



## **Role of elastic stable intramedullary nail in the surgical management of diaphyseal fracture femur in children**

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### **Abstract**

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#### **Introduction:**

Femoral shaft fractures account for 1.6% of all paediatric injuries. In children 5 years or younger, early closed reduction and application of spica cast is an ideal treatment for most diaphyseal fracture. Elastic stable intramedullary nailing of long bone fractures in the skeletally immature has gained widespread popularity because of its clinical effectiveness and low risk of complications.

#### **Material and method:**

The present study consisted of 25 cases with diaphyseal femoral fracture of either sex within age group 5-16 years, admitted in Orthopaedic Department, Guru Nanak Dev Hospital attached to Govt. Medical College, Amritsar and were treated with elastic stable intramedullary nail.

#### **Inclusion criteria:**

- Children and adolescent patients from 5 to 16 years with diaphyseal femur fracture.
- Children of both sexes were included in the study.
- Children with only closed diaphyseal femoral were included fractures.
- Patients otherwise fit for surgery were included.

#### **Results:**

In our study excellent results were obtained in 72% cases and satisfactory in remaining 28% cases.

#### **Conclusion:**

Elastic Stable Intramedullary Nailing (ESIN) is an ideal method for treatment of paediatric femoral fractures as it gives adequate stability with elastic mobility promoting early union at fracture site without loss of reduction

**Keywords:** Elastic stable intramedullary nail, Diaphyseal fracture

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## Introduction

Treatment of pediatric fractures dramatically changed in 1982, when Metaizeau and the team from Nancy, France, developed the technique of flexible stable intramedullary pinning (FSIMP) using titanium pins<sup>1,2</sup>. In the last two decades there was an increased interest in the operative treatment of paediatric fractures, although debate persisted over its indications<sup>3</sup>.

Femoral shaft fractures account for 1.6% of all paediatric injuries. In children 5 years or younger, early closed reduction and application of spica cast is an ideal treatment for most diaphyseal fracture. In skeletally mature adolescents, use of antegrade solid intramedullary rod has become standard treatment. But, the best treatment for children between five to sixteen years of age is still debated. Compared with younger children, patients in this intermediate age group have high risk of shortening and malunion when conservative measures are used<sup>4,5,6</sup>.

Children managed with traction and spica cast as a treatment modality have to undergo various adverse physical, social, psychological and financial consequences, of prolonged immobilization. Various other modalities include external fixation, plates and screws, use of solid antegrade intramedullary nail. However, there is a risk of certain complications, particularly pintract infection and refracture after external fixation or osteonecrosis with solid nails<sup>4,5,6,7</sup>.

Elastic stable intramedullary nailing of long bone fractures in the skeletally immature has gained widespread popularity because of its clinical effectiveness and low risk of complications. Many studies have supported the use of this technique in the femur, citing advantages that include closed insertion, preservation of the fracture hematoma, and a physal sparing entry point<sup>8,9,10</sup>.

## Materials and Methods

The present study consisted of 25 cases with diaphyseal femoral fracture of either sex within age group 5-16 years, admitted in Orthopaedic Department, Guru Nanak Dev Hospital, Amritsar

and were treated with elastic stable intramedullary nail.

## Patient selection

### Inclusion criteria:

- Children and adolescent patients from 5 to 16 years with diaphyseal femur fracture.
- Children of both sexes were included in the study.
- Children with only closed diaphyseal femoral were included fractures.
- Patients otherwise fit for surgery were included.

### Exclusion criteria:

- Patients less than 5 years of age and more than 16 years of age.
- Patients unfit for surgery.

Patients not willing for surgery due to any reason – medical or otherwise.

Open fractures.

Post-operatively all the patients were encouraged to do static quadriceps exercises within 48 hours or as tolerated by the patients. Active knee and hip movements were begun 3-4 days post-operative. Segmental or long spiral fractures were given additional support with thigh laser after the surgery. Partial weight bearing was started at 6 weeks after radiological sign of early union but it was delayed in case of segmental fractures. Full weight bearing was allowed by 8-12 weeks depending on the fracture configuration and consolidation of fracture union.

Follow-up assessment was done at 6, 12 and 24 weeks. At each follow up, patients are assessed clinically, radiologically and for any complication.

