Treatment of the femoral shaft fractures in children by a single elastic stable intramedullary nail

Amro S. El-Sayed

Department of Orthopedic Surgery, Faculty of Medicine, Menoufia University, Menoufia, Egypt

Correspondence to Amro S. El-Sayed, MD, Lecturer of Orthopedic Surgery, Faculty of Medicine, Menoufia University, Menoufia, 32817, Egypt. Tel: 0020422363843; fax: 0482317502;
e-mail: saberamro72@gmail.com

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Introduction
A femoral fracture is the most common major pediatric injury treated by orthopedic surgeons. Although the majority heal without long-term sequelae; the most frequent and expensive complications in the field of orthopedics result from the closed treatment of pediatric femoral fractures. Thus, the occasional unsatisfactory outcome maintains the focus on evolving treatment recommendations. It is a closed surgical procedure that allows early weight bearing and walking. Implantation of flexible nails is performed through very small incisions and does not endanger the physes or the blood supply to the femoral head. It aims at rapid restoration of bone continuity and no joint stiffness, and early rehabilitation.
Patients and methods
This work is a prospective study of 30 children with femoral shaft fracture who had been admitted to El-Menoufiya University Hospital. All cases that fulfilled the inclusion criteria had been treated by a single elastic stable intramedullary nail (ESIN).
Results
In a total of 30 patients, there were 20 male and 10 female with mean age 8.4 years (range: 5–14 years). Twenty (66.7%) fractures were on the right side and 10 (33.3%) were on the left side. Seventeen fractures were caused by road traffic accident (RTAs), 12 fractures caused by falling from height, and one case due to falling of heavy object over the femur. Callus was first noted on follow-up radiographs at an average of 4 weeks. Radiological union was achieved in all cases in a mean time of 8.6 weeks (range: 6–12 weeks). According to the scoring criteria for ESINs by Flynn and colleagues, the results were excellent in 26 (87%) patients, successful in three (10%) patients, and poor in one (3%) patient.
Conclusion
The single elastic stable nailing is an effective treatment option in treating femoral shaft fractures in the 5–15 years age group.
Although midshaft transverse fractures are the most amenable for treatment with ESINs, they can be used in any type of fractures.

Keywords:
elastic intramedullary nailing, nancy nail, pediatric femoral fracture

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Introduction

A femoral fracture is the most common major pediatric injury treated by orthopedic surgeons. Although the majority heal without long-term sequelae; the most frequent and expensive complications in the field of orthopedics result from the closed treatment of pediatric femoral fractures. Thus, the occasional unsatisfactory outcome maintains the focus on evolving treatment recommendations [1].

Indications for operative management of pediatric femoral fractures are based on a sound understanding of remodeling after fracture union. In addition to remodeling, several other factors should be considered by the surgeon before choosing a management plan; fracture pattern, stability, and location are important factors in the determination of the suitability of certain treatment options. As a group, adolescents are best treated surgically, as the complication rate of nonoperative management of these patients is 30%. After consideration of all of these factors and the unique socioeconomic characteristics of the child and family, the surgeon can present possible treatment options [1].

Elastic stable intramedullary nails (ESINs) have been used in the treatment of femoral fracture in children between 5 and 15 years. It is a closed surgical procedure that allows early weight bearing and walking. The technique of ESIN was developed by the team from Nancy in 1982 and represents a compromise between conservative and surgical therapeutic approaches.

Implantation of flexible nails is performed through very small incisions and does not endanger the physes or the blood supply to the femoral head. The implant is sufficiently elastic to respect normal bony curvature and acts as a load sharing (internal splint) that maintains reduction until callus formation appears. It aims at rapid restoration of bone continuity and no joint stiffness, and early rehabilitation [2].

As a result of initial reports, which documented a high percentage of good and excellent results on the use of ESINs, the technique has become very popular [3].

Patients and methods

This work is a prospective study of 30 children with femoral shaft fracture who had been admitted to El-Menoufiya University Hospital. All cases that fulfilled the inclusion criteria had been treated by a single ESIN. The study was approved by Ethical Committee of Faculty of Medicine, Menoufia University; and consent was taken from each patient.

