



## ORIGINAL ARTICLE

**Functional Outcomes of Titanium Elastic Nail Fixation in Diaphyseal Fracture of Femur in Children**Nabin Khadka,<sup>1</sup> Bikram Prasad Shrestha,<sup>2</sup> Raju Rijal,<sup>2</sup> Rajiv Maharjan,<sup>2</sup> Jitendra Shah<sup>2</sup><sup>1</sup>Department of Orthopedics and Trauma Surgery, National Trauma Center, National Academy of Medical Sciences, Mahankal, Kathmandu, Nepal<sup>2</sup>Department of Orthopedics, BP Koirala Institute of Health Sciences, Dharan, Nepal

## ABSTRACT

**BACKGROUND**

The management of femoral shaft fractures in pediatric age has always been a subject of discussion. In this study, we aim to find out the functional outcomes following the use of Titanium Elastic Nails for diaphyseal femoral fractures in children.

**METHODS**

This prospective observational study was performed on 23 patients of age 5 to 15 years with diaphyseal femur fracture who were operated and fixed with intramedullary TENS in the Department of Orthopedics, BP Koirala Institute of Health and Sciences from May 2020 to April 2021. Patients were evaluated to find out the functional outcomes of titanium elastic nail fixation in diaphyseal fracture of femur in pediatric age group using Flynn's scoring criteria, Bhatti's functional hip score and Neer's knee scoring system.

**RESULTS**

All 23 patients were evaluated for a period of 1 year. Radiological union in all cases were attained in a mean time of 14.61±4.06 weeks. Average duration of hospital stay was 4.30±0.70 days. There was no case of significant limb length discrepancy and malalignment. The results were excellent in 21 patients (91.3%), satisfactory in 2 (8.7%) and poor in zero patient at 1 year follow up using Flynn's criteria. Similarly, the results were excellent in 22 patients (95.6%) and good in 1 patient (4.4%) using Bhatti's functional hip score while all the cases showed excellent results using Neer's knee scoring system.

**CONCLUSION**

Based on these results, TENS is a safe and effective method for the management of diaphyseal femur fractures in children.

**KEYWORDS**

Diaphyseal; ESIN; femur fracture; pediatric; outcomes

## INTRODUCTION

Pediatric femoral shaft fractures, representing about 1.7% of all childhood fractures,<sup>1</sup> often result from high-energy trauma such as road accidents or falls. While spica casting is used in toddlers and adolescents over 16 years are treated with intramedullary nailing, treatment in children of 5-15 years remains controversial.

Paediatric femoral shaft fracture are treated with spica casting, external fixators, submuscular plating, elastic titanium nails and rigid nails.<sup>2</sup> Conservative management often leads to complications like limb length discrepancy and malunion. External fixators are likely to cause pin tract infection and

refracture.<sup>3</sup> Elastic nailing is mini-invasive and better for the fractures of middle two-third of the diaphysis.<sup>4</sup> Majority of the femur fractures in children seeking operative interventions are diaphyseal and 62% of them are fixed with elastic titanium nails.<sup>5</sup>

This study aims to evaluate the functional outcomes of TENS fixation in diaphyseal femur fractures among children, focusing on its efficacy and safety.

## METHODS

A prospective observational study was conducted in the Department of Orthopaedics, B.P. Koirala Institute of Health Sciences, Dharan, Nepal, over a period of 1 year from May 2020 to April 2021. Ethical clearance was obtained from the Institutional Review Committee of BPKIHS, Dharan (IRC/1650/019) on 15th May 2020.

The technique was well explained including complications and prognosis and informed consent was acquired from each

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patient's parent. Children of age 5 to 15 years with mid shaft fracture of femur were enrolled. Children of age 5 to 15 years with isolated closed or Gustilo Anderson Grade I mid shaft fracture of femur were enrolled. Patients who refused to give consent, presenting with open fractures (Gustilo Anderson grade II and III), neurovascular compromise, pathological fractures or neuromuscular disorders were excluded. A thorough history including demographic profile, methodology, pertinent clinical and radiological information was recorded in preset pro forma. Immediate skin traction application was done in Emergency Department and patients were scheduled for operative intervention after pre-anaesthetic checkup (PAC) clearance. Wound was inspected on second postoperative day and patient were discharged and asked for follow up at 2 weeks and 6 weeks for wound inspection and regular checkup while functional outcomes were evaluated at 3 months, 6 months and 1 year follow up at Orthopaedic outpatient department (OPD) using Flynn's scoring criteria, Bhatti's functional hip score and Neer's knee scoring system.

