Scholars Journal of Applied Medical Sciences (SJAMS)
Abbreviated Key Title: Sch. J. App. Med. Sci.

A Unit of Scholars Academic and Scientific Society, India
www.saspublisher.com

ISSN 2320-6691 (Online)
ISSN 2347-954X (Print)

Orthopaedics

Tibia Diaphyseal Fracture Fixation in Children by Titanium Elastic Intramedulary Nails – Efficacy and Outcomes

Dr. Deeapk Srivastav[1*], Dr Mithlesh Kumar[2], Dr Arpita Mohan[3]
[1]Assistant Professor Department of Orthopaedics, Hind Institute of Medical Sciences, Lucknow U. P India
[2]assistant Professor Department of Orthopaedics, Government Medical College, Azamgarh U.P India
[3]Assistant professor Department of Dentistry, Hind Institute of Medical Sciences, Lucknow U.P India

Original Research Article

***Corresponding author**
Dr. Deeapk Srivastav

Article History
Received: 04.09.2018
Accepted: 13.09.2018
Published: 30.09.2018

DOI:
10.21276/sjams.2018.6.9.12

Abstract: To evaluate the clinical, functional and radiological outcome of intramedullary fixation of displaced fracture shaft tibia in skeletally immature children using titanium elastic intramedullary nails. 90 Tibial shaft fracture in 84 children aged 6- 14 years were fixed with titanium intramedullary elastic nail under image intensifier control between June 2013 and January 2017.Two nails of proper and equal diameter were used for fracture fixation. No external splint was used after surgery. Outcomes assessed on the basis of Flynn et al scoring criterion. All patients achieved complete healing at a mean of 9.5 weeks. 87 fracture reduced by closed means but 3 needs open reduction. Common size of elastic nail used was 3mm. no major complication was recorded all were minor and can be taken care off. Most common was entry site skin irritation recorded in 30 patients. 90% had excellent result and 10% had satisfactory. Elastic stable intramedullary nailing is the method of choice for the Tibial shaft fracture in paediatric patients, because it is minimally invasive and provide six point fixation and shows very good functional and cosmetic result. It allows early ambulation and shorter hospital stay and higher parent satisfaction. ESIN also provide flexural, translational and rotational stability as well.
Keywords: Elastic stable intramedullary nailing (ESIN); Titanium elastic nail (TEN); Tibial shaft fracture; Paediatric.

INTRODUCTION

Surgical treatment of long bones fractures in children must first consider the fact that excellent results can be achieved with non-operative treatment, with reported union rates of more than 90% and 100% full functional recovery [1]. Occasionally reduction cannot be maintained due to excessive shortening, angulations, or malrotation at the fracture site, making operative intervention necessary [2].

Fracture treatment in children relies on rapid healing and spontaneous correction of angulated fractures; therefore most of the diaphyseal fractures can be treated by plaster alone. Operative treatment of children's fracture is often looked at critically [3].

Conservative treatment of long bone shaft fractures in children is by traction followed by plaster, hip spica or a Thomas splint. Conventional treatment gives good results in children under 6 years of age. But above that age, all long bone fractures in children cannot be treated by conservative methods. There is possibility of loss of reduction, shortening, angulations and malunion. Plaster immobilization has its own complications like pressure sores, nerve palsies, soiling of the skin and the plaster, breakage of plaster, joint stiffness. The child is immobilised and needs an attendant for personal care.

Various methods are used to treat paediatric long bone fractures and these include traction [4], splints/orthotics, plaster casts [5], external fixation [6], open reduction and internal fixation using plates and screws [7] or intramedullary stabilisation with a rod [8]. These modalities are not without complications [9-11]. In addition some require prolonged hospital stay, periods of inactivity and aesthetically unsatisfactory scars.

Reeves *et al*. [12] reported that the cost of non-operative treatment is 40% higher than operative treatment. Over recent years the use of elastic stable intramedullary nails has dramatically increased with the introduction of a variety of nails for paediatric fractures [13].

