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A Comparative Study of Management of Femoral Shaft Fracture in Children

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Abstract

Context: Fracture of the shaft of the femur is one of the major pediatrics trauma resulting in a life-long disability. There are many treatment options available including early application of Spica cast, external surgical fixation, intramedullary nailing or conservative treatment that involves immobilization for a prolonged period of time, mostly in a hospital setup.

Aim: The aim of this study is to examine the consequences and functional outcomes of the fractures of femoral shaft in pediatric department which were treated with intramedullary internal fixation (using K-wire and Titanium elastic nail) as the potential of malunion is greater in elastic nails specially if weight is heavier and it allows full weight bearing without cast .

Study Design and Method: A prospective study conducted at the Department of Orthopedic, Specialist Orthopedic, Al Qassimi Hospital Sharjah EHS United Arab Emirates from February 2019 to January 2020. Total of 80 children were evaluated for this study with age between 4-11 years having unstable in close reduction of femoral shaft. Each participant was followed up for 12 months to check unions, malunions, delayed unions, or nonunions and excellent, good, and poor outcomes

Results: On statistical analysis of the outcome of the treatment and prognosis of the results based on Flynn et al criteria 72.5% had excellent outcome scores in Group A treated with titanium nails) and 70% in Group B (treated with stainless steal K wires. On general statistical analysis, both the groups showed similar rates in post-operative complications.

Conclusion: The two groups showed similar results in terms of union, partial full weight bearing activities after the intramedullary nailing intervention was evaluated. However, stainless steel Kirschner wire has certain advantages over titanium elastic nail making it a slightly better option which include: cost effectiveness, easy availability, lesser pre-operative hospital stay and lesser surgical waiting time.

Keywords: Children, Adolescents, Femoral shaft fractures, femoral fixation, intramedullary nails, titanium elastic nails, Kirschner wire.

Introduction:

Fractures of femoral shaft are one of the most common fractures of the long bones and the most common and major traumas seen in pediatric department being managed by the orthopedic surgeons [1]. The management of pediatric femoral fracture depends on multiple factors which should be considered by

orthopedics before planning the intervention and choice of treatment. The primary components that play a role in determining the choice of treatment are age of the child (as it helps determine the bone age and size), severity of the trauma (personality of trauma), family issues and cost of the intervention (whether the intervention is affordable by the patients' family or not) [2]. Additionally, child abuse should also be considered in young children with femoral shaft fracture. Generally, early application of a Spica cast is the gold standard treatment for the fractures of the shaft if femur for children of age group 1-5 years [3-4]. However, in adolescents with a mature skeleton a different treatment approach is taken. In this age group (>5) solid intramedullary trochanteric nailing technique is used to treat the fracture whereby the nails are inserted in an antegrade manner. Other surgical methods that are being successfully performed are: external fixation, bridge plates, and plate fixation [1-2].

Over the past few years, usage of antegrade intramedullary trochanteric nail has been now been become preferable for femoral shaft fracture treatment in pediatric department, especially in patients over 5 years of age. Intramedullary nailing was forced to catch surgeons attention in Europe by Ender and Simon-Weidner and by Pankovitch in the United States [1-2]. Ender and Simon Weidner first conceptualized the idea of multiple flexible intramedullary nailing (Ender nail) which is more recently advocated by the used of elastic titanium nails. This technique is known as Elastic Stable intramedullary nailing (ESIN). Titanium is biochemically "elastic" is nature which is an important characteristic for a successful femoral fixation with flexibility yet maintaining curvature. More recently, a more cost effective approach to internal fixation has been developed with the same technique that uses closed intramedullary stainless steel Kirschner wire, that in comparison to titanium is much stiffer and requires more force to bend the nails [2,5]. Although K-wire is easily available and is cost effective, but its bio-mechanical properties of: modulus of elasticity, osseointegration, resistance to corrosion, and compatibility with magnetic resonance imaging makes its inferior to titanium.

The aim of this study is to examine the consequences and functional outcomes of the fractures of femoral shaft in pediatric department being treated with intramedullary nailing using K-wire and Titanium elastic nail.

Materials and Methods:

This study was conducted at the Department of Orthopedic, Department of Orthopedic, Specialist Orthopedic, Al Qassimi Hospital Sharjah EHS United Arab Emirates from February 2019 to January 2020. We evaluated a total of 80 children with age between 4-11 years having a closed fracture of femoral shaft were included in the study. The study was first approved by the medical ethics committee of the Institute. 40 children were managed with titanium elastic nails (Group A) and the other 40 children were managed with stainless steel Kirschner wire (K-wire) (Group B).