All the cases were operated by retrograde titanium elastic nailing system. They were fixed with two elastic nails of equal diameter – one from lateral entry point and the other from medial entry point. Patients were kept in fracture table with hip and knee in extension on the affected side and opposite hip was flexed, abducted and externally rotated and knee flexed. Entry point was marked 1-2 cm proximal to the distal femoral physis under the fluoroscopic guidance. A skin incision was made at the marked entry point and a bone awl was used to enlarge the Medullary cavity on lateral side of the femur shaft after which entry point was made on medial side of femoral shaft at the same level.

The diameter of nail was determined as 30-40% of the diameter of isthmus which was measured radiologically as the narrowest diameter on anteroposterior and lateral X-ray image. Nails of measured size were pre-bent and advanced into the medullary cavity. Fracture was reduced using F-tool under image guidance and manipulation. The lateral TENS was driven up to the metaphysis of greater trochanter whereas the medial one was advanced up to the neck of femur or lesser trochanteric area. Nails were inserted in such a way that both nails cross the fracture site concurrently. The ends of nail were cut flushing with the metaphyseal flare without bending the ends. Postoperative X-ray was taken on 1st postoperative day and immediate complication was assessed and patients were discharged on 2nd postoperative day after wound inspection (and if found satisfactory).

Patients were followed up in OPD in 2 weeks, 6 weeks, 3months, 6 months and 1 year and X-rays were done to assess the radiological outcome at every follow up apart from first visit at 2 weeks. The wound was inspected and sutures were removed at the end of 2 weeks. Postoperative physiotherapy and mobilization was initiated by trained physiotherapist on individual basis and patients were encouraged for gradual weight bearing depending upon the fracture stability, degree of reduction achieved and rate of fracture union.

The main aim of the study was to find out the functional outcomes of titanium elastic nail fixation in diaphyseal fracture of femur in children using Flynn's scoring criteria,<sup>6</sup> Bhatti's functional hip score<sup>7</sup> as it addresses the unique sitting habits (squat, kneel and crossleg sitting) accustomed in Asian lifestyle

and Neer's knee scoring system.<sup>8</sup>

The sample size estimation was based on a previous study,<sup>6</sup> which reported the excellent outcome of TENS fixation 82.5% and with a permissible error of 20% and considering 10% loss to follow up, sample size was calculated as 23 using one sample proportion technique.

Data were entered in Microsoft Excel 2013 and converted into a Statistical Package for social sciences (SPSS 11.3) for statistical analysis. Proportion, percentage, mean and standard deviation were calculated. Tabular presentation was also made.

## RESULTS

Initially 30 patients were considered for eligibility in this study. Out of 30 patients, 7 patients were not meeting the inclusion criteria (2 had re-fracture, 3 had Gustilo Grade II open fractures and 2 had pathological fracture) and they were excluded. A total of 23 patients were included and underwent TENS fixation and follow up was conducted for 1 year time duration and subsequently analyzed.

In this study, the number of male and female patients were 15 (65.2%) and 8 (34.8%) respectively. Most of the patients lied in the age group 5-10 years accounting 18 (78.3%) whereas there were only 5 (21.7%) in the age group 11- 15 years, the mean age being 9.13±1.66 yrs. Most of the patients presented with injury to the right thigh, which was 15 (65.2%) whereas only 8 (34.8%) patients had injury to left thigh. Similarly, the most frequent cause of injury was a fall from height, accounting for 11 patients (47.8%) while the cause was fall on ground and road traffic accidents (RTA) in 7 (30.4%) and 5 (21.7%) patients respectively.

The time taken to present after injury was 1.48±0.66 days, injury to surgery time was 3.13±0.92 days while duration of hospital stay was 4.30±0.70 days. The average duration of surgery was found to be 62.70±7.77 min. Intraoperative blood loss was found to be 38.48±10.38ml. The average VAS score for pain in the immediate post-operative period was 4.13±1.05.

Fracture was united in 18 (78.3%) patients by 12 weeks while it was observed by 24 weeks in another 5 (21.7%) patients. The average duration of fracture union was 14.61±4.06 weeks. Twenty patients had full range of motion (0-140 degree) while 2 cases had mild restriction of flexion (0-120 degree) but none had moderate or severe restriction during knee flexion at final follow up at 1 year period.

