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Management of diaphyseal long bone fractures in paediatric age group by tens

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Abstract
Background: Diaphyseal fractures in children are among the most common major paediatric injuries treated by orthopaedic surgeons and account for approximately 1.6% of all fractures seen in this population. Peak incidences occur at 2 & 17 years of age in bimodal distribution and boys have 2.6 times greater incidence than girls. The aim of this study is to evaluate the results of operative treatment of paediatric diaphyseal fractures in the age group between 5 to 12 years using titanium elastic nails (TENs).
Material and Methods: This is a Prospective Study based on patients admitted with Diaphyseal Fractures in Long Bones in the age group of 5 years - 12 years in the Department of Orthopaedics, government general hospital attached to government medical college, Nizamabad, study was conducted between March 2016 to March 2017.
Results: In the age group 5years to 8 years there were 14 (47%) and 9 years to 12 years there were 16 patients (56%). In our study the fracture was transverse in 15 cases (50%), short oblique in 7 cases (24%), spiral in 6 cases (20%), segmental in 1 (3%) and comminuted in 1 case (3%).

Keywords: Diaphyseal fractures, children, TENS, pediatric fractures, long bones, orthopedics

Introduction
Diaphyseal fractures in children are among the most common major paediatric injuries treated by orthopaedic surgeons and account for approximately 1.6% of all fractures seen in this population. Peak incidences occur at 2 & 17 years of age in bimodal distribution and boys have 2.6 times greater incidence than girls [1].
What constitutes appropriate management of diaphyseal fractures in children is a subject of much debate. Treatment ranges from strictly nonsurgical methods (e.g. closed reduction with casting or traction followed by casting and Pavlik harness for femur fractures) to surgical stabilization (using flexible intramedullary nailing, external fixation, or, sub muscular compression plating and screws).
Nonsurgical management has been the standard of care for most children historically but disadvantages of this treatment include prolonged immobilization and necessitate long hospital stay. Casting with or without traction is still the preferred treatment for diaphyseal fractures in children of preschool age.
The transition from non-operative to operative treatment for Diaphyseal fractures in childhood is not sudden. The growing economic concern, prolonged hospitalization required for traction in younger patients, the family's ability to take care of the child in cast, time spent in bed in conservative treatment and psychological implication of trauma in adolescents have prompted a more aggressive approach in managing these injuries. Operative treatment results in shorter hospitalization and early mobilization, which has psychological, social, educational and economic advantages over conservative treatment.
A variety of therapeutic alternatives mentioned above such as external fixator, compression plating, rigid intramedullary nailing and elastic stable intramedullary nailing are being used for Diaphyseal fractures in children. Several studies have shown that FIN/TENS fixation meets these requirements because it allows rapid mobilization, potentially no risk for osteonecrosis,

Low risk for physeal injury, and reduced risk for refracture. ESIN meets the requirements of this ideal device (Flynn *et al*. 2001) [2]. Moreover, much of the indexed publication and literature available on TENS is based on studies conducted outside the Indian subcontinent.

Titanium elastic nail (TEN) fixation was originally meant as an ideal treatment method for femoral fractures, but was gradually applied to other long bone fractures in children, as it represents a compromise between conservative and surgical therapeutic approaches with satisfactory results and minimal complications.

The aim of this study is to evaluate the results of operative treatment of paediatric diaphyseal fractures in the age group between 5 to 12 years using titanium elastic nails (TENs).

Material and Methods

This is a Prospective Study based on patients admitted with Diaphyseal Fractures in Long Bones in the age group of 5 years-12 years in the Department of Orthopaedics, government general hospital attached to government medical college, Nizamabad, study was conducted between March 2016 to March 2017.

Study method

Case selection criteria: During this period all patients posted for titanium elastic nailing were screened using the inclusion and exclusion criteria. Informed consent was taken from all patients that fit the inclusion criteria and all patients willing to undergo the trial were included. Patients were followed up at regular intervals and outcome variables were assessed and recorded.

The study was done on 30 cases of Diaphyseal fractures. Out of 20 cases 21 were Boys and 9 were Girls.

Inclusion criteria

1. Children with Diaphyseal fractures of long bones.
2. Age between 5-12 years.
3. Transverse, short oblique and minimally comminuted fractures.
4. Weight below 50 kg.
5. Closed and type I open fractures.

Exclusion criteria

1. Congenital disorders.
2. Patients who do not give consent.
3. Long oblique, multifragmentary fractures.
4. Medical contraindications to surgery.
5. Children with neuromuscular disease (cerebral palsy).
6. Open grade II and III.