The final outcome based on the above observations is done as per Flynn's criteria (given below)<sup>9</sup>

TENS outcome score

**Table**

<b>Results at 24 weeks</b>	<b>Excellent</b>	<b>Satisfactory</b>	<b>Poor</b>
<b>Variables</b>			
Limb-length inequality	<1.0 cm	<2.0 cm	>2.0 cm
Malalignment	5°	10°	>10°
Unresolved pain	Absent	Absent	Present
Other complications	None	Minor and resolved	Major and lasting morbidity

Additional variables included in our study

**Table**

<b>Variables</b>	<b>Excellent</b>	<b>Satisfactory</b>	<b>poor</b>
Range of movements	Full range	Mild restriction	Moderate-severe restriction
Time for union	8-12 weeks	13-18 weeks	>18 weeks
Unsupported weight bearing	8-12 weeks	13-18 weeks	>18 weeks

**Results**

The present study consisted of 25 cases with diaphyseal femoral fracture of either sex within age group 5-16 yrs, admitted in orthopaedic department, Guru Nanak Dev Hospital Amritsar and were treated with elastic stable intramedullary nail. The patients were regularly followed and results of treatment with complications, if any were recorded and analysed.

In our study excellent results were obtained in 72% cases and satisfactory in remaining 28% cases.

**Age distribution of patients:**

In our study, 25 children with diaphyseal femoral fractures between the age 15-16 years were included. All were fresh cases. The oldest patients in our study was 14 years of age and the youngest being 5 years. 72% of the cases were <10 years of age and 28% were above 10 years age (as shown in Table 1).

**Table 1** Age distribution of patients

<b>Age in years</b>	<b>No. of patients</b>	<b>Percentage</b>
5-8	15	60.0
9-12	7	28.0
13-16	3	12.0
Total	25	100.0

**Time for union:**

Of the 25 cases, 72% of the patients showed radiological union in 8-12 weeks, 24% in 13-18

weeks and 1 patient in 19-24 weeks. No patient had delayed or non union.

Table 2 Time for union

Time for union	No. of patients	Percentage
8-12 weeks	18	72.0
13-18 weeks	6	24.0
19-24 weeks	1	4.0
Delayed union	-	-
Non union	-	-
Total	25	100.0

### Complications

In the present study 4 (16%) patients complained of pain at site of nail insertion during initial follow up evaluation. Superficial infection was

seen in 1 (4%) case which was controlled by antibiotics. 2 patients developed limb shortening of 1.5 cm. One patient developed varus angulation of 5°. Bursa at tip of nail was noticed in 4 cases.

Table 3 Complications

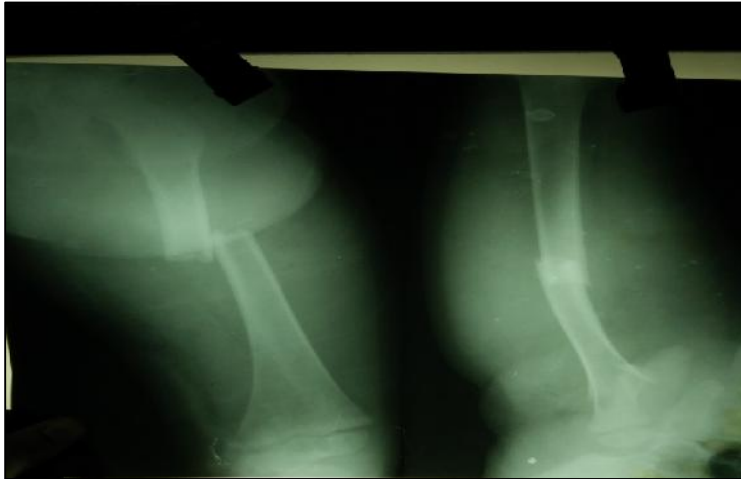
Complications	No. of patients	Percentage
Pain	4	16.0
Infection		
• Superficial	1	4.0
• Deep		
Inflammatory reaction		
Delayed union		
Non union		
Limb lengthening	0	0
Limb shortening	2	8.0
Nail back out		
Malalignment		
• Varus angulation	1	4.0
• Valgus angulation		
• Anterior angulation		
• Posterior angulation		
• Rotational malalignment		
Bursa at tip of nail	4	16.0
Sinking of nail into medullary cavity		

