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Original Article

Comparison between Titanium Elastic Nailing (TEN) and Dynamic Compression Plating (DCP) in Femoral Diaphyseal Fractures in Children

Md Abdul Gaffar Khan[1], M A Hannan[2], Goutam Baran Mistry[3], Sumon Mallik[4], Lata Majumder[5], Mumit Ahmed[6]

[1,5]Assistant Professor, Department of Orthopaedics, Jalalabad Ragib-Rabeya Medical College, Sylhet.

[2,3]Assistant Professor, Department of Orthopaedics, Sylhet M. A. G. Osmani Medical College, Sylhet.

[4]Professor, Department of Orthopaedics, Jalalabad Ragib Rabeya Medical College, Sylhet.

[6]Registrar, Department of Orthopaedics, Jalalabad Ragib-Rabeya Medical College Hospital, Sylhet.

ABSTRACT

Femoral shaft fractures are among the most common fractures of the lower extremity in children. Various methods of treatment can be used successfully, depending on the age of the child and the type of fracture. Immediate application of a spica cast, or traction followed by a cast, remains the standard management for most of these fractures in children. Operative treatment modalities include intramedullary nailing by flexible or rigid nails, external fixation, traditional open reduction and plate fixation, and submuscular bridging plating. The objective of this study was to compare the outcome of titanium elastic nailing and dynamic compression plating in diaphyseal fractures of the femur of children aged 6-12 years. This cross-sectional comparative study was conducted in the department of Orthopaedics, Sylhet MAG Osmani Medical College Hospital, during the period from 1st January 2016 to 31st December 2017. Thirty-six children with femoral diaphyseal fractures aged between 6-12 years of both sexes were included. Patients with pathological fractures, open fractures, fractures with associated neurovascular injury, those who weighed more than 49 kg, those with fractures longer than 2 weeks old and those unwilling to take part in the study were excluded. They were divided by random allocation into group-A (odd number) and group-B (even number) each comprised of 18 patients and treated with titanium elastic nailing and dynamic compression plating, respectively. Outcome was assessed with Flynn criteria at 6 months follow-up. The mean age was [9.56±1.98 years versus 9.67±1.46 years; p>0.05] and sex [15 (83.3%) male and 3 (16.7%) female versus 16 (88.9%) male and 2 (11.15%) female; p>0.05] did not differ significantly between group-A and group-B. Operation time [60.83±11.79 minutes versus 72.06±10.99 minutes; p<0.01], length of postoperative hospital stay [12.00±1.94 days versus 15.72±3.10 days; p<0.01] and time of union [11.11±1.71 weeks versus 12.00±0.0 weeks; p<0.05] were significantly shorter in group A than in group-B. Postoperative mobilization [2.61±1.72 days versus 2.50±0.71 days; p>0.05); time of weight bearing [6.22±0.65) weeks versus 6.33±0.77 weeks; p>0.05] did not differ significantly between the two treatment groups. The recorded complications of entry point bursitis, chronic discharge, mild pain, malalignment did not differ significantly between the two groups. Excellent functional outcome was more in group-A compared to group-B (83.3% versus 66.7%) but not statistically significant (p>0.05). This study concludes that there is no significant difference between functional outcome in TENS group and DCP group, though TENS group has slightly better outcome.

Keywords*: Titanium elastic nail, Dynamic compression plate, Diaphyseal fracture femur.*

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Address of Correspondence:
Dr Md. Abdul Gaffar Khan, Assistant Professor, Dept. of Orthopaedics, Jalalabad Ragib Rabeya Medical College, Sylhet. Email: drgaffar79@gmail.com.

