

Efficacy of Elastic Intramedullary Nails in Treating Axially Unstable Femur Fracture in Children

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ABSTRACT

Introduction: To evaluate the outcomes and complications of treatment in children with femoral fractures who were treated with titanium elastic nail.

Methods: Information on patients who were referred to Namazi hospital from April 2017 to April 2018 because of a femoral fracture and underwent titanium elastic nailing were reviewed retrospectively. The patient's information regarding age, sex, trauma mechanism, side involved, neurovascular status, associated injuries, duration of hospital stay, operation time, and complications. The surgical procedure implied a reposition of bone fragments and osteosynthesis with titanium elastic nails introduced through an incision over the lateral and medial border of the distal femoral metaphysis.

Results: A total of 60 children with a mean age of 7.50 ± 2.28 were examined. Boys constituted 42 (70%) while 18 (30%) of the cases were girls. Two types of transverse and short oblique fractures were placed in one group with a frequency of 35 patients (58.3%) who was axially stable, and two other types of fractures including comminuted and long oblique were placed in a common separate group with a frequency of 25 patients (41.7%) who was axially unstable. There was no significant difference between the two aforementioned groups regarding the pain. Types of fracture sites were divided into two classes; The distal and proximal fractures which included subtrochanteric, supracondylar fractures were located in one class of bone end fractures (frequency of 22 patients 36.7%) and the other class included only the diaphysis. Likewise, there was no significant correlation between the fracture types and pain.

Conclusion: titanium elastic nail satisfied all criteria of minimally invasive bone surgery, and is suitable for all types of femoral fractures.

Keywords: Femur; Fracture; Titanium elastic nails; Flexible intramedullary nailing, Elastic stable intramedullary nailing.

INTRODUCTION

Femoral shaft fracture is the third most common fracture (21.9%) after forearm fracture and elbow fracture and the second most common long bone fracture after forearm fracture. The annual prevalence of this fracture has been reported from 0.25 in 1999 to 0.11 in 2005 per 1000 children in childhood. This decline is due to reduced physical activity and improved safety on the playground and traffic environment [1]. Femoral fractures in adolescents and children are more likely to be caused by severe energy trauma, while in younger children it is more common to seek standing (from a standing height) or to use playground equipment. Likewise, 12% of femoral fractures in children 4 years of age or younger are pathological. Furthermore, the prevalence of femoral diaphysis stress fracture is low and accounts for only 4% of all types of stress fractures in children. Stress fractures in the femoral shaft and neck, although uncommon, are increasingly seen in adolescent athletes who are involved in football, basketball, and other sports [2,3]. The most important symptoms of a femoral shaft fracture are severe thigh pain that increases with pressure on the fracture site or lower limb movement. Inability to move the lower limb, deformity of the lower limb as a result of shortening and external rotation, and swelling of the thigh are other symptoms of femoral fracture. The definitive diagnosis of this fracture is given by using simple radiographs [4,5]. Over the past few decades, the treatment of pediatric

femoral fractures has shifted to surgery rather than conservative treatment; Because it causes faster recovery and shorter periods of immobility. Many studies suggest that children under 5 years of age can be treated with early reduction and hip spica cast and adolescents over 15 years of age would be treated with Elastic stable intramedullary nailing (ESIN) such as titanium elastic nail (TEN). Children between 5 and 13 years old are treated with traction, hip spica cast, elastic stable intramedullary nail, or external fixators in cases of open fractures. In general, in the last two decades, the approach to dealing with femoral shaft fractures, which is associated with displacement in older children, has gradually shifted to surgical treatment [6,7].

