Treatment of femur fractures in children using elastic stable intramedullary nailing

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Introduction
Closed intramedullary nailing is an established method for the management of fractures of the femur in children. It has the advantage of hematoma preservation, which enables callus formation.

Aim of this study
This study was designed to examine the outcomes and complications of elastic stable intramedullary nails in children aged 6–12 years.

Participants and methods
A total of 27 children were treated from 2011 to 2013 at Al-Azhar University Hospital in Damietta. The average follow-up period for these patients was 24 months.

Results
Although most complications were minor, some series report complication rates of more than 50%. Union rates are high. Malunion or mechanical axis malalignment is uncommon, and leg-length discrepancy and overgrowth are also unusual. Refracture was noted to be uncommon in this population.

Conclusion
Elastic stable intramedullary nails is a well-accepted and reliable option for the treatment of femur fractures in children. Advantages are decreased length of hospital stay, early return to function, and high union rates. Care must be taken to achieve and maintain reduction, and caution is advised in older and heavier children.

Keywords:
children, fractures femur, trauma

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Introduction

Femur fractures are common long-bone injuries in children (6–12 years). Various treatment methods are considered acceptable and include external fixation [1,2], traction [3], submuscular plating [4], locked nailing [5], and intramedullary nailing [6]. The main goals of fixation include preservation of physis, anatomic reduction, and stable fixation. Some modalities of fixation also require casting for varying periods of time to provide additional stability. Children in the age group of 6–12 years were heavier than the group with children younger than 6 years of age, and did not tolerate casts as well as their younger counterparts [7].

Each modality of fixation has its own set of complications. External fixations for example, have been associated with pin-tract infection and refracture [1,2], whereas traction leads to prolonged immobilization [3]. Plate osteosynthesis has the potential to expose the child to an extensive scar related to larger incision and extensive soft tissue stripping [4], and locked nailing may potentially damage the physis [8]. Elastic stable intramedullary nails (ESIN) has its own set of problems including nail irritation, refracture, and superficial and deep infections. In addition, some investigators have suggested limited success in older and heavier children [9].

Participants and methods

Between January 2011 and April 2013, 29 children with unilateral diaphyseal femoral fractures were treated using ESIN in a prospective study. Two children did not return for follow-up. Of the 27 children available for evaluation, 16 were boys (59.3%) and 11 were girls (40.7%) (Table 1), with a mean age of 8.8 years (range, 6–12 years). This study approved by the Ethical committee of Al Azhar University.

The right femur was affected in 15 children (55.6%), whereas the left femur was affected in 12 children (44.4%) (Table 2). All were acute traumatic fractures. Twenty fractures were caused by minor falls (e.g. during playing, sliding, or cycling). Seven children were struck by motor vehicles as pedestrians.

All children had closed fractures. Children who were excluded from the study were those with open fractures or those with pathological fractures. The fracture pattern was classified using the classification of the AO/ASIF

(Association for Osteosynthesis/Association for the Study of Internal Fixation) [10].

Surgical technique

With the patient lying supine on a standard fracture table and under fluoroscopic control, closed fracture reduction was performed as the first step of the procedure either by manual traction or by using the nail as a joystick. Two nails were used. Nail diameter should measure 40% of the narrowest diameter of the diaphysis. Nails should be contoured with a long, gentle bend such that the apex of the convexity will be at the level of the fracture. The nails were inserted through two incisions, medial and lateral, at the level of the proximal pole of the patella and extending proximally about 2–3 cm. They were carefully passed up the medullary canal after making a hole in the metaphyseal region away from the growth plate and away from the joint capsule. The medial nail should be advanced toward the femoral neck and the lateral nail should be advanced toward the greater trochanter. Just before advancing the nails to their final position, they are cut, leaving enough length to manipulate and advance them further. Once the nail tips are in their final position, the end of each nail is cut, leaving 1–2 cm protruding from the cortex. The extraosseous portion of the nail should be bent slightly away from the bone [11]. In all cases, this was done in a retrograde manner. No open reduction or bone grafting was needed in our patients (Fig. 1).