INTRODUCTION

In children the leading cause of morbidity and mortality is trauma[1]. After the first year of life in children, it accounts for 50% of mortality and fractures are the most adverse event in their life[2]. Long bone fractures are a frequent cause

of morbidity in such cases. Femoral shaft fractures are the most common paediatric injuries. It occurs in 1.6% of children worldwide, incidence is 20 per 100,000/year, more common in boys with an interesting bimodal distribution at toddlers and adolescents[3]. Common mechanisms of injury are fall, sports injuries, traffic accidents, child abuse, and pathological fractures[4]. Assessment of environmental factors on aetiology of fractures in children can be done by the fact that 47% of fractures occur at home, 13% in road traffic accidents. 21% at school, 17% during play and 2% under other circumstances[2]. Various methods of treatment can be used successfully, depending on the age of the child and the type of fracture. Immediate application of a spica cast, or traction followed by a cast, remains the standard management for most of these fractures in children younger than six years of age[5]. However, in children of 6 to 12 years of age, due to problems associated with prolonged immobilization in spica cast and the care provider's demands for early mobilization, rapid recovery and reintegration of the patient, a variety of therapeutic alternatives have become available thereby decreasing impairment, increasing convenience[6].

An ideal fixation device for paediatric femur fractures would act as a load sharing internal splint, maintaining reduction for few weeks until callus forms. Most importantly, implantation should endanger neither the physis nor the blood supply of femoral head[7]. Operative treatment modalities include intramedullary nailing by flexible or rigid nails, external fixation, traditional open reduction and plate fixation, and submuscular bridging plating. Each operative treatment modality should preserve femoral blood supply, avoid damage to the physis and achieve adequate fracture stability[8].

Plate precontouring as close as possible to the anatomic plate structure is important, as the femur will reduce to the contour of the plate with screw placement[8]. Plating of femoral shaft fracture offers rigid fixation, it requires a larger exposure with the potential for increased blood loss and scarring[9]. Titanium elastic nailing has been the newer implant that is being used regularly. The material properties of titanium confer advantages for an implant used to stabilize paediatric femur fractures[10]. Titanium elastic nails are gaining popularity as the treatment for femoral shaft fractures in 6-12 years of age. They preserve the fracture haematoma as well. Recent publications have suggested that intra medullary titanium elastic nails achieve an earlier union than a plate[11]. Although good results have been reported with elastic intramedullary nails, plate fixation continues to be a viable alternative in surgical treatment of femoral shaft fractures. It is also considered that, compression plate fixation is a safe and effective treatment in children with both isolated femoral shaft fracture and those associated with multiple injuries. Study has recorded good outcomes following the use of titanium elastic nails and compression plating[12].

However, there are few studies comparing the efficiency of titanium elastic nailing and plating for femoral diaphyseal fractures in the paediatric age group. So, this study was designed to evaluate the use of titanium elastic nailing and dynamic compression plating for the treatment of children with diaphyseal femur fractures.

MATERIALS AND METHODS

This cross-sectional comparative study was carried out at the Department of Orthopaedic Surgery, Sylhet MAG Osmani Medical College Hospital, from 1st January, 2016 to 31st December, 2017. All the children aged between 6 and 12 years admitted during the study period fulfilling inclusion and exclusion criteria were enrolled in this study. Closed femoral diaphyseal short oblique or transverse fractures were the inclusion criteria. The patients were informed in detail regarding the procedure of the study and written consent was obtained. The final sample size was 36. The salient results are based on a minimum of 6 months of follow-up. Data were collected by the investigator and then recorded in a structured preformed questionnaire. The quantitative data will be expressed as mean and standard deviation and the qualitative data as frequency distribution and percentage. Data were processed and analysed using computer-based SPSS (Statistical Package for Social Science) software for Windows, version 21. Chi-square and Z-test were applied for statistical analysis. A p-value of less than 0.05 will be considered as significant.

Group-A (procedure for TEN): The patient was placed on a fracture table in a supine position with a traction boot and reduction of the fracture was tried partially by the traction using C-arm guidance. The diameter of the nail (3 mm, 3.5 mm, or 4 mm) depends on the width of the modularly canal. The nails preoperatively were contoured into a bow shape with the nail tip pointing to the concave side of the bowed nail. The contouring of each nail should be similar for a balanced effect. The entry point was 2.5-3 cm proximal to the distal growth plate. A longitudinal incision of 23 cm in length was made both medially and laterally on the distal aspect of the femur. The medullary canal was opened using an awl or drill bit (4.5 or 3.5 mm). The first nail was introduced on the side where the fragment overlaps so that the fracture could be better reduced. The nail was advanced using a sliding hammer attached to the inserter up to the level of the fracture site using C-arm guidance. In a similar manner, the second nail was inserted so that both nails diverge superiorly and advance to the level of the fracture site. At this point, reduction was done under C-arm guidance by using traction. Reduction was done in position by F tool and the

nail, which was easy to pass across the fracture site, was driven approximately 2-3 cm beyond the fracture site under the guidance of C-arm. Similarly, the second nail was driven across the fracture site. The traction was released so that the distraction disappears and the fracture end collapsed. Then nails were advanced till the nail tips got anchored in the metaphysis.