Inclusion Criteria:

1. Fractures that were displaced, with or without communication.

2. multiple fractures which were found to be unstable in close reduction

3. Fractures which displaced during traction.

4. Patients who were irritable and had brain injury.

5. Patients having fractures with poly-trauma and/or under intensive care to facilitate nursing.

6. Associated vascular injury needing immediate repair.

Exclusion Criteria:

Patients who had fractures that were displaced or were in a better position were treated using traction and hip Spica instead. Patients of age less than 4 years and greater than 11 years were excluded from the study. Additionally, children presenting with open fractures, or fractures requiring open reduction were also excluded from the study.

Operative Technique:

A written informed consent was obtained prior to the study from the parents of all the participants. All pediatric patients were administered with a bolus of intravenous antibiotic pre-operatively in supine position under general anesthesia on an orthopedic table. While doing so their feet were fastened to the footplates and a traction was applied longitudinally ensuring that alignment was linear. Each participant was followed after the surgery for the clinical and radiological evaluation and the outcome was accessed based on time required to heal the fractures, extent of joint movements, and success of the implant.

An incision of 2 cm medial and lateral to the level of metaphysis of distal femur tensile elastic nails were used for femoral fixation of 40 participants. An entry point was made with the help of an awl after having the soft tissue of the bone dissected. Then according to femur medullary appropriate sized titanium elastic nails were chosen and were placed through the medial and lateral entry points to perform a fracture reduction. Average size of Titanium elastic nails used in pediatrics femoral shaft fixation is 3.5 mm (2.5-4 mm). At last these implants were cut and then subcutaneous tissue and skin was closed. Out 40 patients 38 required two titanium elastic nails and the remaining 2 only required three titanium elastic nails.

Stainless steel Kirschner wires were prepared by bending them at a 45 degree angle approximately. The K- wires used for intramedullary internal fixation of Group B patients were of length 30-45 cm and diameter 2.5-3.5 mm. 2 cm from both the ends were cut to prevent sharp edges to inadvertently penetrate the cortex and were also inclined at approximately 30 degrees to provide guidance. The wires were not pre-bent in a ‘C’ or ‘S’ curve. Entry portals are made laterally and antero-medially on the distal metaphysis of the femur just proximal to the growth plate. Then via gentle hammering the wires were introduced in a retrograde fashion, whereby the lateral wire is first introduced. The tips of both the wires were placed just distal to the growth plate of the greater and lesser trochanters, the bends pointing towards the side if the entry portal. Lastly, the wound was sealed and dressing was applied.

Post-operative rehabilitation:

On the first day after surgery/ post-operative day, movements of the ankle and the hip joints were planned and weight bearing activities were only advised after considering the clinical examinations’ reports, findings of the radiographs and as much as the patient could tolerate. During follow ups of each patient, the physician made partial or full weight bearing recommendations based in clinical and radiological evaluations. In the clinical examination limb length discrepancy was measured and range of motion at hip, knee and ankle joint was evaluated. In radiographs, union is defined as bridging of callus on two standard views with partial obliteration of the fracture line and when on examination bony tenderness is no longer present. If callus was identified on the radiograph, K-wires were then removed assuming that the reunion was sufficient without a performing a second surgery as the ends of the K-wires were out of the skin. Among Group A patients who received titanium elastic intramedullary nailing the implants were removed through a second surgery via incisions from the first surgery after determining that the union was sufficient based in clinical and radiological data.

Results:

A sample 80 children (68 male, 12 female) with a mean age group of 7.23 +/- 2.61 (Range: 4-11) years were included over the 7 years of course of this study. Of these, 40 (50 %) were treated with titanium elastic nails (Group A) and other 40 (50 %) were treated using stainless steel K-wire (Group B). The mean duration of follow-up was 18.26 +/- 10.66 months for the titanium elastic nail’s group i.e. Group A and 25.32 +/- 6.23 months for the stainless steel K-wire group i.e. Group B.

In both the groups males were more than females where both Groups have 6 females and 34 males each. The right femoral fracture was reported 58 % of the times in Group A and 52 % in Group B. Transverse femoral fracture was the most common fracture reported in both the groups: 52.5% in Group A and 50% in Group B.

The most common site of injury in both the groups was mid shaft fractures (middle one third) with 62.5 % cases in Group A and 57.5% cases in Group B. Proximal one third of the shaft was least fractured

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in both the groups 10% cases reported in Group A and 17.5% cases reported in Group B. Patients from both the groups were followed up for 12 months and both showed comparable time taken for reunion and callus formation i.e. 9.6 weeks.

Group A reported minor post-operative complications compared to Group B reporting some major complications including pain due nail lip irritation (12.5 %) compared to 7.5 % cases reported in Group A which resolved in weeks with administration of analgesics and antibiotics. Two patients in both the groups had varus angulation in anteroposterior plane <120, 3 patients in Group A and 1 in Group B had valgus angulation in anteroposterior plane <150. In both the groups the limb length lengthening was seen in 4 patients (10%). On general statistical evaluation, post-operative complications were similar in both the groups.

