Advantages and Disadvantages of Elastic Stable Intramedullary Nailing for Management of Pediatric Femoral Fractures

Mohamed Abdelfattah Sebaei, Khaled Edris Abdelrahman, Haytham Saif Aleslam Mohammed Ali and Yehia Elbromboly

Abstract

Background: A child's bone, whether diaphyseal, metaphyseal, or epiphyseal, varies from adult bone in many ways. A child's bone changes from primarily weak woven bone to stronger lamellar bone by remodeling during childhood. The increasing diameter and bone area contributes to an increase in bone strength. This progressive increase in bone strength helps explain the bimodal distribution of femoral fractures. In early childhood, the femur is relatively fragile and breaks under conditions of load that have been achieved in normal play. Pediatric femoral fractures heal rapidly owing to a biologically active periosteum and abundant vascularity; the formation and subsequent remodeling of callus are also rapid in children who have sustained femoral fractures. For reasons such as minimally invasive surgery, no need for casting, early mobilization and release, and increased concerns about cost-effectiveness, elastic stable intramedullary nailing (ESIN) has become the standard therapy for fractures of the shaft of the femur in children. Because of faster healing, shorter rehabilitation periods, less immobilization, and less psychological impact on the children, the therapy of pediatric femoral fractures has evolved more towards operative intervention in recent decades. Flexible intramedullary nails are simple to use, don't expose the fracture site, and have little side effects.

Keywords: Elastic Stable Intramedullary Nailing, Femoral Fractures, pediatric

DOI Number: 10.14704/nq.2022.20.10.NQ551034 **NeuroQuantology 2022; 20(10): 10687:10692**

Introduction

A history of high-energy trauma, such as a fall from a large height or a car collision, is common in proximal femoral fractures. These injuries are frequently associated with serious organ system injuries, as well as unconsciousness, seizures, ear, nose, or throat bleeding, and shortness of breath. A conscious patient complains of groin or buttock pain and incapacity to move after the accident **[1]**

Patients with a femoral shaft fracture typically have a history of thigh pain and inability to walk as a result of a fall or a car accident; however, in patients with mental retardation, nonambulatory patients, polytrauma patients, and patients who have had a head injury, the history may be incomplete. There may be a history of thigh discomfort and a recent increase in pain in pathologic fractures **[2].**

In the presence of traumatic brain injury, child abuse can be suspected in children younger than 4 years old who have a history of injury inconsistent with fracture and multiple fractures in various phases of recovery **[3]**

Corresponding author: Haytham Saif Aleslam Mohammed Ali
Orthopedic surgery Department, Faculty of Medicine, Zagazig University, Egypt
E-mail: haythamsaif04@gmail.com

***AAOS Guidelines on Treatment of Pediatric Diaphyseal Femur Fractures* [4]**

In 2020, the American Academy of Orthopedic Surgeons (AAOS) issued updated guidelines for pediatric diaphyseal femur fractures.

Recommendations included the following **[4]:**

- Strong evidence supports the position that children younger than 36 months with a diaphyseal femur fracture should be assessed for child abuse.
- Limited evidence supports treatment with a Pavlik harness or a spica cast for infants aged 6 months or younger who have a diaphyseal femur fracture; results are similar.
- Moderate evidence supports early spica casting or traction with delayed spica casting for children aged 6 months to 5 years who have a diaphyseal femur fracture with less than 2 cm of shortening.
- Limited evidence supports the option to use flexible intramedullary nailing for the treatment of diaphyseal femur fractures in children aged 5-11 years.
- Limited evidence supports rigid trochanteric entry nailing, submuscular plating, and flexible intramedullary nailing as treatment options for children diagnosed with diaphyseal femur fractures between the ages of 11 and skeletal maturity; piriformis and near-piriformis entrance rigid nailing are not options.
- Limited evidence supports regional pain management for perioperative patient comfort.
- Limited evidence supports waterproof liners for spica casts as an alternative for children diagnosed with pediatric diaphyseal femur fractures.