There were three cases of shortening of <0.5cm but none had significant limb length discrepancy and malalignment. Among the 23 patients analyzed at 3 months, 6 months and 1 year, the functional outcome evaluated by Flynn's Scoring system was excellent in 19 (82.60%) patients, satisfactory in 4 (17.40%) patients and poor outcome in none of the cases at 3 months whereas 21 (91.3%) cases had excellent outcome and 2 (8.7%) cases had satisfactory outcome and none of the cases had poor outcome at 6 month and 1 year period.

All the cases were able to squat, sit cross legged and kneel at 1 year follow up except one case who was able to sit cross legged with knee raised from floor for <45°. Thus, the results were excellent in 22 patients (95.6%) and good in 1 patient (4.4%) using Bhatti's functional hip score at 1 year period.

Similarly, none of the cases complain of pain at the end of 1 year follow up. Two cases experienced mild restriction in walking

capacity while there were three case of shortening of 0.5cm while there were no cases with angulation or displacement in X-ray images . Joint movement was greater than 100 degrees in all cases and all cases reported same work capacity as before the accident. So, the functional outcome was excellent in all the cases using Neer's knee scoring system at 1 year period.

**Table 1: Functional outcomes using Flynn's scoring criteria (n = 23)**

Functional outcome	Follow up		
	At 3 months	At 6 months	At 1 year
Excellent	19 (82.60%)	21 (91.3%)	21 (91.3%)
Satisfactory	4 (17.40%)	2 (8.7%)	2 (8.7%)
Poor	0	0	0

**Table 2: Bhatti's Functional Hip Score (n = 23)**

Functional outcome	Time duration	
	6 months	1 year
Excellent	21 (91.3%)	22 (95.6%)
Good	2 (8.7%)	1 (4.4%)
Fair	0	0
Poor	0	0

**Table 3: Neer's Knee Scoring System (n = 23)**

Functional outcome	Time duration	
	6 months	1 year
Excellent	20 (86.95%)	23 (100%)
Good	3 (13.05%)	0
Fair	0	0
Poor	0	0

Out of total cases, 21 (91.3%) patients didn't develop any complications, 1 (4.35%) patient developed superficial infection while there was 1 (4.35%) case of bursitis. The case of superficial infection required a course of oral antibiotics but didn't require debridement or admission. The case of bursitis required symptomatic treatment.

## DISCUSSION

While pediatric femur fractures are frequently seen in our hospital's emergency room, there are no established guidelines or protocols for their management, despite significant research in this area.<sup>9</sup> Femur fractures in children under 5 years are often effectively managed with conservative treatment using spica casting.<sup>10</sup> Femur fractures in children older than 15 years are usually managed with interlocking intramedullary nails, leading to few complications.<sup>11</sup> The management of femur fractures in children aged 5 to 15 years remains a topic of debate. For children in this age group, with weight below 50 kg and with

length-stable fractures, closed reduction and elastic titanium nail fixation are generally considered as more desirable management modality.<sup>12</sup>

In our study there was a male predominance; 15 (65.2%) cases were male patients. The predominance of males may be because of their greater engagement in outdoor activities like playing, climbing tree and contact sports in comparison to their female counterparts. Findings similar to ours were noted in the study by Jolley A et al. where there was male predominance (32 in number) as compared to female (28 in number).<sup>13</sup>

Similarly, most of the patients were of 5-10 years, with the mean age being 9.13±1.66 years. Similar findings were reported in the study by Olivo et al.,<sup>14</sup> the average age was 8.4±2.3 years for cases treated with TENS. Majority of the patients presented with injury to the right thigh, the dominant side. The affected side was right in 15 (65.2%) patients whereas 8 (34.8%) cases were affected on left side. Findings consistent with ours were reported in the study by Arora K K et al.<sup>15</sup> where right side was injured in 52 % of cases, 44% had injury on left side and 4% had bilateral injury.

Similarly, the most frequent cause of injury was a fall from height, accounting for 11 patients (47.8%) and 7 (30.4%) patients with fall on ground. In the remaining 5 (21.7%) patients, RTA was the cause of the injury. Unlike our findings, a study by Jolley A et al.<sup>13</sup> reported road traffic accidents (RTA) as the most common cause of injury followed by fall from height and sports injuries. This difference in the findings is due to the fact that most of the patients in our study reside in hilly region where tree climbing, terrace farming and steep roads are common whereas the study by Jolley A et al.<sup>13</sup> was conducted in city area where road traffic accidents are common.