Over the past two decades the advantages of fixation and rapid mobilization has been increasingly recognised health care cost containment and a desire for early discharge from the hospital have become important factors in treatment of long bones shaft fracture. As a result newer techniques have become popular. An ideal fixation device for paediatric long bones fracture would be a load sharing internal splint maintaining reduction for a few weeks until callus forms. Most importantly implant should endanger neither the physis nor the blood supply. Titanium implants are increasingly being used for elastic stable intramedullary nailing. The material properties of titanium confer advantages for an implant used to stabilise paediatric long bones fractures. Titanium elasticity limits the amount that the nail is permanently deformed during insertion. More importantly elasticity promotes callus formation by limiting stress shielding. Titanium also has excellent biocompatibility.

The biomechanical principal of the TENs is based on the symmetrical bracing action of two elastic nails inserted into the metaphysic, each of which bears against the inner bone at three points [14, 15]. This produces the following four properties that are essential for achieving optimal results; flexural, axial, translational and rotational stability [14]. The ESIN has the benefits of early immediate stability to the involved bone segment, which permits early mobilization and return to the normal activities of the patients, with very low complication rate [16, 17].

MATERIALS AND METHODS

Between July 2013 and June 2017, 84 paediatric patients (53 male and 31 female) with 90 tibial diaphyseal fractures were treated by internal fixation with intramedullary titanium elastic nails at Hind Institute of Medical Sciences, Lucknow, Uttar Pradesh, India.

Inclusion Criteria

- Between 6-14yrs of age
- displaced fracture, with or without comminution
- multiple fractures
- closed and open up to Gustillos grade-II fractures

Exclusion criteria

- children <6 and >14 yrs of age
- metaphyseal fracture
- undisplaced fracture
- open Gustillo grade-III fractures
- pathological fractures

The diameter of TENs nail was determine by formula as stated by Kaser and Beaty

$$\text{Nail diameter} = \frac{\text{medullary canal diameter}}{2} - 0.5$$

Operative technique

Under general or spinal anaesthesia, the patient was placed supine on an orthopaedic table with traction by assistant or by using traction table ensuring correct linear and rotational alignment clinically and radiologically using an image intensifier.

The essential prerequisite is accurate prebending of an elastic titanium nail so that the apex of the bend will lie at the fracture site. Its length should be selected on the basis of pre-operative radiograph of known magnification, and confirmed on the limb before insertion.

In general, the entry site of nail will be in the metaphysis of the bone. It is tempting to make a small stab incision to make insertion. Under image intensifier, the cortex can be breached with an awl or drill according to individual, TENs nail of proper diameter and length tapped along the medulla with the tip angled away from the cortex. The temptation to rotate the nail back and forth should be resisted. If possible, the fracture should be reduced by manipulation and the nail advanced across the fracture site.

Insertion of the later nail in a similar fashion but from the opposite side of the bone. All nails should be inserted up to the fracture site, the fracture reduced, and the nails tapped across the fracture site in an alternating manner for perhaps 1 to 2 cm into the far segment. All nails can then be knocked home, leaving sufficient nail exposed at the site of insertion to enable subsequent removal.

Fig-1: Pre-op x-ray of 7yr male left leg AP and Lateral view

Fig-2: Post-op x-ray of 7yr male left leg AP and Lateral view

Fig-3: x-ray after 9 weeks of 7 yr male left leg AP and Lateral view

Fig-4: x-ray after nail removal of 7yr male left leg AP and Lateral view

Post-operative rehabilitation

No external splints were used. The children were started on non-weight bearing crutch walking and knee physiotherapy 2-3 days after the surgery and were ready for discharge 3-4 days after surgery. The children with polytrauma stayed on for a longer period in the hospital because of associated injuries.

The children were encouraged to attend school 3-4 weeks after surgery avoiding sports and physical training. The school authorities consented to this and allowed an attendant for the children.

Full weight bearing was allowed after clinic-radiological fracture union. Union was defined clinically by the absence of bony tenderness and abnormal mobility at the fracture site and no pain at the fracture site on weight bearing. Radiological fracture union was defined by the presence of callus bridging the fracture and partial obliteration of the fracture lines in 2 views perpendicular to each other.

