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Original Research Article

MANAGEMENT OF PAEDIATRIC LONG BONE DIAPHYSEAL FRACTURES USING TITANIUM ELASTIC INTRAMEDULLARY NAILING SYSTEM

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ABSTRACT

Background: This investigation aims to evaluate the outcomes of titanium elastic intramedullary nailing in paediatric long bone diaphyseal fractures.

Material and Methods: 30 individuals with fractures of diaphysis of the humerus, femur, tibia, humerus, or both forearm bones made up the study's sample who were admitted to Andhra Medical College between August 2020 and August 2022 and who met the inclusion and exclusion criteria.

Results: In the present study, between August 2020 and August 2022, 30 patients had titanium elastic nailing at the Andhra Medical College in Visakhapatnam for diaphysis fractures of femur (12), tibia (9), humerus (3), & both bone forearms (06). Children and teens between the ages of 6 and 15 were involved in the study. 76.6% of the patients were between the ages of 6 and 10 and 46.6% were between ages of 11 and 15, with an average age of 10.3 years. 67 percent of the cases were boys. The median period from trauma to surgery was 3.96 days, with surgery performed on 11 (36.6%) patients in less than two days, on 7 (23.3%) patients in three to four days, and on 3 patients in 5-7 days later (10 percent). Most fracture procedures (27 cases; 90%) were finished in 30 to 90 minutes. An operation took, on average, 59.9 minutes to complete. 9.26 days on average were spent in the hospital. With a 12.1 week average time to union, 24 patients (or 80%) were able to complete the process in within 3 months. Within 12 weeks, functional loading for the upper limb and unsupported full weight bearing walking for 22 (73.33 percent of the patients) both started. All of the patients in the current study exhibited full ranges of motion in the hip, ankle, elbow, wrist, and forearm, however two (6.66%) of them had slight limitations in knee flexion and forearm supination after 12 weeks. Three persons (10%) reported having pain where the nail was inserted during the follow-up examination; however, by end of the 12-week followup, all these cases had vanished.

Conclusion: The present study concluded that, the use of TENS is a safe, minimally-invasive, and physeal protective option for children with lengthy bone shaft fractures that must be stabilised permanently.

Keywords: TENS, Bone Diphyseal Fracture, Humerus, Femur.

INTRODUCTION

One of the main causes of morbidity and mortality in children is trauma. Accidental trauma is the one of the main causes of morbidity for children between the age of 1 and 14 years.

According to literature, at least one bone will fracture in 50 percent of all children during their childhood. About 10 to 15 percent of all childhood trauma is skeletal in nature. Paediatric trauma is more common in boys than in girls, and boys are more likely to suffer a single, isolated fracture (2.7:1).

Children's long bone fracture treatment has evolved continuously over the years. Operative care has become increasingly important in recent years for many paediatric fractures. Operative care typically results in better outcomes than non- operative therapy.[1,2] The ideal course of action for paediatric fractures is still up for dispute. A simple, efficient, and barely intrusive procedure is titanium elastic nailing. It provides solid fixation, quick healing, speedy resumption to regular activity for the youngster, and minimal complication rates.

This investigation aims to evaluate the outcomes of titanium elastic intramedullary nailing in paediatric long bone diaphyseal fractures.

Aims & Objectives

1. To study the functional outcome and union rates of closed reduction and internal fixation of paediatric diaphyseal fractures with TENS.
2. To assess the complications encountered in the procedure of TENS.
3. To determine the demographic (age and sex distribution) of diaphyseal paediatric long bone fractures of tibia, femur, humerus, and forearm.

MATERIAL AND METHODS

30 individuals with fractures of diaphysis of the humerus, femur, tibia, humerus, or both forearm bones made up the study's sample who were admitted to Andhra Medical College between August 2020 and August 2022 and who met the inclusion and exclusion criteria.

Inclusion Criteria

1. Children and adolescents from 6 to 15 years with closed Diaphysis fractures of Humerus, Femur, Tibia, and both forearm bones (Ulna and Radius).
2. Patients whose guardians gave consent
3. Both the sexes were included in the study.