Table 1 Sex of patients

Sex	*n* (%)
Male	16 (59.3)
Female	11 (40.7)
Total	27 (100)

Table 2 Side of injury

Side	*n* (%)
Right	15 (55.6)
Left	12 (44.4)
Total	27 (100)

Figure 1

A diaphyseal femoral fracture in a 9-year-old girl treated using elastic stable intramedullary nails. (a) Preoperative radiograph. (b) Immediate postoperative radiograph. (c) Six-month follow-up.

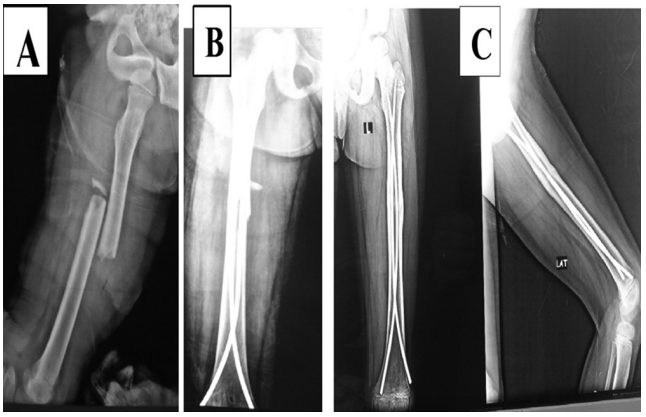
Postoperative care and rehabilitation

Postoperative examinations included a careful assessment of knee motion, limb-length inequality, limb rotation and alignment, and signs of irritation from the nail tip. Radiographs were evaluated for alignment, callus formation, and change in nail position. Cases were followed up to their clinical end point of fracture union and return to full activity, typically several months after nail removal. Postoperative radiography was taken immediately after surgery and every 4 weeks. Thomas splints, above-the-knee slab, or spica cast were applied postoperatively for only 2 weeks. Protected weight bearing according to pain tolerance was allowed in the postoperative period in most cases. Children walked with assistive devices at an average of 21 days. Clinical and radiographic fracture unions were prerequisites for nail removal (usually 6–8 months after surgery). Axial alignment was evaluated using anteroposterior and lateral radiographs obtained before nail removal (Fig. 2).

Results

A total of 27 children (mean age 8.8 years) were treated from January 2011 to April 2013 at Al-Azhar University Hospital in Damietta. The average follow-up duration for these patients was 24 months (range, 14–31 months). The youngest child in the series was 6 years and 2 months old and the oldest was

Figure 2



Radiographs of a 9-year-old boy. (a) Preoperative radiograph. (b) Immediate postoperative radiograph. (c) A 5.10-month follow-up.

11 years and 7 months old at the time of their fracture. Seventeen fractures were classified as AO/ASIF type A (simple) fractures (63%). Ten were type B (wedge) fractures (37%). The most common fracture pattern was the two-part spiral fracture, and more than two-thirds of the fractures occurred in the midshaft (Table 3).

Associated injuries were observed in 11 children (40.7%). These were head injuries in five patients, blunt abdominal trauma in three patients, chest trauma in two patients, and associated upper limb fractures in one patient. The median time for anesthesia and the operative procedure was 45–60 min. No significant blood loss, infection, or wound complications were encountered, and no compartment syndrome or neurovascular injury complicated the nailing procedure. There were no cases of osteomyelitis. The length of hospital stay averaged 2–6 days. All fractures united without additional operations to achieve union. By an average of 9.5 weeks (range, 7–12 weeks), patients walked without assistive devices. Callus was first noted on follow-up radiographs at an average of 4 weeks (Fig. 3).

In general, nail removal was performed after 6 to 8 months. All children had normal range of knee and ankle motion.

A simple scoring system for the outcome of ESIN in a fractured femur is shown in Table 4 [12].

To be judged an excellent result, the case had to fulfill all criteria. In all, 23 children showed an excellent result (85.2%) and four showed a satisfactory result (14.8%).

Discussion

Femur fractures are morbid long-bone injuries in children (6–12 years). They represent a burden on the healthcare system because of the relative cost and effectiveness of each treatment option. In pediatric patients, it is also important to consider the additional home care required for a patient, missed school, and time off from work required by one or both parents to care for the pediatric patient.

