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Surgical Outcome of Fracture Shaft of Tibia in Children And Adolescents Using Flexible Nails

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Abstract:
Aims and Objectives*: To study the surgical outcome of fracture shaft of tibia in children and adolescents using flexible nails in about 20 patients.* ***Materials and Methods:*** *This is a prospective study being conducted in department of orthopedics, Narayana Medical College And Hospital, Nellore from September 2017 to September 2019. The study consisted of 20 patients, age ranging from 4-16 years. Fractures are classified as per AO/OTA Classification. Tibial diaphyseal fractures, simple (closed fractures),Type I and II compound fractures are included in this study. They are treated by CRIF with Flexible nails(titanium) under image intensification and were reviewed with Antero-posterior and Lateral radiographs on their follow up visits at 1,2,3,6 months and a year. Final outcome was measured by Flynn's criteria and graded as Excellent, satisfactory and poor.* ***Results:*** *Mean age group was 9.5 years, mean duration of surgery was 57 minutes, with mean duration of hospital stay was 7.8 ±1.7 days with an average time of union being 12.65 weeks±1.9.We had 1(5%) patient with superficial infection, 1(5%) with deep infection with no significant major angular deformities and limb length discrepancy. We found 95% of excellent outcome, 5% Satisfactory with no poor outcome.* ***Conclusion:*** *Flexible intramedullary nail is an effective method which can be adopted for the treatment of tibial shaft fractures in children and adolescents aged between 5 to 16 years preventing damage to the epiphysis without interfering with fracture hematoma, with no stiffness of the knee and limb length discrepancies and thereby decreasing the morbidity of the patient.*

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I. Introduction

Fractures of tibia and fibula represents the third most common pediatric long bone injuries(15%) after fractures of radial/ ulnar and femur.[1,2,3]The tibial fractures prevelance in both boys and girls has increased since 1950.[4,3]70% of pediatric tibial fractures are individual injuries; ipsilateral fibular fractures occur with 30% of tibial fractures.[2, 3,5,6]The fracture can be incomplete (torus, green stick) or complete. Most tibial fractures in children under 11years of age are caused by torsional force.[3,8]If incase there is not an associated fibula fracture the intact fibula can prevent significant tibial shortening; however, varus angulation develops in approximately 60% of tibial isolated fractures within the first two weeks of injury.[3,8] The second most commonly fractured bone in children who undergo abuse is Tibia.[3,7]A tibial diaphyseal fracture along with complete fibula fracture usually results in valgus malalignment because of the action of muscles in antero-lateral aspect of leg.[3]In infants and young children, the tibial shaft is relatively porous and is more likely to bend, buckle, or sustain a nondisplaced spiral fracture than to fracture completely. The surrounding periosteum is strong and imparts stability to the fracture site. This limits displacement and shortening.[9] In contrast , the adolescent tibial shaft is composed of more dense cortical bone and a thinner, weak periosteum. Fractures in the adolescents group are more often the result of high-energy trauma and are associated with greater fracture displacement, comminution, and slower healing rates than in younger children.[9]Infants and toddlers have the ability to correct approximately 50% of residual angulation with growth. In children older than 10 years, only 25% of the axial malalignment improves.[9]

II. Materials And Methods

This is a prospective study is carried out in department of orthopedics, Narayana Medical College And Hospital, Nellore from September 2017 to September 2019. The study consisted of 20 patients, age ranging from 4-16 years.

Study Design: Prospective cohort study

Study Location: This study is done in department of Orthopaedics, Narayana Medical College And Hospital, Nellore , Andhra Pradesh, India.

Study Duration: September 2017 to September 2019.

Sample size: 20 patients.

Inclusion criteria:
1. Children and adolescent patients 4-16 years of age
2. Diaphyseal fractures
3. Simple fractures (closed fractures)
4. Type I and II compound fractures.

