FUNCTIONAL OUTCOME OF TIBIA DIAPHYSEAL FRACTURE TREATED WITH TITANIUM ELASTIC NAILING SYSTEM IN PEDIATRIC AGE GROUP

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ABSTRACT

Aim: The aim of our study was to assess radiologically and functionally outcome in tibial diaphysea fracture treated with titanium elastic nail system in paediatric age group.

Methods: This hospital based prospective study was conducted in the Department of Orthopaedics, JLN Medical College & Hospitals, Ajmer during the June 2022 to December 2023. 30 cases of diaphyseal fracture of tibia in children were included in this study.

Results: In our study 30 % of patients (9 out of 30) were age 5 to 9 years, 36.67% of patients (11 out of 30) were between 10 to 13 years of age. In our study 73.33 % of patients (22 out of 30) were male and 26.67% of patients (8 out of 30) were female. In our study, closed fractures were 70 % (21 out of 30) and Open fractures GA Type II were 16.67% (5 out of 30). In our study, middle shaft fractures were 63.33 % (19 out of 30), distal third fracture were 33.33 % (10 out of 30). In our study, transverse fractures cases were 56.67% (17 out of 30), short oblique fracture cases were 40.00 % (12 out of 30). Infection (Superficial and Deep) was seen in 3 cases (9.97%). Limb length inequality 2 (6.67%) cases, delayed union 1 (3.33%) case, nail irritation was present in 2 (6.2%) cases, malalignment in 6 (19.9%) cases and bursa at the tip of the nail in 1 (3.33%) case. Final outcome was excellent in 83.33% (25 out of 30), satisfactory or good in 13.3 % (4 out of 30) cases and poor outcome was reported in 1 case (3.33%) only.

Conclusion: Elastic nails are an effective way for the treatment of pediatric tibial diaphysis fractures; they control the length, angulations, and rotation as they provide stability through three points of fixations for each nail. It is a simple and easy method but with radiation risk. Although elastic nails had complications, all are avoidable and minor that managed with minimal intervention.

Keywords: radiological outcome, functionally outcome, tibial diaphysea fracture, titanium elastic nail system, paediatric age group

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1. INTRODUCTION

For the vast majority of tibial shaft fractures in the children, closed reduction and casting is an effective form of treatment and remains the gold standard of care. Occasionally, reduction cannot be maintained due to excessive shortening, angulation, or malrotation at the fracture site, making operative intervention necessary.[1] In other cases, surgical treatment is warranted because of open fracture, polytrauma, compartment syndrome, or severe soft tissue compromise.

Historically, external fixation and plate and screw fixation were the treatment options available for those unstable tibial shaft fractures that required operative fixation. Complications associated with these techniques include infection, overgrowth, and refracture.[2-4] Reamed locked intramedullary nails, while shown to be effective in the skeletally mature, pose unnecessary risk to the proximal tibial growth plate, and have limited indications in those children with open physes. Elastic stable intramedullary nailing of long bone fractures in the skeletally immature has gained widespread popularity because of its clinical effectiveness and low risk of complications. Many studies have supported the use of this technique in the femur, citing advantages that include closed insertion, preservation of the fracture hematoma, and a physeal-sparing entry point.[5-7] A few small series have previously described the use of flexible intramedullary nails in the tibia.[8-11]

Elastic nail (TENS) usually does not require casting, and avoid repeated re-manipulations often needed in non-operative treatment to maintain axial alignment.[12] Elastic nail are load sharing device act as internal splint, allow early mobilization and early discharge from hospital.[13] Elastic nailing (TENS) of tibia fracture in children has gained popularity because of its high effectiveness and less complication rate.[14] The advantage of elastic intramedullary nails include closed insertion, small incision during surgery, minimum soft tissue injury, preservation of fracture hematoma, low infection rate[15] and the most importantly, a physeal sparing entry point.[16] Elastic nailing has high union rates, effective and safe treatment for closed and open tibia fracture in children.[17]

The aim of our study was to assess radiologically and functionally outcome in tibial diaphysea fracture treated with titanium elastic nail system in paediatric age group.

2. MATERIALS AND METHODS

This hospital based prospective study was conducted in the Department of Orthopaedics, JLN Medical College & Hospitals, Ajmer during the June 2022 to December 2023. 30 cases of diaphyseal fracture of tibia in children were included in this study.

