



## Titanium elastic nailing in femoral diaphyseal fractures in children of 6-14 years age

Manoj Kumar RAJAK, Rajesh THAKUR, Anil CHOUDHARY, Indranil BHADURI, Sachin KUMAR

*From the department of Orthopaedics, Tata Main Hospital, India*

**Background :** Traditionally conservative methods were used in managing paediatric femoral diaphyseal fractures. There has been a renewed interest for operative treatment with Titanium elastic nail system (TENS) in the age group of 6-14 years.

**Materials and Methods :** This prospective study was done on 20 patients. Two titanium nails were used for stabilization. We followed them for maximum of two years. The results were evaluated using Flynn's scoring criteria.

**Results :** In our study we had fifteen males and five females with average age 10.35 years. Average time for fracture union was 9.0 weeks, full weight bearing 9.2 weeks, hospital stay 8.6 days and return to school at 10 weeks. The results were excellent in 14, good in 5 and poor in 1 patient. Most common complication was irritation at nail entry site. No delayed union or nonunion seen.

**Conclusion :** Treatment of diaphyseal femoral fracture in selected pediatric patients by TENS is reasonably effective.

**Keywords :** pediatric femoral diaphyseal fractures, titanium elastic nail system.

treated conservatively. In adolescents antegrade locked intramedullary nail is preferred. In children between six to fourteen years of age, diaphyseal femur fracture, many times, do not recover completely with conservative treatment. Angulation, shortening, malrotation are not always corrected and noncompliance or intolerance to plaster for long and psychosocial problems needs to be considered. Management in them has shifted to a more operative approach. More so, a minimal invasive procedure is associated with a reduction in soft-tissue trauma, more rapid recovery, shorter hospital stays, earlier mobilization or early functional activity which encourages faster healing of fracture, preservation of tone of the muscles, restoration of the joint movements, promotion of mental recovery and prevention of psycho-social complications (7,8,13).

### INTRODUCTION

Femoral shaft fractures are among the most common major pediatric injuries treated by orthopaedic surgeons (2). Femoral shaft fractures in children younger than six years of age can be

- Manoj Kumar Rajak (Sr. Consultant).
- Rajesh Thakur.
- Anil Choudhary.
- Indranil Bhaduri.
- Sachin Kumar.

*Department of Orthopaedics, Tata Main Hospital, India*

Correspondence : Manoj Kumar Rajak, Department of Orthopaedics, Tata Main Hospital, India.

E-mail : drmanojrajak@gmail.com

© 2016, Acta Orthopædica Belgica.

*The authors report no actual or potential conflict of interest in relation to this article.*

Acta Orthopædica Belgica, Vol. 82 - 4 - 2016

The ideal device for the treatment of most femoral fractures in these children would be a simple load-sharing implant that allows early mobilization of the limb and maintenance of alignment and limb length until bridging callus forms. The device would exploit the ability of child's bone for rapid healing and ability to remodel without risking damage to the epiphysis and the blood supply to the capital femoral epiphysis. Titanium Elastic Nailing (TENS) also known as elastic stable intramedullary nailing (ESIN) has become the choice of stabilization in pediatric femoral shaft fractures (7,13).

### MATERIAL AND METHODS

This prospective study was conducted between October 2011 and September 2013. After getting approval from our institutional board, 20 pediatric patients of either sex, aged 6-14 years having closed femoral diaphyseal fractures were included. Informed consent was taken and these patients were treated with TENS. Children who were excluded from the study were less than six years and more than fourteen years of age, having femoral metaphyseal fractures, open femoral diaphyseal fractures, other associated severe injuries, pathologic fractures, having underlying neuromuscular disorder or a metabolic bone disorder. The average age being 10.35 years (age range 6-14years). There were 15 boys and 5 girls who had sustained 13 right sided and 7 left sided fractures. The most common mechanism of injury was fall from height (12 patients). Initially skin traction was applied and all these patients were operated within 7 days (range 3-7 days) of injury.

Two Titanium Elastic Nails of identical diameter were used to stabilize each fracture. The diameter of the nail to be used was determined on the basis of the size of medullary canal of the femur of the particular patient. We were able to achieve closed reduction in all these cases. These patients were evaluated clinically and radiologically for maximum of two years. In the postoperative period patients were mobilized without weight bearing as early as possible. Partial weight bearing was allowed at 3 weeks as tolerated with support and full weight bearing was started

depending on fracture configuration and callus response. They were followed up clinically and radiologically at monthly intervals for first three months and then at three monthly intervals till maximum of two years after surgery (Figure 1). The final results were evaluated using the Flynn's scoring criteria (4). Nails were removed nine months after surgery.