Group-B (procedure for ORIF with DCP): By posterolateral approach, the femur was exposed. Analysis of the fracture geometry and achieving the temporary anatomical reduction was done by bone-holding forceps. The fracture was fixed with DCP with screws. After proper haemostasis, wound closure was done in layers.

Post-operative care: Postoperatively, intravenous second-generation cephalosporin was used 8 hourly for 24 hours, and oral antibiotics were used for 3 days. Isometric quadriceps strengthening exercises and hip and knee joint mobilisation exercises were advised after pain subsides. Stitch off was done on the 14th postoperative day. The patient was followed up at 2 weeks, 6 weeks, 8 weeks, 12 weeks, and 24 weeks after the operation.

Outcome: Outcome was measured by Flynn's Scoring Criteria[7] and levelled as excellent, good and poor outcome.

RESULTS

In this study, a total of 36 patients with femoral diaphyseal fractures in children were selected and were divided into group-A and group-B by random allocation. Titanium elastic nailing (TENS) was performed in the patients of group-A and dynamic compression plating (DCP) in the patients of group-B.

The age of the patients ranged from 6 to 12 years, with the mean age of 9.56±1.98 years in group-A; while it was 8 to 12 years and 9.67±1.46 years, respectively, in group-B. Male were predominantly affected by femoral diaphyseal fractures in children [15 (83.3% versus 16 (88.9%)] (table-I). Twelve (66.7%) patients had the cause of injury in femoral diaphyseal fractures in children was road traffic accident (RTA) and remaining 6 (33.3%) patients were fall from height in group-A. It was 15 (83.3%) and 3 (16.7%) patients respectively in group B. Right side was involved in 12 (66.7%) and 14 (77.8%) of patients, respectively, in group A and B. Transverse fracture in 10 (55.6%) patients and oblique fracture in 8 (44.4%) patients in group-A. It was 11 (61.1%) and 7 (38.9%) patients respectively in group B. Operation time ranged from 45 to 90 minutes with the mean of 60.83±11.79 minutes in group-A; while it was 50 to 90 minutes and 72.06±10.99 minutes, respectively, in group-B (table-II). The operation time was significantly shorter in group A than that of group (Z=-2.954; p<0.01) (table-III). In the present study postoperative mobilization ranged from 1 to 7 days with the mean of 2.61±1.72 days in titanium elastic nailing group; while it was 1 to 3 days and 2.50±0.71 days, respectively in dynamic compression plating group. Postoperative mobilization did not differ significantly between titanium elastic nailing group and dynamic compression plating group (p>0.05). Length of hospital stay ranged from 8 to 15 days with the mean of 12.00±1.94 days in group-A; while it was 10 to 20 days and 15.72±3.10 days, respectively in group-B. The length of postoperative hospital stay significantly shorter in group A than that of group-B (Z=-4.316; p<0.01) (table-IV). The mean time of partial weight bearing was 6.22±0.65 weeks in group-A and 6.33±0.77 weeks in group-B (table-V). The mean time of union was 11.11±1.71 weeks in group-A and 12.00±0.0 weeks in group-B. The mean time of union was significantly shorter in group A compared to group-B (Z=-2.204; p<0.05) (table-VI).