### Results:

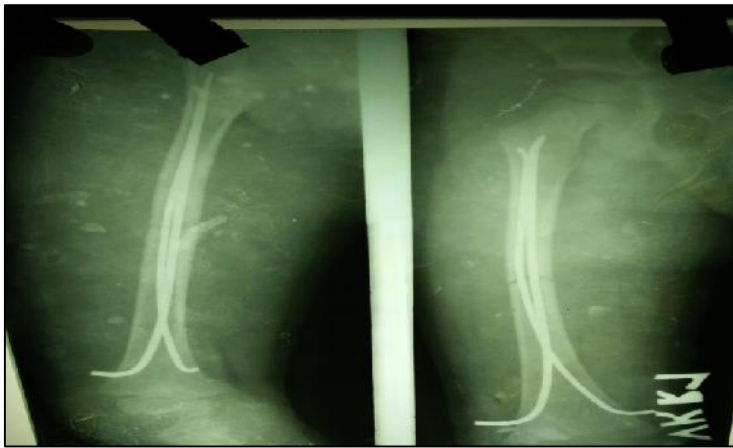
In our study, excellent results were obtained in 72% cases, satisfactory results in the remaining 28% cases.

Table 4 Results

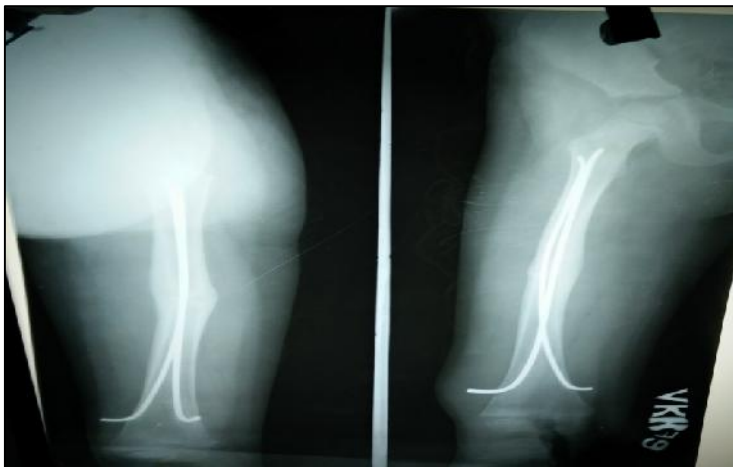
Result	No. of patients	Percentage
Excellent	18	72.0
Satisfactory	7	28.0
Poor	0	0
Total	25	100.0



Pre-operative  
X-ray



Post-operative  
X-ray



Complete union





Range of movements at 24 weeks

## Discussion

In the present study conducted in GNDH, 25 patients with diaphyseal femur fracture within age group 5-16yrs were treated with elastic stable intramedullary nail. Overall final outcome of surgical management was assessed in accordance with the Flynn's criteria.

In the our study ,15 patients were between 5-8yrs, 7 between 9-12 years and 3 between 13-16 years of age. Average age in our study was 8.16 yrs. J.

N. Ligier et al studied children ranged from 5-16 years with a mean of 10.2 years<sup>7</sup>. Rohilla et al had a mean age of 7.6 years in their study of 73 cases.<sup>26</sup>

There were 6 (24%) girls and 19 (76%) boys in the present study. The sex incidence is comparable to other studies in the literature. In their study J. N. Ligier et al. out of 118 cases, had 80 (67.7%) boys and 38 girls<sup>7</sup>. In the study of

Gamal El-Adl et al. out of 66 patients, there were 48 (72.7%) male and 18 (27.3%) females.<sup>11</sup>

In the present study RTA was the most common mode of injury accounting for 22 (88%) cases and fall from height accounted for 3 (12%) of the cases. J. M. Flynn et. al, in their study of 234 cases reported 136 (58.1%) following RTAs, 46(19.6%) following fall due to skidding and remaining 43(28.8%) as a result of fall from height<sup>9</sup>.

In our study, transverse fractures accounted for 12(48%) cases, oblique fractures - 5(20%), spiral fractures - 6(24%) and 2(8%) segmental fractures. In their study J. N. Ligier et al. out of 123 femoral fractures studied 47 (38.2%) were transverse fractures, comminuted fractures- 25 (20.3%), oblique fractures - 7(23.3%), spiral fractures - 19 (15.4%) and 4 (3.2%) were segmental fractures<sup>7</sup>.

