Journal of Cardiovascular Disease Research

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 04, 2023

Original research article

A prospective study on management of upper limb and lower limb long bone fractures by titanium elastic nailing system in children

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Abstract

Background: Despite ongoing disagreement regarding its indications, interest in operating to treat paediatric fractures has grown during the past 20 years. There is some debate over the best way to repair long bone fractures in kids under the age of six (POP cast) and teenagers over the age of sixteen (locked intramedullary nailing, plating).

Objectives: To analyze the results of fixation of long bone fracture with TITANIUM ELASTIC NAILING SYSTEM (TENS) in the treatment of fracture shaft of long bones in children aged between 5 to 16 years with special emphasis on complications.

Material & Methods: This prospective study done in the Department of Orthopaedics, MVJ Medical College and Research Hospital, Hoskote, from April 2022 to March 2023. All children and adolescent patients between 5-16 years of age with diaphyseal fractures of long bones admitted in the department of Orthopedics who have undergone Titanium Elastic Nail System.

Results: We studied 7(35%) femoral and 6(30%) tibial fractures, 3 (15%) humerus, 4(20%) radius/ulna in which transverse fractures accounted for 10(50%) cases, communited fractures-2(10%), oblique fractures-5(25%), spiral fractures-3(15%) and there were no segmental fractures. The duration of stay in the hospital ≤ 7 days for 3 (15%) patients, 8-10 days for 7 (35%), 11-15 days for 10 (50%). One case was operated within 6 days of injury, developed superficial infection which had to be dressed regularly, so stayed for 11 days. Another cases were who had multiple soft tissue injury had to stay 14 days. The average duration of hospital stay in the present study is 10.25 days.

Conclusion: We draw the conclusion that the ELASTIC STABLE INTRAMEDULLARLY NAILING approach is the best course of action for treating paediatric long bone diaphyseal fractures. It provides elastic mobility that encourages quick union at the site of the fracture and stability that is perfect for early mobilisation. When compared to other forms of treatment, it has a reduced rate of complications and produces positive results.

Keywords: Titanium elastic nailing system, elastic stable intramedullarly nailing, paediatric long bone diaphyseal fractures

Introduction

When Métaizeau and the team from Nancy, France, invented the technique of elastic stable intramedullary nailing (ESIN) utilising titanium nails in 1982, the way paediatric fractures were treated underwent a significant transformation [1, 2].

Despite ongoing disagreement regarding its indications, interest in operating to treat paediatric fractures has grown during the past 20 years. There is some debate over the best way to repair long bone fractures in kids under the age of six (POP cast) and teenagers over the age of sixteen (locked intramedullary nailing, plating) [3].

Fixation with flexible intramedullary nails has gained popularity over the past seven years for stabilising femoral fractures in school-aged children and has since been extended to other long bone fractures in children [4, 5]. It is a compromise between conservative and surgical therapeutic approaches with good outcomes and few side effects [6, 7, 8].

Femur fractures make for 1.6% of paediatric fractures, and when treated with traction and a spica cast, they might have negative physical, social, psychological, and financial effects due to the extended immobilisation. Other treatment options include using solid antegrade intramedullary nails, external fixation, plates and screws. However, there is still a chance for some problems, most notably pin tract infection and refracture [9, 10].

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 04, 2023

Closed reduction and casting, which continues to be the gold standard of care, is a successful treatment for the vast majority of paediatric tibial shaft fractures. On occasion, severe shortening, angulation, or malrotation at the fracture site prevent reduction from being maintained, necessitating surgical intervention [11].

Because of its clinical efficacy and low risk of sequelae, elastic stable intramedullary nailing of long bone fractures in the skeletally immature has acquired wide acceptance. The use of this approach in the femur has been validated by numerous studies [12, 13, 14[, stating benefits such as closed insertion, preservation of the fracture hematoma, and a physeal-sparing entry location. The tibia, radius, ulna and humerus have all been treated with flexible intramedullary nails in a few small series in the past [15, 16].

Despite efforts made initially by French surgeons, later by European surgeons, and most recently by the Paediatric Orthopaedic Society of North America (POSNA), orthopaedic surgeons will still face a challenge in treating this age group with less morbidity at a lower cost. This study's objective was to demonstrate the outcomes of ESIN fixation of unstable long shaft fractures.

Objectives: To analyze the results of fixation of long bone fracture with TITANIUM ELASTIC NAILING SYSTEM (TENS) in the treatment of fracture shaft of long bones in children aged between 5 to 16 years with special emphasis on complications.