The recorded complications were entry point bursitis [1 (5.6%) versus 0 (0.0%); χ^2=1.029, p>0.05]; wound infection [0 (0.0%) versus 2 (11.1%); χ^2=2.118, p>0.05]; mild pain [1 (5.6%) versus 1 (5.6%)]; implant failure [0 (0.0%) versus 1 (5.6%), χ^2=1.029, p>0.05]; malrotation of 5 degrees [1 (5.6%) versus 1 (5.6%)] and malrotation of 7 degree [0 (0.0%) versus 1 (5.6%), χ^2=1.029, p>0.05] did not differ significantly between two groups. Outcome was measured by using Flynn's criteria. There were 15 (83.3%) excellent, 2 (11.1%) good and 1 (5.6%) poor in group-A; whereas 12 (66.7%) excellent, 3 (16.7%) good and 3

Table-I: *Distribution of the patients according to age and sex.*

	Group-A n (%)	Group-B n (%)	p-value	Test value
Age (years)				
6-8	5 (27.8)	5 (27.8)		
9-10	6 (33.3)	8 (44.4)		
11-12	7 (38.9)	5 (27.8)		
Mean age (years)	9.56±1.98	9.67±1.46	>0.05	Z=0.192
Sex				
Male	15 (83.3)	16 (88.9)	>0.05	χ^2=0.232
Female	3 (16.7)	2 (11.1)		
Total	18 (100)	18 (100)		

*Z= z-test, χ^2= Chi-square test

Table-II: *Distribution of patients according to fracture type.*

Fracture type	Group-A n (%)	Group-B n (%)	p-value	χ^2-value
Transverse	10 (55.6)	11 (61.1)		
Oblique	8 (44.4)	7 (38.9)	>0.05	0.114
Total	18 (100)	18 (100)		

Table-III: *Distribution of patients by operation time.*

Operation time (minutes)	Group-A n (%)	Group-B n (%)	p-value	Z-value
45-60	13 (72.2)	5 (27.8)		
61-75	3 (16.7)	8 (44.4)		
76-90	2 (11.1)	5 (27.8)		
Mean±SD (minutes)	60.83±11.79	72.06±10.99	>0.05	-2.954

Table-IV: *Distribution of patients by length of hospital stay.*

Length of stay	Group-A n (%)	Group-B n (%)	p-value	Z-value
8-10 days	5 (27.8)	1 (5.6)		
11-15 days	13 (72.2)	7 (38.9)		
16-20 days	0 (0)	10 (56.6%)		
Mean±SD (days)	12.00±1.94	15.72±3.10	>0.01	-4.316

Table-V: *Distribution of patients by time of union.*

Time of union (weeks)	Group-A n (%)	Group-B n (%)	p-value	Z-value
8	4 (22.2)	0 (0)		
12	14 (77.8)	18 (100)		
Mean±SD	11.11±1.71	12.00±0.0	>0.05	-2.204

Table-VI: *Distribution of patients by outcome.*

Outcome	Group-A n (%)	Group-B n (%)	p-value	χ^2-value
Excellent	15 (83.3)	12 (66.7)		
Good	2 (11.1)	3 (16.7)	>0.05	1.533
Poor	1 (5.6)	3 (16.7)		
Total	18 (100)	18 (100)		

(16.7%) poor in group-B. The outcome did not differ significantly between two treatment group (p>0.05).

DISCUSSION

In the present study, the age of the patients ranged from 6 to 12 years, with the mean age of 9.56 (SD 1.98) years in the titanium elastic nailing group, while it was 8 to 12 years and 9.67 (SD 1.46) years, respectively, in the dynamic compression plating group. The age of the patients did not differ significantly between the two groups (p>0.05). This result correlated with the study of Ahmed et al.[11] that the mean age of patients in the titanium elastic nailing group was 8.75 (SD 1.77) years, and in the dynamic compression plating group was 8.87 (SD 1.74) years. The minimum age of patients in both treatment groups was 6, and the maximum age was 12 years.

In this study male children were predominantly affected by femoral diaphyseal fractures in children [15 (83.3%) versus 16 (88.9%)]. The sex difference between the patients of the titanium elastic nailing group and the dynamic compression plating group did not show any statistically significant difference (p>0.05) Ahmed et al.[11] supported this study that there were 25 male and 7 female patients in the titanium elastic nailing group. Whereas 26 patients were male and 6 patients were females in the dynamic compression plating group. Jolly et al.[13] reported 18 (60%) male and 14 (46%) females in the titanium elastic nailing group and 12 (40%) males and 16 (54%) females in the dynamic compression plating (DCP) group.

