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Role of Elastic Stable Intramedullary Nailing in Diaphyseal Fractures in Children

Mohammed Hazem Mahmoud, Adel Mohammed Salama,
Mohamed Abd El-Fatah Sebai, Eslam Ahmed Elsayed Hassan*
Orthopaedic Surgery Department, Faculty of Medicine, Zagazig University, Egypt
***Corresponding author:** Eslam A. Hassan, **Mobile:** (+2)01200089970, **Email:** drdrill78@gmail.com

ABSTRACT
Background: All femoral or tibial fractures regardless of associated injuries, intramedullary nailing (IMN) has its more advantages in rapid rehabilitation, good effects on the child and his family and strong fixation.
Objective: To assess the role of elastic stable IMN in union of diaphyseal fractures of long bones in children.
Patients and Methods: A prospective and retrospective analytical study on ten children with isolated femoral or tibial fractures who were admitted to Orthopedic Department, Zagazig University Hospitals. They were divided equally into group I that included 5 patients with femoral shaft fracture managed with IMN and group II, which included 5 patients with tibial shaft fracture managed with IMN. Their mean age was 4.7 years old.
Results: When the groups compared, the spica cast group was found to have a shorter duration of hospital stay compared to elastic nail group. The knee range of motion of the spica cast group was found to be better compared to the elastic nailing group. The elastic nailing group was found to have started walking earlier both with and without support. Patients with intramedullary nailing started to walk with aid after one month and independently after 2 weeks. Patients with spica cast started to walk with aid after 2 months and independently after 12 weeks.
Conclusion: None of the available treatment tools to fix diaphyseal long bones fractures in preschool children is perfect because each method has its own set of complications. However, constitute the motive for developing new techniques or changing the design of currently available devices.
Keywords: Elastic stable intramedullary, Nailing, Diaphyseal fractures, Children.

INTRODUCTION

Diaphyseal long bones fractures are the most common major pediatric injuries treated by the orthopedic surgeons [1, 2]. The cause of these injuries varies with age; in preschool children the most common mechanism is a fall from a height of less than 1 m. In children aged 4–12 years accidental injury during sport is the predominant cause [3].

A vast majority of diaphyseal fractures in children heal without any long-term sequelae irrespective of the treatment method [4]. However, excessive shortening and angular deformity has been reported in 43 % of patients treated by an early cast [5]. The greatest problems of immediate spica casting on patients and families following femoral shaft fractures in children were transportation, cast intolerance by the child, and keeping the child clean [6]. With better understanding of biology of fracture healing and with advances in fixation methods and operative techniques, there has been a general trend toward operative stabilization of shaft fractures in children [7]. Operative treatment options for fractures in children include plating, rigid intramedullary nailing, flexible intramedullary nailing, and external fixation.

Previous experience had suggested that elasticity and stability were not easily combined in one construct. However, working from the concept of three-point fixation used with a single Rush nail, surgeons were able to improve stability significantly by using two pre-tensioned nails inserted from opposite sides of the bone[8]. Titanium nails, which were accurately contoured and properly inserted greatest problems could impart excellent axial and lateral stability to diaphyseal fractures in long bones. Rotational stability was also better than had previously been experienced, although this was to remain the weakest point of the technique [9].

To correct angulation and to avoid plaster immobilization in diaphyseal fractures in childhood, intramedullary nailing with flexible titanium pins is an easy and safe method. Under radiographic control, fractures of femur and tibia are stabilized with two crossing pins. This method is safe in elective trauma surgery and will especially be useful in polytraumatized children in whom multiple fractures should be stabilized with minimal x-ray exposure in a short time [10].

In this study we assessed the role of elastic stable intramedullary nailing in union of isolated diaphyseal fractures of femur or tibia in children compared to casts to assess the best method of management of femoral fractures in this age.

PATIENTS AND METHODS

A prospective and retrospective analytical study on children with isolated femoral or tibial fractures who were admitted to Orthopedic Department. Children aged 4–14 years who sustained a non-pathological femoral and tibial shaft fracture were divided equally) as follow: Group I included 5 patients with femoral shaft fracture managed with IMN. Group II included 5 patients with tibial shaft fracture managed with IMN.

