COMPREHENSIVE STUDY OF MANAGEMENT OF DIAPHYSEAL FRACTURES OF LONG BONES IN CHILDREN BY TITANIUM ELASTIC NAILING SYSTEM

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ABSTRACT

BACKGROUND

Paediatric fractures are usually treated conservatively with POP casts, as intramedullary nailing is contraindicated in growing bones and plating is associated with wound complications. These fractures heal satisfactorily with conservative treatment but may be associated with malunion and plaster complications sometimes. Titanium Elastic Nailing System (TENS) can be used in the internal fixation of paediatric fractures with satisfactory results and minimal complications. We wanted to study the functional outcome following the use of Titanium Elastic Nailing for the treatment of diaphyseal fractures of long bones in children.

METHODS

30 patients were treated with Titanium Elastic Nail System (TENS) for diaphyseal fractures of long bones who were admitted in Osmania General Hospital, Hyderabad during the study period- from October-2014 to October-2016. Patients were assessed clinically, radiologically and the complications were noted.

RESULTS

We studied 17 (56.7%) femoral, 7 (23.3%) tibial fractures, 1 (3.3%) humeral and 5 (16.6%) forearm bone fractures. Average age of the patients is 10.93. In our study, the final outcome was excellent in 22 (73.33%) cases, satisfactory in 8 (26.67%) cases and there are no poor outcome cases.

CONCLUSIONS

We conclude that titanium elastic nailing system (TENS) technique is an ideal method for treatment of paediatric diaphyseal fractures of long bones.

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BACKGROUND

In the last two decades there was an increased interest in the operative treatment of paediatric fractures, although debate persisted over its indications. There is little disagreement concerning the treatment of long bone fractures in children less than 5 years (POP cast) and adolescents older than 16 years (locked intramedullary nailing).¹ Controversy persists regarding the age between 5 to 16 years.

Orthopaedic surgeons will continue to be challenged to treat this age group with less morbidity at a lower cost, as no clear guidelines have been available until now despite efforts done initially by French surgeons, later on by European surgeons and recently by the Pediatric Orthopedic Society of North America (POSNA).² 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.²

Aims and Objectives

1. To study the functional outcome following the use of Titanium Elastic Nailing for the treatment of diaphyseal fractures of long bones in children in the age group between 5 to 16 years.
2. To study the safety of Titanium Elastic Nailing in the treatment of diaphyseal fractures of long bones in children in the age group between 5 to 16 years.
3. To evaluate the complications of Titanium Elastic Nailing in the treatment of diaphyseal fractures of long bones in children in the age group between 5 to 16 years.

METHODS

A case series of all children and adolescent patients between 5-16 years of age with closed, diaphyseal fractures of long bones admitted at Osmania General Hospital, Hyderabad during the study period from October-2014 to October-2016 were the subjects for the study. Patients with head injury were not included in the study. All the patients with Metaphyseal fractures, Compound fractures and Pathological fractures were excluded from the study. Each child was followed up to 1 year to 1 year 6 months after the surgery.

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Procedure for TENS Nailing of Diaphyseal Fracture

A systemic antibiotic, usually a 3rd generation cephalosporin was administered 1 hour before surgery. General/ Spinal anaesthesia is administered, and patient is placed in supine on a radiolucent table. The operative extremity is then prepared and draped. Under fluoroscopy, the fracture site and entry points are marked. The starting point for nail insertion is a point on metaphysis 2.0 cm away from the physis (Distal femur, proximal tibia, proximal/distal humerus, proximal ulna and distal radius). A longitudinal 2 cm incision is made on both the lateral and medial side of the metaphysis at the desired bony entry point. Using a haemostat, the soft tissues are bluntly dissected down to bone. Based on preoperative measurements, an appropriately sized implant is selected so that the nail diameter is 40% of the diameter of the narrowest portion of the medullary canal (it should be 60% if a single nail is used. A drill roughly 0.5 cm larger than the selected nail is then used to open the cortex at the nail entry site; angling the drill distally down the shaft facilitates nail entry. Both nails are then inserted through the entry holes and advanced to the level of the fracture site.

Under fluoroscopic guidance, the fracture is reduced in both the coronal and sagittal planes, and the first nail is advanced past the fracture site. If proper intramedullary position of the nail after crossing the fracture site is confirmed on anteroposterior and lateral views, then the second nail is tapped across the fracture site. Both nails are advanced until the tips lie just short of the physis at opposite end of the bone. Fluoroscopy is again used to confirm proper fracture reduction as well as nail position.

To minimize soft tissue irritation, the nails are backed out a few centimeters and cut along proximal tibial metaphysis. A tamp is used to re-advance the implants until <1 cm of nail lies outside of bone. Care is taken not to bend the nails away from the bone to facilitate cutting, as we have found that this increases 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.