This study demonstrated that 12 (66.7%) patients had the cause of injury in femoral diaphyseal fractures in children was road traffic accident (RTA) and the remaining 6 (33.3%) patients were fall from height in the titanium elastic nailing group. It was 15 (83.3%) and 3 (16.7%) patients, respectively, in group B. Cause of injury did not differ significantly between the two treatment groups (p>0.05). This result was supported by Jolly et al.[13] that the predominant mechanism of injury was road traffic accidents (40%) and sports injuries (26%) in the TENS nail group. In the compression plate group, common modes of injury were similar to the TENS group, which were road traffic accidents (46%) and sports injuries (33%).

In this study, operation time ranged from 45 to 90 minutes, with the mean of 60.83 (SD 11.79) minutes in the titanium elastic nailing group, while it was 50 to 90 minutes and 72.06 (SD 10.99) minutes, respectively, in the dynamic compression plating group. The operation time was significantly shorter in group A than that of group B (p<0.01). This result was supported by Reddy et al.[12] that the duration of surgery in the TENS group was 83.0 (SD 5.94) minutes, whereas in the compression plating group it was 102.5 (SD 11.18) minutes. The duration of surgery in the TENS group was significantly shorter compared to the compression plating group (p<0.001). Jolly et al.[13] found that the average time duration of surgery in the TENS nail group was 37 minutes, whereas in the compression plating group it was 63 minutes. But Kumar et al.[14] found that the time taken for the completion of the procedure in the DCP group was 95.60 (SD 8.47) minutes and was 93.0 (SD 9.04) minutes in the TENS group with a p-value of 0.496 indicating the difference was not significant. Ahmed et al.[13] found that the mean operative time of the TENS and DCP-treated groups was 29.91 (SD 4.61) and 53.28 (SD 6.86) minutes, respectively. According to p-value, mean operative time for both treatment groups was statistically different. Operative time was higher for DCP patients.

In the present study, postoperative mobilization ranged

from 1 to 7 days, with the mean of 2.61 (SD 1.72) days in the titanium elastic nailing group, while it was 1 to 3 days and 2.50 (SD 0.71) days, respectively, in the dynamic compression plating group. Postoperative mobilization did not differ significantly between the titanium elastic nailing group and the dynamic compression plating group ($p>0.05$). This result was consistent with the study of Reddy et al.[12] that the mean postoperative mobilization was 2.0 (SD 0.56) days in the titanium elastic nailing group and 3.4 (SD 0.50) days in the dynamic compression plating group. But postoperative mobilization was differed significantly between the titanium elastic nailing group compared to the dynamic compression plating group ($p<0.001$).

Length of postoperative hospital stay in this study ranged from 8 to 15 days with the mean of 12.00 (SD 1.94) days in the titanium elastic nailing group, while it was 10 to 20 days and 15.72 (SD 3.10) days, respectively, in the dynamic compression plating group. The length of postoperative hospital stay was significantly shorter in the titanium elastic nailing group than that of the dynamic compression plating group ($p<0.01$). Kumar et al.[14] found that the mean hospital stay was 11.80 (SD 5.87) days in the TENS group and was 15.30 (SD 6.14) days in the DCP group. This result was consistent with the study of Reddy et al.[12] that the mean length of postoperative hospital stay was 3.3 (SD 1.02) days in the titanium elastic nail group and 5.0 (SD 0.76) days in the dynamic compression plating group. The length of postoperative hospital stay was significantly shorter in the titanium elastic nailing group than that of the dynamic compression plating group ($p<0.001$).