Femoral shaft fractures can be treated non-operatively or surgically with excellent results if the patients are carefully selected. The kind of therapy depends on the age of the kid, the severity of the injury, and other circumstances, as well as whether the femur fracture was caused by a single event or a sequence of episodes. There are acceptable angulation and shortening values in pediatric femoral fractures **[5].**

For reasons such as minimally invasive surgery, no need for casting, early mobilisation and release, and increased concerns about cost-effectiveness, elastic stable intramedullary nailing (ESIN) has become the standard therapy for fractures of the shaft of the femur in children **[6].**

Advantages and disadvantages of Elastic Stable Intramedullary Nails

A- Advantages of ESIN

The most common indications for elastic nailing are femur diaphyseal fractures. Femoral diaphysis fractures are also a good indication, albeit many of these can be treated successfully in a cast with good function both during and after treatment **[7].**

Because of faster healing, shorter rehabilitation periods, less immobilization, and less psychological impact on the children, the therapy of pediatric femoral fractures has evolved more towards operative intervention in recent decades. Flexible intramedullary nails are simple to use, don't expose the fracture site, and have little side effects**[8].**

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 utilizing the nails of the same diameter. This technique also provides certain

advantages, including minimally invasive surgery, freedom from preselection of proper implant length (any excess nail length is cut off), and the fact that no power instrument is needed for implant insertion **[9].**

Flexible nail therapy aligns and opposes fracture fragments, allowing for controlled movement across the fracture site and assisting in the creation of external callus. External callus thus aids in the early bridging of fracture fragments and provides bone strength. Children's fracture healing is rapid and age-dependent**[10].**

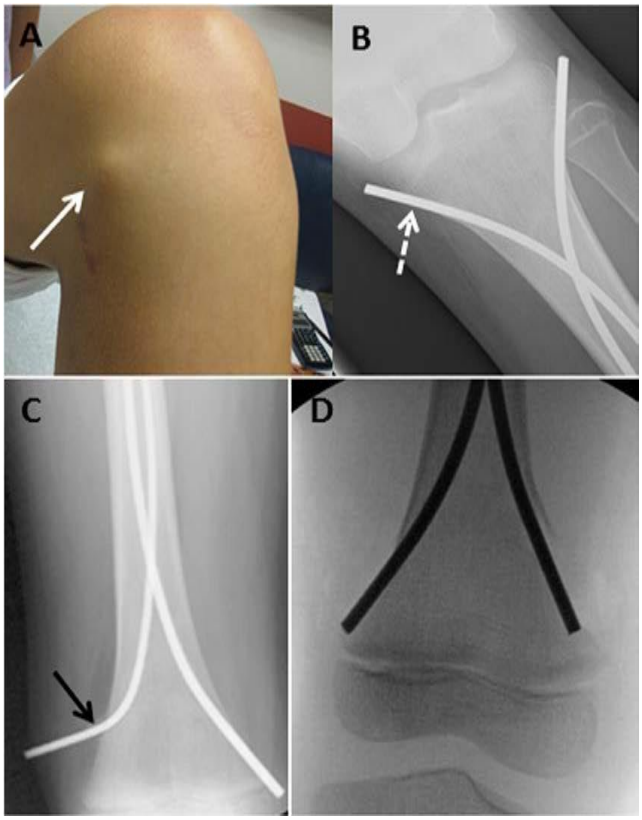

Figure (1) A Nail prominence (white arrow) is the most frequent complication with ESIN. Figs. B and C Prominence is frequently due to the nails being left long (white dashed arrow in Fig. B) or being bent (black arrow in Fig. C). Fig. D the nails should be cut flush to the metaphysis and should end around the level of the physis **[11].**

B- Disadvantages of ESIN:

1- Nail Prominence

Nail prominence and discomfort at the nail entrance site are the most commonly reported ESIN complications. Skin breakdown, superficial or deep infection, effusion at the surrounding joint and stiffness due to soft tissue irritation, bursitis, reoperation to perform nail trimming or nail advancement, and early implant removal with the danger of re-fracture are all possible complications of nail prominence **[11].**

2- Loss of Reduction and/or Malunion

The rate of angular malunion after femoral ESIN has been reported to range from 0% to 16%. (Table 4). Minor (1 cm) overgrowth is more prevalent than shortening after femoral ESIN, especially in children under the age of ten. Malunion is caused by a number of factors, including age and body weight, fracture pattern, and nail size and substance. In the case of femoral fractures, ESIN should not be utilised in older, heavier individuals **[12].**