*Fig. 1A.* — Preoperative X Ray



*Fig. 1B.* — Immediate Postoperative X Ray



*Fig. 1C.* — Postoperative X Ray after 4 weeks



*Fig. 1D.* — Postoperative X Ray after 8 weeks, fracture united

## RESULTS

Out of twenty femoral diaphyseal fractures there were eleven transverse (55%), four short oblique (20%), two spiral (10%) fractures and three had some comminution (15%). Each of these fractures were treated with two titanium elastic nails of equal diameter. All twenty patients showed fracture union within 12 weeks time (average of 9 weeks). The results were excellent in fourteen patients (70%), good in five (25%) and poor in one patient (5%) as per the scoring criteria for TENS by Flynn et al.

The average duration of surgery was 65 min (50-90 min). The mean hospital stay was 8.6 days (5-18 days). All 20 patients were evaluated for a mean of 18 months (12 - 24 months). Radiological union was achieved in fifteen cases in eight weeks and rest five within twelve weeks from date of surgery (average 9 weeks). Full weight bearing was possible in a mean time of 9.2 weeks (8 - 12 weeks). Children started going to school at an average of 10 weeks.

Complications: Entry site irritation occurred in eight patients and this was commonest. Two

patients had varus angulation ( $10^\circ$  and  $7^\circ$  each) whereas one had valgus angulation ( $9^\circ$ ). Three patients had skin breakdown at entry site due to more prominent nail end which led to superficial infection. Nail trimming was done in all of them. Two resolved within a week with oral course of antibiotics but in third case it took 18 ds. This third patient experienced pain and decreased range of motion for long period. Pain subsided later and range of motion at knee improved to  $0^\circ$  to  $120^\circ$  only after physiotherapy. In three patients limb shortening of less than 1.5 cm was found.

No deep infection or osteomyelitis, physeal growth disturbance till last follow up and no refracture was observed in this study.

## DISCUSSION

Femoral shaft fractures are among the most common major pediatric injuries but overall incidence is relatively less and deciding any one treatment method is challenging. These patients can be divided in three overlapping groups. One is below 6 years of age where conservative



Fig. 1E. — Postoperative X Ray after 6 months

management is the preferred method. Another group is the age group beyond 14 years. Here solid locked intramedullary nail is the implant of choice. The third group lies in between these two i.e 6-14 years (3,7,8). To avoid disadvantages of prolonged immobilization, chances of loss of reduction, malunion, intolerance to plaster, better nursing care, to reduce school day loss and to help such children getting out of bed early, the operative approach is gaining popularity (10).

Titanium elastic nail appear to be a good implant in this age group of 6 to 14 years. It is simple, load sharing internal splint, respects epiphysis on either end and vascularity of femoral head (7,11), preserves periosteum and fracture hematoma, allows early

mobilization, allows micromotion at fracture site and thus early callus formation, and maintains alignment and limb length till bridging callus takes over (8). The axial stability is provided either by cortical contact in end to end reduction or by fixing the ends of nail in metaphysis at both ends of femur. This technique also provides certain advantages such as minimally invasive surgery, freedom from preselection of proper implant length (any excess nail length is cut off), and the fact that very less complicated instruments are required for implant insertion (8). Flynn et al. found TENS superior over hip spica in the treatment of femoral shaft fracture in children (5).

In this study all fractures united within 12 weeks (average 9 weeks). There was no nonunion or delayed union. Union was considered clinically when no pain at fracture site on full weight bearing and radiologically when union was evident on two perpendicular views (Anteroposterior and lateral views). Oh et al. in his series of such 31 cases reported that the fractures united within 12 weeks (mean 10.5 weeks) with no delayed union (11).

Average time for full weight bearing in present series was 9.2 weeks which is comparable to those reported in other studies (1,11). Average hospital stay in our series was 8.6 days. Reeves et al. observed in his comparative series that mean hospital stay in conservatively treated patient was 29 days and in surgically treated cases was only 15 days which was considerably lower (12). Less hospital stay results in early return to home environment, less economic burden and early return to jobs by parents and also hospital beds becoming available for other patients (8).

Return to school averaged 10 weeks in present series. Flynn et al. reported that children treated

Table I. — Functional outcome assessment: Flynn et al (4) scoring criteria for TENS

	Excellent	Good	Poor
Limb length discrepancy	< 1 cm	< 2 cm	> 2 cm
Angulation in degrees	< 5	5 - 10	> 10
Pain	Absent	Absent	Present
Complications	Absent	Mild	Major/Extended period for resolvable morbidity

with TENS had shorter hospitalization and returned to school earlier when compared with children treated with traction and cast (5).