This study demonstrated that the mean time of starting partial weight bearing was 6.22 (SD 0.65) weeks in the titanium elastic nailing group and 6.33 (SD 0.77) weeks in the dynamic compression plating group. The mean time of partial weight bearing did not differ significantly between the titanium elastic nailing group and the dynamic compression plating group ($p> 0.05$). Kumar et al.[14] found that the mean duration for toe touch walking was 3.97 (SD 1.68) weeks in the titanium elastic nailing group and 7.85 (SD 2.23) weeks in the dynamic compression plating group. This result was consistent with the study of Reddy et al.[12] that the time of starting partial weight bearing was 3.7 (SD 1.3) weeks in the titanium elastic nailing group and 7.4 (SD 1.1) weeks in the dynamic compression plating group. The mean time of partial weight bearing was significantly shorter in the titanium elastic nailing group compared to the dynamic compression plating group ($p<0.001$). Jolly et al.[13] found that the average time of starting partial weight bearing was 3.8 weeks in the titanium elastic nailing group and 5.2 weeks in the dynamic compression plating group.

The mean time of union in the present study was 11.11 (SD 1.71) weeks in the titanium elastic nailing group and 12.00 (SD 0.0) weeks in the dynamic compression plating group. The mean time of union was significantly shorter in the titanium elastic nailing group compared to the dynamic compression plating group ($p<0.05$). This result was consistent with the study of Reddy et al.[12] that the average time taken for union in the TENS group was 11.3 (SD 1.22) weeks and that of the DCP group was 16.1 (SD 1.12) weeks, which was statistically significant. Kumar et al.[14] found that the mean time of union was 13.00 (SD 1.37) weeks in the titanium elastic nailing group and was 17.90 (SD 5.09) weeks in the dynamic compression plating group; the difference was statistically significant ($p<0.001$).

The recorded complications in this study were entry point bursitis [1 (5.6%) versus 0 (0%) $\chi^2=1.029$, $p>0.05$]; chronic discharge [0 (0%) versus 2 (11.1%), $\chi^2=2.118$, $p>0.05$]; mild pain [1 (5.6%) versus 1 (5.6%)]; implant failure [0 (0%) versus 1 (5.6%), $\chi^2=1.029$, $p>0.05$]; malrotation of 5 degrees [1 (5.6%) versus 1 (5.6%)] and malrotation of 7 degrees [0 (0%) versus 1 (5.6%), $\chi^2=1.029$, $p>0.05$] did not differ significantly between the two groups. Reddy et al.[12] noted the limb length inequality was around 15% in the DCP group and around 10% in the TENS group, but the distribution was statistically similar in both groups. They also reported that all cases of limb length inequality were ≤ 2 cm in both groups. There is a wide range of limb length inequality reported in other studies. Eren et al.[15] reported limb length inequality around 54% in femur shaft fractures treated with DCP. In patients treated with TENS reports, Saikia et al.[16] and Singh et a.[10] reported limb length inequality in 13.6% and 8.5%, respectively. Reddy et a.[12] noted malalignment (angulation or rotation) was not found in the DCP group and was 10% in the TENS group (angulation only, no rotation), which was statistically similar in both groups; none of the cases showed >50% malalignment. Saikia et al.[16] and Singh et al.[10] reported 9.09% and 8.57% of malalignment in cases treated with TENS, respectively.

In this study, functional outcome was assessed with Flynn's TENS outcome score applied to both groups at the end of 6 months of follow-up. Functional outcome was excellent in 83.3%, good in 11.1%, and poor in 5.6% of cases in the titanium elastic nailing group, whereas functional outcome was excellent in 66.7%, good in 16.7% and poor in 16.7% of cases in the dynamic compression plating group. Reddy et al.[12] found that functional outcome was excellent in 70% and satisfactory results in 30% of cases in the titanium elastic nailing group, whereas functional outcome was excellent in 70%, satisfactory results in 25% and poor in 5% of cases in the dynamic compression plating group. Kumar et al.[14] found that functional outcome was satisfactory in 12 cases (20%) and excellent in 48 cases (80%) in the titanium elastic nailing group, whereas

functional outcome was poor in 3 cases (5%), satisfactory in 15 cases (25%) and excellent in 42 cases (70%) in the dynamic compression plating group.

CONCLUSION

This study shows titanium elastic nailing and dynamic compression plating in paediatric femoral diaphyseal fractures have comparable promising results of complications and functional outcomes, but operation time, length of hospital stay, and time of union were significantly shorter in titanium elastic nailing. Based on these findings, it may be concluded that titanium elastic nailing may be a better option for paediatric femoral diaphyseal fractures.

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