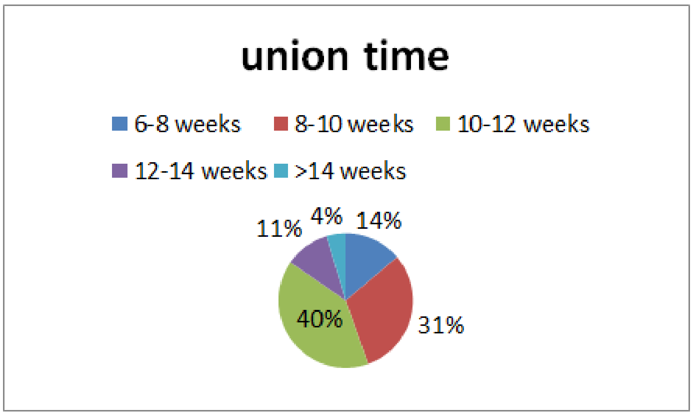
The children were assessed for any malunion both linear and rotational, and for any limb length disparity. The wires were removed without anaesthesia in the outdoor with the help of pliers and t-handle.

RESULTS

Among the 84 children of 6-14 yrs of age, maximum 42 children (50%) were in the age group 9-11year. Out of 90 diaphyseal fracture tibia 50 were of right side. Mostly children were hurted by road traffic accident 60 and 24 by sports related injuries. On the basis of pattern 12 were transverse, 41 oblique, 27 spiral and 10 were communited. Most of them 69 children were not associated with any other injuries but 8 had clavicle fracture, 1 had pelvic injury and 6 were associated with head injury. 45 fractures were closed and 30 of grade I, 15 were grade II open fracture.

All patients underwent surgery under general anaesthesia and titanium nails were used in each patient. Most of the children (70) were operated within a week of injury. Cases operated late included that were associated with head injury or wound. The average operative time was 35 min (range 15-65 minutes). 87 (96.66%) patients the fracture was reduced by closed means; whilst in the other 03 (03.33%) open reduction was required. Open reduction needed a minimum exposure with minimum blood loss, minimum handling of periosteum and, no increase in the morbidity or alteration in the post-operative rehabilitation. The commonest titanium nail size used was 3mm. 80% (67) patient were discharged within 3 days of operation on oral drugs which was one of the big advantage in comparison to conservative management but one child who develops infection post-operatively had stay for 20 days till the infection controlled.

All patients achieved complete clinic-radiological healing at a mean of 9.5 weeks (range 6-15 weeks). Closed fractures healed more quickly (mean 8.3 weeks) than open fractures (mean 12.6 weeks). In a subjective measure of outcome at follow-up, 70% of the patients were very satisfied and 30% satisfied; no patients or parents reported their outcomes as not satisfied. Routine removal of the nails was undertaken in all patients. At follow up patients went on to osseous union and regained a full range of movement after rehabilitation. There were no cases of delayed union, non-union or malunion. After removal of the nails all patients regained full function and all complications resolved.



Diag-1: Showing time taken for radiological union

Complications

Most common complication found was entry site skin irritation in 30 patients which was subsided after nail removal. Exurbent callus formed in children with head injury, but this did not affect the final outcome. Others were protrusion of nail in one patient, infection develops in one patient who was controlled with antibiotics and nail removed early and subsequently settles. Joint stiffness develops in two patients as they were not doing exercise, recovered with proper physiotherapy. There was no instance of loss of reduction, or nail migration during post-operative period. No clinically significant deformities and any limb length discrepancy were observed.

Table-1: Complications

Complications	No. of cases (n=90)
Entry site irritation	30
Superficial infection	1
Deep infection	None
Limb length discrepancy	None
Refracture	None

Classifying our treatment outcomes based on the ten outcome scoring system by Flynn et al. we found 90% excellent result, 10% satisfactory result and 0% poor result.

Table-2: Flynn et al's Scoring Criteria for TENS

	Excellent	Satisfactory	Poor
Limb length inequality	< 1.0 cm	1.0-2.0cm	> 2.0 cm
Malalingnment	$<5^{o}$	$5\text{-}10^{o}$	$>10^{o}$
Pain	None	None	Present
Complications	None	Minor & resolved	Major & lasting morbidity
No. of cases (90)	81	9	0