Two patients had varus angulation (10° and 7° each) whereas one had valgus angulation (9°) in this series. One of these had some comminution at fracture site, another had transverse fracture at junction of middle and lower third of femoral shaft and in one case we unfortunately used thinner nails (equal diameter) than what we should have used. It was observed by Schmittenebecher et al. that thinner nails in lower extremity can cause unacceptable results (14). It is recommended that each nail diameter should correspond to 40% of narrowest medullary space (at the isthmus) (1,3). In each patient we always used two nails of the same diameter because it is stated that the use of elastic stable intramedullary nailing for the treatment of pediatric femoral shaft fractures is based on the principles of elastic stability and balanced forces, achieved by using the nails of the same diameter (8).

In present series entry site irritation occurred in eight patients which is reported as most common problem associated with TENS in other literature (8). This is frequently associated with more prominent and bent nail at entry site (>2 cm) (1). It can cause not only irritation but can lead to necrosis, skin breakdown and infection which occurred in our three patients and one of them had poor result due to prolonged morbidity. Nail trimming was done in all and oral course of antibiotics was given. Two resolved within a week but in third case it took 18 ds. In this third case patient had pain at knee and decreased range of motion for prolonged period. The pain resolved later and range of motion at knee improved (0° to 120°) after regular physiotherapy.

Limb shortening of less than 1.5 cm was found in three cases which was acceptable according to concept of Kassler and Beaty (6). Two of them had some comminution and third one with oblique fracture line.

No incidence of deep infection was noticed which may be due to small incisions, less tissue handling and less operative time. Titanium intramedullary nails have been associated with lower rates of infection in animal study (9). No refracture or other major complication was observed (1).

## CONCLUSION

Titanium elastic nail is a good option for fixation in femoral shaft fractures in the age group of 6-14 years. It is relatively simple and rapid method and helps in early mobilization and includes advantages of a minimally invasive procedure. It provides biomechanical environment for early callus formation and accelerated union. Most of the complications associated are related to inadequate technique and can be reduced or eliminated if we adhere to basic principles.

## REFERENCES

1. Anastasopoulos J., Petratos D., Konstantoulakis C., Plakogiannis C. and Matsinos G. Flexible intramedullary nailing in paediatric femoral shaft fractures. *Injury*, 2010-06-01, Volume 41, Issue 6 : 578-582.
2. Beaty, James H, Kasser, James R. Rockwood and Wilkins, Fracture in children 7<sup>th</sup> edition 2010, Lippincott Williams and Wilkins, Chap 22, Femoral Shaft Fractures : 797-841.
3. Deakin D, Winter H, Jain P, and Bache C. Malunion following flexible intramedullary nails for tibial and femoral fractures in adolescents. *J Child Orthop*. 2010 ; 4 : 571-577.
4. 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. *J Pediatr Orthop*. 2001 ; 21 : 4-8.
5. Flynn JM, Luedtke LM, Ganley TJ, et al. Comparison of titanium elastic nails with traction and a spica cast to treat femoral fractures in children. *J Bone Joint Surg Am*. 2004 ; 86(4) : 770-777.
6. Kasser JR, Beaty JH. Rockwood and Williams, Fractures in children. 5<sup>th</sup> ed. New York: Lippincott Williams and Wilkins ; 2001 : 941-980.
7. Khazzam M, Tassone C, Liu XC, Lyon R, Freeto B, Schwab J, and Thometz J. Use of Flexible Intramedullary Nail Fixation in Treating Femur Fractures in Children, *Am J Orthop*. 2009 ; 38(3) : 49-55.
8. Ligier JN, Metaizeau JP, Prevot J, Lascombe P. Elastic stable intramedullary nailing of femoral shaft fractures in children, *J Bone Joint Surg [Br]* 1988 ; 70-B : 74-77.
9. Melcher GA, Hauke C, Metzendorf A, Perren SM, Printzen G, Schlegel U, Ziegler WJ. Infection after intramedullary nailing: an experimental investigation on rabbits. *Injury*. 1996 ; 27 Suppl 3 : 23-26.
10. Metaizeau JP. Stable elastic nailing for fractures of the femur in children. *J Bone Joint Surgery. Br* 2004 ; 86 : 954-957.

11. **Oh CW, Park BC, Kim PT *et al.*** Retrograde flexible intramedullary nailing in children's femoral fractures. *Int Orthop (Sicot)*. 2002 ; 26(1) : 525.
12. **Reeves RB, Ballard RI, Huges JL.** Internal fixation versus traction and casting of adolescent femoral shaft fractures. *J Pediatr Orthop*. 1990 ; 10 : 592-595.
13. **Sawyer JR, Bowen RE.** Trauma to Pelvis, Hip and Femur: Pediatrics, Orthopaedic Knowledge Update 11, 2014 AAOS, Chap-61, 847-858.
14. **Schmittenebecher PP, Dietz HG, Linhart WE *et al.*** Complications and problems in intramedullary nailing of children's fracture. *Eur J Trauma*. 2000 ; 26 : 287-293..