Management Plan

Patients once included in the trial were assessed pre operatively and post operatively using clinical, radiological and functional measures. All the patients were followed up at 1month, 3 months, 6months and minimum 1 year/till implant removal whichever was earlier. The Clinical parameters that were assessed pre and post operatively include the Range of movement, limb length discrepancy, and presence or absence of pain at the nail site and by the Flynn outcome scoring [3], All patients were evaluated and treated for life and limb threatening injuries. Displaced fractures were immobilized using skin traction with Thomas splint (femur/tibia)/Plaster Of Paris Slab/Cramer Wire Support till the day of surgery. Postoperative data collected was no. of nails, postoperative immobilization, and period of hospital stay, period of radiological union, return to normal work, any complication, and time to nail removal. Radiographs were evaluated for alignment, nail size, nail shape (C or S), callus formation, nail position, and measurement of fracture location. Major postoperative complications are defined as nonunion, delayed union, sagittal angulation of more than 20°, coronal angulation of more than 10° (malalignment criteria based on previous studies), and infection, refracture, nail irritation requiring hardware removal, and nail breakage. Minor postoperative complications are defined as nail irritation that resolved without intervention, asymptomatic nail migration, and any perioperative problem that resolved without surgical intervention or early hardware removal.

Final outcome was graded excellent, satisfactory or poor based on criteria described by Flynn *et al*. 6 Functional outcome was assessed by using LEFS and DASH scoring at final follow up. Then all the data will be evaluated using statistical measures.

Results

Table 1: Age wise distribution of study population

Age in years	No. of cases	Percentage (%)
5 to 8	14	47%
9 to 12	16	53%

In the age group 5years to 8 years there were 14 (47%) and 9years to 12 years there were 16 patients (56%).

Table 2: Sex wise distribution

Sex	No. of cases	Percentage (%)
Male	21	70%
Female	9	30%

Out of the 30 children there were 21(70%) males and 9 (30%) females.

Table 3: Mode of injury

Nature of Trauma	No. of patients	Percentage (%)
Road traffic accident	12	40%
Fall from height	18	60%

The major cause of fracture in our study was Road traffic accident in 12 cases (40%), 18 cases (60%) were due to fall from a height.

Table 4: Side affected

Side affected	No. of patients	Percentage (%)
Right	18	60%
Left	12	40%

In our study right side was involved in 18 cases (60%) and left was involved in 12 cases (40%).

Table 5: Bone affected

Bone affected	No of cases	Percentage (%)
Humerus	1	3%
Forearm	9	30%
Femur	13	44%
Tibia	7	23%

In our study 1 case of humerus fracture (3%), 9 cases of forearm Fractures (30%), 13 cases of femur Fractures (44%), 7 cases of tibia fracture (23%).

Table 6: Type of Fracture

Pattern of fracture	No. of cases	Percentage
Transverse	15	50%
Short Oblique	7	24%
Spiral	6	20%
Segmental	1	3%
Comminuted	1	3%

In our study the fracture was transverse in 15 cases (50%), short oblique in 7 cases (24%), spiral in 6 cases (20%), segmental in 1 (3%) and comminuted in 1 case (3%)

Table 7: Level of fracture

Level of fracture	No. of cases	Percentage
Upper Third	3	10%
Middle Third	23	77%
Lower 1/3rd	4	13%

In our study upper third of diaphysis was involved in 3 cases (10%), middle third in 23 cases (77%) and Lower third in 4 cases (13%).

Table 8: Difficulties during operation

Difficulties during operations	No. of cases	Percentage
Difficulty in reduction	3	10%
Difficulty in passing nail	1	3%
None	26	87%

Difficulty in reduction of fracture was encountered in 3 cases (10%), difficulty in passing nail was noted in 1 case (3%). This problem was because of lack of space for maneuvering the nail.

Table 9: Time for union

Time for union	No of cases	Percentage
Grade 2 callus at 8 weeks	1	3%
Grade 3 callus at 4 weeks	5	17%
Grade 3 callus at 6 weeks	18	60%
Grade 3 callus at 8 weeks	6	20%

Grade 3 callus formation according to Anthony *et al.* scale4 was seen at 4 weeks in 5 cases(17%), at 6 weeks in 18 cases (60%) and 8 weeks in 6 (20%) and 1 case(3%) showed Grade 2 callus formation at 8 weeks.

Table 10: Range of motion at adjacent joints

Range of motion of adjacent joints	No. of cases	Percentage
Complete at 6 weeks	24	80%
Incomplete at 6 weeks and complete at 12 weeks	6	20%

Complete range of motion at hip and knee joints was obtained by the end of 6 weeks in 24cases (80%) and in rest of 6 cases (20%) complete range was obtained by the end of 12 weeks.