Criteria of inclusion

Patients included in this study have to meet the following criteria:

(1) Age and sex: between 5 and 15 years; boys or girls.
(2) Fracture: diaphyseal fracture femur.
    (a) Nonpathologic origin.
    (b) Closed fracture or first degree or clean second degree open fractures.
(3) Diseases: children with systemic disorders, such as diabetes mellitus or renal problems were excluded.
(4) Radiographic criteria: fracture in the area between lesser trochanter and 5 cm proximal to distal femoral epiphysis.

All the cases with high-energy trauma; examination was started by advanced trauma life support protocol. The initial assessment was directed to the Airway, Breathing and Ciculation (ABCs). All limbs were stripped of clothing during the initial exam. Once the patient was stabilized, a secondary survey was done. The limbs were evaluated for further injury by looking in for bruises or deformity and palpatation for tenderness, crepitus, and pulse.

Surgical technique [4–6]

Anesthesia

In all the cases, the procedure was usually performed under general anesthesia.

Patient positioning

Proper patient positioning on the operating table is essential. The procedure was done with the patient in supine position.

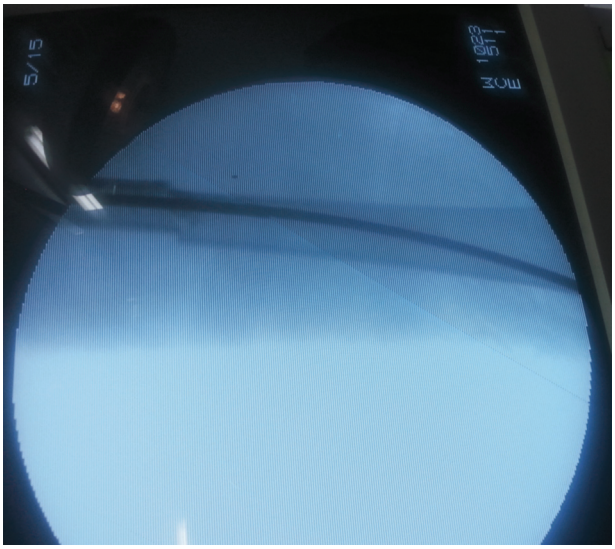
The use of a fracture table, which would seem logical in the majority of cases, is not an absolute requirement in small children who may be simply positioned supine on a standard operating table (Figs 1 and 2).

(1) Introduce the nail on the side where the fragments overlap.
(2) The nail is pushed through the fracture site.
(3) The tip of the nail is directed towards the fracture site and the nail is pushed upwards.
(4) The nail is pushed near the metaphysis, but do not penetrate the cancellous bone.
(5) After reduction of the fracture, the nail is introduced into the cancellous bone of the metaphysis.
(6) The base of the nail is cut.

Figure 1

Clinical picture during nail insertion.

Figure 2



C-arm picture.

Postoperative care

Immediate postoperative anteroposterior and lateral radiographs were done. The lower limb was elevated; a pillow was placed under the thigh for a few days, the limb was put in above knee back slap for 2 weeks. A simple dressing was applied and replaced on the second postoperative day.

Active mobilization of the knee and foot was encouraged on the second day postoperative. The child was instructed to lift the leg off the bed. As soon as possible; the child got out of bed and began to walk with two crutches, being careful to put no weight on the injured leg. The length of hospital stay was usually less than 6 days.

Both the child and the family were informed that subcutaneous prominence of the nails is absolutely normal and will disappear as soon as the nails are removed. Once the wound had healed, the child was requested to gently mobilize the skin area around the cut ends of the nails to prevent tissue adhesion.

Rehabilitation

When reduction and stability were satisfactory, postoperative immobilization was unnecessary. Partial weight bearing started early (second week) in stable fractures as in transverse fracture of the middle-third but in spiral and comminuted fractures weight bearing was postponed until callus was seen in radiographs (about 5 weeks). Physical therapy helped hasten recovery of functional independence. It was focused on active quadriceps exercises and achievement of full knee extension. With respect to flexion, only gentle exercises were performed due to the painful prominence of nail tips (Figs 3 and 4).