In our study 7 (28%) had fracture in the proximal 1/3<sup>rd</sup> region, 17(68%) in the middle 1/3<sup>rd</sup> and 1(4%) in the distal 1/3<sup>rd</sup>. In Hanumantharaya et al. et study, out of 20 cases 25% were proximal 1/3<sup>rd</sup>, 65% were in the middle 1/3<sup>rd</sup> and 10% were in the distal 1/3<sup>rd</sup> region of femur.<sup>12</sup> In J. N. Ligier et al study among 123 femoral shaft fractures, 42 (34%) fractures were in the proximal 1/3<sup>rd</sup>, 45 (36.5) in the middle 1/3<sup>rd</sup> and 36(29%) were in the distal 1/3<sup>rd</sup>.<sup>7</sup>

In the present study, 18(72%) cases were operated within 2 days, 5(20%) cases within 3-5 days and 2(8%) cases were operated after 5 days. Out of these two, one patient reported to our hospital after 5 days of injury and was operated on 7<sup>th</sup> day. The other patient was operated on 8<sup>th</sup> day of injury due to delay in surgical fitness because of head injury. Gamal el al operated 56.1% of cases between 3-4 days after injury, 21.2% cases between 3 -4 days and 22.7% cases after 7 days<sup>11</sup>.

In the present study, duration of surgery was < 30 mins in 2(8%) cases, 30-60 mins in 17 (68%) cases, 61-90 mins in 6 (24%) cases. average duration of surgery was 48.6 mins. Surgery time >60 minutes was mostly due to difficulty in reduction in segmental and long spiral fractures.

In Hanumantharaya et al study, average duration of surgery was 82 mins<sup>12</sup>. In Heybeli et al study (2004), average duration of surgery was 55 mins<sup>62</sup> and in Bar-On et al study (1997) it was 74 mins<sup>13</sup>.

The duration of stay in the hospital was <7 days in 19(76%) cases and 8-12 days in the remaining 6(24%) cases. The average duration of stay in hospital was 6.5 days. The mean hospital stay was 12 days in Kalenderer O et al study<sup>14</sup>. Average hospitalization time was 11.4 days in the study conducted by Mann DC et al<sup>15</sup>. Gross RH et al conducted a study on cast brace management of the femoral shaft fractures in children and young adults. The average length of hospitalization in their study was 18.7 days<sup>16</sup>. Compared to the above studies conducted on conservative methods and cast bracing, the average duration of hospital stay was less in our study i.e. 6.5 days. The reduced hospital stay in our series is because of proper selection of patients, stable fixation and less incidence of complications.

In our study union was achieved in 18(72%) cases in less than 12 weeks, in 6(24%) cases within 13-18 weeks and >18 weeks in 1 case. Average time of union was 10.9 weeks. Oh C.W et al<sup>28</sup> reported average time for union as 10.5 weeks. Aksoy C, et al compared the results of compression plate

fixation and flexible intramedullary nail insertion. Average time to union was 7.7 (4 to 10) months in the plating group and 4 (3 to 7) months for flexible intramedullary nailing<sup>17</sup>. In our study, closed reduction of the fracture, leading to preservation of fracture hematoma, improved biomechanical stability and minimal soft tissue dissection led to rapid union of the fracture compared to compression plate fixation.

In the present study, unsupported full weight bearing was started in <12 weeks for 18 (72%) of the patients, between 13 and 18 weeks in 5 (20%) and at 20 weeks in 2 (8%) patient. The average time of full weight bearing was 11.6 weeks. The average time of full weight bearing in Flynn et al (2002) study was 8.5 weeks.

19 (76%) patients had full range of hip and knee motion in the present study and 6 (24%) patients

had mild restriction in knee flexion at 12 weeks, but normal range of knee flexion was achieved at 8 months. J.M.Flynn et al. reported 2 (0.9%) cases of knee stiffness out of 234 fractures treated with titanium elastic nails<sup>9</sup>.

In our study, 4(16%) patients had developed pain at site of nail insertion during initial follow up evaluation which resolved completely in all of them by the end of 16 weeks. J.M.Flynn et al. reported 38 (16.2%) cases of pain at site of nail insertion out of 234 fractures treated with titanium elastic nails<sup>9</sup>.

Superficial infection was seen in 1(4%) case in our study which was controlled by antibiotics. J.M.Flynn et al. reported 4 (1.7%) cases of superficial infection at the site of nail insertion out of 234 fractures treated with titanium elastic nails<sup>9</sup>.