Complications

Limb length discrepancy:-Limb shortening was noted in 2 case (7%) at the end of one year of which 1 case (3%) had 1cm shortening and 1 case had 0.5cm shortening. Limb lengthening was noted in 1case (3%) at final follow up. Malalignment: Varus angulation of 10 degree was noted in 1 case (3%) and valgus in 1 case (3%). Anteroposterior angulation was noted in 0 cases (0%) our study. Rest patients had no malalignment.

Pain: Pain was noted in 1 cases (5%) at 6 weeks, as they had skin irritation at the entry point due to protruding nail. Pain subsided after removal of nail and these patients had no complaint of pain in operated limb at the end of 1 year.

Minor complications:-Skin irritation was noted in 2 cases (10%) and bursa formation was noted in 2 cases (10%) in our study.

Major complications: None of the cases developed delayed union, nonunion or implant failure however 2 patients had pin entry site infection which settled after a course of antibiotics for 2 weeks.

Complications in Upper Limb: 1 case developed elbow stiffness due to lack of exercises.

Discussion

As shown in Table 1 more patents 16 (56%) were in the age group of 9 to 12 years and 14 (47%) were and 5 to 12 years age group. Male patients were 21(70%) and female patients were 9 (30%) as shown in Table 2.

The major cause of fracture in our study (Table 3) was Road traffic accident in 12 cases (40%), 18 cases (60%) were due to fall from a height. Similar findings male predominance was seen in other studies like Narayanan UG, Joshua HE, Andrew MW, Mercer R, *et al*. [5] Saikia KC, Bhuyan SK, Bhattacharya TD, Saikia SP *et al*, [6] Khazzam M, Tassone C, Liu XC, Lyon R, [7] Iqbal M, Manzoor S, Cheema GM, Ahmed E, [8] Navdeep S, Kanav P, Suhail V, Harish D [9]. Kumar N, Chaudhary L [10]. In the present series, RTA is the most common mode of injury. There is a rise in motor vehicles on the road and improper regulation of traffic rules. Because of poor socio economic status in this region, working parents are not able to keep an eye on their children, which lead to high road traffic accidents.

As shown in Table 4, right side was involved in 18 cases (60%) and left was involved in 12 cases (40%). In other studies Ligier JN, Metaizeau JP, Prévot J, Lascombes P [11], Narayanan UG, Joshua HE, Andrew MW, Mercer R, *et al*, [5] Singh R, Sharma SC, Magu NK, Singla A. *et al*, [12] Saikia KC, Bhuyan SK, Bhattacharya TD, Saikia SP *et al*, [6] showing the same outcome of right- sided involvement. We did not encounter with any case of bilateral involvement.

As shown in Table 6,type of fracture was transverse in 15 cases (50%), short oblique in 7 cases (24%), spiral in 6 cases (20%), segmental in 1 (3%) and comminuted in 1 case (3%). Our study is comparable to other studies Flynn JM, Hresko T, Reynolds RA, Blasier RD *et al*. [3] reported most frequent fracture type was transverse in middle 3rd of shaft. Sink EL, Faro F, Polousky J, Flynn K, Gralla J [13]. showed improved results of pediatric femoral fractures with the use of TENS in stable fractures. We concluded that transverse fracture is maximum in number & best stabilized with TENS.

In our study Table 7 site of fracture, upper third of diaphysis was involved in 3 cases (10%), middle third in 23 cases (77%) and Lower third in 4 cases (13%). In other studies also like Houshian S, Bajaj SK *et al*, [14] Singh R, Sharma SC, Magu NK, Singla A. *et al*, [12] Khazzam M, Tassone C, Liu XC, Lyon R, [7] maximum number of fractures occurred in middle 1/3rd of shaft.

Most common complication seen in our study was entry site irritation and pain. This was seen due to prominence of nail end (more than 1cm outside the medullary cavity). To reduce this complication: We realize that bending of nail ends to be avoided, less than 1cm nail should be left outside the

medullary cavity and passive knee bending just after approximation of skin to sink the nail in muscles.

Two cases developed skin erosion at entry site by prominent nail end and was subsided after nail removal. We encountered with one case (3.33%) of infected Grade-II compound fracture of femur that approached us after 3 days of injury. Fracture was stabilized by TEN after wound debridement and appropriate antibiotics were given after culture sensitivity but infection did not subside, so early implant removal was done in 4 months. We did not encounter any delayed union, non-union, malunion or nail migration. Limb length was measured clinically in each follow up and we found no significant limb length discrepancies or gait abnormality.

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