After Surgery

Postoperatively, patients were immobilized in a slab support. Patients were started on static quadriceps exercises in case of lower limb fractures and active movements of fingers in case of upper limb fractures as soon as the pain subsided. POP cast was applied at the time of suture removal. POP cast was removed, and the range of motion exercise were started after 6 weeks. Partial weight bearing was started after visible callus was seen. With radiological evidence of union, full weight bearing was started after 6-8 wks. In patients with humerus fracture, fracture was either splinted or placed into a soft dressing and given a sling for comfort for 10-14 days. In case of forearm bone fractures, we immobilized the patient for 3 wks. in a posterior slab followed by allowing ROM exercises for elbow and wrist, sling for another 3 more wks.

Nail Removal

Usually nails are removed from 6 to 9 months after the surgery, depending on radiological union.

Follow Up

Assessment was done at 6, 12 and 24 weeks and at 1yr. At each follow up patients were assessed clinically, radiologically and the complications were noted.

Clinical Assessment

1. Pain.
2. Range of movements.
3. Measurement of limb length – noted for shortening/lengthening.
4. Time of weight bearing.

Radiological Assessment

- X-ray of the part (Thigh/leg/arm/forearm) full length with one joint above and one joint below – AP and LATERAL views
- Alignment: sagittal/coronal angulation (in degrees - <10 or >10) rotational malalignment (in degrees - <10 or >10)
- Circumferential callus formation – good/ adequate/poor.
- Visibility of fracture line – seen clearly/ masked/ not seen.

Complications⁴

1. Pain at the site of nail insertion,
2. Angulation (Sagittal, coronal and rotational malalignment) at final follow-up (24 weeks),
3. Limb length discrepancy (Shortening/lengthening) at final follow-up (24 weeks),
4. Inflammatory reaction to nails,
5. Superficial infection at site of nail insertion,
6. Delayed union,
7. Deep infection,
8. Loss of reduction requiring new reduction or surgery,
9. Delayed or non-union leading to revision.

The final outcome based on the above observations is done as per Flynn's criteria. Flynn's criteria.^{2,3,4}

RESULTS

In the present study 6(20%) of the patients were 5-8 years, 14 (46.7%) were 9 to 12 years and 10(33.3%) were 13 to 16 years age group with the average age being 10.93 years. There were 8 (26.7%) girls and 22 (73.3%) boys in the present study.

In the present study RTA was the most common mode of injury accounting for 20 (66.7%) cases, self-fall accounted for 8 (26.7%) cases and fall from height accounted for 2 (6.6%) of the cases.

We studied 17 (56.7%) femoral, 7 (23.3%) tibial fractures, 1(3.3%) humeral and 5 (16.6%) forearm bone fractures. In our study, transverse fractures accounted for 10(33.3%) cases, comminuted fractures accounted for 8(26.7%) cases, oblique fractures accounted for 7 (23.3%) cases, spiral fractures accounted for 5(16.7%) cases and there were no segmental fractures.

In the present series, average duration between trauma and surgery was 3.9 days. The average duration of surgery in our study was 59.9 minutes.

In our study, 21 (70%) cases were immobilized (In above knee POP cast for femur and tibia fractures, "U" slab for humerus and Above elbow slab for forearm bone fractures)

postoperatively for 6 weeks and such immobilization was for 9 weeks in rest of the 9 (30%) of the cases. The period of immobilization was followed by active hip and knee, knee and ankle mobilization with non-weight bearing crutch walking for lower limb fractures, shoulder, elbow and wrist mobilization for upper limb fractures. The average duration of immobilization was 6.9 weeks.

The average duration of hospital stay in the present study is 11.6 days.

In our study union was achieved in <12 weeks in 24 (80%) of the patients, 13 – 18 weeks in 5 (16.7%) and 20 wks. in 1 (3.3%). Average time to union was 12.1 weeks.

In the present study, unsupported full weight bearing walking was started in < 12 weeks for 19 (79%) of the patients, between 13 and 18 weeks in 4 (17%) and at 20 weeks in 1 (4%) among the total of 24 lower limb fractures. The average time of full weight bearing was 11.5 weeks.

Complications	No. of Patients (30)	Percentage
Pain at nail insertion site	3	10%
Superficial infection	1	3.3%
Decreased ROM of joint	2 (knee joint)	6.6%
Limb length discrepancy	1 (1 cm)	3.3%
Angular deformity	1 (5°)	3.3%

Assessment of Outcome

In the present study, the final outcome was excellent in 22 (73.33%) cases, satisfactory in 8 (26.67%) cases and there are no poor outcome cases.