All the data were collected and evaluated:

(1) Operation time was recorded.
(2) Intraoperative complications.
(3) Postoperative complications.
(4) Hospital stay.
(5) Radiological follow-up.
(6) Time of mobilization and weight bearing.
(7) Time of removal of the implant.

Results

A total of 30 patients met the inclusion criteria for the current study. All the patients were managed with titanium ESINs.

There were 20 male and 10 female in this study with mean age 8.4 years (range: 5–14 years).

Twenty (66.7%) fractures were on the right side and 10 (33.3%) were on the left side. Seventeen fractures were caused by road traffic accident (RTAs), 12 fractures caused by falling from height, and one case due to falling of heavy object over the femur.

The most common level of fracture was midshaft (15), four were distal and 11 were proximal. According to the shape of the fracture, 17 fractures were transverse, nine were short oblique, three were spiral, and one fracture was comminuted.

Twenty fractures among the group were on the right side accounting for 66.7% of cases and 10 (33.3%) fractures were on the left side.

Mean hospital stay was 4.9 days with maximum of 15 days stay in hospital.

The average insertion time was 54 min and the average removal time was 31 min. The average interval between insertion and removal of the nail was 152 days (range: 121–272 days).

Figure 3

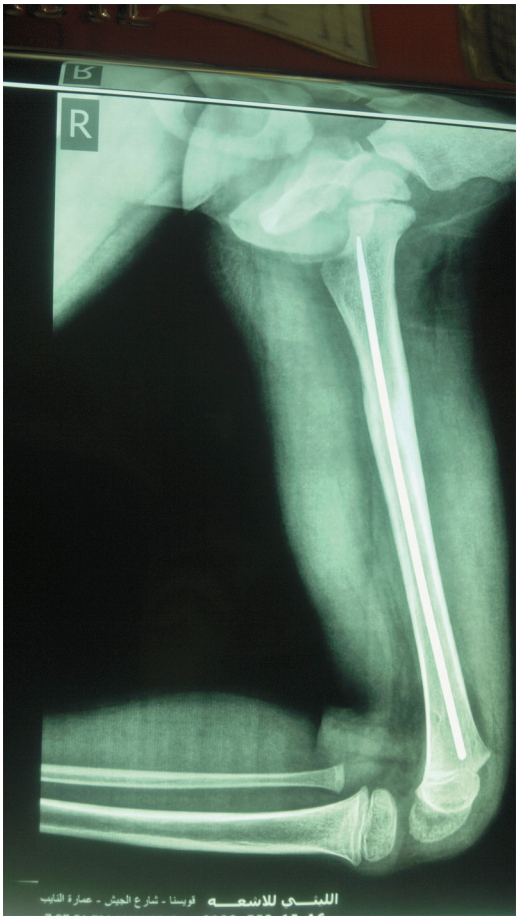
Anteroposterior view.

In most cases, nails were routinely removed ~6 months after injury (when circumferential callus was solid and the fracture line was no longer visible). Despite the initial concerns about ingrowth into the titanium implant, all nails were extracted easily, with the latest removal being 9 months after the implantation.

Regarding complications summary; it was as follows:

(1) Intraoperative surgical difficulties: open reduction was needed in two cases due to difficult closed reduction.
(2) Knee range of motion: all the cases had complete range of knee flexion. Three cases had extension lag of about 10°. After removal of the nails, normal movement was regained.
(3) Reoperation: only one case needed reoperation because the nail were not cut short enough and this led to irritation at the entry site.
(4) Limb length discrepancy: shortening greater than 2 cm occurred in one case that was the only poor result. In other three cases, 1–2 cm of limb length discrepancy occurred where the results were satisfactory. One of these three cases had overgrowth of the fractured limb.

Figure 4



Lateral view.

Table 1 Flynn's criteria for long-term assessment of elastic stable intramedullary nails

	Excellent result	Satisfactory result	Poor result
Length discrepancy	<1.0 cm	1–2 cm	>2.0 cm
Misalignment	5 grades	10 grades	>10 grades
Pain	No	No	Yes
Complications	None	Minor and solved	Major and/or residual morbidity

Callus was first noted on follow-up radiographs at an average of 4 weeks. Radiological union was achieved in all cases in a mean time of 8.6 weeks (range: 6–12 weeks).