INCLUSION CRITERIA

1. Age 5 to 17 years.
2. Closed tibia diaphyseal fractures
3. Open tibia diaphyseal fractures grade I, II, IIIA

EXCLUSION CRITERIA:

1. Patients with malunited, non-union tibial fractures.
2. Patients who are medically unfit.
3. Open fractures Gustilo-Anderson type III B and III C fractures.
4. Patients with age < 5 years and > 17 years.
5. Pathological fractures

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History:
All the cases were subjected to detailed history with emphasis on age, sex, mode of injury, duration of reporting after injury and time interval between injury and treatment.
Clinical examination
Clinical examination includes general examination, local examination, neurovascular status, systemic examination and for associated injuries like head, chest- visceral injuries and other associated skeletal injuries. All information about patient history, clinical examination and follow up was recorded in Proforma. Radiological assessment was done with the help of antero-posterior and lateral X-ray views and diagnosis was established by both clinical and radiological means.

Pre operative work up:
Time of surgery:
In our study, closed reduction internal fixation which TENS nail of all cases was done as early as possible (within 48 hours).

Pre operative preparation of patients:
- All patients were kept overnight fasting prior to surgery. Emergency patients were NBM (nothing by mouth) minimum 6-8 hours before surgery.
- Adequate amount of cross matched blood was kept ready for any possible needs.
- Patients were tagged with name, age, sex, registration number and ward name.
- Lower limbs below the umbilicus, including the genitalia were prepared according to requirements.
- All patients were administered with systemic third generation cephalosporin antibiotic, 1 hour before surgery.

DEFINITIVE MANAGEMENT
Implant and Instruments Set:

1. Knife
2. Bone entry awl
3. Titanium elastic nails
4. Inserter with key
5. Hammer
6. Cutter

Nail size Selection: -
- TENS nail of size 1.5 to 4 mm.

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• Nail length : Lay one of the selected nail over the leg and determine that it is of the appropriate length by fluroscopy.
• Nail Width : The diameter of the individual nail is selected according to :
(i) Intra operative assessment : The diameter of nail is taken approximately 40% of medullary canal occupancy.
(ii) Flynn's et al20. formula : Diameter of nail = width of the narrowest point of medullary canal on AP and LATERAL view X 0.4 mm

Patient Positioning
• The patients were placed supine on radiolucent operation table and bump is placed below the knee and tourniquet is applied to upper thigh. The tourniquet usually is not inflated, but it can be inflated if required during procedures.
• The C-arm image intensifier was positioned ipsilaterally fracture side.

Anesthesia
• The patients were taken up for surgery under spinal or general anesthesia.

Exposure
• Painting and draping was done under all aseptic precautions.
• With use of fluoroscopy, mark on the skin the fracture site, the proximal tibial physis and the starting points for nail entry. The starting point for nail entry hole is 1.5 to 2.0 cm distal to the physis in AP view and approximately centrally in lateral view.
• Make lateral longitudinal 2 cm incision over the proximal tibial metaphysis just proximal to starting points Select two appropriately sized nails based one the width of medullary canal, choosing the largest possible diameter nails that will fit the medullary canal.
• Use a drill 0.5 cm larger than the nail in a soft tissue sleeve to create the entry hole, confirming the entry hole with fluoroscopy in both AP and lateral views. Take care to avoid the tibial tubercle apophysis. Drill the hole in the midpoint of anteroposterior dimension, starting perpendicular to the physis under fluoroscopic guidance, angle the drill caudad until it is 45 degrees from the long axis of tibia, taking care not to drill out the far cortex or migrate toward the physis.
• The nails come with a beveled blunt tip. Bent the tip of nail to 45 degree to facilitate passage along the opposite cortex and aid in fracture reduction.
• Contour the entire length of nails to a gentle curve such at or near the fracture site after reduction. The depth of the curve should be approximately three time the diameter of canal to achieve the optimal balance between ease of insertion and stability.
• Place the pre bent nail on an inserter and insert it from the side opposite the tibial displacement in antegrade fashion.
• Under the fluoroscopic guidance, slide the nails along the opposite cortex until fracture is reached.
• Reduce the fracture and advance the nail across the fracture. embed the nail in distal tibial metaphysic without violating the cortex or the physis.
• Place the second nail from the other side in a similar fashion. If necessary, rotate the bent tips of nails after passing the fracture site to achieve an anatomic reduction, taking care not to distract the fracture site. Bend the proximal nail ends and cut them 1 cm from the cortical surface so that the nail end will sit deep to the compartment fascia but be protruding enough for easy retrieval. Close the wounds with absorbable fascial and subcuticular stitch. Sterile compression dressing done and GT slab applied.