ESIN is a minimally invasive procedure that provides elastic and stable osteosynthesis conditions. ESIN involves inserting two elastic indigos through the metaphysis into the medullary canal, passing them through the fracture site, and securing them in the opposite side metaphysis. These C-shaped elastic nails are formed before their application, which helps to precisely orient them and create a deformation-resistant tensile system. The surgical technique is completely in accordance with the principles of minimally invasive surgery. Surgery without opening the fracture helps keep the hematoma at the fracture site. Since osteosynthesis is performed by inserting the nails at a distance away from the fracture site, the risk of bacterial contamination is eliminated. Choosing the appropriate nail diameter allows micromovements and compression at the

fracture site during walking and help to stabilize the fracture. ESIN shortens the length of the hospital stay and provides a quick recovery so that there is no need for immobilization due to casting. Due to the short period of hospitalization, the cost of fracture treatment in children is significantly reduced. Although there are many benefits to using ESIN, there are some complications listed in various articles. Avascular necrosis of the femoral head, skin irritation at the nail entry site, granuloma formation, refracture, and infection are among the most common complication. These complications are more pronounced in supracondylar, subtrochanteric, and axially unstable fractures [8-14]. Therefore, in this study, we aimed to assess the results and complications of pediatric femoral fractures that have been treated with TEN.

METHODS

In this retrospective cohort study, patients aged 4 to 12 years referring to the Namazi hospital from April 2017 to April 2018 with a diagnosis of femoral fracture which has been fixed with titanium elastic nail (TEN) were included. Patients older than 12 years of age, and younger than 4 years of age, had a history of simultaneous fracture in other sites or nerve injury, patients operated in other centers, and those who lost on follow up, were treated non-operatively or treated operatively with a method other than TEN, and had incomplete records file were excluded.

Data were collected retrospectively using a checklist prepared from patients' records. This checklist has three sections. The first part of the demographic characteristics of patients regarding age, gender, date of fracture, hospitalization, operation, discharge, and cause of the fracture. The second part of the clinical information is about the fracture side, type of fracture, number of fractures, concomitant injuries, treatment performed, and complications. The third part is about the relevant radiological findings.

All the enrolled patients were regularly assessed radiographically and clinically 7 days, 1, 3, and 6 months after surgery. Radiological assessment was performed

using standard lateral and anteroposterior position to estimate the consolidation and also to identify the possible complications such as shortening, secondary displacement, delayed union, hardware migration, re-fracture, and nonunion or malunion. A single walking spica cast was also embedded after TEN insertions for 2 to 3 weeks so that the child could walk. Subjective data regarding stiffness, perceived pain, and effect on daily activities, and objective data including surgical site infection, skin lesions, and range of motion were recorded. Complete healing was defined as a full return to normal activities and sports.

This study was conducted after obtaining permission from Shiraz University of Medical Sciences, Shiraz, Iran. Written informed consent was filled by all patients before, including in the study, and the researchers safeguarded patients' information, if subjects are under 18, and/or illiterate, informed consent was filled by a parent and/or legal guardian Also, the authors declare no conflict of interest in this study.

The patient's demographic, clinical, and paraclinical data were analyzed using SPSS version 22.0 software. In order to analyze the data, an independent t-test and chi-square test were used. A P value lower than 0.05 was assigned as significant.

RESULTS

In this study, 60 children were examined. The mean age of the participants was 7.50 with a standard deviation of 2.28 years. The youngest was 4 years old and the oldest child was 12 years old. Boys constituted 42 (70%) while 18 (30%) of the cases were girls.

Fig. 1. shows the frequency distribution of patients based on the type of trauma. According to the recorded information, 10 different types of trauma in patients caused injuries, which the most common of them was a car accident.