DISCUSSION

The majority of emergency in most trauma centres are fractures of long bones. Although the majority of long bones shaft fractures in children can be treated with closed reduction and casting, occasionally surgical stabilization is required. Historically, external fixation has been the treatment of choice; however, risk includes pin track infections, non-union, and refracture [2, 16]. Reamed locked intramedullary nails, while shown to be effective in the skeletally mature, pose unnecessary risk to the long bones physis, and have limited indications in those children with growth remaining. The elastic stable intramedullary nailing (ESIN) is now commonly used for the treatment of paediatric long bones fractures and their use has minimised the surgical scarring previously caused by open reduction and plating [13]. This method achieves biomechanical stability from the divergent "C" configuration which creates six points of fixation and allows the construct to act as an internal splint [2, 18]. The ESIN provide stable and elastic fixation, allowing for controlled motion at the fracture site which results in healing by external callus. Several studies have demonstrated the safety and efficacy of this technique [1, 19, 20, 21, 17, 22]. The ESIN is not without the possibility of complication. Complications usually are based on mistakes concerning the indication or technical errors [23, 24]. The most common reported complications associated with these techniques include infection, over growth, entry site skin irritation and re-fracture [2, 13, 21]. The most common complication was irritation of skin at the entry site. We have not observed any major complications. This is similar with complication rate reported by previous studies [2, 13, 23, 24].

Age, fracture pattern, fracture location, soft tissue injury, presence of other fractures, physician and family preference, and the social situation all affect the treatment of a child with tibial shaft fracture. Treatment modalities include traction, immediate spica casting, traction followed by spica casting, external fixation, plating, flexible nailing, and intramedullary nailing [17, 25]. Fixation by flexible nails is appropriate for patients over the age of six years [17, 25, 26]. Usually, tibial shaft fractures in children younger the age of six years are treated conservatively.

Based on the results of Goodbody et al. elastic stable intramedullary nailing with titanium elastic nails is an effective surgical technique which allows rapid healing of tibial shaft fractures with an acceptable rate of complications [27].

The aim is to encourage the formation of bridging periosteal callus. The elastic nail, the bone and the muscles provide the stability. The muscle act as guy ropes, so even in an irritable child or the hyperactive child, the muscle activity just complements the fixation. Muscle action also causes spontaneous correction of any angular deformities. Micromotion allowed by the elasticity of the fixation promotes external bridging callus. The periosteum is not disturbed and being closed procedure there is no evacuation of fracture hematoma or risk of infection. Callus formation is twice as fast as with conventional methods [15].

CONCLUSION

Titanium elastic nailing seems to be more physiological and effective method of treatment of tibial shaft fractures in 6-14 years old children. It is simple, rapid and safe procedure with advantages of early union, early mobilization and early return to function with minimal complications. Elastic medullary nailing advantages make it a valuable choice to consider in managing children shaft tibial fractures.