Exclusion Criteria

1. Patients unfit for surgery
2. Compound fractures
3. Patient whose guardians are not willing to give a valid informed consent.

Follow Up

Assessment was done at 2, 6, and 12 weeks as well as at 24 weeks. At each follow up appointment, patients were assessed radiologically, clinically and for complications.

Radiological

Fracture union evidence

Disimpaction (if present) in AP & Lateral planes

Nail migration & Nail penetration

Evaluation of Results

Results were evaluated both anatomically and functionally according to the following criteria (Flynn's scoring criteria).

Excellent: When there was anatomical or near anatomical alignment, no limb length discrepancy with no perioperative problems

Satisfactory: When there was acceptable alignment or limb length discrepancy with resolution perioperative problems.

Poor: In the presence of unacceptable alignment or limb length with unresolved perioperative problems.

Table 1:

TYPE	PERCENTAGE OF MOVEMENT
FULL RANGE	100% POSSIBLE
MILD	10- 20% RESTRICTION
MODERATE	20- 50% RESTRICTION
SEVERE	> 50% RESTRICTION

RESULTS

In our study the range of age was between 6-15 years the mean age was

10.03 years and the incidence were high in the age group of 6-10 years.

In a total of 30 cases, 20 fractures were in males and 10 fractures were in females.

In our study of 30 cases 15 cases were as a result of RTA, 10 cases were due to self-fall and 5 cases were due to fall from height. [Table 2]

In our study of 30 fractures, 12 fractures were of femur, 9 were of tibia, 6 were of forearm both bones fractures and 3 were of humerus. [Table 3]

In our study of 30 cases 12 patients had fracture on the right side and 18 patients had fracture on the left side. there are no cases of bilateral fractures in our study. [Table 4]

In our study of 30 cases 12 were of transverse fractures, 10 were of oblique fractures, 5 were of spiral fractures and 3 were of Communited fractures. There were no segmental fractures encountered in our study. [Table 5]

In our study of 30 cases 11 patients were operated within 2 days of trauma, 7 were operated between 3rd and 4th day of trauma, 9 were operated between 5th and 7th day of trauma and 3 were operated after 7 days of trauma. [Table 6]

In our study of 30 cases 1 patient with forearm fracture was operated within 30 minutes, 13 cases were operated in between 30-60 mins., 14 cases were operated between 61-90 mins., and 2 cases were operated between 91-120 mins. [Table 7]

In our study of 30 cases 11 cases were discharged in 5-8 days, 17 cases were discharged between 8-10 days, and 2 cases were discharged after 10 days. [Table 8]

In our study of 30 cases, 24 cases had union in less than 12 weeks, 5 cases had union between 12-18 weeks and one case had union between 18-24 weeks. [Table 9]

In our study of 30 patients 28 patients were able to do full range of movements by 24 weeks a movements at the end of 24 weeks. nd 2 patients had

mild restriction (10-20% of restriction of ROM) of. [Table 10]

In our study of 30 cases 24 patients returned to total functional loading in less than 12 weeks, 5 patients returned to total functional loading in between 12-18 weeks, one patient with Communited humerus fracture took 20 weeks for functional loading. [Table 11]

In our study of 30 patients 9 patients had only minor complications and 21 patients had no complications. [Table 12]

Results

Excellent results were obtained in 70 percent cases whereas 30 percent patients had satisfactory results according to Flynn et al. Scoring.

In our study of 30 patients 21 patients had excellent outcome, 9 had satisfactory outcome. No patient had a poor outcome. [Table 13]

In our study of 30 cases, 3 patients had pain at the site of nail insertion, one had migration of the nails, one had superficial infection which subsided with antibiotic therapy, 2 patients had shortening of <2 cm and 2 patients had mild limitation of range of movements. [Table 14]

Table 2: Mode of Injury of patients studied

Mode of Injury	No of Patients	%
RTA	15	50.00
Self-Fall	10	33.33
Fall from height	5	16.66
TOTAL	**30**	**100.00**