Material & Methods

Study design: A prospective hospital based observational study.
Study area: Department of Orthopaedics.
Study period: April 2022 to March 2023
Study population: All children and adolescent patients between 5-16 years of age with diaphyseal fractures of long bones admitted in the department of Orthopedics.
Sample size: Study consisted of 20 subjects.
Sampling method: convenient sampling.

Inclusion criteria

1. Age between 5-16 years of age.
2. Diaphyseal fractures.
3. Closed fractures.

Exclusion criteria

1. Metaphyseal fractures.
2. Open fractures.
3. Pathological fractures.
4. Fractures with distal neurovascular deficit.

Ethical consideration: Institutional Ethical committee permission was taken prior to the commencement of the study.

Study tools and Data collection procedure

As soon as the patient was brought to casualty, patient's airway, breathing and circulation were assessed. Then a complete survey was carried out to rule out other significant injuries. Plain radiographs of AP and lateral views of long bone including one joint above and one joint below to assess the extent of fracture comminution, the geometry and the dimensions of the fracture.

On admission to ward, a detailed history was taken, relating to the age, sex, and occupation, mode of injury, past and associated medical illness Routine investigations were done for all patients. Patients were operated as early as possible once the general condition of the patient was stable and patient was fit for surgery. After prior informed consent, a pre-operative anaesthetic evaluation is done. Pre-op planning of fixation is made.

Preoperative planning

Nail Size and Nail width: The diameter of the individual nail is selected as per.

1) Flynn *et al's* formula [17]

Diameter of nail= width of the narrowest point of the medullary canal on AP and LATERAL view X 0.4mm.

2) Intra operative assessment: Diameter of the nail is chosen so that each nail occupies atleast 1/3rd - 40% of the medullary cavity.

Nail length: Lay one of the selected nails over, and determine that it is of the appropriate length by fluoroscopy. Forearm fractures in children typically require a single nail inserted in each bone. It is

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 04, 2023

recommended that the nail be placed in the radius from a distal approach and the nail be placed in the ulna from a proximal approach. The nail diameters are normally between 2.0 mm and 3.0mm, depending upon patient anatomy (80% of the minimum diameter of radius or ulna).
The nail for femur should extend from the level of the distal femoral physis to a point approximately 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.

Instrumentation Set: 1. Titanium elastic nails, 2. Bone awl, 3. Inserter, 4. Beveled tamp, 5. Hammer, 6. Steffe cutter.
Post-operatively, patients are immobilized with above knee POP slab for 6 weeks for Lower limb and above elbow slab for 4 weeks for fore arm, U slab for humerus fracture. Immobilization was continued for another 2-3 weeks based on radiological assessment. The period of immobilization was followed by active hip and knee/knee and ankle/elbow and forearm mobilization with non-weight bearing crutch walking and active and passive movements at shoulder, elbow and wrist. Full weight bearing is started by 8-12 weeks depending on the fracture configuration and callus response.

Follow UP: Assessment done at 3, 6, 12 and 24 weeks. At each follow up patients are assessed clinically, radiologically and the complications are noted.

Statistical analysis
Data was entered into Microsoft excel data sheet and was analyzed using SPSS 22 version software. Categorical data was represented in the form of Frequencies and proportions. Chi-square test was used as test of significance for qualitative data. Continuous data was represented as mean and standard deviation. Analysis of variance (ANOVA) was used for various continuous variables in different groups to find the statistical significance. P value <0.05 will be a statistically significant study.

Observations & Results

Table 1: Age Distribution of Patients Studied

Age in years	Number of patients	%
5-8	6	30
9-12	8	40
13-16	6	30
Total	20	100

In the present study 6 (30%) of the patients were 5-8 years, 8(40%) were 9 to 12 years and 6(30%) were 13 to 16 years age group with the average age being 9.8 years.

Table 2: Gender Distribution of Patients Studied

Gender	Number of patients	%
male	17	85
Female	03	15
Total	20	100

There were 3(15%) girls and 17 (85%) boys in the present study.
In the present study RTA was the most common mode of injury accounting for 13 (65%) cases, accidental fall accounted for 6 (30%) cases and fall from height accounted for 1(5%) of the cases.