The management of femoral fractures in children is controversial [6,13]. The AAOS guidelines committee recently published their recommendations on the treatment of femoral fractures in children of various age groups. The committee agreed that there are various acceptable modalities of treatment and that it is an option for physicians to use flexible intramedullary nailing to treat children 5–11 years of age diagnosed with diaphyseal femur fractures [14].

ESIN has its own set of problems like any other modality of fracture fixation. Malalignment was noted to be a significant issue in a majority of studies, with a malangulation rate of up to one-third of patients [15]. Many rotational malunions were also observed [6,15–17]. Despite our initial concerns about potential loss of rotational alignment, it did not occur in our cases.

Limb-length discrepancy was reported by several investigators, either as a result of fracture shortening or femoral overgrowth as a result of physeal stimulation from injury and hyperemia [6,9,15,17–24]. Moreover, the issue of limb-length discrepancy is inherent to femur fractures by itself and it may not be entirely reasonable to translate it to the fixation modality, although conceptually, in comminuted unstable fractures, use of ESIN may lead to length instability and collapse. Excessive malposition or malangulation

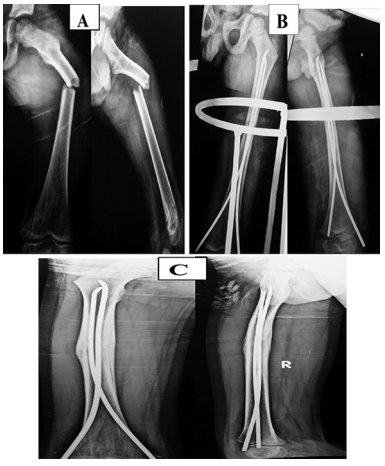
Table 3 Classification of femoral fractures

Fracture	*n* (%)
A1	3 (11.1)
A2	5 (18.5)
A3	9 (33.4)
B1	6 (22.2)
B2	4 (14.8)

Table 4 Elastic stable intramedullary nail outcome scoring [12]

Postoperative outcome	Excellent result	Satisfactory result	Poor result
Leg-length inequality (cm)	<1.0	<2.0	>2.0
Malalignment (deg.)	5	10	>10
Pain	None	None	Present
Complication	None	Minor and resolved	Major complication and/or lasting morbidity

Figure 3



An 8-year-old boy was a pedestrian struck by a car (a) preoperative radiograph. (b) Immediate postoperative radiograph. (c) A 5.5-month follow-up.

resulting in revision surgeries [15,18], symptomatic hardware necessitating early removal [16–19,25], and infections ranging from superficial cellulitis to deep infection have all been reported as complications [6,9,17–19,21,23,26].

Several authors have reported satisfactory results with the use of elastic nails in pediatric femoral fractures. Union occurs readily, and joint motion is preserved, with only a few, mostly minor, complications [7,18–20,27–29]. The current study compares favorably with these reports. All fractures united without additional grafting or revision of the fixation method. No deep infection occurred, and all patients achieved their preinjury level of activity.

Refractures were relatively rare events, with few studies reporting this complication [15,18,20,21,24,26,30–32]. We recommend waiting until callus is solid and the fracture line is no longer visible before nail removal.

Local irritation and nail protrusion at the insertion sites are still common problems reported in up to 52% of the cases with this type of nailing [6,20]. Nails should, therefore, be advanced to lie against the supracondylar flare of the femur to avoid muscle irritation [20,33].

From a cost-analysis standpoint, some studies suggested that the overall cost was significantly lower when ESIN was used compared with traction, followed by spica casting [19,26]. Another study showed that patients treated with ESIN were able to ambulate sooner after surgery and returned to school earlier than patients treated with traction, followed by spica casting [26]. We have had a similar experience in our own practice in terms of early ambulation and early return to school.

Conclusion

Our study has shown that ESIN is a successful low-morbidity alternative in treating lower limb fractures in skeletally immature patients 6–12 years of age that enables early ambulation with good functional results. Preoperative planning, intraoperative details, and technical execution as well as appropriate postoperative care and follow-up are all important in predicting good outcomes. On account of the risk of infection as documented by the systematic review of the literature, we would recommend the use of routine perioperative antibiotics. While cutting the ends of the nails, one should be careful not to make the nails too prominent to decrease the rate of early removal and nail migration. Parents should be advised that minor complications are not uncommon, and that implant removal may be necessary particularly when symptomatic.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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