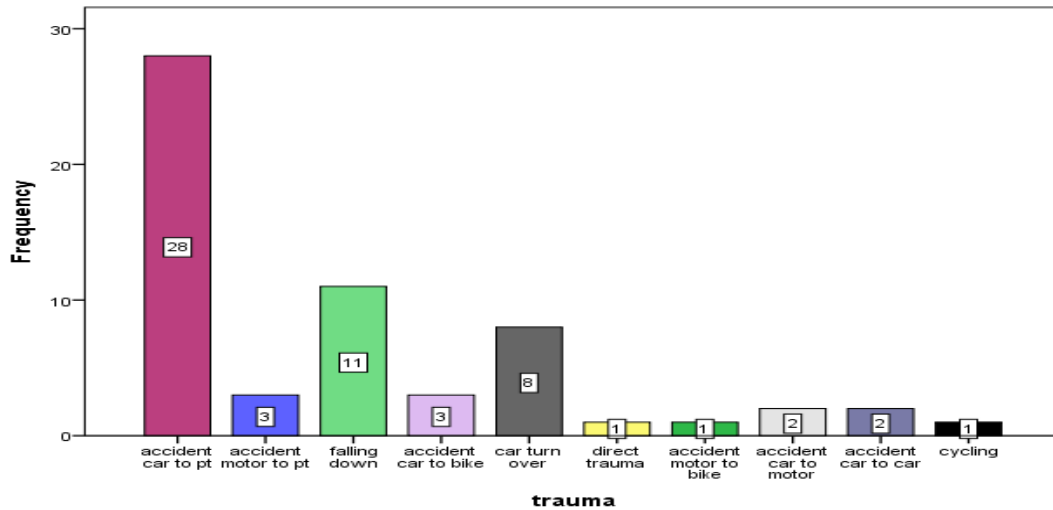


Fig. 1. Frequency distribution of patients by type of trauma.

Of the 60 children with femoral fractures studied in this study, 46 (76.7%) underwent close surgery and 14 (23.3%) underwent open surgery. Likewise, 70% had a difference in length of less than one centimeter and 30% had a difference in length between 1 and 2 cm.

57 patients (95%) did not report pain and only 3 patients (5%) suffered from pain. Likewise, 55 patients (91.7%) had no complications, 5 patients (8.3%) had minor complications. No one suffered from major complications. None of the patients developed knee stiffness. To describe precisely, 54 patients (90%) had normal knee ROM despite the trauma, and only 6 patients (10%) reported limited knee ROM. Likewise, 45 patients (75%) had normal hip ROM and 15 (25%) had limited hip ROM.

The mean duration of surgery was 97.17 with a standard deviation of 27.92 minutes. The minimum surgery time was 60 minutes and the maximum surgery time was 180 minutes. The duration of surgery in patients who underwent open surgery was significantly longer than close surgery. (P.value <0.001)

The mean length of the surgical incision was 4.47 cm with a standard deviation of 3.19. The smallest surgical incision length was 1 cm and the largest was 15 cm. The

mean length of the surgical incision in patients who underwent open surgery was significantly longer than close surgery.

The mean number of days between trauma and surgery was 3.92 days with a standard deviation of 2.19 (range: 1-10 days). The mean days between trauma and surgery in patients who underwent open surgery were significantly higher than close surgery.

Fig. 2. shows the frequency distribution of patients based on the type of fracture. According to the chart, out of a total of 60 children with femoral fractures, the most type of fracture is related to transverse fracture with a frequency of 43.3% and the lowest type of fracture is related to short oblique and comminuted fractures, each with a frequency of 15%. Long oblique fractures with a frequency of 16 patients (26.7%) were in the middle. Also, in other words, two types of transverse and short oblique fractures were placed in one group with a frequency of 35 patients (58.3%) who was axially stable, and two other types of fractures including comminuted and long oblique were placed in a common separate group with a frequency of 25 patients (41.7%) who was axially unstable.

variable	Type of surgery		P.value
	Close surgery	Open surgery	
Surgery duration: minute ± SD	88.04± 21.35	127.14± 26.43	<0.001
Surgical incision length: centimeter± SD	8.64± 3.93	3.20± 1.34	<0.001
Trauma and surgery interval: days± SD	3.57± 1.96	5.07± 2.58	0.023