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Inclusion criteria:

Children from four to fourteen years old of both genders. Patients with stable and unstable isolated fractures. Mode of trauma included both low and high velocity injury.

Exclusion criteria:

Patients with bilateral femoral or tibial fractures. Multiple trauma patients with other surgical injuries. Medically unfit patients who can't undergo anesthesia and surgery in general. Severe soft tissue problems in area of surgical approach (burns, necrosis, and acute infection) and pathological fractures.

The clinical data of the patients fulfilling the inclusion criteria had been achieved. History was taken from the patient including the date of the injury, full history was taken to define the type and mechanism of trauma. Physical examination has been documented.

Radiographic Evaluation:

The patients had the following radiological examinations: An antero-posterior (AP) view of the pelvis and an AP and a cross table lateral view of the involved femur. Computed tomography (CT) and magnetic resonance imaging (MRI) was not necessary for any case.

Management plan:

A- Intramedullary nailing:

The patient has been positioned supine on a standard radiolucent orthopedic table with traction piece and fluoroscopic control. The nail was applied in the standard manner. At the level of the distal femoral metaphysis, the femur was reached with medial and lateral incisions. To avoid residual angulation, the nails had introduced at the same level. The medullar canal was reached through the first opening.

The tip of the commercial nail has been ready to bend with an angle of 45°. The implant diameter was selected to be one-third or 40 % of the narrowest diameter of the femoral diaphysis. The titanium elastic nail was bent with a similar gentle curvature, so as to have contact at three points. Following closed reduction under fluoroscopy, the medial and lateral nails have been advanced to the proximal. To avoid soft-tissue irritation, only a small part of nail was left outside. Open reduction was not been necessary for any case.

Post-operative follows up:

Postoperative radiographs have been requested to check for reduction and nail length. Stitches were removed after 10 days. Postoperative mobilization has encouraged from the second day. Partial weight-bearing will be allowed after 3–5 weeks, according to the stability of reduction, type of fracture, weight, and compliance of the child. Full weight-bearing was allowed after union had been achieved. Nail removal has been done at least 7 months after surgery.

B- Spica casts:

Spica cast has been applied with the patient under general anesthesia. A plaster cast or a sitting spica cast, which allows the child to be placed in a sitting position in the chair, was applied. The plaster has applied with 15° up to 90° of flexion, 30° of abduction, and 15° of external rotation at the hip and with 15° up to 90° flexion at the knee. The plaster was molded anteriorly and laterally to prevent anterior and varus bowing. Acceptable reduction comprises less than 15° of angulation and less than 2 cm of shortening. If reduction is not acceptable, the spica cast was reapplied after remanipulation. The spica cast was kept in place for 4-8 weeks.

Follow up:

The patients were followed up until full union and walking undependably occur, which took from two to six months.

Ethical approval:

The study was approved by the Ethical Committee of Zagazig Faculty of Medicine. An informed consent was obtained from every patient in this research. Every patient received an explanation for the purpose of the study. All given data were used for the current medical research only. This work was carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

Data were collected, tabulated and statistically analyzed by SPSS statistical package version 20. Descriptive statistics including qualitative data were represented as number (No), percent (%). Quantitative data were represented as mean(x-), standard deviation (SD), median and range. P-value of ≤ 0.05 was considered statistically significant.

RESULTS

A total of 10 patients diagnosed with and treated for femoral or tibial fracture were evaluated throughout this study. The demographic data of the studied patients were illustrated in Table (1). Five patients with femoral shaft fracture were treated with elastic nail fixation and another five with tibial shaft fracture were treated also with elastic nail fixation. All the fractures were closed fractures. The mechanism of the injury, fracture location and fracture types of groups are listed. No significant difference was determined when the groups were compared according to these parameters (Table 1).

We assessed the role and benefits of elastic stable intramedullary nailing in union of diaphyseal fractures of long bones in children (4-14 yrs, <77 kg). Preoperative and postoperative radiographs of a patient treated with elastic nails were shown in figure (1).