Table 3: Bone Affected

Bone affected	Number of patients	Percentage
Humerus	3	15
Radius/ulna	4	20
Tibia	6	30
Femur	7	35
Total	20	100

We studied 7(35%) femoral and 6(30%) tibial fractures, 3 (15%) humerus, 4(20%) radius/ulna.
In our study, transverse fractures accounted for 10(50%) cases, communited fractures-2(10%), oblique fractures-5(25%), spiral fractures-3(15%) and there were no segmental fractures.
Fractures involving the middle 1/3rd accounted for 12 (60%) cases, proximal 1/3rd-4 (20%) and distal 1/3rd-4 (20%) of cases in our study. In the present series, 11 (55%) patients underwent surgery within 3 days after trauma, 8(40%) in 4-6 days and 1(5%) in 7-9 days. Average duration between trauma and surgery was 3.65 days in the study.

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 04, 2023

Table 4: Duration of Surgery in Minutes

Duration of surgery in minutes	Number of patients	%
30-60	7	35
61-90	10	50
91-120	3	15
Total	20	100

In the present study, duration of surgery was < 60 mins in 7(35%) case, 60- 90 mins in 10 (50) cases and 90-120 mins in another 3 (15%) cases Among the 3 cases in which duration was more than 90 minutes- one was case no.1(humerus) which was middle third fracture which took 100 minutes.

In our study, 19 (95%) cases were immobilized postoperatively for 6-8 weeks and such immobilization was for 9 weeks in one case (5%). The period of immobilization was followed by active hip and knee/knee and ankle mobilization with non-weight crutch walking and active movements of shoulder elbow and wrist.

Table 5: Duration of Stay in Hospital Stay in Days

Duration of stay in hospital stay in days	Number of patients	%
≤7	3	15
8-10	7	35
11-15	10	50
>15	0	
Total	20	100

The duration of stay in the hospital ≤ 7 days for 3 (15%) patients, 8-10 days for 7 (35%), 11-15 days for 10 (50%). One case was operated within 6 days of injury, developed superficial infection which had to be dressed regularly, so stayed for 11 days. Another cases were who had multiple soft tissue injury had to stay 14 days. The average duration of hospital stay in the present study is 10.25 days.

Table 6: Time for Union

Time for union	Number of patients	%
< / = 12 weeks	17	85
>12-18 weeks	3	15
>18-24 weeks	0	0
Total	20	100

Table 7: Range of Movements at 24 Weeks (DEGRESS)

Range of movements	Number of patients	%
Full range	18	90
Mild restriction	2	10
Moderate restriction	0	
Severe restriction	0	
Total	20	100

Table 8: Complications

Complications	No. of cases	%
Unresolved Pain at the entry site	-	-
Infection		
Superficial	01	5
Deep	-	
Delayed union and non-union	-	-
Limb lengthening		
< 2 cm	-	-
> 2 cm	-	-
Limb shortening		
< 2 cm	02	10
> 2 cm	-	-
Nail back out	-	-
Mal alignment		
a. Varus angulation	-	-
b. Valgus angulation		
c. Anterior angulation	-	-
d. Posterior angulation	-	-
e. Rotational Malalignment	-	-

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 04, 2023

Bursa at the tip of the nail	2	10
Sinking of the nail into the medullary cavity	-	-

Table 9: Outcome of the Study

Outcome	Number of patients	%
Excellent	18	90
Satisfactory	2	10
Poor	0	0

In the present study, the final outcome was excellent in 18 (90%) cases, satisfactory in 2 (10%) cases and there were no poor outcome cases.

Table 10: Outcome for Additional Variables in the Present Study

Outcome Variables	Excellent (%)	Satisfactory (%)	Poor (%)
Range of movements	18	2	0
Time for union	17	3	0
Unsupported weight bearing	14	6	0

Discussion

In the present study 6 (30%) of the patients were 5-8 years, 8(40%) were 9 to 12 years and 6(30%) were 13 to 16 years age group with the average age being 9.8 years. Study done by J.N. Ligier *et al*. [5], the average age being 10.2 years, Study done by ATUL BHASKAR [18] the average age being 10 years and Study done by D. Furlan & Z. Pogorelic [19] the average age being 10 years which were consistent with our study.

There were 3(15%) girls and 17 (85%) boys in the present study. In the present study RTA was the most common mode of injury accounting for 13 (65%) cases, accidental fall accounted for 6 (30%) cases and fall from height accounted for 1(5%) of the cases. We studied 7(35%) femoral and 6(30%) tibial fractures, 3 (15%) humerus, 4(20%) radius/ulna. In D. Furlan & Z. Pogorelic [19] study had 42(24.28%) femoral, 36(20.80%) tibial, 53(30.64%) humeral and 42(24.28%) forearm bone fractures.