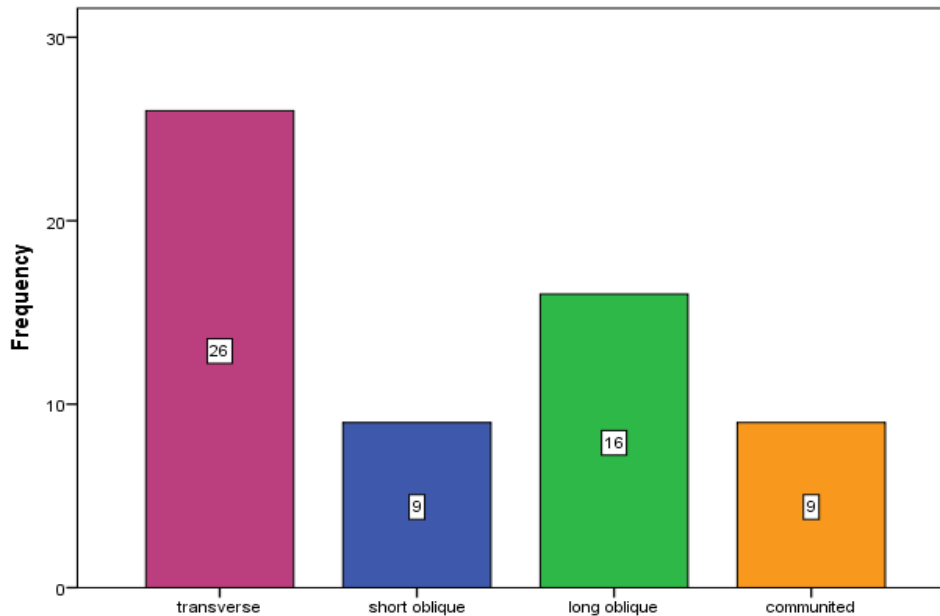


Fig. 2. Frequency distribution of patients by type of fracture.

Regarding the fracture site, diaphyseal fractures were the most frequent site (63.3%) and the lowest fracture site was in the distal section with a frequency of 11.7%. The proximal fracture was in the middle with a frequency of 25%. Types of fracture sites were divided into two classes; The distal and proximal fractures which included

subtrochanteric, supracondylar fractures were located in one class of bone end fractures (frequency of 22 patients 36.7%) and the other class included only the diaphysis. Likewise, there was no significant correlation between the fracture types and pain.

DISCUSSION

Although the trend today is towards non-surgical treatments for pediatric fractures, it is not always effective for femoral fractures in children. In one report, 50% of children under the age of 10 with high-energy femoral fractures who were treated non-surgically, needed surgically reduction. Patients with traumatic brain injuries or multiple injuries, floating knees, burns, large and heavy children have surgical indications for pediatric femoral shaft fractures [15]. Likewise, economic, social, and educational considerations sought a way to shorten hospital stays. Along with the development of flexible intra-canal rods, a great change has taken place in the treatment of long bone fractures in children and many benefits have been expressed in the use of this method in the treatment of femoral fractures [16]. Intramedullary rods allow proper alignment and rotation in fracture healing. Also, with its elastic properties and good stability, it causes micro-movements at the fracture site and stimulates the callus formation, and finally accelerates the welding process. Likewise, surgical treatment is performed with a small incision and the risk of infection is very low [17,18]. In a comparative study of two methods including surgical treatment of external fixation and elastic stable intramedullary nailing in femoral fractures, faster return of children to previous activity and school along with creating a normal range of motion in a short time were reported in a group who were treated with elastic stable intramedullary nailing. On the other hand, it is believed that more side effects occur in treatment with external stabilizers [19]. Although intramedullary nail insertion, whether interlocked or elastic, is the preferred method for pediatric femoral fractures, it is not without complications. Avascular necrosis of the femoral head, skin irritation at the nail entry site, granuloma formation, refracture, and infection are among the most common complication of elastic stable intramedullary nailing [8-14]. Likewise, the previous study usually evaluated ESIN such as TEN in transverse diaphyseal and axially stable patients. Consequently, there is little information regarding TEN effectiveness in long oblique, subtrochanteric, and supracondylar as well as axially unstable fractures. Therefore, we assessed the titanium elastic nails in femoral fractures of different sites and stability status.