When the groups compared, the spica cast group was found to have a shorter duration of hospital stay (1 ± 1 day) compared to elastic nail group (3 ± 2 days). The knee range of motion of the spica cast group (132°± 4) was found to be better compared to the elastic nailing group (129°± 5).

The elastic nailing group was found to have started walking earlier both with and without support. Patients with intramedullary nailing started to walk with aid after one month and independently after 2 months. Patients with spica cast started to walk with aid after 2 months and independently after 12 weeks **(Table 2)**.

A case of female patients (9 years old) complaining from pain, tenderness with edema over the left thigh and limitation of the movement of the hip and knee joints. There was no history of congenital, chronic diseases or operations.

Imaging x-ray was done in both A-P and lateral views that showed fracture at the shaft of the left femur. The patient was admitted and prepared for closed reduction and internal fixations by two Nancy nails under general anaesthesia. Post-operative x-ray was done after the operation in both A-P and lateral view. The patient has been followed every two weeks to detect union (Figure 2).

Table (1): Demographics of the patients and fractures

Data	N=10	
Age (years)		**Mean (4.7)**
Sex		
Male	**6**	**(60%)**
Female	**4**	**(40%)**
Side Right	**7**	**(70%)**
Left	**3**	**(30%)**
Mechanism		
A fall	**6**	**(60%)**
Accident	**4**	**(40%)**
Nature		
Closed	**10**	**(100%)**
Open	**0**	**(0 %)**
Level		
Upper third	**1**	**(10%)**
Upper-middle junction	**2**	**(20%)**
Middle third	**4**	**(40%)**
Lower-middle junction	**2**	**(20%)**
Lower third	**1**	**(10 %)**
Morphology		
Transverse	**7**	**(70%)**
Oblique	**3**	**(30%)**
Spiral	**0**	**(0%)**
Associated injuries	**0**	**(0 %)**

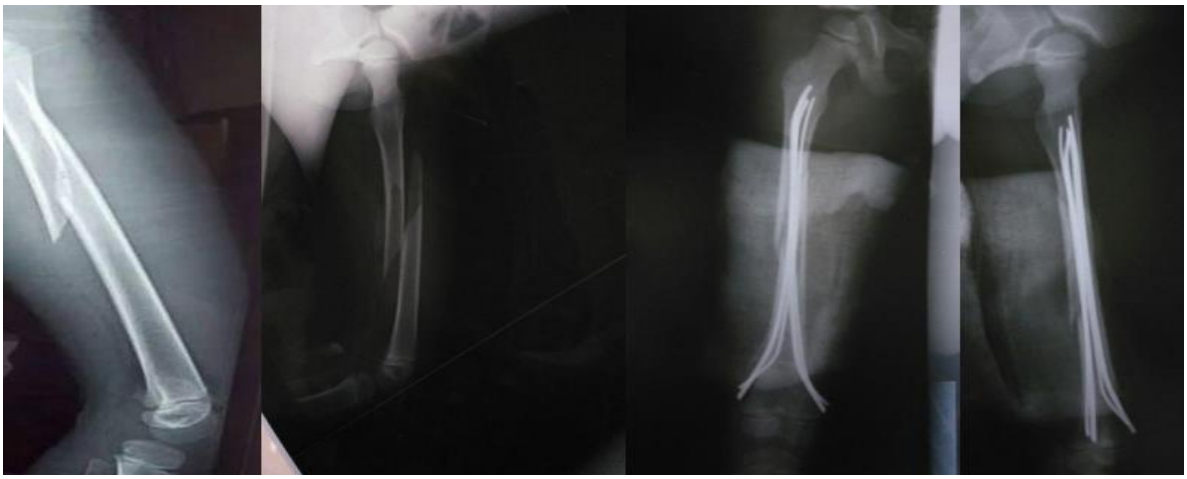

Figure (1): Preoperative and postoperative radiographs of a patient treated with elastic nails.