In our study, transverse fractures accounted for 10(50%) cases, communited fractures-2(10%), oblique fractures-5(25%), spiral fractures-3(15%) and there were no segmental fractures. In their study J.N. Ligier[5] *et al*. out of 123 femoral fractures studied 47(38.2%) were transverse fractures, communited fractures-25 (20.3%), oblique fractures-7(23.3%), spiral fractures-19 (15.4%) and 4 (3.2%) were segmental fractures. Wudbhav N. Sankar [20] 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.

Fractures involving the middle 1/3rd accounted for 12 (60%) cases, proximal 1/3rd-4 (20%) and distal 1/3rd-4 (20%) of cases in our study. In their study J. N. Ligier *et al*. [5] among 123 femoral shaft fractures, 42 fractures Wudbhav N. Sankar [20] studied 19 tibial shaft fractures out of which 15 were middle 1/3rd, 2- proximal 1/3rd and 2 were distal 1/3rd.

In the present study, duration of surgery was < 60 mins in 7(35%) case, 60-90 mins in 10 (50) cases and 90-120 mins in another 3 (15%) cases Among the 3 cases in which duration was more than 90 minutes-one was case no.1(humerus) which was middle third fracture which took 100 minutes. In our study, 19 (95%) cases were immobilized postoperatively for 6-8 weeks and such immobilization was for 9 weeks in one case (5%). The period of immobilization was followed by active hip and knee/knee and ankle mobilization with non-weight crutch walking, and active movements of shoulder elbow and wrist. The average duration of immobilization was 7.2 weeks. The average length of immobilization in plaster was 9.6 weeks in Gross R.H. *et al*. study [21].

The duration of stay in the hospital ≤ 7 days for 3 (15%) patients, 8-10 days for 7 (35%), 11-15 days for 11 (50%). One case was operated within 6 days of injury, developed superficial infection which had to be dressed regularly, so stayed for 11 days. Another cases were who had multiple soft tissue injury had to stay 14 days. The average duration of hospital stay in the present study is 10.25 days. The mean hospital stay was 12 days in Kalenderer O *et al*. study [22]. Average hospitalization time was 11.4 days in the study conducted by Mann DC, *et al*. [23].

In our study union was achieved in <3 months in 17 (85%) of the patients and 3-4.5 months in 3 (15%). Average time to union was 10.35 weeks. Oh C.W *et al* reported average time for union as 10.5 weeks [24]. 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 [25].

In the present study full weight bearing walking was started in <12 weeks for 14 (70%) of the patients and between 12 and 18 weeks in 6 (30%). The average time of full weight bearing was 11.8 weeks. Wudbhav N. Sankar *et al*. [20] in their study allowed full weight bearing between 5.7-11.6 weeks an average of 8.65 weeks.

ISSN:0975 -3583,0976-2833 VOL14, ISSUE 04, 2023

Table 11: Complications

Complications	Present Study (% incidence)	Previous Studies (% incidence)	
Pain at the site of nail insertion	0	16.2	J.M. Flynn *et al.* [26]
Superficial infection	5	1.7	J.M. Flynn *et al.* [26]
Range of motion	10	0.9	J.M. Flynn *et al.* [26]
Limb Length Discrepancy (minor)			
Lengthening	3.3	5.0	Ozturkman Y. *et al.* [27]
Shortening	10	2.5	Ozturkman Y. *et al.* [27]
Nail back out	-	2.6	Carrey T.P. *et al.* [12]
MALALIGNMENT(minor)			
Varus/Valgus	-	4.3	J.M. Flynn *et al.* [26]
Anteroposterior	-	8	Heinrich SD, *et al.* [28]
Rotational deformities	-	3.2	Heinrich SD, *et al.* [28]
Nail back out	-	2.6	Carrey T.P. *et al.* [12]

In the present study, the final outcome was excellent in 18 (90%) cases, satisfactory in 2 (10%) cases and there were no poor outcome cases.

Table 12: Assessment of Outcome

Studies	Excellent (%)	Outcome Satisfactor Y (%)	Poor (%)
Present study	90	10	-
D. Furlan & Z. Pogorelic [19]	89	11	-
Gamal El Adl *et al.* [29].	75.8	24.2	-
J.M.Flynn *et al.* [26]	77.7	14.6	7.8
Richter D *et al.* [30]	80	16.6	4

Conclusion

We draw the conclusion that the ELASTIC STABLE INTRAMEDULLARLY NAILING approach is the best course of action for treating paediatric long bone diaphyseal fractures. It provides elastic mobility that encourages quick union at the site of the fracture and stability that is perfect for early mobilisation. When compared to other forms of treatment, it has a reduced rate of complications and produces positive results.

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ISSN:0975 -3583,0976-2833 VOL14, ISSUE 04, 2023

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