Table 3: Bone affected

Bone Affected	No of Patients	%
Femur	**12**	**40.00**
Tibia	**9**	**30.00**
Humerus	**3**	**10**
Forearm (Radius, Ulna)	**6**	**20.00**
TOTAL	**30**	**100.00**

Table 4: Side affected

Side Affected	No of Patients	%
Right	12	40.00
Left	18	60.00
TOTAL	**30**	**100.00**

Table 5: Pattern of fracture

Pattern of Fracture	No of Patients	%
Transverse	12	40.00
Oblique	10	33.33
Spiral	5	16.66
Segmental	0	0.00
Communited	3	10.00
TOTAL	30	100.00

Table 6: Time interval between trauma and surgery

Time of Interval between Trauma & Surgery	No of Patients	%
< 2 Days	11	36.66
3 – 4 Days	7	23.33
5 – 7 Days	9	30.00
> 7 Days	3	10
TOTAL	30	100.00

Table 7: Duration of surgery in minutes

Duration of Surgery (In Mins)	No of Patients	%
< 30	1	3.33
30 – 60	13	43.33
61-90	14	46.7
91-120	2	6.7
TOTAL	30	100.00

Table 8: Duration of stay in hospital stay in days

Hospital stay	No of cases	Percentage
5-8 days	11	36.66
8-10 days	17	56.66

>10 days	2	6.66
Total	30	100

Table 9: Time for union

Time of Union	No of Patients	%
<12 Weeks	24	80.00
12-18 Weeks	5	16.70
18-24 Weeks	1	3.30
TOTAL	30	100.00

Table 10: Range of movements at 24 weeks (degrees)

Range of Movements in degrees	No of Patients	%
Full Range	28	93.33
Mild Restriction	2	6.66
Moderate Restriction	0	0
Severe Restriction	0	0
TOTAL	30	100

Table 11: Time taken for return to total functional loading

Time of full Activity	No of Patients	%
≤ 12 weeks	24	80.00
12 -18weeks	5	16.70
18-24 weeks	1	3.30
TOTAL	30	100.00

Table 12: Complications

COMPLICATIONS	MINOR	MAJOR	NILL	TOTAL
No. Of Patients	9	0	21	30
Percentage	30	-	70	100

Table 13: Results

Overall Results	No of cases	Percentage
Excellent	21	70
Satisfactory	9	30
Poor	0	0
Total	**30**	**100**

Table 14: Complications

Complications	No of cases	Percentage
1.pain at the site of nail insertion	3	10
2.migration of nails	1	3.33
3. Infection		
a) Superficial	1	3.33
b) Deep	0	0
4. Bed sores	0	0
5. Implant failure	0	0
6. Shortening < 2 cms	2	6.66
7. Mal union with rotational deformity	0	0
8. Limitation of joint movements		
a) MILD (10-20%)	2	6.66
b) MODERATE (20-50%)	0	0
c) SEVERE 50%	0	0
9.Reoperation	0	0

DISCUSSION

Age incidence:

The patients in this study had a mean age of 10.03 years, with 16 (53.3%) of them being between the ages of 6 and 10 and 14 (46.66%) being between the ages of 11 and 15.

The age range of the children J. N. Ligier et al.[1] investigated was 5 to 16, with a mean of 10.2 years.

The participants in Atul Bhaskar's [2] study ranged from 6 - 12 years old, with average age of 10 years.

Sex incidence

In this study, there were 20 boys & 10 girls, or 33.3% and 36.3% respectively. Comparable to other research in the literature, the sex incidence is low.

Out of 118 instances in their investigation, J. N. Ligier et al.[1] found that 80(67.7%) were males and 38 were girls.

Gamal El Adl et al.[3] discovered that 48 (72.7%) of the 66 patients in their study were men and 18 (27.3%) were women.

Mode of Injury:

With 15 (50.0 percent) instances, RTA injuries were the most common type in the current study. Ten

(33.3%) of the incidents involved self-falls, whereas five (16.6%) involved falls from height.

J. M. Flynn et al research of 234 incidents revealed that 136 (58.1%) of them included RTA, 46 (19.6%) were self-inflicted falls, and the remaining 43 (288%) were falls from height.[4]

Affected Bones

We investigated 12 (40%) femur fractures, 9 (30%) tibial fractures, 3 (10%) humeral fractures, and 6 (20%) fractures.