Table (2): Clinical outcomes of the studied patients

Outcomes	IMN n=5	Spica cast n=5
Hospital stay(days)	3 ± 2	1 ± 1
Malalignment	0 (0 %)	1 (20 %)
Infection	1 (20 %)	0 (0%)
Knee range of motion (˚)	129 ± 5	132 ± 4
Walking with aids (days)	25 ± 7	59 ± 10
Walking independently (days)	49 ± 12	79 ± 9

Figure (2): A female case (9 years) complaining of pain, tenderness and edema over the left thigh and limitation of the movement of the hip and knee joints (a) pre-operative images showing mid shaft femur fracture (b) post-operative images after Nancy nails and (c) post-operative at 3 months showing good union.

DISCUSSION

The positive attributes of intramedullary nailing (IMN) of femoral fractures in children included reduced need for postoperative immobilization, an earlier range of motion of the hip and knee joints, and perhaps greater ease of care since the family can avoid the challenges associated with a child wearing a spica cast for several weeks [(4)]. The negative attributes of surgery included permanent visible scars and the introduction of the risk of infection, a theoretical risk of injury to adjacent neurovascular structures (an unlikely but potentially serious complication), and the frequent necessity for a second surgical procedure to remove the instrumentation (either electively or because the implant is symptomatic) [(9)].

All fractures in the present study were closed fractures. The treatment for lone bones fractures varies according to factors such as the age of the patient, the fracture type, localization and surgical experience. Despite the increase in surgical treatment choices, with the increase in fixation techniques and improved imaging methods, the basic rules described for the treatment for pediatric fractures remain valid today [(10)]. These basic rules as described by **Dameron and Thompson** [(4)] are: the simplest treatment is best; the initial treatment should be permanent where possible; perfect anatomic reduction is not essential for perfect function; restoration of alignment is more important than fragment position; overtreatment is usually worse than undertreatment [(4)].

Femur fracture is the most disabling fracture in children. Children at school age are treated using various methods, such as compression plating, submuscular plating, locking bridge plates, and rigid intramedullary nails. Stainless steel or titanium elastic nails and external fixators were used [(11)].

Minimally invasive submuscular and bridging plating for pre-school children has been successful**.** It offers more rigid fixation than flexible nails, which is reflected in easier mobilization and safer weight-bearing. However, it is more invasive and its invasiveness can increase at the time of metal removal, where bony overgrowth may develop over plate ends, which requires open release of plate ends. Formal plating carries the same risks besides blood loss, periosteal stripping, which might lead to femur overgrowth, and infection [(12)].

Our surgical time, resorting to open reduction, time to union, incidence of painful nail ends, time to nail removal, rotational malalignment, limb overgrowth, shortening, and angulation are more or less similar to other reported series. Spiral fractures were significantly correlated to shortening, slower union, and overgrowth (which did not reach clinical significance). **Assaghir** [(12)] reported care should be practiced during the trimming of nail ends at the completion of surgery because too long nail ends lead to soft tissue irritation and a second surgery for re-trimming is definitely an avoidable complication. A bursa overlying one or both ends may imply irritation by the nail ends.

Kocher *et al.* [(13)] revealed that this minimally invasive technique required short hospital stay compared to other methods of treatment, and this series proved that it can be done with minimum hospital stay, as most children were discharged on the day of surgery.

Preschool children constituted a small number of patients treated in many series, but, to the best of our knowledge, only five articles have specifically addressed this age group and only three of them were about elastic nailing. The children studied were treated using the one-surgeon–one-technique approach, which would give a better assessment of the results [(14)].

d'Ollonne *et al.* [(15)] reported that external fixators were reserved for open fractures of grades II or III (Gustilo's). Plating was also reserved for comminuted fractures where restoring and retaining the femur length would not be feasible with elastic nails and for solid malunion where an open osteotomy is required [(14)].

A rigid nailing option is not on the table in these young femurs, so we were left with two options for fractures without inherent instability: spica cast and Titanium Elastic Nails (TEN). Our choice of TEN was based on frequent complications of spica cast, lack of ideal cast care in rural communities, which constitute the main referral base of our institution, choice by the

child's parents, and the better results of TEN compared to spica [16, 17]. So IMN in 4 up to 14 years old children in our study and in other studies has achieved good results.

CONCLUSION

None of the available treatment tools to fix diaphyseal long bones fractures in preschool children is perfect because each method has its own set of complications. However, constitute the motive for developing new techniques or changing the design of currently available devices.

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