For length-stable (transverse or short oblique) fractures, ESIN should be employed. When elastic nails were utilised in fractures with fragmentation of more than 25% of the shaft diameter, **Narayanan et al. [2]** reported increased problems, including malunion **[2].**

Malunion should be avoided by adhering to the ESIN biomechanical principles. Femoral malunion has been linked to mismatched nail sizes, incorrect nail sizes, and nail material **[13].**

For lower-extremity long bone fractures, stainless steel elastic nails are recommended, especially in older, heavier patients or those with a length-unstable fracture. If titanium

nails are used, they must have a wider diameter than stainless steel nails **[14].**

If early in the postoperative phase, collapse at the fracture site results in shortening, it can be treated with a cast, traction, exchange nailing with larger nails, external fixation, or plate fixation. Because limb-length discrepancy can improve with growth, any limb equalisation treatment should be postponed **[14].**

After ESIN, the rate of clinically significant malunion necessitating a repeat reduction or other treatment was minimal. For unstable fractures, additional postoperative support, such as a brace or cast, is recommended **[15].**

If angular deformity and loss of reduction are detected early in the postoperative period, before fracture healing, the principle of balanced nailing can be used by removing the deformity-causing nail **[16].**

3- Delayed Union/Nonunion

After ESIN of long bones in children, delayed union (no callus at twelve weeks) and nonunion (no osseous healing after six months) are uncommon. It could take almost a year to completely integrate the delayed union **[17].**

4- Implant Removal/ Refracture

The need for routine elastic nail removal after fracture healing in children is debatable. Avoiding**[18] ;**

(1) Trouble performing future orthopaedic procedures.

(2) Difficulty obtaining good-quality pictures.

(3) Bone fragility and fracture related with stress-shielding and stress risers.

(4) Nail discomfort or prominence are all common reasons for routine removal.

The following are some of the justifications against their removal: (1) difficulty in removal; (2) removal time and cost; (3) the need for a second operation; and (4) probable complications during removal, including as incomplete removal, fracture, and infection. Seven (7%) of ninety-six patients who had their elastic nails removed had difficulties, including two patients with refracture, two with pain, two with superficial infection, and one with wound dehiscence, according to one study**[18]** .

5- Iatrogenic Injuries of bone

Because of the procurvatum of the femoral shaft and anteversion of the femoral neck, the nail tip can perforate the calcar posteriorly during retrograde femoral ESIN. The construct may become unstable as a result of the perforation of the cortex and protrusion of the nail **[19].**

6- Leg Length Discrepancy

The average bone overgrowth before the age of ten is 8.8 mm, and it is most commonly found in transverse fractures. Overgrowth rapidly compensates for early shortening in spiral and oblique fractures, where 10 mm shortening is common following the treatment. Overgrowth decreases significantly after the age of ten, eventually stopping around the age of thirteen or fourteen. This explains why transverse fractures have a good prognosis, whereas other fractures do not compensate for the initial shortening**[20].**

References

1- **J. A. Keeney, J. V Ingari, K. D. Mentzer, and E.** T. Powell IV, "Closed intramedullary nailing of femoral shaft fractures in an echelon III facility," *Mil. Med.*, vol. 174, no. 2, pp. 124–128, 2009.

2- **U. G. Narayanan, J. E. Hyman, A. M. Wainwright, M. Rang, and B. A.** Alman, "Complications of elastic stable intramedullary nail fixation of pediatric femoral fractures, and how to avoid them," *J. Pediatr. Orthop.*, vol. 24, no. 4, pp. 363–369, 2004.

3- **J. M. Geiderman and D. Katz, "General principles of orthopedic injuries,"** *J. Marx. ed.—St Philadelphia, Pa Mosby Elsevier.—2006.—122 p*, 2006.

4- **M. S. Kocher *et al.*, "Treatment of pediatric diaphyseal femur fractures,"** *JAAOS-Journal Am. Acad. Orthop. Surg.*, vol. 17, no. 11, pp. 718–725, 2009.

