ORIGINAL ARTICLE

Comparison of Dynamic Compression Plate Versus Titanium Elastic Nailing System in the Management of Pediatric Femoral Diaphyseal Fractures

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ABSTRACT

Objective: To compare the clinical outcomes of Dynamic Compression plate (DCP) versus Titanium Elastic Nailing System (TENS) in the surgical management of pediatric femoral diaphyseal fractures in a tertiary care hospital in Pakistan.

Study Design: Prospective non-randomized comparative study.

Place and Duration of Study: Imran Idrees teaching hospital Sialkot, 8 months.

Materials and Methods: This prospective non-randomized comparative study was conducted at Imran Idrees Teaching Hospital, Sialkot from April–December 2023. A total of 60 children (aged 7–12 years) with isolated femoral shaft fractures were enrolled and divided into DCP (n=30) and TENS (n=30) groups. Outcomes measured included fracture union time, operative duration, and postoperative complications. Statistical analysis was performed using SPSS v26, with p value <0.05 taken as significant.

Results: The mean time for fracture union was substantially lower in DCP group. (11.53 ± 0.571 weeks) compared to the TENS group (14.10 ± 2.524 weeks, p=0.001). Conversely, TENS showed a significantly lower operative time (30.83 ± 0.986 minutes) than DCP (53.20 ± 1.243 minutes, p=0.001). A moderate inverse correlation was found between BMI and fracture union time in the TENS group (ρ = -0.455, p=0.013).

Conclusion: Both DCP and TENS are effective surgical options for pediatric femoral shaft fractures. DCP enables faster fracture healing, while TENS reduces operative time. Treatment decisions should be individualized based on patient profile and surgical context.

Keywords: *Dynamic Compression plates, Femoral Fractures, Orthopedic Procedures, Pediatrics.*

Introduction

Pediatric femoral shaft fractures are significant injuries that account for approximately 1.6% to 2% of all pediatric fractures, leading to substantial morbidity worldwide.[1] The management of these fractures in children aged 7 to 12 years has evolved, with surgical intervention becoming the preferred approach to facilitate early mobilization and reduce complications associated with prolonged immobilization.[2] Dynamic Compression Plate (DCP) fixation and Titanium Elastic Nailing System (TENS) are widely used surgical options for pediatric femoral shaft fractures, each offering specific benefits and limitations. The incidence of these fractures varies worldwide and is influenced by socioeconomic factors, traffic safety, and recreational activities, with an estimated annual incidence of 20 per 100,000 children in high-income countries.[3] In underdeveloped countries, the incidence is likely higher due to increased exposure to risk factors, though comprehensive epidemiological data are lacking.[4] These fractures often result from high-energy trauma, such as motor vehicle accidents and falls from significant heights, leading to considerable healthcare utilization and economic burden.[5]

Historically managed conservatively, pediatric femoral fractures in children aged 7–12 years now favor surgery for faster recovery and improved alignment.[6] The American Academy of Orthopaedic Surgeons (AAOS) recommends surgical fixation for this demographic to optimize functional recovery and minimize psychosocial impacts.[7]

DCP provides rigid fixation for complex fractures but

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requires extensive dissection, increasing risks of infection and blood loss.[8] TENS uses flexible intramedullary nails for stabilization, retaining periosteal blood supply, promoting rapid healing, and enabling early weight-bearing.[9] However, TENS may be less effective in managing certain fracture types, such as those that are length-unstable or in older, heavier children.[10]

Recent comparative studies have sought to evaluate the efficacy of DCP versus TENS. A study by Venkataraman et al. reported that both methods achieved satisfactory outcomes, but TENS was associated with shorter operative times and hospital stays.[11] Similarly, Debnath et al. found that TENS resulted in a higher rate of excellent outcomes compared to DCP, with fewer complications. Conversely, some studies suggest that DCP may offer superior stability in complex fractures, albeit with a higher risk of infection due to the invasive nature of the procedure.[12]

Most studies on DCP vs. TENS for pediatric femoral shaft fractures are from high-income countries, leaving a data gap in LMICs like Pakistan. This study aims to compare DCP and TENS outcomes—including union rates and complications—in Pakistani children aged 7-12, providing evidence-based recommendations for resource-constrained settings.