Exclusion criteria:
1. Patients age less than 4 year and more than 16 years of age
2. Patients medically unfit for surgery
3. Comminuted and segmental fractures
4. Type III compound fractures
5. Very proximal (or) very distal fractures that precludes nail insertion
6. Metaphyseal fractures

III. Procedure Methodology

As soon as the patient brought to casualty, patient's airway, breathing and circulation were evaluated. Then a complete survey was conducted. Plain radiographs of antero-posterior and lateral views of the leg including knee and ankle to assess the degree of fracture comminution and the geometry.

On admission to ward, a thorough history was taken, regarding the age, sex, and occupation, mode of injury, past history and associated co-morbid conditions. Routine investigations were done for all of the patients. Patients were operated as soon as possible once the general status of the patient was stable and fit for surgery. After former informed consent, a pre-operative anaesthetic evaluation has been done.
Pre-op planning of fixation has been made.

Preoperative planning
1)Nail Size:
2)Nail width:
The diameter of the individual nail is decided as per Flynn et al's formula.
Diameter of nail= width of the closest point of the medullary canal on AP and LATERAL view X 0.4mm

Intra operative assessment:

Nail size:Diameter of the nail is determined so that each nail occupies atleast 1/3rd (40%) of the medullary cavity.

Nail length:Lay one of the chosen nails over the thigh / leg, and determine that it is of the appropriate length by fluoroscopy. The nail for femur must extend from the level of the distal femoral physis to a point roughly 2 cm distal to the capital femoral physis and 1 cm distal to the greater trochanteric physis and for tibia it should extend 2cm from the proximal physis till 5mm proximal to the distal physis.

Procedure for flexible nailing of diaphyseal tibial fracture of antegrade fixation

Under General / Spinal anesthesia is administered, and patient is placed on a radiolucent table in supine position. The operative extremity is then prepared, scrubbed and drapped . Under C-Arm, the fracture site and proximal tibial physis are marked. The starting point of nail insertion is 1.5–2.0 cm distal to the physis, adequately posterior in the sagittal plane to prevent insult to the tibial tubercle apophysis. Proximal to the desired bony entry point, a longitudinal 2 cm incision is made on both the medial and lateral side of the tibia metaphysis . Using a hemostat, blunt dissectionis done upto to bone.

Based on preoperative measurements, a properly sized implant is selected so that the nail diameter must be 40% of the diameter of the narrowest portion of the medullary canal. A drill with roughly 0.5 cm more than the selected nail is used to dill the cortex at the nail entry site; angulating the drill distally down the shaft facilitates nail entry. Both the nails are then inserted through the entry holes and advanced to the level of the fracture site.

Under flouroscopic guidance, the first nail is advanced past the fracture site after the fracture is reduced in both sagittal and coronal planes . The second nail is introduced across the fracture site after confirming the intramedullary position of the first nail distal to the fracture site on anteroposterior and lateral views. Both nails are introduced till the tips lie just proximal to the distal tibial physis. Adequate fracture reduction as well as nail position is confirmed by flouroscopy.

To depreciate soft tissue irritation, the nails are cut along proximal tibial metaphysis after backing out few centimetres. A tamp is used to re-introduce th implants until <1 centimetre of nail lies outside of bone. Care

is to be taken not to bend the nails away from the bone to facilitate cutting otherwise can lead to nail prominence and subsequent skin irritation. The two incisions for nail entry are closed in a layered fashion, and the wounds are well padded with gauze.

Postoperative Care:
Patients were kept nil orally 4 to 6 hours post operatively.
IV fluids / blood transfusions were given as needed.
Analgesics were given according to the needs of the patient.
IV antibiotics were continued for 5 days and switched over to oral antibiotics on the 5th day and continued till the 12th day.
Sutures were removed on the 12th postoperative day and patients were discharged.
Post-operatively, patients are immobilized with above knee POP cast for tibia fracture for 6 weeks and such immobilization was continued for another 2-3 weeks based on radiological assesment.
The period of immobilization was followed by knee and ankle mobilization. Full weight bearing is started by 8 - 12 weeks depending on the fracture configuration and callus response.

Follow up:
Assessment done at 6, 12 and 24 weeks
At each follow up patients are assessed clinically, radiologically and the complications were noted.