Post operative management
• Adequate analgesics, three shot of IV antibiotics were given after surgery and. IV antibiotics switch over to oral antibiotics up to 5th post-operative day in closed fracture.

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- IV antibiotics were given up to 5th post-operative day for compound fracture grade 2 and 3 and after this oral antibiotics were administered till removal of sutures. Post OP check X-rays were obtained.
- Static quadriceps exercise started after next day of surgery.
- Suture site dressing and long leg knee brace is applied after 5th day of surgery.
- Active knee and ankle mobilization exercise started after 5th day of surgery and Sutures were removed on 12th post-operative day, non-weight bearing with walker started after 3 weeks of surgery. Partial weight bearing started at 6 weeks. Full weight bearing is started after fracture is united.

Follow up

- Follow up in post-operative period was done at 4 week, 8 week, 12 week and 6 months. In each visit patient was assessed by clinical examination and radiological examination. Final outcome after 6 months is graded as excellent, satisfactory, or poor based on criteria described by Flynn et al20 and need for early removal of TENS would be required.

Clinical Assessment was done as per following basis :

1. Limb length : For shortening or lengthening
2. Localised pain and tenderness : Present or absent
3. Range of motion over knee and ankle

Weight bearing : On the basis of partial and full weight bearing (in weeks)

Radiological Assessment on the basis of Callus formation, alignment and fracture line visibility. X-ray view : full length leg X-ray including knee and ankle joint in both AP and lateral view.

1. Circumferential callus formation – good / adequate / poor.
2. Alignment :

a. rotational malalignment (in degrees - <10 or >10)

b. Coronal angulation (in degrees - <10 or >10)

3. Fracture line visibility seen clearly / masked / not seen

The final outcome based on the above observations is done as per Flynn's criteria.[13]

3. RESULTS

Table 1: Demographic data

Age Group (in years)	Numbers of patients	%
5-9	9	30.00
10-13	11	36.67
14-17	10	33.33
Gender		
Male	**22**	73.33
Female	**8**	26.67
Mode of injury		
RTA	**21**	70.00
Self-fall	**2**	6.67
Sport related injury	**4**	13.33
Fall from Height	**3**	10.00
Side affected		
Right	**17**	56.67
Left	**13**	43.33

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In our study 30 % of patients (9 out of 30) were age 5 to 9 years, 36.67% of patients (11 out of 30) were between 10 to 13 years of age. In our study 73.33 % of patients (22 out of 30) were male and 26.67% of patients (8 out of 30) were female. In our study majority (70%) of patients (21 out of 30) had injury due to road traffic accident and 13.33% (4 out of 30) due to sports related injury. In our study, right side 56.67 % (17 out of 30) was involved more than left side 43.33% (13 out of 30).

Table 2: Character, level and pattern of fracture

Character of fracture	**Number of patients**	**%**
Closed	21	70.00
Open GA Type 1	4	13.33
Open GA Type II	5	16.67
Open GA Type III	0	0.00
Level of fracture		
Proximal	1	3.33
Mid Shaft	19	63.33
Distal Shaft	10	33.33
Pattern of fracture		
Transverse	17	56.67
Short oblique	12	40.00
Long oblique	0	0.00
Spiral	1	3.33
Comminuted	0	0.00

In our study, closed fractures were 70 % (21 out of 30) and Open fractures GA Type II were 16.67% (5 out of 30). In our study, middle shaft fractures were 63.33 % (19 out of 30), distal third fracture were 33.33 % (10 out of 30). In our study, transverse fractures cases were 56.67% (17 out of 30), short oblique fracture cases were 40.00 % (12 out of 30).

Table 3: Duration of surgery (min), duration of hospital and time for union

Duration of surgery (min)	**Number of patients**	**%**
< 30	3	10.00
31-60	22	73.33
61-90	5	16.67
Duration of Hospital Stay (Days)		
< 5	13	43.33
6-7	15	50.00
> 8	2	6.67
Time for Full Union		
10 - 12 weeks	26	86.67
13 -15 weeks	2	6.67
> 15 weeks	2	6.67

In our study average duration of surgery was 49 minutes. The duration of stay in the hospital was < 7 days for 93.33% (28 out of 30) patients, 8-11 days for 2 patients. In our study most of cases (86.67%) were united upto 12 weeks of surgery. Only 1 case of delay union was noted. The mean time for union was 12 weeks.