Leg length discrepancy is the most common sequela after femoral shaft fractures in children and adolescents. No patient in our study had major limb length discrepancy (i.e.  $> \pm 2$ cm). only 2 patients had shortening of 1.5cm. Beaty et al. reported, two patients had overgrowth of more than 2.5 cm necessitating epiphysiodhesis, after conservative treatment<sup>18</sup>. Ozturkman Y. et al observed mean leg lengthening of 7mm in 4 (5%)

patients and mean shortening of 6mm in 2 (2.5%) children<sup>19</sup>. Cramer KE, et al noted average limb lengthening of 7mm (range 1-19mm) in their study<sup>20</sup>. Clinically significant limb discrepancy ( $> 2$ cm) did not occur in any patient in their study. John Ferguson et al noted more than 2cm shortening in 4 children after spica treatment of pediatric femoral shaft fracture<sup>21</sup>. In the present study, limb lengthening of more than 10mm was present in 2 (10%) cases. Comparing to limb length discrepancy in conservative methods, limb length discrepancy in our study was within the acceptable limits.

In the present series, nail back out was not seen in any case. Carrey T.P. et al out of 38 cases, noted nail back out in one case in their study, which necessitated early removal<sup>8</sup>.

Some degree of angular deformity is frequent after femoral shaft fractures in children, but this usually remodels after growth. In our study 1(4%) patient presented with varus angulation of 5 degrees. J.M.Flynn et al reported 10 (4.3%) cases of minor angulation out of 234 fractures treated with titanium elastic nails<sup>9</sup>. Herndon WA, et al compared the results of femoral shaft fractures by spica casting and intramedullary nailing in adolescents. They noticed varus angulation ranging from 7 to 25° in 4 patients treated with spica casting and no varus angulation in surgical group<sup>22</sup>. The varus malalignment that occurred in our study is within the acceptable limits. In the present study, no patients had anteroposterior angulation. Ozturkman Y et al noted an anterior angulation of 7° and a posterior angulation of 6° in 2 patients respectively<sup>19</sup>. Herndon WA, et al noticed anterior angulation ranging from 8° to 35° in patients treated with traction and spica casting<sup>22</sup>. 96.8% of the patients had an average anterior or posterior angulation of 8° in Heinrich SD, et al study<sup>23</sup>. 16 out of 143 nails were removed due to protrusion, skin irritation and discomfort by Simanovsky et al.<sup>27</sup>

No patient in our study had significant rotational deformity. Heinrich SD, et al out of 183 fractures studied, reported 8 degree out toeing in 4 children and two children with 5 degree in toeing following flexible intramedullary nailing<sup>23</sup>.

In the present study, the final outcome was excellent in 18(72%) cases, satisfactory in 7 (28%) cases and there were no poor outcome cases. J.M.Flynn et al. treated 234 femoral shaft fractures and the outcome was excellent in 150(65%) cases, satisfactory in 57 (25%) cases and poor in 23 (10%) of the cases<sup>9</sup>. Heybeli et al (2004) observed excellent results in 25(71.4%) cases, satisfactory in 9(25.7%) cases and poor in 1(2.9%) case<sup>24</sup>. Moroz et al (2006) found excellent results in 150 (65%) cases, satisfactory in 57(25%) cases and poor in 23(10%) cases<sup>25</sup>.

## Conclusion

Based on our experience and results we conclude:

- Elastic Stable Intramedullary Nailing (ESIN) is an ideal method for treatment of



paediatric femoral fractures as it gives adequate stability with elastic mobility promoting early union at fracture site without loss of reduction.

- It is simple, easy, rapid and effective method for management of paediatric femoral fractures with shorter operative time, lesser blood loss and shorter hospital stay.
- ESIN is a reliable, minimally invasive and physal-protective definitive treatment modality for diaphyseal fracture femur in children.
- It acts as biocompatible internal splint which provide adequate stability with minimal risk of infection.
- It helps in reducing the chances of malunion as loss of fracture reduction is not observed in our study.
- Early mobilisation of knee and hip can be initiated because of no immobilization of hip and joint as is compulsarily required in conservative treatment.
- Early weight bearing can be resorted to in all patients treated by ESIN without any fear of loss of reduction at the very first radiological sign of callus formation.
- The development of ESIN has put an end to misplaced fear of surgical treatment in paediatric femoral fractures vis-à-vis conservative method is not associated with any bone growth disturbance , any bone damage or weakening, due to physeoprotective surgical technique and elasticity of construct.

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