Pediatric femoral neck fractures are not considered by surgeons because of their rarity, but because of the wide range of complications that follow. In this type of fracture, avascular necrosis is one of the complications associated with trauma. In published reports, the rate of complications varies from 13% to 58% and there is not an effective action or treatment to prevent these complications [20]. Aslani et al believed that the most important complication in the use of ESIN was bursitis that required removal of the device [21]. Barlas et al. also claimed that faster return of children to previous activity and school as well as the earlier normal joint ROM achievement was seen in a group who managed with ESIN. On the other hand, it is believed that more complications occur in treatment with external stabilizers [19]. Razak Abdel et al., in a study of children with open femoral shaft fractures due to traffic accidents treated with flexible intra-canal bars, showed that this treatment was associated with shorter hospital stays and patients

recovered more quickly. Based on their observations, excellent treatment results were obtained in 71.4%. This study identified flexible intra-canal rods as a preferred treatment for open femoral shaft fractures in children aged 5 to 15 years. Therefore, it is a suggestive acceptable method for the treatment of open femoral fractures in children [22].

Based on our results, 5% of patients suffered from pain after surgery. Likewise, 8.3% had minor complications and no one had major complications. Furthermore, 25% developed abnormal hip ROM and 10% had abnormal knee ROM. It is noteworthy that no significant difference in complication and pain was recognized with respect to the fracture sites (e.g., subtrochanteric, supracondylar, long oblique, and transverse). Moreover, axially unstable fractures had the same response to TEN insertions in comparison to their axially stable counterparts. Khazzam et al. also reported the results of TEN uses for a total of 138 femoral fractures in 135 patients with an average age of 9.7 years and an average follow-up of 15.6 months. They reported a total of 16 complications (11.5%), including 2 cases of delayed healing, 3 refractures, 3 valgus or varus angulation, 5 cases of skin irritation at the site of the nail entrance, and 1 asymptomatic proximal migration of nail. These results show the success of using the TEN in femoral fractures, regardless of the type and location of the fracture.

Since the multi fragmentary and axially unstable diaphyseal long bone fractures are associated with a high prevalence of complications and a poor final outcome, it is known as one of the major problems of pediatric traumatology. That is why some authors suggested the surgical treatment in children whose immobilization did not achieve treatment success [23]. On contrary, Aksoy et al. reported the treatment of 9 complicated cases of femoral fracture by the ESIN. He also has been reported no infections nor neurovascular injuries in the study [23]. To sum up, everything that has been stated so far, TEN insertions along with a single walking spica cast could be a good choice in all forms of pediatric femoral fractures. Of course, it cannot be ignored that further studies with a large sample of each fracture group (e.g., subtrochanteric, supracondylar, long oblique, and transverse) are needed to evaluate the specific complication and success rate concerning the particular fracture sites as well as axially stability of fractures.

According to the results of the present study, 80% had 5° malalignment, 18.3% had 5° to 10° malalignment and only 1.7% had more than 10° malalignment. Saberi et al. showed in their study that the degree of rotation was less than 5 in 8.6%, five to 10 degrees in 75.7%, and between 10 and 15 degrees in 15.7% [25]. Braten et al. reported the result of nailing in 110 patients with femoral shaft fractures that 19% of patients had more than 15 degrees of rotation, of which 38% were symptomatic [26]. In patients with a rotation rate of 10 to 15 degrees, clinical symptoms were present in only 12% of cases. In patients with less than 10 degrees of rotation, there was no clinical manifestation, which in our study did not show any significant correlation between the degree of rotation and clinical complications. In Jiang et al. study, 36 patients with femoral shaft fracture were examined. The degree of

rotation of 15 degrees or more was observed in 19.4% and between 10 and 15 degrees in 47% of patients [27]. It seems that TEN insertions as the current suggestive treatment method for femoral fracture didn't accompany malalignment significantly. Moreover, patients with this complication are usually asymptomatic and were diagnosed on radiographs taken for other reasons, such as bone union assessment.

CONCLUSION

To sum up, we conclude that ESIN such as TEN gratified all criteria of minimally invasive bone surgery, and is suitable not only for diaphyseal femoral fractures but also for subtrochanteric, supracondylar, and axially unstable fractures in children. It is a very efficient method with esthetic outcomes and excellent function as well as a low complication rate.

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