Statistical Analysis:
Descriptive statistics like numbers, percentages, mean, standard deviations had been used. Data had been analyzed in the form of tables and graphs whenever necessary.

IV. Observations

Case 1:


Image 1.1 image 1.2

Immediate postop


image 1.3 image 1.4

At 6 weeks


Image 1.5 image 1.6

At 12 weeks


image 1.7 image 1.8

Case 2:

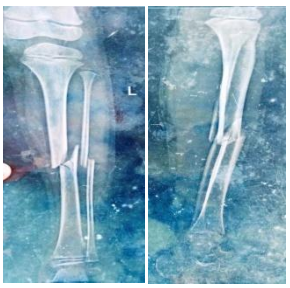


Image 2.1 image 2.2

Immediate postop

image 2.3 image 2.4

At 6 weeks

image 2.5 image 2.6

At 12 weeks At 24 weeks After implant removal

Image 2.7 image 2.8 image 2.9 image 2.10 image 2.11 image 2.12

Case 3: At 6 weeks At 12 weeks

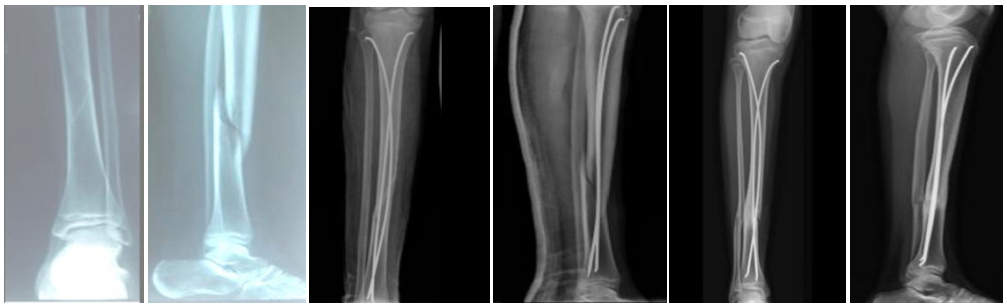
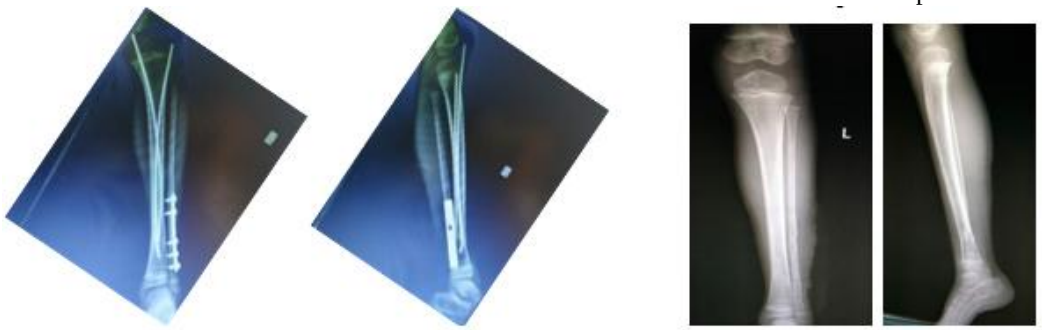


Image 3.1 image 3.2 image 3.3 image 3.4

Case 4: At 6weeks At 12 weeks

At 24 weeks After implant removal



V. Results

Table :1

Time for union	Number of Patients	%
10 - 12 weeks	12	60
13 – 15 weeks	7	35
>15 weeks	1	5
Total	**20**	**100.0**

Table :2

Range movements (degrees)	Number patients	%
Full range	18	90
Mild restriction	02	10
Moderate restriction	00	0
Severe restriction	00	0
Total	**20**	**100**

Table:3

Time of full weight bearing	Number of patients (n=20)	%
< 10 weeks	1	5
10 - 12 weeks	11	55
13 – 15 weeks	7	35
>15weeks	1	5
Total	**20**	**100**

Outcome according to Flyn's criteria	Number of patients (n=20)	%
Excellent	19	95
Satisfactory	1	5
Poor	0	0