Materials and Methods

This was a Prospective non-randomized comparative study conducted in the Department of Orthopedic Surgery at Imran Idrees Teaching Hospital (IITH), Sialkot, Punjab, Pakistan, following ethical approval granted by the Institutional Review Board (Ref: 2023/IITH/RA/0023, dated 24th April 2023). Patients included in this study were selected through a non-probability consecutive sampling technique from April 2023 to December 2023. Inclusion criteria encompassed pediatric patients aged 7 to 12 years presenting with isolated closed or Gustilo-Anderson Grade I open femoral diaphyseal fractures. Patients with pathological fractures, polytrauma, head injury, neurovascular compromise, previous surgical intervention on the same limb, or fractures involving the proximal or distal femoral metaphyseal or epiphyseal regions were excluded.

The sample size calculation was based on the primary outcome measure (fracture union time). Taking a data from the current similar study by Venkataraman et al. (2022), mean difference in union time of approximately 2.5 weeks between DCP and TENS was anticipated, with a pooled standard deviation of approximately 2.5 weeks. Using OpenEpi software (version 3.01), with 80% statistical power, a 5% significance level (alpha), and assuming equal distribution in each group, the minimum calculated sample size was determined to be 28 patients per group. To account for a potential 10% dropout rate, the sample was increased to 30 patients per group, resulting in a total sample size of 60 patients for the study[3]. Participants were prospectively allocated into two groups based on surgical intervention after informed written consent from their guardians: Group A (n=30) underwent Dynamic Compression Plate (DCP) fixation, involving open reduction and internal fixation with minimal periosteal disruption using AO-standard dynamic compression plates; Group B (n=30) underwent Titanium Elastic Nailing System (TENS), using closed or minimally invasive retrograde insertion of flexible intramedullary nails. Standardized surgical care was taken to prevent complications during the procedure and it was performed under general anesthesia by qualified orthopedic surgeons. Postoperative management was uniform across both groups, comprising prophylactic antibiotic therapy, analgesia, and structured physiotherapy programs. Early range-of-motion exercises commenced as tolerated, with partial weight-bearing initiated between 3–4 weeks in the TENS group and 5–6 weeks in the DCP group based on radiographic evaluation. Follow-up assessments were systematically performed at intervals of 2, 6, 12, and 24 weeks postoperatively. Clinical and radiological data, including demographics, time from injury to surgery, operative duration, fracture union (defined radiologically by bridging callus on three cortices on radiographic views[3].) all postoperative radiographs were evaluated independently by two orthopedic seniors surgeons who are not co authors in this study with more than five years of experience in pediatric fracture management. Both assessors were blinded to the intervention group (DCP vs. Flexible Nail) to minimize detection bias. Postoperative complications (infection, implant irritation, malunion, nonunion), and the necessity for

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secondary procedures were recorded on a structured, validated data collection form. The form underwent internal validation and pilot-testing prior to use. Statistical analyses were conducted using SPSS Statistics (version 26.0). Continuous variables were expressed as mean ± standard deviation and compared via independent-samples Mann–Whitney U test and spearman correlation with statistical significance defined as p-value <0.05.

Results

Table I presents the distribution of participants across different groups and gender. In terms of the group category, there is an equal distribution, with 30 participants (50%) in the Dynamic Compression Plate group and 30 participants (50%) in the Flexible Nail group. Regarding gender, there are 17 females (28.3%) and 43 males (71.7%), giving a total of 60 participants in the study. Mean age of participants was 9.25±1.323 years. The mean Body Mass Index (BMI) of participants was 16.45±1.545. The average operative time was 42.02±11.332 minutes. The mean fracture union time was 12.82±2.228 weeks. The average duration of the fracture prior to treatment was 2.80 ±1.424 days.

Table II shows Dynamic Compression Plate group had a mean operative time of 53.20± 1.243 minutes versus 30.83± 0.986 minutes for the Flexible Nail group, with a significant difference p = 0.001. For fracture union, the Dynamic Compression Plate group had a mean of 11.53 weeks (± 0.571), while the Flexible Nail group had 14.10± 2.524 weeks, also significantly different p = 0.001. No significant difference was found in the duration of the fracture, both groups having a mean of 2.80 days p = 0.848.