TENS Outcome Score (Flynn et al)

	Excellent	Satisfactory	Poor
Limb length inequality	< 1 cm	1-2 cm	>2 cm
Malalignment	< 5°	5°-10°	>10°
Unresolved pain	Absent	Absent	Present
Complications	None	Minor and resolved	Major and/or lasting morbidity
No. of cases (30)	22	8	0

Figure 1. Preoperative and Postoperative X-Rays

Figure 2. Preoperative and Postoperative X-Rays

Figure 3. Preoperative and Postoperative X-Rays

DISCUSSION

In our study, the average duration of immobilization was 6.9 weeks. It is shorter duration compared to conservative management. The advantage of the present study was early mobilization of the patients.

Study	Duration of Immobilization (in Weeks)
Present study	6.9
Gross R.H. et al. ⁵ (Immediate cast bracing)	9.6
John Ferguson ⁶ (Immediate hip Spica casting)	10-12

The average duration of hospital stay in the present study is 11.6 days. Gross RH, et al conducted a study on cast brace management of the femoral shaft fractures in children and young adults. The average length of hospitalization in their study was 18.7 days.⁵

Study	Duration of Stay in Hospital (in Days)
Present study	11.6
Kalenderer O. et al ⁷ (ender nail)	12
Mann DC et al ⁸ (elastic nail)	11.4
Gross RH et al ⁵ (cast bracing)	18.7

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. 11.6 days.

In our study union was achieved in <12 weeks in 24 (80%) of the patients, 13 – 18 weeks in 5 (16.7%) and 20 weeks in 1 (3.3%). Average time to union was 12.1 weeks.

Aksoy C, et al compared the results of compression plate fixation and flexible intramedullary 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.

Study	Average Time for Union (in Weeks)
Present study	12.1
Oh C.W. et al ⁹ (Flexible intramedullary nail)	10.5
Aksoy C, et al ¹⁰ (Plating + flexible intramedullary nail)	16

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.

In the present study, unsupported full weight bearing walking was started in < 12 weeks for 19 (79%) of the patients, between 13 and 18 weeks in 4 (17%) and at 20 weeks in 1 (4%) among the total of 24 lower limb fractures. The average time of full weight bearing was 11.5 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.¹¹

Study	Average Time of Start of Full Weight Bearing (Weeks)
Present Study	11.5
Wudbhav N. Sankar ¹¹	8.65

Complications	Present Study (%) Titanium Elastic Nail	Previous Studies (%) Titanium Elastic Nail
Pain at The Site of Nail Insertion	10	16.2 J. M. Flynn et al.
Superficial Infection	3.3	1.7 J. M. Flynn et al.
Decreased ROM	6.6	0.9 J. M. Flynn et al.
Limb Lengthening	0	5 (<1 cm) Ozturkman Y. et al.
Limb Shortening	3.3 (<1 cm)	2.5 (<1cm) ¹² Ozturkman Y. et al
Nail Back Out	0	2.6 Carey T.P. et al ¹³
Varus Valgus Angulation	3.3	4.3 J. M. Flynn et al
Antero Posterior Angulation	0	8 % Heinrich SD et al
Rotational Deformity	0	3.2 Heinrich SD et al ¹⁴

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.¹⁵

John Ferguson et al noted more than 2 cm shortening in 4 children after Spica treatment of paediatric femoral shaft fracture.⁶

Herndon WA, et al compared the results of femoral shaft fractures by spica casting and intramedullary nailing in adolescents. They noticed varus angulation ranging from 7° to 25° in 4 patients treated with spica casting and no varus angulation in surgical group.¹⁶

Herndon WA, et al noticed anterior angulation ranging from 8° to 35° inpatients treated with traction and spica casting.¹⁶

Assessment of Outcome

In the present study, the final outcome was excellent in 22 (73.33%) cases, satisfactory in 8 (26.67%) cases and there are no poor outcome cases. In D. Furlan and Z. Pogorelic study, the final outcome was excellent in 89% cases, satisfactory in 11% cases and there were no cases showing poor outcome.¹⁷

Outcome (%)	Excellent (%)	Satisfactory (%)	Poor (%)
Present Study	73.33	26.67	0
D. Furlan & Z. Pogorelic Study	89	11	0

CONCLUSIONS

Titanium Elastic Nailing System (TENS) technique is an ideal method for treatment of paediatric diaphyseal fractures of long bones. It is a simple, easy, rapid, reliable and effective method for management of paediatric long bone fractures in patients between 5 to 16 years of age, with shorter operative time, lesser blood loss, lesser radiation exposure and reasonable time to bone healing. It appreciably reduces the hospital stay and eliminates the need for prolonged bed rest. It gives elastic mobility promoting rapid union at fracture site and stability which is ideal for early mobilization. It is associated with lower complication rate, good outcome when compared with other methods of treatment. Because of early weight bearing, rapid healing and minimal disturbance of bone growth, TENS may be considered to be a physiological method of treatment and can be safely considered in the management of diaphyseal fractures of long bones in children and adolescents aged 5 to 16 years.

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