Table 1: Patients' demographic data *(n=80)*

	Group A Titanium Elastic nails *(n=40), n (%)*	Group B K- wire *(n=40), n (%)*
Gender		
Male	34 (85)	34 (85)
Female	6 (15)	6 (15)
Site of injury		
Proximal one third	4 (10)	7 (17.5)
Middle one third	25 (62.5)	23 (57.5)
Distal one third	11 (27.5)	10 (25)
Etiology		
Road traffic accident	19 (47.5)	22 (55)
Fall from height	5 (12.5)	3 (7.5)
Sport injuries	16 (40)	15 (37.5)
Physical abuse	0 (0)	0 (0)
Type of fracture		
Transverse	21 (52.5)	20 (50)
Oblique	11 (27.5)	9 (22.5)
Spiral	5 (12.5)	6 (15)
Comminuted	2 (5)	3 (7.5)
Segmental	1 (2.5)	5 (12.5)
Complications		
Infections (Superficial)	15 (37.5)	18 (45)
Limb length shortening (<1 cm)	7 (17.5)	6 (15)
Limb length lengthening (<1.5 cm)	4 (10)	4 (10)
Implant protrusion	1 (2.5)	1 (2.5)

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Nail tip irritation	3 (7.5)	5 (12.5)
Non union	0 (0)	0 (0)
Mal-union	2 (5)	2 (5)
Delayed union	3 (7.5)	1 (2.5)
Varus angulation (<120)	2 (5)	2 (5)
Valgus angulation (<150)	3 (7.5)	1 (2.5)
Average hospital stay (days)	6.01 +/- 2.12	4.96 +/- 2.98
Time for union (weeks)	9.6	9.6

Statistical Analysis:

The final outcome were accessed based on the criteria of Flynn et al [5] (Table 2). The statistical analysis took into account the limited data and calculations of percentage of patients in both the groups who had union, malunion, delayed unions or no unions and excellent, good and poor results. A detailed questionnaire was designed as part of subjective assessment whereby participants from both the groups were asked whether they were very satisfied, only satisfied or not satisfied at all with the outcome of their treatment.

Table 2: Outcome of the treatment based on Flynn et al. criteria

	Excellent	Good	Poor
Group A n=40 (%)	29 (72.5)	13 (27.5)	0
Group B n=40 (%)	28 (70)	12 (30)	0

Discussion:

Over the past few decades there had been a growing interest in the surgical intervention of pediatric fractures. Conservative treatments such as closed traction and cast have rapidly been replaced by intramedullary femoral nailing which is still evolving and controversial in surgery[6,7]. With evolution in imaging capabilities of radiographs, biomaterial design and health care infrastructure trauma patients have become easier to be identified and systemic complications have been significantly reduced.

Children of age 3 or below who undergo a fracture of femoral shaft are usually treated with a Spica casting or traction for up to 4 weeks. This time of immobilization and no weight bearing can lead to loss of mineral tissue in the bones resulting in atrophied muscles. Hence increasing the risk of further fractures. Ideally, treatment of femoral shaft fractures in children should be simple which allows early mobilization yet maintaining the alignment and length of the limb.

Ever since the development of the intramedullary nailing technique, the intervention has been continuously evolving biomechnically allowing nail improvement hence its current success. In 1940s, intramedullary nailing became increasingly popular when Kunstcher revolutionized the first ever intramedullary nailing method's design [8]. Initially the nail allowed alignment and stability through press-fit fixation but now it has evolved to an extent to providing stability that is achieved through interlocking screws mechanically between nail and bone [8-10].

With time, many other surgical interventions have been devised one of which includes external fixation of the femoral shaft. In this method, despite improvement in pin design complications such as refracture and limb length discrepancy can occur [11-15]. Whereas the primary goal of the treatment is to stabilize

the fracture, control length and alignment, and reduce overall complications for the child and family [16].

Flexible Intramedullary nailing for femoral shaft fractures in children have distinct benefits over other conservative and surgical techniques as it allows early mobilization, easy and minimal requirement of nursing care and avoidance of psychological problems [17-20]

Conclusion:

Hence it can be evaluated according to this study that for the management of femoral shaft in childrens the out come of two strategy used were very similar in terms of union, partial or full weight bearing activities after the intramedullary nailing intervention. The use of stainless steel Kirschner wire instead of Titanium elastic nail in the intramedullary fixation of the femoral shaft fractures in the children of age 4-11 may be beneficial surgical treatment strategy as it is cost effective, has lesser pre-operative hospital stay, has easily available material supply and lesser surgical waiting time. In addition to these, since the ends of the K-wires are left outside of the skin second surgery is not required preventing complications such as joint and/or medullary migration. However, the pin tract infections reported post-operatively in this intervention may present as a serious complication. Further studies should be conducted to address the complete prospective and to measure the frequency of pin tract infections in such cases.

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Conflicts of Interests:

There were no potential conflicts of interests throughout the course of this study.

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