In their research, 23 (30%) femoral, 14 (20%) tibial, 5 (7.14%) humeral, and 28 (40%) forearm fractures were reported by H. Till et al.[5]

Out of 173 cases, 42 (24.3%) had femoral fractures, 36 (20.8%) had tibial fractures, 55 (31.7%) had humeral fractures, and 42 (24.3%) had radius and ulna fractures.[6]

Pattern of Facture

In our study, there were no segmental fractures, however there were 12 (40%) transverse fractures, 3 (10%) comminuted fractures, 10 (33.3%) oblique fractures, and 5 (16.7%) spiral fractures.

J. N. Ligier et al,[1] looked at 123 femur fractures, and found that 47 (38.2%) were transverse fractures, 25 (20.3%) were comminuted fractures, seven (23.3%) were oblique fractures, 19 (15.4%) were spiral fractures, and four (3.2%) were segmental fractures. Arun Kumar et al. [2] discovered that 10 (33 percent) of the 30 long bone shaft fractures they studied were transverse, 7 (23 percent) oblique, 8 (27 percent) spiral, and 5 (17 percent) comminuted.[7]

Time interval from trauma to surgery:

In the current series, surgery was done on 11 patients (36.6%) within two days after the trauma, seven patients (23.3%) over the next three to four days, nine patients (30%) during the next five to seven days, and three patients (10%) during the following seven days. Case No. 3 and Case No. 14 were two of the two cases with durations longer than 7 days, they both received surgery 8 days after the trauma (admission). Another example was case number 29, which needed surgery ten days after the trauma (admission) since the patient had abrasions at incision site and we needed to wait for them to heal

Duration of stay in the hospital:

11 patients (36.7%) spent 5-8 days in the hospital, 17 patients (56.6%) spent 8–10 days in the hospital, and 2 patients (6.6%) spent more than 10 days there. Case No. 3, whose trauma (admission) and operation were separated by a longer length of time, stayed for 14 days, was one of the two patients who stayed for longer than 10 days. Another was Case No. 29, who had surgery 10 days after the injury (admission) and was hospitalised for fifteen days as he awaited the decision on his plan. An average stay in hospital in the current study was 9.26 days.

In the study of Arun Kumar C et al., the typical hospital stay was 9.9 days.[7]

In research on the treatment of fractures of femur shaft in children and young adults, Gross RH, et al. used cast braces. In their investigation, the typical hospital stay lasted 18.7 days.[8]

The average hospital stay duration in our study, at 9.26 days, was less than in the studies on conservative treatments and cast bracing mentioned above. Our series' shorter hospital stays are the result of careful patient selection, reliable fixation, and a lower frequency of problems.

Union Time:

In our investigation, union was accomplished in less than three months in 24 (80%) of the patients, between three and four and a half and five months in one case (3.3 percent). It took 12.1 weeks on average to reach union. According to Atul Bhaskar, the average length of a union was 10.5 weeks.[2]

In our investigation, closed reduction of fracture, which retained the fracture hematoma, biomechanical stability improvement, and required less soft tissue dissection than compression plate fixation, resulted in rapid fracture union.

Time for return to functional loading:

Unsupported full weight-bearing walking for lower limb and activity for upper limb began in the current study within 12 weeks for 22 patients (73.33 percent), between 12 & 18 weeks for 6 patients (20 percent), and at 20 weeks for two patients (6.6 percent). The time it took to resume regular activities was 11.5 weeks on average.

In their study, WudbhavN. Sankar et al. permitted complete weight bearing for an average of 8.65 weeks between 5.7 and 11.6 weeks.[9]

COMPLICATIONS:

Nail insertion site pain:

During the first follow-up assessment in the current study, 3 (10%) participants reported feeling pain where the nail was inserted. All these patients had fully healed from this pain at the end of the 16-week time frame.