Table :4

Complications	No. of cases	Percentage
Pain	2	10
Nail site irritation	2	10
Infection		
Superficial	1	5
Deep	1	5
Inflammatory reaction	Nil	0
Delayed union and non union	Nil	0
Limb lengthening		
< 2 cm	Nil	0
> 2 cm	Nil	0
Limb shortening		
< 2 cm	1	5
> 2 cm	Nil	0
Nail back out	Nil	0
Mal alignment		
a. Varus angulation	1	5
b. Valgus angulation		
c. Anterior angulation	Nil	0
d. Posterior angulation	Nil	0
e. Rotational malalignment	nil	0
Bursa at the tip of the nail	Nil	0
Sinking of the nail into the medullary cavity	1	5

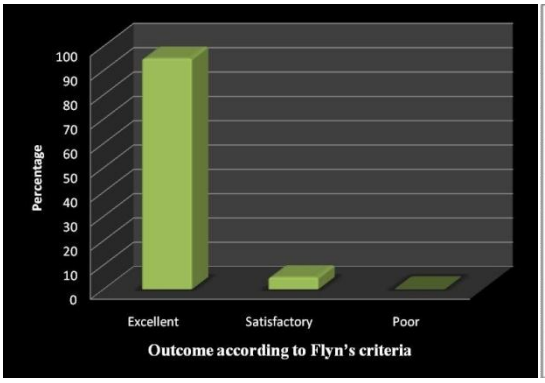


FIG:1

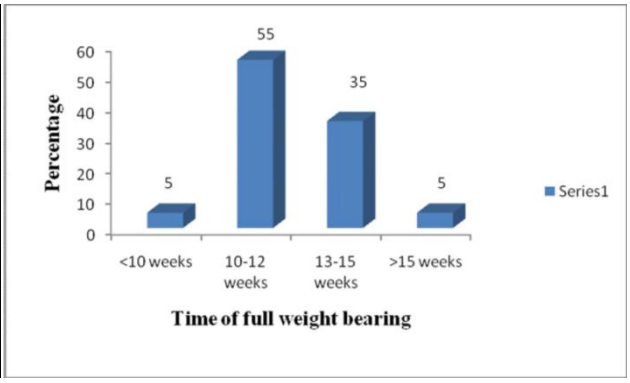


FIG:2

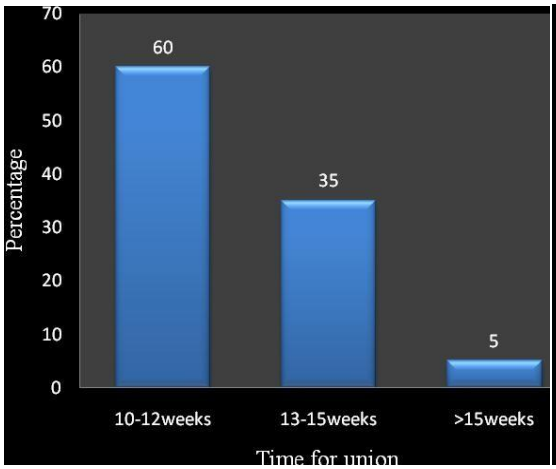


FIG:3

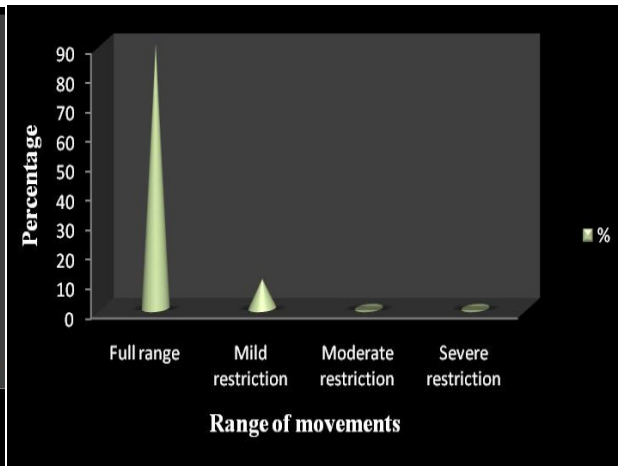


FIG:4

VI. Discussion

The ideal device to treat paediatric fractures of the tibia would be a simple load-sharing device, which would maintain alignment, allow mobilization until bridging callus forms and would not cross the physis. It should also be easy to insert and remove after bony union.