Moreover, the average time from injury to surgery was 3.13±0.92 days. Similar findings to ours were noted in the study by Arora K K et al.<sup>15</sup> where eighty percent of patients underwent surgery within 2 days of injury, 12% were operated on between 3 to 5 days, and 8% presented after 5 days, with surgery performed on the 7th day.

In this present study, the average time of hospital stay was 4.30±0.703 days. Similar findings were noted in the study by Vishwanath et al.<sup>2</sup> where the mean hospital stay was 8.8 days. The mean duration of surgery (time from skin incision to closure) was 62.70±7.77 minutes. Findings consistent with ours was noted in the study conducted by Reddy et al.<sup>17</sup> where average the time period of surgery was 83.0 minutes.

The average blood loss was 38.48±10.38 ml and the number of patients requiring blood transfusion was nil. The result was similar to the study by Reddy et al.<sup>17</sup> in which the average blood loss was 45.3±6.58 ml.

Furthermore, the mean duration of fracture union was 14.61±4.061 weeks. Similar findings to ours was reported in the study by Reddy et al.,<sup>17</sup> in which they found the radiological union in 11.3±1.22 weeks.

In our study, only three cases had shortening <0.5cm but none had significant limb length inequality. Findings consistent with ours were reported in the study by Ho CA et al.,<sup>20</sup> in which only 2.19% cases had persistent limb length discrepancy > 2cm. Also, clinically significant malalignment in any plane was not found in patients in our study. Malalignment was <5 degree in all the patients. Similar findings to ours were noted in the study by Sarkar S et al.<sup>21</sup> where varus angulation was found in only 5.71% patients with TENS fixation.

Regarding postoperative complication, there was no complication in 21 (91.3%) patients while there was 1 (4.35%) case of superficial

infection and skin irritation each. The findings were consistent to ours in the study by Bhuyan BK et al.,<sup>6</sup> where there were 2 cases of superficial infection and 7 cases of skin irritation. Similarly, 21 (91.30%) patients had full range of motion (0-140 degree of flexion) while two cases had mild restriction of flexion (0-120 degree) in our study. Similar findings were noted in the study by Arora KK et al.<sup>15</sup> in which eighty percent of patients achieved a full range of knee movement, while 20% experienced mild restriction in movement.

This study showed excellent result in 21 (91.3%) cases whereas satisfactory result in 2 (8.7%) patients. None of the cases had poor outcome. The findings were similar to ours in the study conducted by Bhuyan BK et al.<sup>6</sup> and Memeo et al.<sup>16</sup> in which an excellent outcome was observed in 82.5% and 82% patients respectively.

All the cases were able to squat, sit cross legged (Palathi) and kneel (Tashahhud) at 1 year follow up except one case who was able to sit cross legged with knee raised from floor for <45°. Endurance was good in all cases while knee range of motion was partially restricted in two cases but there was no discomfort or limping. Thus, the results were excellent in 22 patients (95.6%) and good in 1 patient (4.4%) using Bhatti's functional hip score at 1 year period.

Similarly, none of the cases complained of pain at the end of 1 year time period. There was mild restriction in walking capacity in two of the cases while shortening of 0.5cm was reported in three cases but there was no angulation or displacement in X-ray images. Joint movement was greater than 100 degrees in all cases and all cases reported same work capacity as before the accident. So, the score ranged from 93-100 using Neer's knee scoring system at 1 year period suggesting an excellent outcome in all the cases.

The lower incidence of surgical wound complications, reduced operative time, minimal blood loss, and quicker recovery with titanium nails in treating pediatric femur fractures, as observed in our study, aligns with findings from other similar studies and case series. This supports titanium elastic nailing as the effective method for fixing femur fractures in children aged 5 to 15 years.

This study was limited by a small sample size conducted in a single institution and follow-up was done for a smaller period of time due to which complications like knee stiffness and malalignment were difficult to be assessed appropriately. So, a prolonged study period with a greater number of participants is suggested for a more comprehensive assessment and improved management of complications.

## CONCLUSION

On the basis of these findings, Titanium Elastic Nailing System (TENS) is a safe and excellent method for treating pediatric femoral diaphyseal fractures.

## CONFLICT OF INTEREST

None

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