J.M. Flynn et al. reported 38(16.2 percent) instances of pain at nail insertion site out of 234 fractures that were treated with elastic nails.[4]

Infection

In our investigation, there was one incidence of superficial infection (3.3%) that was treated with antibiotics.

J.M. Flynn et al. discovered 4 (1.7 percent) cases of superficial infection at the site of nail insertion out of 234 fractures treated with titanium elastic nails.[4]

A significant drawback of external fixation application is pin tract infection. Two incidences of deep pin tract infection were described by Bar-on E. et al. in patients who had external fixation.[10]

Range of motion:

Only two individuals (6.66 percent) in the current study had a little limitation; the remainder all displayed complete range of movements. 1 patient had a 50-degree limitation in supination at the time of the last checkup, but no additional surgery was done because deformity was in the non-dominant forearm and did not affect everyday activities. The other patient had a 50-degree supination restriction.

According to J.M. Flynn et al,[2] (0.9 percent) of the patients who had 234 fractures fixed using titanium elastic nails complained of knee discomfort.[4]

Limb length discrepancy:

This is the second-most common consequence after femur shaft fractures in children & adolescents (2.66 percent) of the population had a shortening (2 cm). In our investigation, there were no patients with significantly different limb lengths (i.e., > 2 cm).

Ozturkman Y. et al. reported mean leg shortenings were 6mm and 7mm, respectively, in 2 (2.5%) children and 4 (5%) patients.[11]

There was no change in leg length between the 19 tibial shaft fractures that Wudbhav N. Sankar examined.[29]

Four children who received spica therapy for a paediatric femoral shaft fracture showed more than 2 cm of shortening, according to John Ferguson et al.[12]

Comparing the difference in limb length between conservative approaches, in our study, there was an acceptable amount of discrepancy.

Nail back out

Nail back out was observed in one (3.33%) of the cases in the current series. In their study, Atul Bhaskar et al. found that out of 60 instances, three occurrences of nail back out—one in the radius and two in the femur—required early removal.[2]

Malalignment

Children who sustain femoral shaft fractures frequently develop some degree of angular deformity, but this typically corrects itself as they grow.

Varus/valgus malalignment: No patients had angulation that was valgus or varus.

J.M. Flynn et al. observed that ten (4.3 percent) of the 234 fractures treated using titanium elastic nails had minor angulation.[4]

Heinrich SD, et al. discovered that 6° varus or valgus malalignment on average occurred in fractures of 11% of children with 5° of varus angulation.[13]

Herndon WA et al. examined the outcomes of spica casting and intramedullary nailing for adolescent femur shaft fractures. There was no varus angulation in the surgical group, but they did notice varus angulation in 4 of the patients who got spica casting treatment, ranging in angle from 7 to 25°[9]

Antero-posterior angulation:

There were no patients with anteroposterior angulation in the current study. Patients receiving traction and Spica casting had anterior angulation ranging from 8° to 35°, according to Herndon WA, et al.[14]

In the Heinrich SD, et al. study, eight percent of the patients had an average anterior or posterior angulation of 8°.[10]

Rotational deformities: Significant deformity has traditionally been defined as a discrepancy greater than 10 degrees.

In our analysis, there were no patients with noticeable rotational deformities.

Other complications

In one example in our investigation, proximal migration of the medial nail was observed; the nail was removed after creating a cortical window. In one instance, proximal nail migration was observed by Bar-on E, et al.[10]

Assessment of Outcome according to Flynn et al. scoring

In 21 (70%) of the study's instances, the outcome was excellent, in 9 (30%) cases, it was adequate, and there were no situations where the outcome was subpar.

CONCLUSION

Based on our research and expertise, we conclude that TITANIUM ELASTIC NAILING SYSTEM method is the most effective way to treat paediatric long bone diaphyseal fractures. It offers stability that is ideal for early mobilisation as well as elastic mobility that promotes fast union at fracture site. It is less complex and gives good outcomes. TENS may be regarded as a physiological way of treatment due to early functional loading, quick healing, and less disruption of bone growth. The use of TENS is a safe, minimally-invasive, and physeal protective option for children with lengthy bone shaft fractures that must be stabilised permanently.

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