The table III. showed a moderate negative correlation BMI and fracture union in weeks (Spearman's rho = -0.373), with a statistically significant p-value of 0.003 (N = 60). A weak negative correlation was found between the duration of fracture in days and fracture union in weeks (Spearman's rho = -0.083), but the p-value of 0.528 indicates that this result is not statistically significant (N = 60). A strong negative correlation was observed between operative time in minutes and fracture union in weeks (Spearman's rho = -0.707), with a highly significant p-value of 0.000 (N = 60). A very weak negative correlation was found between age and fracture union in weeks (Spearman's rho = -0.048), with a non-significant p-value of 0.717 (N = 60).

Table IV presents the correlation between patient and operative variables with fracture union, stratified by fixation method (Dynamic Compression Plate vs. Flexible Nail). Spearman's rho correlation coefficients and corresponding p-values are reported. No significant correlations were observed with age or duration of fracture in either group. In the Dynamic Compression Plate group, BMI and operative time showed weak, non-significant associations. In contrast, in the Flexible Nail group, higher BMI ($\rho = -0.455$, $p = 0.013$) and longer operative time ($\rho = -0.738$, $p < 0.001$) were significantly negatively correlated with fracture union, indicating delayed union with increasing BMI and operative duration.

Table I: Descriptive Statistics

Category	Frequency (n)	Percent (%)
Group		
Dynamic Compression Plate	30	50.0
Flexible Nail	30	50.0
Gender		
Female	17	28.3
Male	43	71.7
Total (Gender)	60	100.0
Variable	**Mean**	**Standard Deviation**
Age	9.25	1.323
BMI	16.45	1.545
Operative Time in Minutes	42.02	11.332
Fracture Union in Weeks	12.82	2.228
Duration of Fracture in Days	2.80	1.424

Table II. Comparative Analysis of Surgical Metrics Between Treatment Modalities

Variable	Group	Mean ± SD	Mann-Whitney U	p-value
Operative Time (minutes)	Dynamic Compression Plate	53.20 ± 1.243	0.000	0.001
	Flexible Nail	30.83 ± 0.986		
Fracture Union (weeks)	Dynamic Compression Plate	11.53 ± 0.571	30.000	0.001
	Flexible Nail	14.10 ± 2.524		
Duration of Fracture (days)	Dynamic Compression Plate	2.80 ± 1.518	437.500	0.848
	Flexible Nail	2.80 ± 1.349		

Table III. Correlation Between variables and Fracture Union Time

Variable	Correlation With	Spearman's rho	p-value	Sample Size (n)
BMI	Fracture Union in Weeks	-0.373	0.003	60
Duration of Fracture in Days		-0.083	0.528	
Operative Time in Minutes		-0.707	0.000	
Age		-0.048	0.717	

Table IV. Fracture Union Correlation by Fixation Method

Variable	Dynamic Compression Plate		Flexible Nail	
	Spearman's rho	p-value	Spearman's rho	p-value
Age	-0.038	0.843	-0.087	0.643
BMI	-0.144	0.495	-0.455	0.013
Operative Time (mins)	-0.101	0.595	-0.738	0.000
Duration of Fracture (days)	0.187	0.324	-0.069	0.713

Discussion:

Femoral shaft fractures are a significant concern in pediatrics, affecting both the child and their family. The incidence follows a bimodal distribution, peaking in infancy and mid-adolescence. Treatment approaches vary depending on the age and fracture pattern[1]. The current study was about 43 males (71.7%) and 17 females (28.3%), which reflects the higher prevalence of fractures in males, consistent with findings from a study involving 911,206 subjects reported that males had a 12.25% incidence of traumatic long-bone fractures, while females had a 6.25% incidence, indicating a higher fracture rate among males[13]. The average age of participants was 9.25±1.323 years ,which is consistent with a study showing that the highest frequency of fractures occurs at 6 years of age in boys and 7 years in girls[14]. The mean BMI of 16.45 was normal, aligning with an average healing time of 12.82±2.228 weeks. Obesity is known to delay fracture healing[15]. The average operative time was 42.02±11.332 minutes, similar to the findings in other pediatric fracture surgeries, where operation times range between 30-60 minutes. Longer operative times may be influenced by factors such as fracture complexity[16]. The average fracture-to-treatment time was 2.80 days (SD = 1.518 for DCP and SD = 1.349 for Flexible Nail), with no significant difference between the two groups (U = 437.500, p = 0.848). This suggests that the time from fracture occurrence to treatment initiation was similar for both groups. Timely surgical intervention following a fracture is essential to minimize the risk of complications and promote efficient healing. Delays beyond 5 days post-injury have been associated with increased complication rates, underscoring the importance of prompt treatment[20].

