to activities.

The final outcome was analysed with Titanium Elastic Nailing outcome scoring system proposed by Flynn.et al. and we observed that 12 patients had excellent results, eight patients had satisfactory results. No poor results were observed in our study. Satisfactory results were due to either irritation at the nail entry site or surgical site infection. This is in cocncordance with study done by Byanjankar et al.

V. CONCLUSION:

Tibial Elastic intramedullary Nailing is a safe and reliable surgery for pediatric tibial shaft fractures as it has high effectiveness with minimal complication rate and with cosmetic incisions.

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