The development of flexible intramedullary nails, which satisfy most of these criteria, has allowed an increasing number of surgeons to use this type of nail for treating paediatric long-bone fractures. There are several advantages of this technique. Three- point fixation within the medullary canal allows maintenance of both alignment and rotation for most fractures. Flexible intramedullary nails provide fixation that is stable as well as elastic, allowing micromotion at the fracture site when load is applied. This encourages abundant bridging callus formation and facilitates early union15,16. It is important that both nails are of equal diameter, otherwise differential loading of opposite cortices may lead to an angular deformity.

Because there is no reaming of the medullary canal, the endosteal blood supply is not compromised. The technique allows early weight-bearing in a Sarmiento-type cast or functional brace22.

Age incidence:

In the present study 45% of the patients were 5-8 years of age, 35% were between 9 to 12 years and 20% were between 13 to 16 years of age group with the average age being 9.5 years.
Wudbhav N Sankar et al studied children ranged from 7.2-16 years with a mean of 12.2 years.[12]
Vallamshetla et al study showed mean age incidence was 12 years ranging from 4 to 16 years.[14]

Sex incidence:

There were 12(60%) males and 8(40%)females in the present study the sex incidence is comparable to the other studies in the literature.
In their study, Gamal El-Adl et al[10] out of 66 patients, there were 48 (72.7%) male and 18 (27.3%) females.[10]

Mode of Injury:

In the present study RTA was the most common mode of injury accounting for 13(65%) cases(4vehicle versus pedestrains,7 vehicle versus bicycle,2 vehicle versus vehicle), self fall accounted for 2 (10%) cases, fall from height accounted for 3 (15%) of the cases and sports related injury 2(10%)(kho-kho, kabaddi).
J. M .Flynn et. al, in their study assessing 234 cases, 136(58.1%) were following RTAs, 46(19.6%) were following self fall and remaining 43(28.8%) were as a result of fall from height.[18]

Pattern of Facture:

In our study, transverse fractures accounted for 4(20%) cases, communited fractures- (5%), Short oblique fractures - 6(30%), Long oblique fractures - 7(35%), spiral fractures – 2(10%), communited 1(5%).
Wudbhav N. Sankar studied 19 tibial shaft fractures out of which 9 (47.3%) were transverse, 7 (36.8%) were oblique, 2 (10.5%) were spiral and 1 (5.2%) was communited.[12]

Level of Fracture:

Fractures involving the middle shaft accounted for 16 (80%) cases, proximal shaft 2 (10%) and distal 2 (10%) of cases in our study.

Wudbhav N. Sankar studied 19 tibial shaft fractures out of which 15 were middle 1/3rd, 2 proximal 1/3rd and 2 were distal 1/3rd [12].

Time interval between trauma and surgery:

In our study we found that the mean time interval between trauma and surgery was 3.45days. 10% of cases were <2days 65% of the cases the time interval was between 2-3days,15% ranged from 5-6 days and the rest 10% ≤8 days.

Gamal el adl operated 56.1% of cases between 3-4 days after injury, 21.2% cases between 3 -4 days and 22.7% cases after 7 days.[10]

K C Saika et al. oprated 77.27% patients within 7 days of injury.[17]

Duration of surgery in minute:

In our study we average duration of surgery was 57 minutes ranging from 30-90minutes.

In Khurram Barlas et al. study, the average duration of surgery was 70 mins.[19] In a study by K C Saikia et al. , the duration of surgery ranged from 50 – 120
mins with a median of 70 mins.[17]

In the study of GAmal El-Adl et al, the average time of nail insertion was 28 minutes.