An inverse relation was significantly found between BMI and fracture union time (Spearman's rho = -0.373, p = 0.003). This indicates that higher BMI is associated with longer fracture healing times. Supporting this finding, Heath et al. reported that obese pediatric patients had a mean time to union of 152 days, significantly longer than the 93.59 days observed in non-obese patients ($p < 0.001$)[21]. The correlation between the duration of the fracture and fracture union time was weak and not statistically significant (Spearman's rho = -0.083, p = 0.528). This suggests that the time elapsed since the injury does not significantly impact the healing time in this cohort. Similarly, Grauberger et al. (2020) found no significant differences in time to union between patients treated within 18 hours of admission and those treated later ($p > 0.05$)[17,22]. A strong negative correlation was observed between operative time and fracture union time (Spearman's rho = -0.707, p = 0.000). This indicates that longer operative times are associated with slower healing. Supporting this, Cintean et al. noted that longer surgical times could be associated with increased complications, potentially affecting healing outcomes[23,24]. The correlation between age and fracture union time was weak and not statistically significant (Spearman's rho = -0.048, p = 0.717). This suggests that age does not have a significant influence on fracture healing time in this sample.

Our data showed no correlation between patient age and fracture union time in both treatment groups (DCP plating: $\rho = -0.038$, $p = 0.843$; ESIN flexible nailing: $\rho = -0.087$, $p = 0.643$). This outcomes is according to the recent studies. For instance, Lakhani

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et al. reported that school-aged children (mean age ~11.5 years) treated with submuscular DCP plating all achieved bone union at an average of about 11 weeks, with no significant age-related delay in healing[25]. In the current study in (DCP) cohort, There was no significant relation seen between BMI and union time (ρ = –0.144, p = 0.495), indicating that heavier vs. lighter children healed at similar rates. In contrast, our ESIN (flexible nail) group demonstrated a moderate inverse correlation between BMI and union time (ρ = –0.455, p = 0.013), meaning higher-BMI patients had shorter union times. In the Flexible Nail group, a significant negative correlation between BMI and fracture union time (Spearman's rho = -0.455, p = 0.013) was observed, suggesting that higher BMI was associated with shorter union time. Similarly, Heath D et al. reported that obesity significantly delayed fracture healing in femoral fractures treated with intramedullary nailing (p = 0.001)[26]. Our study revealed a strong negative correlation between operative time and fracture union time in the Flexible Nail group (Spearman's rho = -0.738, p < 0.001), indicating that longer operative times were associated with shorter union times. No significant correlation between the injury-to-surgery interval and fracture union time in either treatment group. This is consistent with findings by Kumar et al., who reported no statistical difference in final outcomes between patients operated before or after five days (p = 0.6)[21].

Limitations included a single-center setting and small sample size. The 24-week follow-up was limited, missing long-term outcomes. Future studies need larger, multicenter cohorts and Randomized Controlled Trials (RCTs) to improve generalizability and provide robust evidence.

Conclusion

This study demonstrates that both Dynamic Compression Plate (DCP) and Titanium Elastic Nailing System (TENS) are viable surgical techniques for pediatric femoral shaft fractures, each with distinct clinical advantages. DCP was associated with a significantly shorter time to fracture union, making it a favorable option in cases where rigid fixation is essential. TENS, with its minimally invasive approach and shorter operative duration, remains a practical choice in settings where reduced surgical exposure and faster recovery are prioritized. The findings stress the importance of individualized care planning based on fracture type, patient status, and resources of institution. These results contribute valuable regional data to support evidence-based surgical decision-making in pediatric orthopedics, especially in low-resource healthcare settings.

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CONFLICT OF INTEREST

Authors declared no conflicts of Interest.

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DATA SHARING STATEMENT

The data that support the findings of this study are available from the corresponding author upon request.