5- **G. Z. Q. Liau, H. Y. Lin, Y. Wang, K. R. Y. Nistala, C. K.** Cheong, and J. H. P. Hui, "Pediatric Femoral Shaft Fracture: An Age-Based Treatment Algorithm," *Indian J. Orthop.*, pp. 1–13, 2020.

6- **J. A. Khan, G. P. Singh, and A. Pandey,** "Outcome of titanium elastic intramedullary nail in the treatment of shaft of femur fracture in children," *Kathmandu Univ. Med. J.*, vol. 13, no. 3, pp. 195–199, 2015.

7- **D. Furlan *et al.*,** "Elastic stable intramedullary nailing for pediatric long bone fractures: experience with 175 fractures," *Scand. J. Surg.*, vol. 100, no. 3, pp. 208–215, 2011.

8- **L. Bopst, O. Reinberg, and N. Lutz,** "Femur fracture in preschool children: experience with flexible intramedullary nailing in 72 children," *J. Pediatr. Orthop.*, vol. 27, no. 3, pp. 299–303, 2007.

9- **E. J. Wall, V. Jain, V. Vora, C. T. Mehlman, and A. H. Crawford**, "Complications of titanium and stainless steel elastic nail fixation of pediatric femoral fractures," *JBJS*, vol. 90, no. 6, pp. 1305–1313, 2008.

10- **C. A. Ho, D. L. Skaggs, C. W. Tang, and R. M. Kay,** "Use of flexible intramedullary nails in pediatric femur fractures," *J. Pediatr. Orthop.*, vol. 26, no. 4, pp. 497–504, 2006.

11- **J. M. Flynn and R. M. Schwend, "Management of pediatric femoral shaft fractures,"** *JAAOS-Journal Am. Acad. Orthop. Surg.*, vol. 12, no. 5, pp. 347–359, 2004.

12- **S. Houshian, C. B. Gøthgen, N. W. Pedersen, and S. Harving,** "Femoral shaft fractures in children Elastic stable intramedullary nailing in 31 cases," *Acta Orthop. Scand.*, vol. 75, no. 3, pp. 249–251, 2004.

13- **R. Govindasamy, R. Gnanasundaram, S. I. Saravanan Kasirajan, and J. J. Melepuram,** "Elastic stable intramedullary nailing of femoral shaft fracture-experience in 48 children," *Arch. Bone Jt. Surg.*, vol. 6, no. 1, p. 39, 2018.

14- **L. A. Moroz *et al.*,** "Titanium elastic nailing of fractures of the femur in children: predictors of complications and poor outcome," *J. Bone Joint Surg. Br.*, vol. 88, no. 10, pp. 1361–1366, 2006.

15- **P. Tornetta III, M. S. H. Kain, and W. R. Creevy,** "Diagnosis of femoral neck fractures in patients with a femoral shaft fracture: improvement with a standard protocol," *JBJS*, vol. 89, no. 1, pp. 39–43, 2007.

16- **C. May, Y.-M. Yen, A. Y. Nasreddine, D. Hedequist, M. T.** Hresko, and B. E. Heyworth, "Complications of plate fixation of femoral shaft fractures in children and adolescents," *J. Child. Orthop.*, vol. 7, no. 3, pp. 235–243, 2013.

17- **S. Duffy, Y. Gelfer, A. Trompeter, A. Clarke, and F. Monsell,** "The clinical features, management options and complications of paediatric femoral fractures," *Eur. J. Orthop. Surg. Traumatol.*, pp. 1–10, 2021.

18- **S. Ko, J. Lee, and J. Nam,** "Effectiveness of orthopedic implant removal surgery in patients with no implant-related symptoms after fracture union of isolated lower extremity shaft fractures: patient-centered evaluation," *Arch. Orthop. Trauma Surg.*, pp. 1–8, 2021.

19- **T. F. Slongo and L. Audigé,** "Fracture and dislocation classification compendium for children: the AO pediatric comprehensive classification of long bone fractures (PCCF).," *J. Orthop. Trauma*, vol. 21, no. 10 Suppl, pp. S135-60, 2007.

20- **P. Lascombes and J.-D. Métaizeau,** "Femoral Fracture," in *Flexible Intramedullary Nailing in Children*, Springer, 2010, pp. 197–230.