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Table 4: Range of Movement at 24 Weeks

Range of Movement at 24 Weeks	**Number of patients**	**%**
Full range	28	93.33
Mild restiction	2	6.67
Moderate restriction	0	0.00
Severe restiction	0	0.00
Total	**30**	100.00

In our study full range of motion was present at knee and ankle joint after surgery at 24 weeks in 93.33% patient in our study. 2 patients (6.67%) had mild restriction in ankle dorsiflexion and Knee flexion.

Table 5: Complications

Complications	**No. of cases**	**Percentage**
Nail site irritation	2	6.67
Pain	0	0.00
Infection		
Superficial	2	6.67
Deep	1	3.33
Recurrent fracture	0	0.00
Delayed union and nonunion	1	3.33
Limb lengthening		
<2 cm	1	3.33
>2 cm	0	0.00
Limb shortening		
<2 cm	1	3.33
>2 cm	0	0.00
Nail back out	0	0.00
Malalignment		
a. Varus angulation	1	3.33
b. Valgus angulation	2	6.67
c. Anterior angulation	2	6.67
d. Posterior angulation	0	0.00
e. Rotational malalignment	1	3.33
Bursa at the tip of the nail	1	3.33
Sinking of nail into the medullary canals	0	0.00

In our study infection (Superficial and Deep) was seen in 3 cases (9.97%). Limb length inequality 2 (6.67%) cases, delayed union 1 (3.33%) case, nail irritation was present in 2 (6.2%) cases, malalignment in 6 (19.9%) cases and bursa at the tip of the nail in 1 (3.33%) case.

Table 6: Outcome according to Flynn's criteria

Outcome according to Flynn's criteria	**Number of patients**	**%**
Excellent	25	83.33
Satisfactory	4	13.33

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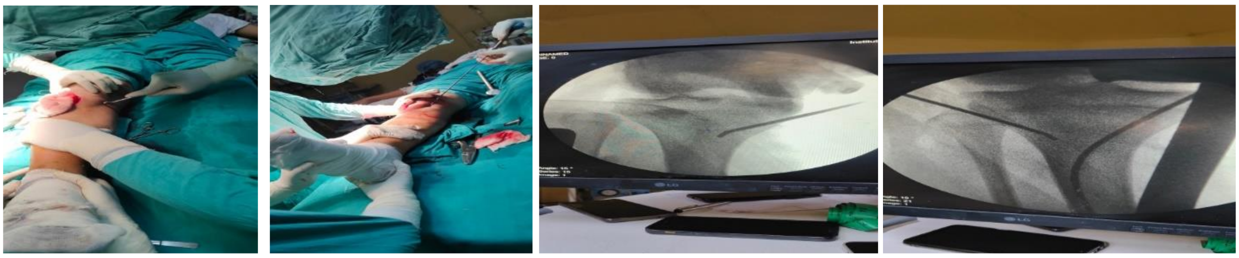
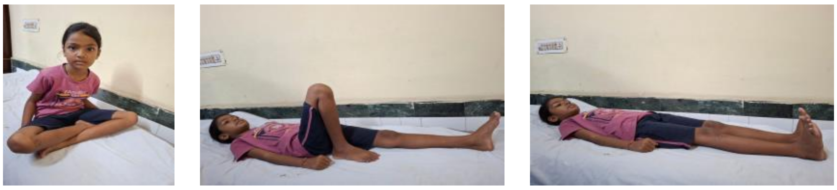
Poor	1	3.33
Total	**30**	100.00

In our study, the final outcome was excellent in 83.33% (25 out of 30), satisfactory or good in 13.3 % (4 out of 30) cases and poor outcome was reported in 1 case (3.33%) only.

DEFINITIVE MANAGEMENT



RADIOLOGICAL & CLINICAL ASSESSMENT



4. DISCUSSION

Tibial shaft fractures are the third most common long-bone fractures in children with a reported incidence of 15%. After the femoral fractures, these fractures are the second most common bony injuries which require hospitalization.[18-20] Approximately 39% of tibia fractures occur in the midshaft (diaphysis), 50% occur in the distal third, and 11% occur in the proximal third. Tibial shaft fractures most commonly occur in isolation (70%) and the majority of these injuries result from low-energy rotational mechanisms (e.g., pivoting or direct trauma with a planted foot). Tibial shaft fractures can also result from higher-energy trauma, most commonly motor vehicle accidents.[21] This is similar to adults where simple spiral fractures, isolated to the tibia, are the most common fracture pattern (34% of tibial shaft fractures), although there is a higher prevalence of high-energy trauma and complex fracture patterns in young, adult males.[22]
In our study 9 (30%) of the patients were 5-9 years, 11 (36.67%) were 10 to 13 years and 10 (33.33%) were 14 to 17 years age group with the average age being 11.35 years, which is similar to observation of Pandya NK et al[23] (between 2003 to 2010), Griffet J et al[24] (2011). In the present study, 22 (73.33%) were boys and 8 (26.67%) were females which was similar to the study of Choudhury G et al (2020)[25] and Debnath S et al (2017).[26] In the present study RTA