Full weight bearing was possible in a mean time of 9 weeks (range: 7–12 weeks). The average duration of follow-up was 11.6 months (range: 6–24 months).

According to the scoring criteria for ESINs by Flynn *et al*. [10], the results were excellent in 26 (87%) patients, successful in three (10%) patients, and poor in one (3%) patient. This poor result was a child of 8 years old, who had bilateral closed fracture femur and the one treated by ESINs was a long spiral midshaft fracture that healed in 2.5 cm shortening and 10° of external rotation.

Assessment of the results

Follow-up

Clinical and radiological follow-ups were scheduled at 2, 6, 12, and 24 weeks postoperatively. The anteroposterior and lateral views showing the hip, entire femur, and knee were done at each visit (Table 1).

Discussion

Although femoral shaft fractures constitute fewer than 2% of all pediatric fractures, the choice of treatment has remained a constant challenge to the orthopedics family. Conservative treatment was the preferred method for the treatment of diaphyseal fractures in children and young adolescents. However, to avoid the effects of prolonged immobilization, to reduce the loss of school days, and for better nursing care, the operative approach gained popularity for the last three decades [7].

Methods currently used in the surgical treatment of pediatric femoral fractures include: external fixation, plate fixation, rigid intramedullary rod fixation, and flexible intramedullary rod fixation [8].

Titanium elastic nail gained popularity in treating fracture femur in children over other surgical methods particularly in the young age group because it is simple, is a load-sharing internal splint that does not violate open physis, allows early mobilization, and maintains alignment. Micromotion increased by the elasticity of the fixation promotes faster external bridging callus formation. The periosteum is not disturbed and being a closed procedure there is no disturbance of the fracture hematoma, thereby less risk of infection [9].In this study; 30 fractures in 30 children were treated with ESINs with mean age 8.2 years and an average follow-up of 11.6 months. Excellent results were obtained in 26 (86.7%) cases, satisfactory results in three (10%) cases, and only one (3.3%) poor case. Callus was first noted on follow-up radiographs at an average of 4 weeks. Radiological union was achieved in all cases in a mean time of 8.6 weeks (range: 6–12 weeks). Full weight bearing was possible in a mean time of 9 weeks (range: 7–12 weeks).

Flynn *et al*. [10] published a critical analysis of early results and complications of ESINs that were trialed at several major North American Pediatric Trauma Centers prior to their widespread release. Four centers and 16 surgeons participated in the study, beginning in 1997, and the mean age of patients studied was 9.5 years. Fifty eight consecutive femoral shaft fractures in 57 patients were stabilized with ESINs, resulting in excellent or satisfactory results in 57 of the fractures. Callus was noted on postoperative radiographs at an average of 4 weeks and, by an average of 8.5 weeks postoperatively, patients walked without assistive devices.

In the current study, there were no major complications; only one (3.3%) case of nail site irritation. One (3.3%) patient had shortening more than 2 cm. No children had significant angular or rotational deformities. Nail site irritation occurred in the first case due to prominent nail end and this was avoided in all the next cases. No cases of refracture were reported.

In this study, one comminuted and three spiral fractures besides 17 transverse and nine short oblique fractures were treated using single ESINs; and there was no difference in the results between these types of fractures as long as the exact principles of ESINs fixation were used. No postoperative knee immobilizer or leg cast was used in any case.

Conclusion

(1) The ESIN is an effective treatment option in treating femoral shaft fractures in the 5–15 years age group.
(2) Although midshaft transverse fractures are the most amenable for treatment with ESINs, they can be used in any type of fractures.
(3) A strong knowledge of the principles and the techniques is mandatory to obtain excellent results.
(4) Leaving no more than 2 cm at the end of the nail outside the bone is very important to avoid nail-entry irritation, which is the most common complication in this technique.
(5) This procedure can be done efficaciously and safely even in small hospital settings. It decreases the cost by shortening the hospital stay and postoperative care.

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Conflicts of interest
There are no conflicts of interest.

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