REFERENCES

1. El-Adl G, Mostafa MF, Khalil MA, Enan A. Titanium elastic nail fixation for paediatric femoral and tibial fractures. Acta Orthopædica Belgica. 2009 Aug 1;75(4):512.
2. Sankar WN, Jones KJ, David Horn B, Wells L. Titanium elastic nails for pediatric tibial shaft fractures. Journal of children's orthopaedics. 2007 Oct 17;1(5):281-6.
3. Huber RI, Keller HW, Huber PM, Rehm KE. Flexible intramedullary nailing as fracture treatment in children. Journal of Pediatric Orthopaedics. 1996 Sep 1;16(5):602-5.
4. Pearce MS. Calcaneal pin traction in the management of unstable tibial fractures. Australian and New Zealand Journal of Surgery. 1993 Apr;63(4):279-83.
5. Pollak AN, Cooperman DR, Thompson GH. Spica cast treatment of femoral shaft fractures in children--the prognostic value of the mechanism of injury. The Journal of trauma. 1994 Aug;37(2):223-9.
6. Blasier RD, Aronson J, Tursky EA. External fixation of pediatric femur fractures. Journal of Pediatric Orthopaedics. 1997 May 1;17(3):342-6.
7. Caird MS, Mueller KA, Puryear A, Farley FA. Compression plating of pediatric femoral shaft fractures. Journal of Pediatric Orthopaedics. 2003 Jul 1;23(4):448-52.
8. Buford JD, Christensen K, Weatherall P. Intramedullary nailing of femoral fractures in adolescents. Clinical orthopaedics and related research. 1998 May(350):85-9.
9. Skaggs DL, Leet AI, Money MD, Shaw BA, Hale JM, Tolo VT. Secondary fractures associated with external fixation in pediatric femur fractures. Journal of Pediatric Orthopaedics. 1999 Sep 1;19(5):582.
10. Gonzalez-Herranz P, Burgos-Flores J, Rapariz JM, Lopez-Mondejar JA, Ocete JG, Amaya S. Intramedullary nailing of the femur in children. Effects on its proximal end. The Journal of bone and joint surgery. British volume. 1995 Mar;77(2):262-6.
11. Fernandez FF, Egenolf M, Carsten C, Holz F, Schneider S, Wentzensen A. Unstable diaphyseal fractures of both bones of the forearm in children: plate fixation versus intramedullary nailing. Injury. 2005 Oct 1;36(10):1210-6.
12. Reeves RB: Internal fixation versus traction and casting of adolescent femoral shaft fracture. J Pediatr Orthop. 1990, 19: 551
13. Helenius I, Lamberg TS, Kääriäinen S, Impinen A, Pakarinen MP. Operative treatment of fractures in children is increasing: a population-based study from Finland. JBJS. 2009 Nov 1;91(11):2612-6.
14. Kissel EU, Miller ME. Closed Ender nailing of femur fractures in older children. J Trauma. 1989;29:1585-8
15. Ligier JN, Metaizeau JP, Prévot J, Lascombes P. Elastic stable intramedullary nailing of femoral shaft fractures in children. The Journal of bone and joint surgery. British volume. 1988 Jan;70(1):74-7.
16. Bar-On E, Sagiv S, Porat S. External fixation or flexible intramedullary nailing for femoral shaft fractures in children: a prospective, randomised study. The Journal of bone and joint surgery. British volume. 1997 Nov;79(6):975-8.
17. Flynn JM, Hresko T, Reynolds RA, Blasier RD, Davidson R, Kasser J. Titanium elastic nails for pediatric femur fractures: a multicenter study of early results with analysis of complications. Journal of Pediatric Orthopaedics. 2001 Jan 1;21(1):4-8.
18. Salem KH, Lindemann I, Keppler P. Flexible intramedullary nailing in pediatric lower limb

fractures. Journal of Pediatric Orthopaedics. 2006 Jul 1;26(4):505-9.

19. Li Y, Stabile KJ, Shilt JS. Biomechanical analysis of titanium elastic nail fixation in a pediatric femur fracture model. Journal of Pediatric Orthopaedics. 2008 Dec 1;28(8):874-8.
20. Mahar A, Sink E, Faro F, Oka R, Newton PO. Differences in biomechanical stability of femur fracture fixation when using titanium nails of increasing diameter. Journal of children's orthopaedics. 2007 Aug 17;1(3):211-5.
21. Wall EJ, Jain V, Vora V, Mehlman CT, Crawford AH. Complications of titanium and stainless steel elastic nail fixation of pediatric femoral fractures. JBJS. 2008 Jun 1;90(6):1305-13.
22. Metaizeau JP. Stable elastic intramedullary nailing for fractures of the femur in children. The Journal of bone and joint surgery. British volume. 2004 Sep;86(7):954-7.
23. Rajan RA, Hawkins KJ, Metcalfe J, Konstantoulakis C, Jones S, Fernandes J. Elastic stable intramedullary nailing for displaced proximal humeral fractures in older children. Journal of children's orthopaedics. 2007 Dec 6;2(1):15-9.
24. Fernandez FF, Eberhardt O, Wirth T. Elastic stable intramedullary nailing as alternative therapy for the management of paediatric humeral shaft fractures. Zeitschrift fur Orthopadie und Unfallchirurgie. 2010 Jan;148(1):49-53.
25. Leventhal JM, Thomas SA, Rosenfield NS, Markowitz RI. Fractures in young children: distinguishing child abuse from unintentional injuries. American Journal of Diseases of Children. 1993 Jan 1;147(1):87-92.
26. Simanovsky N, Porat S, Simanovsky N, Eylon S. Close reduction and intramedullary flexible titanium nails fixation of femoral shaft fractures in children under 5 years of age. Journal of Pediatric Orthopaedics B. 2006 Jul 1;15(4):293-7.
27. Sankar WN, Jones KJ, David Horn B, Wells L. Titanium elastic nails for pediatric tibial shaft fractures. Journal of children's orthopaedics. 2007 Oct 17;1(5):281-6.