was the most common mode of injury accounting for 21 (70%) cases, sport related injury 4 (13.33%), fall from height 3 (10%) cases which is similar to series of Debnath S et al. (2017)[26] and Pogorelic Z et al (2022).[27] In our study, closed fractures were present in 21 (70%) cases, open Gustilo Anderson type II 5 (16.67%) and open Gustilo Anderson type I 4 (13.33%) which was similar to Tu KK et al (2015)[28], Heo Z et al (2016).[29] Fractures involving the middle 1/3rd accounted for 19 (66.33%) cases, distal 1/3rd – 10 (33.33%) and there was no proximal one third fracture of tibia cases in our study which is similar to Wudbhav N. Sankar et al (2007)[30], Pogorelic Z et al (2022).[27]
In the present study, transverse fractures were 17 (56.67%) cases, short oblique fractures 12 (40%), spiral 1 (3.33%) and there were no long oblique, and segmental fractures. The case study of Wudbhav N. Sankar (2007)[30] and N. Ligier et al (1988)[31] studied 20.3% cases communited, and 3.2% case segmental fracture which is contrary to our observation. Almost 100% cases operated within 5 days of trauma in our present study with average time taken was 2.5 days after trauma which was similar to Pogorelic Z et al (2022)[27] and Debnath S et al. (2017).[26] In our study, duration of surgery was 30-60 minutes in 25 (83.33%) cases, 61-90 minutes in another 5 (16.67%) cases. The average duration of surgery in our study was 49 minutes which is similar to study of Griffet J et al (2011).[24] The average duration of surgery was 70 minutes in series of K C Saikia et al (2007)[32] which is contrary to our present study observations.

The d ration of stay in the hospital < 7 days for 28 (93.33%) patients, 8-11 days for 2 (6.66%), no patient stay after 11 days which is similar to study of Pogorelic Z et al (2022).[27] Full weight bearing average time was 12.07 weeks for all patients. Wudbhav N. Sankar et al (2007)[30] in their study allowed full weight bearing between 5.7 – 11.6 weeks an average of 8.65 weeks. The average of full weight bearing for all tibia fracture in children was >20 weeks in study of Srivastava et al (2008)[33] which is similar to our observation.
In the present study, 28 (93.33%) cases was achieved full range of motion at knee and ankle joint after surgery at 24 weeks. 2 (6.67%) cases had mild restriction in ankle dorsi flexion and knee flexion. Tu KK et al (2015)[28] reported 1 (3.12%) case suffered with restricted range of motion at ankle. Nail site irritation was seen only in 2 (6.67%) cases in our present study. Kumar A et al. (2020)30 reported 15% nail prominences and skin irritation which is contrary to our present observation. Superficial infection was seen in 2 (6.67%) case in our study which was resolved with oral antibiotics administration. Deep infection was seen only in 1 case and resolved later after removal of implant on complete union. In our present study, 2 (6.67%) cases reported with limb length discrepancy. Srivastava et al (2008)[33] reported 1 (4%) limb length discrepancy in their study. In our present study, refracture and nail back out was not seen in any cases which was similar to Pogorelic Z et al. (2022).[27] The final outcome of our present study was excellent in 25 (83.33%) cases. Satisfactory 4 (13.33%) cases and only 1 (3.33%) poor outcome case was reported. Debnath S et al. (2017)[26] in their study of 30 tibial shaft fracture reported 17 (56%) excellent, 9 (30%) satisfactory and 4 (14%) poor results.

5. CONCLUSION

Historically, the preferred method of treatment of diaphyseal fracture of tibia in children has been conservative. Recent studies have concentrated on displaced tibial or both bone fracture leg. Elastic nails are an effective way for the treatment of pediatric tibial diaphysis fractures; they control the length, angulations, and rotation as they provide stability through three points of fixations for each nail. It is a simple and easy method but with radiation risk. Although elastic nails had complications, all are avoidable and minor that managed with minimal intervention.

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