Post operative immobilization/mobilization:

In our study the mean time of post operative immobilization was 7.4 weeks ranging from 6-9 weeks.

The average length of immobilization in plaster was 9.6 weeks in Gross R.H. et al study. [20]

The advantage of the present study was early mobilization of the patients.

Duration of stay in the hospital:

The average duration of hospital stay in the present study is 7.8 days. The mean hospital stay was 12 days in Kalenderer O et al study.[11]

Average hospitalization time was 11.4 days in the study conducted by Mann DC, et al.[13]

Compared to the above studies conducted on conservative methods and cast bracing, the average duration of hospital stay was less in our study i.e. 7.8 days. The reduced hospital stay in our series is because of proper selection of Patients,stable fixation and less incidence of complications.

Time for union:

In the present study the mean time for union was found to be 12.6 weeks ranging from 10-16 weeks**.**

Aksoy C, et al compared the results of compression plate fixation and flexible intramedulalry nail insertion. Average time to union was 7.7 (4 to 10) months in the plating group and 4 (3 to 7) months for flexible intramedullary nailing.[21]

In our study, closed reduction of the fracture, leading to preservation of fracture hematoma, improved biomechanical stability and minimal soft tissue dissection led to rapid union of the fracture compared to compression plate fixation.

Time of full weight bearing:

In our study the average time for full weight bearing was 12.25 weeks ranging from 9-16 weeks.

Wudbhav N. Sankar et al. in their study allowed full weight bearing between 5.7 – 11.6 weeks an average of 8.65 weeks.[12]

VII. Complications

Difficulty in achieving reduction:

One cases in our study developed difficulty in passing the nail in distal fragment, which was about 10 days interval from the time of trauma to the surgery. Hence we had to open the fracture site, but on follow up at 24 weeks of the case, fracture united without any complication.

Nail entry site irritation:

The most common complication we came across in our study is irritation at the nail insertion site seen in 2(10%) of cases which persisted for about 2-3 weeks later the symptoms subsided without any intervention.

As in study conducted by Wudbhav N. Sanker et al, Irritation at the nail entry site was the most common complications following nail insertion, occurring in five patients (26%). One child required early removal of the nails for this complaint.[12]

Pain at the site of nail insertion:

Following irritation next common complication was pain found in 2 cases (10%) of the cases at nail insertion side which subsided by analgesics by 4 weeks but for no cases removal of nail was required.

J.M.Flynn et al. reported 38 (16.2%) cases of pain at site of nail insertion out of 234 fractures treated with titanium elastic nails.[18]
Wudbhhav N. Sanker et al, found 26% of thier patients complained of pain over the proximal insertion sites[12].

Infection:

Superficial infection was seen in 1(5%) case in our study which was controlled by antibiotics and regular dressing.
One case (5%) developed deep infection which was manage by implant removal, subsequently after serial dressing, an the patient was immobilized by an above knee POP cast for about 16 weeks fracture healed without any deformity.
J.M.Flynn et al. reported 4 (1.7%) cases of superficial infection at the site of nail insertion out of 234 fractures treated with titanium elastic nails.[18]
Pin tract infection is a major disadvantage of external fixation application. Bar-on E, et al reported 2 cases of deep pin tract infection in their patients treated with external fixation.[23]

Range of motion:

Two of the cases develop mild (10^0) of restriction of dorsiflexion at ankle joint at the end of 24 weeks but later improved on physiotherapy. No cases of knee restriction were observed.
J.M.Flynn et al. reported 2 (0.9%) cases of knee stiffness out of 234 fractures treated with titanium elastic nails.[18]

VIII. Conclusion

Based on our experience and results, we conclude that flexible intramedullary nailing provides elastic and stable fixation allowing micro motion at the fracture site without compromising endosteal blood supply and without interfering with fracture hematoma.

Flexible intramedullary nailing is a relatively simple, rapid, reliable and effective method for treating tibial shaft fractures in children and adolescents with fewer complications and an excellent functional outcome, allowing early mobilization, hereby decreasing the patients morbidity and duration of hospital stay.

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